IRSE

Institution of Railway Signal Engineers

Proceedings

2019-2020

The Institution of Railway Signal Engineers

Proceedings for the Year 2019-20

Table of Contents

IRSE Proceedings 2019-20
Introduction & Summary of the Year

The IRSE's Presidential Year started in April 2019 with the 106th Annual General Meeting held at the Institute of Engineering and Technology in London, chaired by retiring President Markus Montigel. The inauguration of new President George Clark took place who then gave his Presidential Address with the theme, *Delivering Change*. Before giving his address, George paid tribute to Markus for his leadership of the IRSE during the past year.

Over 200 delegates from 17 countries attended the 2019 ASPECT conference held at Delft University of Technology in the Netherlands. A total of 19 sessions with Q&As were held during the conference and the event saw the launch of a dynamic app to replace the traditional printed programme, helping to reduce the environmental footprint of the event.

The IRSE's International Technical Committee (ITC) has 32 fully participating and ten correspondence members from across the world. During the year the ITC held five meetings in Western Europe and produced six papers all of which have been published in IRSE News and/or Signal & Draht. Frans Heijnen stepped down as Chair of the ITC in November 2019 after four years in the role, with Paul Hendriks taking over.

The IRSE makes a number of awards each year to recognise, reward and encourage the professional development of engineers, particularly those in the early stages of their career. The purpose behind this is not simply to assist their career development, but to promote high standards of engineering excellence, thereby contributing to the public benefit objectives of the Institution.

Reece Martin MIRSE was awarded the 2019 Thorrowgood Scholarship for attaining four passes with credits in the Exam sat in October 2018. The IRSE Signet Award, awarded to the candidate with the highest marks in any single module, was presented to Paul Hobden AMIRSE for excelling in Module 1 (Safety of Railway Signalling & Communications).

IRSE Merit Awards were presented to Ian Moore FIRSE and David Nicholson FIRSE. Ian was nominated for his long service to the Institution and in particular the York Section, and David was nominated for his assistance to Institution members in their preparation for the professional Exam.

The Dell Award was made to Janagan Yoganathan for his work on the 4LM project delivering a new CBTC signalling system for the four sub-surface underground lines comprising the Metropolitan, District, Hammersmith & City and Circle lines.

In 2019 eight people benefited from the Frank Hewlett Bequest and Alan Fisher Memorial Fund, enabling them to attend the IRSE's ASPECT Convention in the Netherlands.

No award was made in 2019 for the IRSE/Network Rail Apprentices of the Year due to re-structing of Network Rail's apprentice awards scheme.

We received 425 applications for new membership in 2019 (133 for corporate and 292 for non-corporate) and this was slightly down on 2018 (452). There was a slight increase in membership figures from last year from 4,953 to 4,992 members. There was a good number of applications for professional registration with the Engineering Council with the IRSE approving 28 new registrants in 2019 – nine Chartered Engineers, six Incorporated Engineers and 13 Engineering Technicians.

Blane Judd
Chief Executive and General Secretary, IRSE
December 2020

The Institution of Railway Signal Engineers

Annual Report 2019

IRSE

Institution of Railway Signal Engineers

Annual Report

Number 107

1 January to 31 December 2019

Contents

This Annual Report briefly describes the activities undertaken by the Institution of Railway Signal Engineers (IRSE) throughout the world during 2019. Our President from April 2019 has been George Clark from the United Kingdom.

For up to date information about the Institution or its activities, or to download a membership application form, log on to the IRSE website **www.irse.org**.

Follow us on Twitter **@IRSEHQ**

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An introduction from our President

The IRSE is a very active Institution, with the activities of its various local sections, in the UK and around the world. It also has obligations to the Rail Industry in terms of the Licensing System, as well as to the Profession of Railway Signalling. However, it always surprises me when an annual report is published which shows the depth and diversity of work the Institution has undertaken in the previous 12 months.

The Institution has always had a very small dedicated team at its London HQ and relies heavily on the work of volunteers – members who give their time to take forward the profession and encourage new entrants as well as the continuous development of its existing members. I have been a Member and Fellow for many years; a trustee of the charity and more recently a director of IRSE Enterprises, its 'not for profit' company. I have served as a Member and Fellow at Council, as well as at Management Committee and it's an honour to be President.

When I wrote my presidential address, I took the time to reflect upon my career, progressing from an apprenticeship into Rail Control Systems and from design into Engineering Management through to my current role as an Engineering Director. I could overlay my knowledge and skill development with becoming an IRSE member. I would attend many lectures together with a regular read of IRSE News. This would give me a window into the industry, not just in the UK but around the world and in combination with my day-job, enabled me to be the best I could be. Our professional community has many who share their experiences, whether on their current projects or applying their experience to the challenges of the day. So, whilst I continue to learn, I also seek to share my experience and support the Institution.

I started my Presidential year in April 2019 and so some of the annual report really does belong to my predecessor, Markus Montigel. In reality the Presidential year doesn't start in April. Presidential work usually commences two years earlier, as Junior Vice President and then Senior Vice President – with responsibilities which grow over time. In recent years I have seen at Council, the growth in local sections in such places as China and India, whilst our overall membership has grown to almost 5000 members with about 50% of them in the UK.

The main technical lectures have now moved from London to be delivered around the world and hence the arrival of a local section for London and the South East has proven a great success with a busy series of events.

This year, as Council Chair, has been an eventful period, and some might say a 'roller-coaster'. We started with the drive to embed the modern brand and image of the Institution which was to be visualised in the much awaited new website. As a former software engineer and manager of software-based systems, I could see we had to work hard within the IRSE to get it right and took a phased approach (there is more to come in website functionality in the future) but our old website died just at the worst time and led to the need to urgently provide an interim site which I know left a lot of you frustrated and furthermore lead to a massive effort by the HQ team to ensure we were able to manage the annual subscriptions. However, we now have a website to be proud of – it's our shop window to those who have yet to join us as well as an ever increasing tool to support members in knowledge sharing, research and continuous development.

There are two other highlights I would promote and the first has to be the excellent work of IRSE staff and volunteers in the development of a new, modern examination structure which seeks to enable career progress ultimately aligned with such status as EngTech, IEng and CEng – levels that become more recognised within the Industry as well as Academia. The first of these is module A – effectively an introduction into the profession and one which excites me as I see this as a key part of encouraging more people, especially those young people from diverse backgrounds who work in our industry, but have yet to align with our profession as well as those who want to have a basic knowledge of railway signalling and control systems. My final highlight is the work of a small group of senior staff and volunteers in the development of our future Strategy. The old five-year plan has now reached its end and it was vital we set out the vision for the future. Such a task is never easy and required the determination of our CEO, Blane Judd, to ensure we didn't get distracted and provided a focussed to the task. The Strategy has been presented to a number of audiences and will shortly be loaded onto the website and seeks to take us forward from the Winds of Change theme set out by my predecessor through my theme of Delivering Change and beyond with a vision to Deliver Safe and Sustainable Global Railways.

Returning to my Presidential year and theme, Delivering Change, provided an appreciation of the challenge in providing Traffic Management systems on the UK national network and was followed by how Denmark has created an environment to successfully deliver their national ERTMS programme. Recognising the global influence the IRSE has, these lectures have set new standards in providing live web-streaming and subsequent uploading onto the website. This has proved very successful, as over 5 times the local audience has benefited from the lectures which continue to be available on-line. This international interest continued with the final 2019 Presidential lecture on the challenges of delivering new technology in a sustainable manner in Hong Kong. Returning to my Presidential address, I highlighted the pace of change in technology and the webinar on future Telecommunication systems illustrated what was currently being embraced in the rail industry and blended that with the development by companies such as Vodaphone who are generations beyond and stimulated some debate on the pace of change and indeed the role of standards, which can help target research and development.

I cannot complete my review of 2019 without mentioning the ASPECT conference, which was very successful in both quality and a quantity of papers and created a forum for debate on resilience with an audience that was diverse in both experience and gender.

To conclude, I look back and see that 2019 was a year of delivering changes in technology, and in people but building upon the strengths of the Institution – its members; its staff and its many volunteers around the world. I would like to take this opportunity to recognise and thank volunteers for the work they do, willingly giving the Institution hours of their time, often free of charge. We have a Strategy and a vision for an Institution which seeks to engage and develop its members, growing its network and assuring that the talent pipeline of competent, Professional Engineers into 2020 and beyond.

George Clark, London, 2020

Objectives of the Institution

The Institution's objectives are written in its Articles of Association. They can be traced back to the formation of the Institution in 1912 and are:

a) The advancement for the public benefit of the science and practice of signalling by the promotion of research, the collection and publication of educational material and the holding of conferences, seminars and meetings, and

b) The maintenance of high standards of practice and professional care amongst those working within the industry and the promotion of improved safety standards for the protection of the general public.

Although it might appear that the IRSE is concerned only with railway signalling, the full text of the objectives makes clear that all forms of train control and traffic management, and communications systems, are all within our scope of interest.

There is a clear emphasis in the objectives on 'public benefit'. This is most obvious in the sense of contributing to safety on the world's railways, where train control systems play a critical role. But we are also interested in ensuring that railways are efficient, cost-effective and sustainable (in the widest sense). We meet our obligations to the public through the following principal mechanisms:

- The dissemination of knowledge, experience and good practice in the fields of railway signalling, control and communications and allied topics, to help ensure that those working in the profession do so with the best available knowledge for the safe, efficient and cost-effective construction and operation of the world's railways.
- The provision and management of the IRSE Licensing Scheme to assure the competence of those working in the profession. The Scheme is focused predominantly, but not exclusively, on ensuring safety in the design, construction, testing and maintenance of signalling and telecommunications systems.
- Our Code of Professional Conduct, with which IRSE members are required to comply in the course of their work. It emphasises topics such as personal responsibility for work undertaken or managed by IRSE members, the importance of safeguarding the public interest (particularly safety), environmental management, the efficient use of resources, handling conflicts of interest etc.
- Undertaking specific initiatives to help ensure the safety and efficiency of railways. By bringing the IRSE Sections around the world together, we will facilitate the sharing of best practice and new initiatives to help engineers and others enhance their knowledge and professionalism. We will continue to reach out and grow our network of professionals around the world to harness the collective knowledge they possess for the benefit of all operators and users of railway transport.

The financial resources of the Institution are applied to achieve the objectives of the Institution, in addition to which members make a significant contribution to delivering the Institution's aims by their volunteer activities. The Institution has only a small number of full and part-time staff and most of the activities are organised by our members acting in a voluntary capacity.

Our Strategy

As 2020 approaches a new strategic plan, which will extend into the new decade, has been developing. Through engagement with the membership, external bodies, staff and Council, Beyond 2020 Vision is being made ready to launch in the new year.

The key activities of the Institution as cited in our Articles of Association have not changed, but a renewed emphasis on the key areas, has helped to inform the development of this important new document.

While looking to the future, it was important to make sure that any key activities in the current implementation plan were either completed or carried forward. This was overseen by the Council and its sub committees as part of their governance activities.

Key elements of the current plan include:

- Enabling growth of the IRSE as a global engineering Institution to promote professional standards throughout the world.
- Tackling the skills gap facing railway signal, control and communications engineering in the UK and other countries in the world.
- Encouraging employer support for IRSE to help ensure that the Institution's activities align with the needs of the wider industry.

Progress continued to be made throughout the year in developing the international dimension of the Institution, with plans for the Toronto Convention in 2020 well underway and work beginning on ASPECT 2021. We continue to support the local sections, and the work of the Local Section Coordinator has made a significant contribution in supporting this aim.

As part of the focus on new entrants into the sector, the Institution is working with training providers in the area of apprenticeships. We will be assisting in the End Point Assessment processes. There will be developments into 2020 as programmes are delivered and candidates progress through to completion.

Building on the back of the Digital Railway white paper we have agreed to work with Industry partners including WSP, KPMG and the UK's Rail Delivery Group on similar publications as we move into the next stage of our strategic development.

The end of the year saw the new website being populated with exciting content including video and live streaming of lectures and conferences. All of these developments support our global membership and our aim to be accessible 24/7/365 to all who have access to the internet.

Governance

Council

The IRSE is governed by an elected Council of 21 corporate members, led by the President, who are the trustees of the Institution.

Six meetings of the Council were held during the year in which the business of the Institution was conducted. The Articles of Association permit the current Chairs of all local sections, both in and outside the UK, and also Country Vice-Presidents to attend Council meetings. During the year a number of Chairs and Country Vice-Presidents attended meetings, either in person or using video conference facilities.

In addition to conducting all the normal Council business during the year, Council discussions included the following topics:

- Progress with the Strategy 2015-20 and the associated implementation plan.
- Development of the Strategy for 2020 and beyond.
- Oversight of the new website build and launch.
- Development of the new Industry partnership scheme.
- Establishing a succession plan for the office of President
- Consideration of changes to voting to facilitate greater scrutiny and accessibility.

Council also receives and reviews the annual report from each of the international Sections of the IRSE.

Committees

The Institution has a number of committees which are accountable to Council, through which our activities are managed. The principal committees and their relationships to Council are shown in the diagram below. In addition, ad-hoc working groups are formed from time to time which focus on specific tasks.

Audit

External Audit

A number of areas of the Institution's business are audited on a regular basis by various external audit bodies:

- All areas of finance are subject to audit annually by independent external auditors who submit their report to the Annual General Meeting.
- The Licensing Scheme is subject to an annual external audit by the United Kingdom Accreditation Service (UKAS).
- As a registered charity, the Institution is subject to periodic external review by the Charity Commission.
- As the Institution is licensed by the Engineering Council in the UK to register Chartered and Incorporated Engineers and Engineering Technicians, it is subject to a review every five years by the Engineering Council in order to ensure compliance with their registration standards.

Internal Audit

The IRSE's internal Audit Committee undertakes independent audits to complement the external audits, in order to ensure the Institution is running efficiently and effectively. The audits focus primarily on the role and remit of each of the principal committees of the Institution.

The Audit Committee normally performs two audits per annum. Each audit results in a report, which is presented to the Chair of that committee and subsequently the Council, which uses the recommendations to improve the management of the Institution's affairs for public benefit and for the benefit of its members. The Institution maintains a Risk Register, which is reviewed annually by Council, and this is used as the basis for audit.

IRSE Enterprises

IRSE Enterprises Ltd is the trading company wholly owned by the Institution. The trading company handles a number of activities which are associated with but outside the direct scope of the charity. The Directors of the company appointed for the year April 2019 to April 2020 were:

- Chairman (Immediate Past President): Markus Montigel
- President: George Clark
- Senior Vice President: Daniel Woodland
- Junior Vice-President: Ian Bridges
- IRSE Treasurer: Andrew Smith
- IRSE Chief Executive: Blane Judd

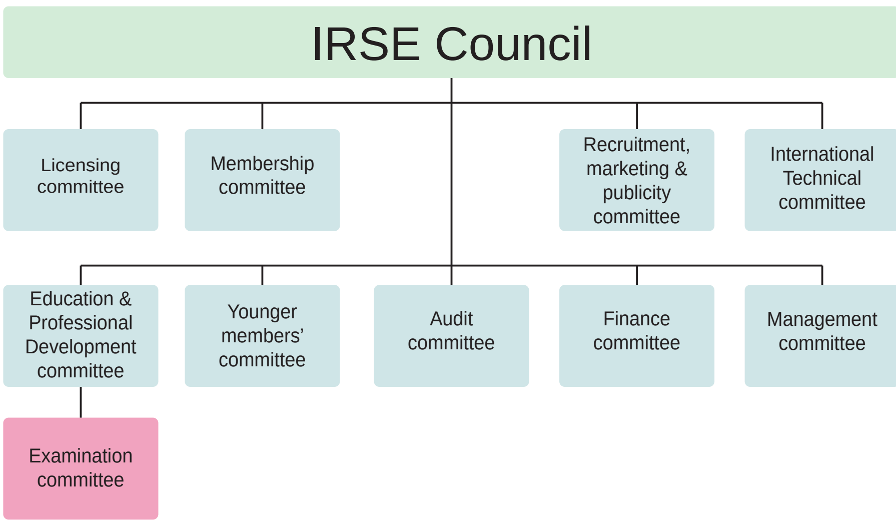
Any profits from the company are, where possible, gift-aided back to the Institution.

Sections

The IRSE sections around the world exist by authority of the IRSE Council, and they operate in accordance with a set of Articles of Association (or Byelaws) that have been approved by Council. At the end of 2019 there were 21 sections in total. 16 sections outside the UK in various parts of the world (Australasia, China, France, Hong Kong, India, Indonesia, Ireland, Japan, Malaysia, Netherlands, North America, Singapore, Southern Africa, Swiss, Thailand) and six of which are UK-based. The North America Section includes the USA, Canada and Mexico. The Ireland Section includes both Northern Ireland and the Republic of Ireland.

Two other sections also exist – the Younger Members' Section and the Minor Railways' Section. These are not geographically-based, although their activities are predominantly within the UK. Some geographical sections also have younger members' groups.

Each section has an organising committee, with elected officers for key roles. Information about the activities of the sections is provided elsewhere in this report.



Professional development

Supporting professional development of IRSE members and prospective members throughout the world is a key objective of the IRSE.

To do this, we have Judith Ward as our Professional Development Manager, the Education and Professional Development Committee and the Examination Committee.

IRSE Professional Examination

The IRSE professional examination is a Masters-level academic qualification which tests knowledge and understanding of railway systems with a particular emphasis on safety. To pass the exam, the candidates must pass four modules including a compulsory module on safety systems.

Passing the IRSE exam is one route to obtain either Associate Member or Member of the IRSE. Passing the IRSE exam can "top up" engineering or technology qualifications for professional registration with UK's Engineering Council. An accredited Bachelor's degree with honours plus IRSE exam may demonstrate knowledge and understanding for Chartered Engineer applicants and an accredited Higher National Diploma/Foundation degree plus IRSE exam may demonstrate knowledge and understanding for Incorporated Engineer applicants.

Many volunteers run exam study groups and the independent exam forum website to support prospective examination candidates.

The number of candidates sitting the exam and the quality of their scripts was similar to that of 2018. 222 candidates sat the exam in 16 exam centres across the globe with 59% achieving pass grade or higher.

Council approved changes proposed by Education & Development Committee for the restructure of the professional exam in April 2019. These changes will begin to be implemented in 2020 with a computer-based new foundation-level module and will be fully implemented in 2021 with a further three mandatory modules covering the whole syllabus to the same high standards.

Continuing Professional Development (CPD)

The Engineering Council requires that from 2020, those who do not engage in the CPD monitoring process are removed from their register.

Information about the importance of developing and maintaining members' professional competence through CPD has continued to be provided through IRSE NEWS and the website.

The IRSE recommends the use of the 'Mycareerpath' system for CPD planning, recording, reflecting and reviewing. More information about Mycareerpath is available on the IRSE website.

Certified courses

The IRSE offers a process by which training providers can have their courses assessed and certificated by the IRSE.

This year ILEX Academy gained IRSE certification for their Post Graduate Diploma in railway signalling and telecommunications courses being run at Riyat-Bahra University and Ramaiah University of Applied Sciences.

Other training providers are in the process of having their signalling and telecommunications courses assessed.

Professional Registration

The IRSE is licensed by the UK's Engineering Council to register suitably qualified members as Chartered Engineer (CEng), Incorporated Engineer (IEng) and Engineering Technician (EngTech).

The requirements for these are defined by the Engineering Council for knowledge, understanding, competence, relevant work experience and commitment. Brief definitions are that: Engineering Technicians apply proven techniques and procedures to practical problems; Incorporated Engineers maintain and manage applications of current and developing technology; Chartered Engineers develop solutions to engineering problems using new or existing technologies and/or have technical accountability for complex systems with significant levels of risk.

Apprenticeships

The IRSE is an End Point Assessment Organisation (EPAO) for two English apprenticeships: Rail Engineering Design Technician (Level 3) and Rail Engineering Technician (Level 3).

Professional development is a key element of every professional engineer's life. The IRSE supports this by providing many of the various channels of development, shown in green in this table.

IRSE Section meetings	Standards briefings	Mentoring / buddying	Professional awards	Conferences
IRSE exams	Professional registration	STEM/STEAM activities	"lunch and learn"	Project/location placements
IRSE News	Local safety/ sustainability champion	IRSE Presidential Programme via live link	Formal training courses	IRSE membership
Presenting to IRSE Section	Technical qualification	Supporting IRSE exam study group	Being on an IRSE Section committee	Volunteer days

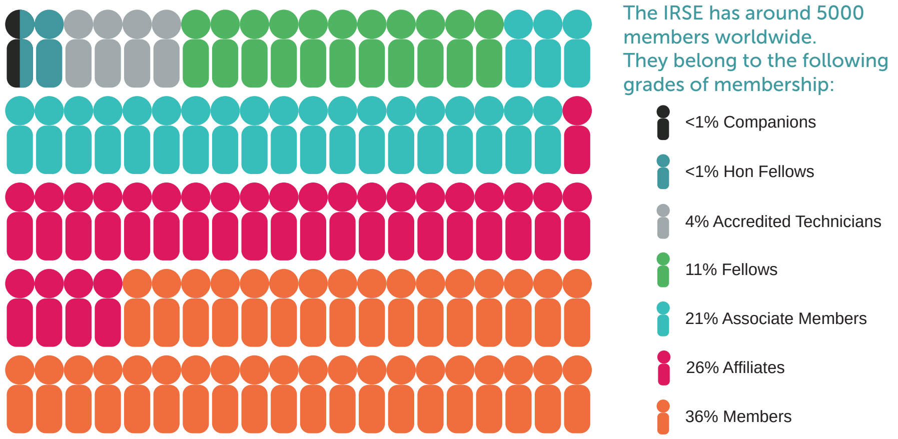
Membership and registration

2019 was another busy year for the Membership Committee assessing applications for IRSE membership and Engineering Council registration, as well as considering procedural and policy matters. There were 425 successful membership applications, 133 for corporate and 292 for non-corporate, this was slightly down on 2018 (452).

A new process of notifying successful applicants by email will be introduced in 2020 enabling them to register to use the IRSE online portal and encouraging them to pay their first (and subsequent) membership subscription through the online payment process.

The online Affiliate form continues to prove popular. We are hoping to better incorporate this into the IRSE website, and develop an online application process for corporate membership, over the coming year and to feed applicant information directly into the membership database.

There was a slight increase in membership figures from last year, from 4953 members to 4992.



There continues to be a steady flow of applications for professional registration with the Engineering Council. In 2019 the IRSE approved 28 new registrants for the Engineering Council's register – nine Chartered Engineers, six Incorporated Engineers and 13 Engineering Technicians.

The Institution was sad to report the deaths of the following members during 2019:
Jacques Catrain, David Crabtree, Adriaan Heijnen, Barry Mogford, Noel Reed, Rakesh Chandra Agrawal, Hennie van de Venter, Roderick Townsend, Charles Beatson, Anthony Cook, Bin Ning, Colin Waters, Robin Mitchell and Craig Longley.

Licensing

The IRSE operates a competence certification scheme, known as the IRSE Licensing Scheme, which exists to provide assurance for the competence of individuals to carry out technical safety-critical or safety-related work on rail control systems. The Scheme provides a cross-industry accepted benchmark of competence for personnel carrying out a range of activities. All competence standards are reviewed at least five-yearly to ensure that the competence criteria remain consistent with Industry developments and, during 2019, the Engineering Manager and Senior Engineering Manager Suites of licences have been under review.

There are a range of licence categories that have been mapped to the UK Engineering Council competences for Engineering Technician. This allows licence holders of those categories with appropriate qualifications to apply for EngTech registration without having to complete any further competence assessment paperwork or, in most cases, attend an interview. It also supports the UK Apprenticeship End Point Assessments.

The Scheme is managed by the Licensing Registrar supported by a small team in the IRSE offices in London, which works under the direction of the Licensing Committee, chaired by Colin Porter. Since August 2017 the Registrar position has been covered by David Weedon, currently supported by Karen Boyd as Deputy Registrar and Licensing Assistants Roger Button and Laura Freeborn.

During the year, 1481 licences were issued, which was significantly more than the expectation of about1350, based on the total of c.6800 valid licences at the end of 2019 and the requirement for 5 yearly renewal or revalidation. There are no identified trends or underlying reasons that would suggest a significant change in the number of licences in the immediate future, although licence issue has been above expectations and there has been increased compliance by major UK stakeholders to infrastructure standards requiring licensing of S&T staff.

For operations within the UK, the Licensing Scheme continues to hold full accreditation by the United Kingdom Accreditation Service (UKAS) against the competence standard for the certification of persons: ISO17024:2012, with four-yearly re-accreditation successfully achieved during 2018.

IRSE Assessing Agents are approved and appointed for the purposes of performing assessments of candidates for licences, and they are an essential part of the Licensing Scheme. Currently the number of approved assessing agencies is 26, with one ceasing to operate during the year.

Awards

The IRSE makes several awards each year. The majority of these are to recognise, reward and encourage the professional development of engineers, particularly those in the earlier stages of their careers. The purpose behind this is not simply to assist their career development, but to promote high standards of engineering excellence, thereby contributing to the public benefit objectives of the Institution.

Thorrowgood Scholarship

Reece Martin

The Thorrowgood scholarship is awarded under a bequest of the late W J Thorrowgood (Past President) to assist the development of a young engineer employed in the signalling and telecommunications field of engineering.

The award is made to a candidate who has excelled in the IRSE professional examination and comprises an engraved medallion and funding for a study tour of railway signalling installations or signalling manufacturing facilities.

This year's winner was Reece Martin MIRSE for attaining four passes with credits in the Exam sat in October 2018. Reece is planning to visit China to study high speed railways.

Reece was presented with the award at the 2019 Annual General Meeting by outgoing president Markus Montigel.

Dell Award

Janagan Yoganathan

The Dell award is made annually under a bequest of the late Robert Dell OBE (Past President). It is awarded to a member of the Institution employed by London Underground (or its successor bodies) for achievement of a high standard of skill in the science and application of railway signalling. The award takes the form of a plaque with a uniquely designed shield with an engraved plate being added each year with the recipient's name.

This year's Dell Award was presented to Janagan Yoganathan for his work on the 4LM project delivering a new CBTC signalling system for the four sub-surface underground lines comprising the Metropolitan, District, Hammersmith & City and Circle lines.

Janagan collected his award from Markus Montigel at the 2019 Annual General Meeting.

IRSE Merit Award

Ian Moore and David Nicholson

The Merit Award was introduced in 2007 In order to recognise exceptional service to the Institution by a volunteer or staff member anywhere in the world. The award is made by the Council following receipt of a nomination and takes the form of a plaque mounted on a rectangular plinth with an engraved citation.

This year Merit Awards were presented to Ian Moore FIRSE and David Nicholson FIRSE. Ian was nominated for long service to the Institution and in particular the York Section. David was nominated for his assistance to Institution members in their preparation for the professional Exam.

David (top photo) was presented with his award at the SNC-Lavalin Atkins in London, and past-president Colin Porter made the presentation to Ian at the York Dinner.

IRSE -Signet Award

Paul Hobden

The IRSE-Signet award is the most recent of awards, introduced in 2016 and sponsored by Signet Solutions. This Award is given annually to the person who obtains the highest marks in any single module of the IRSE Examination.

The Award takes the form of the Signet logo 'person' on a small plinth, engraved with the name and year of the winner, and bearing the IRSE's logo. Funding for the winner to attend the annual IRSE Convention is also included.

This year's award was presented to Paul Hobden AMIRSE for his excellent results in the IRSE professional exam sat in October 2018.

He is planning to attend the IRSE International Convention in Toronto in 2020.

Frank Hewlett Bequest and Alan Fisher Memorial Fund

Frank Hewlett was an Associate Member of the Institution. He died in September 2008 and left a very generous and substantial bequest to the Institution. In 2009 the IRSE Council launched an appeal to establish a memorial fund for Alan Fisher, who died unexpectedly during his Presidency of the Institution. The intention was to use the fund to support the development of young S&T engineers, particularly those outside the UK.

The income from the two funds is used predominantly to provide a number of travelling bursaries for younger members from all over the world to support their attendance at major IRSE events.

In 2019 eight people benefited from the fund, enabling them to attend the IRSE's ASPECT Convention in the Netherlands.

IRSE/Network Rail Apprentices of the Year

No award was made this year due to re-structuring of Network Rail's apprentice awards scheme.

London office and personnel

The Institution leases a small suite of offices on the 4th floor of the Institution of Mechanical Engineers building, 1 Birdcage Walk, London, UK, from where the centrally organised activities of the Institution are managed – membership, licensing, events administration and financial administration.

The Chief Executive and General Secretary of the Institution is Blane Judd, a Chartered Engineer and Fellow of the Institution of Engineering and Technology. He is responsible for directing and managing the resources of the Institution in order to implement the decisions of Council in an efficient manner and in compliance with UK company and charity law. He is accountable to the Council. He also provides the focal point of contact for other Institutions and external organisations, including the UK's Engineering Council and the Royal Academy of Engineering, government agencies, the chief officers of other professional bodies, and the scientific, engineering and technology community. He is also responsible for ensuring compliance with the requirements of the Institution's Articles of Association, Companies House, the Charities Commission and relevant legislation.

The office team comprises:

- Polly Whyte, Head of Membership and Registration
- Hilary Cohen, Executive Assistant
- Judith Ward, Director of Operations (part-time)
- David Weedon, Licensing Registrar
- Karen Boyd, Deputy Licensing Registrar
- Roger Button, Licensing Assistant
- Caterina Indolenti, Membership and Registration Administrator
- Anja Laitinen, Administration Assistant (part-time)
- Hannah Mueller, Finance Assistant (part-time)
- Laura Freebourn, Administration Assistant (part-time) started Oct 2019

2019 marked the retirement of one of our longest serving staff, Christine White, who stepped away from the IRSE in February after 13 years.

Marketing and Communication activities have been operated externally by Lindsay Jones of LJPR Ltd. Lindsay is a qualified journalist and she is successfully promoting the Institution to a much wider International stakeholder group. We are also receiving excellent support from Howard Elwyn-Jones of Prettybright on a wide range of social media activity, which includes the much improved e-bulletin and video livestreaming of events.

Andrew Smith is the Institution's Treasurer, with responsibility for the production of the budgets and accounts, and for monitoring the health of the Institution's savings and investments.

Debbie Bailey is our HR Manager.

These staff work on part-time contract basis.

Presidential programme

Each year the IRSE President plans a programme of major events, comprising a series of high-profile technical papers, the annual Convention and other events as appropriate.

Our President to April 2019 was Markus Montigel whose presidential theme was 'The Winds of Change', and the final four technical papers in his year presented in early 2019 were on the subjects of 'The main line ATO Journey', 'Challenges in Designing Secure and Resilient Railway Command and Control Systems' and 'Human Factors in Aircraft Cockpits, Lessons Learned'.

George Clark, our President for twelve months from April 2019, chose 'Delivering Change' as the theme for his year as a natural follow-on from Winds of Change. Reflecting the international nature of the IRSE, more presidential events are being held outside the UK. The paper 'Delivering Change through the Danish ERTMS programme' was presented in at the end of the year in Denmark. Two further Presidential presentations will take place in Holland and Sydney during 2020.

Presidential technical papers presented in the UK during the rest of 2019 were 'Delivering Change through Intelligent Traffic Management' and 'Delivering CBTC in Hong Kong'. 'Future Communications Systems' was the Institution's first ever webinar, broadcast live to an international audience in December.

All the papers are published in our monthly journal, IRSE News, and the presentations are available as webcasts on the IRSE website. Our Presidential presentations are also being live-streamed, available to members and non-members.

Section activities

In addition to the Presidential Programme, every year there is a programme of lectures, seminars and technical visits organised by the Institution's 21 sections across the globe. Our sections are in Australasia, China, France, Hong Kong, India, Indonesia, Ireland, Japan, Malaysia, Netherlands, North America, Singapore, Switzerland, Thailand, and Southern Africa. Within the UK, sections cover London & South East, Midland & North Western, Plymouth, Scottish, Western, York and Minor Railways.

The geographical sections vary considerably in size (from around 40 members up to several hundred), and in levels of activity. Each has its own organising committee, elected officers and programme of events. They report annually to the Council on their work. In 2019 highlights included:

Australasian Section: Technical meetings and visits in Brisbane on the theme of 'A new generation – people and technology'.

French Section: Conference on future communications for rail.

China Section: Several technical papers and seminars. President Bin Ning sadly passed away during 2019.

Hong Kong Section: Technical forum on cybersecurity systems.

India Section: Celebrated their 10th anniversary with a joint convention with IRSTE at Jabalpur.

Indonesia Section: Participation in the trial ride of MRT Jakarta Lines.

Irish Section: Technical paper and demonstration on axle counters.

Japan Section: Working in study groups discussing the following fields of railway signalling, management and strategy,technology in general, technology in details, cost and certification and standards.

London & South East Section: Technical visit to HOBRIBA MIRA (formally known as the Motor Industry Research Association).

Malaysia Section: Discussion on a seminar with IEM and Trade/Industry Attaché, Embassy of Japan.

Midland & North Western Section: Annual Steam Lunch on the Churnet Valley Railway.

Minor Railways Section: Celebrated their tenth anniversary with a technical visit to the East Lancashire Railway.

Plymouth Section: Technical paper on the Cornwall Capacity enhancement project.

2018-2019 President Markus Montigel visited the Thailand Section this year.

Netherlands Section: The Section was heavily involved in the planning and running of ASPECT2019.

North American section: Fourth annual conference and technical visits on CBTC.

Scottish Section: Technical paper on the Waterloo incident.

Singaporean Section: Technical papers on Crossrail signalling and advancing the SCORES-Signalling simulator to training tool.

Southern African Section: Technical paper "SIL-4 is not always SIL-4" by IRSE President Markus Montigel.

Swiss Section: Technical visits to Stammtisch and Chemin de fer du Kaeserberg.

Thailand Section:Joint technical paper with Kasetsart University during IRSE President Markus Montigel's visit.

Western Section: Technical papers on cloud computing and the Cornwall Capacity enhancement project.

York Section: Participated in the North Eastern Railway Engineers' Forum.

The Council wishes to record its thanks to the Officers, Committee members and all others involved in the operation of all the sections, for the excellent work they undertake in organising technical meetings and other events. Council also very much appreciates the help and support given by many companies in facilitating and supporting the events organised by the sections all over the world. Charles Page continues his excellent work in the role of Local Section Coordinator, supporting the sections.

Younger Members

The Younger Members' Section exists to ensure that the activities of the Institution are relevant and valuable to the professional development of current younger and less experienced members. Events are open to all and the section greatly appreciates the many members who help out with presentations and sponsorship throughout the year.

Keith Upton continued as the chair in 2019 with only minor changes to the remaining committee members.

The Younger Members Section is currently going through a renewal and the plan will be to relaunch the section during 2020. The section welcomes ideas from all members of the IRSE from around the world.

The section has always been committed to supporting the preparation for the IRSE exams and 2019 has been no different. In February it hosted the Exam Review event to inform all exam candidates the good, bad and ugly from 2018 exams. This was recorded and available to all IRSE members via the website. It also provided two exam study events in June 2019, kindly supported by Signet Solutions and Atkins, a member of the SNC-Lavalin Group. The first was a Module 2, 3 and 5 study weekend at Signet in Derby, UK, and the second was a Module 1 and 7 study day in Birmingham, UK.

ASPECT 2019 in Delft, Netherlands, was well attended by Younger Members from around the world and over half of the bursary winners from 2017 returned this year. Together with other Younger Members who also presented their papers, this was a fantastic achievement of which the section is justifiably proud.

The Younger Members also helped to pioneer a new collaboration between the IRSE Younger Members, the IMechE's (Institution of Mechanical Engineers) Railway Division, YRP (Young Rail Professionals), and the IET's (Institution of Engineering Technology) Railway Technical Professional Network, called Young Rail Tours (YRT). This new collaboration will deliver an ambitious programme of UK, European and international study tours designed to be affordable, accessible and relevant to young professionals working in the UK and global rail industry. Members visited Scotland (UK) in September 2019 and are planning a trip to Japan in March 2020.

Young Members events are extremely varied, ranging from study days for the IRSE examination to technical visits to places of interest, normally with an informal element for sociable networking.

Annual General Meeting

The IRSE's 106th Annual General Meeting, chaired by the retiring President, Markus Montigel, was held at the Institution of Engineering and Technology, London on Friday 26th April 2019.

After conducting the formal business of the AGM, Markus commented on the Annual Report for 2018 (published on 1st April 2019), and the Treasurer, Andrew Smith, commented on the accounts for 2018.

Markus announced the ballot for the election of members to Council had resulted in Jane Power (TFL, UK), Ian Allison (Park Signalling, UK), Rod Muttram (Fourth Insight, UK), Peter Allan (Siemens, UK) and Keith Upton (Atkins Global, UK) joining Council.

It was noted the sad news that Mr R C Agrawal FIRSE, one of the Council election candidates, had passed away after the close of the elections.

Announcements and presentations were made to the recipients of the Dell Award, Thorrowgood Award, the IRSE-Signet Award and Merit Awards (for more details see the Awards section of this Report).

This was followed by the inauguration of the new President, George Clark who paid tribute to Markus for his leadership of the IRSE before launching the theme 'Delivering Change' in his Presidential Address.

IRSE Council 2019-2020	
President	George Clark
Vice Presidents	Daniel Woodland, Ian Bridges
Members of Council from the class of Fellow	Peter Allan, Ian Allison, Steve Boshier, Bogdan Godziejewski, Yuji Hirao, Pierre-Damien Jourdan, Andy Knight, Rod Muttram, Jane Power, Ajay Vijayvargiya (co-opted for one year)
Members of Council from the class of Member	Rob Burkhardt, Martin Fenner, Cassandra Gash, Ryan Gould, Lynsey Hunter, Paul McSherry
Members of Council from the class of Associate Member	Xiaolu Rao, Keith Upton
Co-opted Past Presidents	Markus Montigel, Charles Page, Peter Symons

Annual Dinner

The 55th Annual Dinner was held at The Savoy on Friday 26 April 2019 following the AGM and the inauguration of new President George Clark. It was a sold out event again with 351 diners.

The President's guest of honour was Mike Brown MVO, Commissioner, Transport for London (TfL). He spoke about TfL, its challenges and the contribution of railway signalling and telecommunications to meet the capacity demands in London.

This year the Chief Executive launched a collaboration with RedR, a disaster relief charity which matches volunteers with technical skills to assistance tasks in response to disasters across the world. A collection at the dinner raised £3019 for this charity.

The dinner once again relied on generous sponsorship and on this occasion, we were grateful to SNC-Lavalin Atkins for being our sponsors.

The IRSE Annual Dinner has been at capacity for several years with potential attendees having to be declined. Exploration and assessment of options was initiated in autumn 2018 and as a consequence the 56th Annual Dinner in 2020 is planned to be held at The Landmark Hotel at Marylebone. This venue has the capacity for us to expand towards the venue's capacity of 500.

Members' Luncheon

On Wednesday 12 June 2019 the Institution held the 21st Annual Members' Lunch at the Union Jack Club in London where members and staff gathered to reminisce and to exchange news. The President, George Clark, welcomed everybody to the event and, after lunch, spoke about the pace of change, both in railways and in the world generally. He acknowledged the work of IRSE members and licence-holders worldwide – "Today IRSE members and licence holders around the world are introducing the latest technology systems from Sydney to Copenhagen, Toronto to Hong Kong. Many industries face huge technical complexity and challenges, but few, if any, must contend with the full range of challenges of railway system engineers."

Blane Judd, our CEO, was unable to be present because of a long-standing engagement, so Francis How (the previous CEO) delivered Blane's look-back at the previous year. For the first time in our history, impressive Presidential Papers were delivered in Paris, Zurich, Germany and Australia, all live streamed for members across the world to watch in real time or on demand. Our regional sections have been busy too, holding technical seminars and visits all of which help to further the professional development of members and carry our important message. He looked forward to ASPECT 2019, in Delft in October, and to the introduction of the new website. He also referred to the fact that the IRSE Council is in the process of refreshing our Vision and Strategy for 2020 and beyond.

In closing, Francis expressed the thanks of the whole Institution for the dedication of the IRSE's staff.

ASPECT 2019

Over 200 delegates from 17 countries attended the 2019 ASPECT conference and enjoyed the exceptional hospitality of the Dutch local section.

The quality of the papers presented, together with the active engagement of delegates with the Q&A after each of the 19 sessions, helped to make this event a highlight of the year.

Central to ASPECT is this enthusiastic collaborative exchange between colleagues, a sharing of ideas that reinforces the importance of this event not only for our members, but for our sector as a whole. No event in our calendar could be more in line with our vision as we seek to grow the IRSE and to build and extend our global network of talented rail professionals.

It was great to see different local sections come together and offer support to one another as well as enjoying the local social and cultural experience in the beautiful city of Delft.

The generous support of our corporate sponsors is so essential to the success of this event and each of them said that they found ASPECT a useful opportunity to forge and deepen relationships across our sector.

This year's conference included some technical firsts in its organisation, including a dynamic app to replace the traditional printed programme and reduce our environmental footprint.

In addition to details and timings for each day, this technology allowed the provision of enhanced detail on each speaker and grant instant access to papers, including the detailed range of reserve papers that could not be presented live at the event.

ASPECT2019///
Institution of Railway Signal Engineers | Delft University of Technology | IRSE Nederland

Parallel sessions offered an increased choice of subject matter for delegates, while this year's use of simultaneous video recording meant that choosing one presentation need not mean missing out on another.

In addition to press, media and promotion for ASPECT, our communications team worked with IET.TV to engage with attendees and provide additional insight into the conference this year.

We are indebted to the organising committee for all their efforts in assembling this year's conference. Our thanks also go Rob Goverde, TU Delft and the responsive and capable team at the AULA conference centre, an ideal venue for this flagship event. The committee was ably and fully supported by our comms team and the dedicated staff at IRSE HQ and volunteers who are so very central to the impressive range of regular events and activities the Institution is able to provide.

To everyone involved – "Dank je wel"

International Technical Committee

The IRSE's International Technical Committee (ITC) has 32 fully participating and ten 'correspondence' members from many parts of the world, including Japan, USA, the UK, Netherlands, Italy, Germany, Switzerland, Belgium, Finland, France, Australia, Spain, Singapore and Canada.

The ITC's primary purpose is to provide thought leadership and disseminate learning on strategic or technical topics relevant to train control and communications systems in the railway environment, thereby providing value not only to IRSE members but to the wider rail industry. Its particular strength lies in its international membership at senior level, enabling engineering principles and practices from a diverse range of countries to be brought to bear upon the subjects that ITC debates.

During the year, the ITC held five meetings, in Western Europe. The ITC produced six papers, all of which have been published in IRSE News and/or Signal & Draht. This is a drop from the previous year's publications due to work pressures of our members, all of whom are voluntary. All ITC papers can be found on the IRSE website.

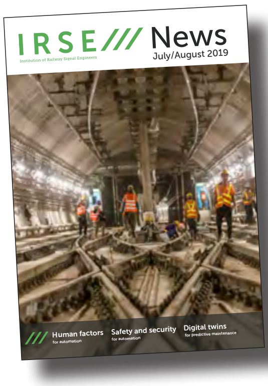
The meetings are hosted by members in their country and minutes are produced for each meeting. An annual report is produced for the Council summarising the ITC activities during the year.

After four years, Frans Heijnen stepped down as Chair of the ITC in November with Paul Hendriks taking over the role.

Publications and communications

This year was a landmark year for the Institution as we continue to deliver on our strategy of driving up both the standard and reach of our communications. The brand-new website was launched in July giving us improved functionality and we held our first ever webinar in November, broadcasting our 'Future Communications' seminar live to an international audience.

IRSE News

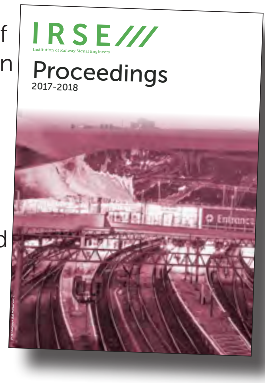


IRSE News is published monthly, its purpose being primarily to inform IRSE members worldwide about industry news, technical developments, and the work and activities of the IRSE and its Sections. Presidential Programme papers are published in IRSE News, together with a wide range of other internationally sourced educational papers and articles. We held a survey amongst the readership of the IRSE News to ensure the content of our publication continues to meet the expectations of members and are delighted to report that an overwhelming majority of readers were happy with the current format. Constructive suggestions were made regarding additional content that could be included which will be considered for future issues of the publication. We'd like to extend our thanks to the editorial team for another excellent year.

Website

The website, **www.irse.org**, provides details of Institution events, Sections, information about the governance and operation of the IRSE, material for members taking the IRSE professional examination, how to become a member, as well as a wealth of information relating to professional development. Members (and registered non-members) can update contact details, book events, order publications, and pay their subscriptions on-line. We also advertise industry vacancies that may be of interest to IRSE members and non-members.

Proceedings



The Proceedings provide a summary of the Institution's activities and have been produced annually since 1913. A hard copy of the Proceedings is supplied to the British Library and to the library of the Institution of Engineering and Technology. PDF versions of the Proceedings are available for all to read via our website, **irse.info/proceedings**.

E-communication

A monthly email bulletin is sent to all members, containing information about upcoming events and other topical information. In addition, we send out ad-hoc electronic communications to members highlighting key presidential events and other important information.

Social Media

The Institution has a social media presence on LinkedIn, Facebook and Twitter. Key events, presentations and topical news stories are posted on all these feeds on a regular basis to help keep Members informed and raise the profile of the Institution amongst the wider railway industry.

Railway industry media

During this year several articles on the IRSE were published in industry magazines including Rail Engineer and Rail Professional. The ASPECT conference was covered by leading Dutch railway journal Spoor Pro, and ITC member Alan Rumsey's view on a speech by the New York Governor in relation to New York City Transit's problems was published online by Railway Age. We are working hard to develop wider relationships with railway media.

Publications

The IRSE publishes a range of books on railway train control and communications systems, which provide a useful source of educational material for those relatively new to the profession, as well as providing a valuable record of the development of signalling. Extensive work is ongoing to edit and modernise the Metro Signalling Handbook.

Library

Members of the Institution are permitted to use the library of the Institution of Engineering & Technology in London by appointment, and there is also an archive collection of publications available on request at the IRSE's London offices.

IT Systems

The three major IT components that support the Institution's operations are the membership and licensing database, the website, and the London office IT systems.

Last year we took the decision to migrate our office software systems to a more secure cloud-based server facility, which allowed us to abandon the local servers which were reaching end of life. We have been using the new system through the year and had some training on how to take full advantage of the collaborative nature of the products.

The first quarter of 2019 also saw the introduction of a new website. Although we were moving from older legacy systems to protect the services we offer to members through the web, the old system failed and could not be restored. This resulted in a lot of additional effort by the head office team on top of their normal duties.

These issues alone would have been enough to bring many teams to their knees, but to compound the problems we also had a failure of the invoice processes which resulted in invoicing for membership renewal being delayed.

Stability returned towards the end of the year, proving the decision to migrate the IT systems correct. In 2020 we will be focusing on improving systems in to increase reliability of service.

Collaboration

The IRSE has both formal and informal working relationships with other organisations in the UK and, either directly or through its sections, with organisations in other parts of the world. In China and South East Asia in particular, sections are forging closer links with other engineering,educational organisations and governments. This is to be welcomed.

In late 2018 a new Industry Partnership Scheme was launched and work commenced in 2019 to look more closely at how we build this into a new and engaging service to employers of IRSE members. Progress was slowed somewhat by the requirement to focus all resources into resolving the challenges of the outdated IT systems mentioned elsewhere in this report. As a result, the development of the programme has been deferred to the start of the new strategic plan which will begin in 2020.

An important element of our current five-year strategy which comes to an end this year, is to strengthen our engagement with external bodies, including not only rail industry companies, but also other relevant organisations. The Institution enjoys good working relationships with, and support from, many companies, but our ambition is to grow this further for mutual benefit. As a result the development of the Future Integrated Rail Think Tank (FIRTT), a collaboration with WSP, KPMG, the UK's Rail Delivery Group and ourselves, has focused on a number of key areas of railway operation, bringing together key players for both in and associated with the sector, to debate key issues. The first of these will be held in 2020.

This year the IRSE started the first of its two year terms as chair of the Rail Engineers Forum. This body is made up of representatives from all of the professional engineering institutions who have a rail interest and includes: IMechE, IET, ICE, PWI, IRO, INCOSE, CILT, RCEA and the Young Railway Professionals (**theref.org.uk**). The chairman, Andrew Simmonds, is a Past President of IRSE and he is working with HQ to help to focus on REF's aim to harmonise the various strengths of the constituent institutions in devising and implementing their programmes of activities in support of the railway community. This encompasses conferences, seminars, lectures, training, information services, publications and statements of policy to Government and other regulatory bodies.

A closer relationship with the Royal Academy of Engineering and Engineering UK is helping us to gain a better traction with activities focusing on encouraging young people into careers in science, technology, engineering and mathematics as a career opportunity. By working with these bodies whose key focus is on these activities we are able to gain a better focus than if we used our smaller resources.

The UK's Engineering Council is responsible for the regulation of engineers, particularly in the UK. The IRSE is a licensed body of the Engineering Council and is thus licensed to register Chartered Engineers, Incorporated Engineers and Engineering Technicians.

Finances

The financial results are shown on pages 16 to 20. They are extracted from the consolidated accounts for the IRSE and its wholly owned trading subsidiary, IRSE Enterprises Limited. The term 'Group' at the top of a set of tables refers to the two companies combined, and 'Charity' to the IRSE alone. As far as possible, these extracted results use the titles and the format of the consolidated accounts.

Probably the headline figure from the 2019 financial results is the total charity funds in the first table on page 16. After a dip in 2018, this figure has returned to be £14 000 higher than in 2017. However, this increase, as last year's decrease, is largely due to a significant increase in value of the investments, in the form of shares, we hold at Rathbones Investment Management Limited, as may be seen in Note 1 on page 16. As members will be aware from the internet, or the report in IRSE News, during the year we replaced the website. This has caused the value of our assets to rise, although they will gradually fall away again as its costs complete their depreciation over the next two years.

In last year's report it was noted that we hoped to balance our yearly income and expenditure during 2019. Unfortunately, a slight fall in the number of members and the number of companies acting as licensing Assessing Agents means our income during the year fell, as shown in the Consolidated Statement of Financial Activities. Fortunately our costs fell a little so that, overall, the loss before considering the gain on our investments reduced from 2018. Also in this table, the large increase in donations and legacies, which can be seen on the consolidated statement of financial activities, is mostly as a consequence of a very generous donation left in the will of a late member, for which we are very grateful.

The eagle-eyed among you will have noticed that two figures in Note 8 have changed very significantly between 2018 and 2019, and yet the net figure, near the bottom of the table, is hardly changed. This is a consequence of the ASPECT conference being organised entirely from the Netherlands. As a result, whilst last year the institution's bank accounts saw almost all of the income and consequential expenditure associated with the 2018 Convention, this year we simply received the surplus from the event which was due to us. The following line, the gain/loss on revaluation of investments, directly shows the change in value of some of our stock market investments, with an increase in value of over £93 000. This table also reveals what can happen if a planned event is not as successful as hoped. It will be noted that, despite a financially very successful CBTC seminar, our costs on visits and seminars slightly exceeded our income on them. This was a consequence of a seminar which was financially unsuccessful.

There are a number of actions currently underway which will, hopefully gradually lead to a return to a more positive financial situation without relying on the stock market, although it is likely that this will be a programme that will take several years to achieve.

Consolidated accounts (extract)

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS
CONSOLIDATED BALANCE SHEET AS AT 31st DECEMBER 2019

	Notes	Consolidated 2019 £	Consolidated 2018 £	Charity 2019 £	Charity 2018 £
Fixed Assets					
Tangible assets		31,227	9,382	16,871	9,381
Investments	1	1,812,394	1,493,734	1,342,570	1,103,927
		1,843,621	1,503,116	1,359,441	1,113,308
Current Assets					
Stocks	3	45,110	46,846	36,076	42,125
Debtors	4	194,705	176,349	269,580	310,305
Investments	5	209,205	207,707	209,205	207,707
Cash in hand		338,188	461,043	108,013	154,123
		787,208	891,945	622,874	714,260
Creditors: amounts falling due within one year	6	(438,934)	(414,400)	237,003	(231,770)
				385,871	
Net current assets / (Liabilities)		348,274	477,545	385,871	482,490
Total assets less current liabilities		2,191,895	1,980,661	1,745,312	1,595,798
Creditors: amount falling due after more than one year	7	(258,883)	(268,273)	-	-
Net assets		1,933,012	1,712,388	1,745,312	1,595,798
Funds	2				
Unrestricted funds		1,896,893	1,675,701	1,709,193	1,559,111
Restricted funds		36,119	36,687	36,119	36,687
Total charity funds		1,933,012	1,712,388	1,745,312	1,595,798

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS
CONSOLIDATED CASH FLOW STATEMENT AS AT 31st DECEMBER 2019

	2019 £		2018 £	
Net cash (used in) operating activities		(78,758)		(110,864)
Cash flow from investing activities:				
Purchase of tangible fixed assets	(44,793)		(1,947)	
Purchase of fixed asset investments	(231,680)		(266,101)	
Sale of fixed asset investments	193,471		279,421	
Interest received	2,534		5,168	
Dividends received	36,371		32,059	
Net cash provided by / (used in) investing activities		(44,097)		48,600
Change in cash and cash equivalents in the year		(122,855)		(62,264)
Cash and cash equivalents at start of year		461,043		523,307
Cash and cash equivalents at end of year		338,188		461,043

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS
CONSOLIDATED STATEMENT OF FINANCIAL ACTIVITIES AND INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER 2019

	Notes	Unrestricted £	Restricted £	Total 2019 £	Total 2018 £
INCOME AND ENDOWMENTS FROM:					
Charitable activities:					
Donations and legacies	9	41,708	-	41,708	1,763
Other trading activities:					
Non-ancillary trading income	10	425,921	-	425,921	590,739
Other activities	10	448,263	-	448,263	452,035
Investments:					
Investment Income	11	38,844	61	38,905	37,102
Total Income		954,736	61	954,797	1,081,639
EXPENDITURE ON:					
Raising Funds	12				
Other activities		8,567	-	8,567	9,714
Investment		7,865	-	7,865	8,067
Non-ancillary trading		438,884	-	438,884	562,274
		455,316	-	455,316	580,055
Charitable activities	12				
Awards		24,229	300	24,529	32,102
Promoting best practice		534,779	-	534,779	557,098
		559,008	-	559,308	589,200
Total Expenditure		1,014,324	300	1,014,624	1,169,255
Net Expenditure before (loss) / gain in investments		(59,588)	(239)	(59,827)	(87,616)
Net (loss) / gain on investments		280,780	(329)	280,451	(118,978)
NET INCOME / (EXPENDITURE)		221,192	(568)	220,624	(206,594)
RECONCILIATION OF FUNDS					
Total funds brought forward		1,657,701	36,687	1,712,388	1,918,982
TOTAL FUNDS CARRIED FORWARD		1,896,893	36,119	1,933,012	1,712,388

ANNUAL MEMBERS' REPORT WITH SUPPLEMENTARY MATERIAL

The tables set out on pages 15 to 19 are extracted from the full audited accounts of the Institution for the year ended 31 December 2019. They constitute supplementary material to this Annual Members' Report. Section 426A of the Companies Act 2006 requires the following statements to be made in respect of the supplementary material:

1. This annual report is only part of the company's annual accounts and reports prepared under the Companies Act.
2. A full copy of the company's annual accounts and reports may be obtained upon request from The Institution of Railway Signal Engineers, 4th Floor, 1 Birdcage Walk, Westminster, London SW1H 9JJ.
3. The auditor's report on the annual accounts was unqualified.
4. The auditor's statement under section 496 of the Companies Act (whether the Trustees' Report is consistent with the accounts) was unqualified.

A P Smith
Treasurer

Approved by the Trustees on 12 March 2020.

G CLARK	**D WOODLAND**
President	**Vice-President**
Director and Trustee	**Director and Trustee**

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS
NOTES TO THE CONSOLIDATED ACCOUNTS
FOR THE YEAR ENDED 31st DECEMBER 2019

1 Fixed Asset Investments (Group)

	Equities £	Government Securities £	Total £
Market value			
At 1 January 2018	1,309,362	184,372	1,493,734
Additions	207,054	24,626	231,680
Disposals	(174,442)	(14,817)	(189,259)
Revaluations	260,171	16,068	276,239
At 31 December 2018	1,602,145	210,249	1,812,394

2 Movement in Funds (Group)

Unrestricted funds	At 1.1.19 £	Net movement in funds £	At 31.12.19 £
General Fund	691,352	165,133	856,485
Scholarship fund	76,232	896	77,128
Alan Fisher / Frank Hewlett Fund	423,017	(15,946)	407,071
General Development	307,000		307,000
Future ASPECT Conference	10,000		10,000
International Convention	27,500		27,500
Textbook Preparation	7,500		7,500
IRSE Enterprises - General Fund	133,100	71,109	204,209
	1,675,701	221,192	1,896,893
Restricted funds			
Dell Bequest	23,985	(553)	23,432
Thorrowgood Bequest	12,702	(15)	12,687
TOTAL FUNDS	36,687	(568)	36,119

The company holds 20% or more of the issued share capital of the following company:

Company	Country of incorporation	Share class	%age owned
IRSE Enterprises Limited	England and Wales	Ordinary	100

	Share capital and reserves	Profit for year
IRSE Enterprises Limited	£192,116	£71,109

3 Stock

	Consolidated 2019 £	Consolidated 2018 £	Charity 2019 £	Charity 2018 £
Stock	45,110	46,846	36,076	42,125

4 Debtors

		£		£
Trade debtors	58,801	104,214	-	-
Other debtors	9,707	4,507	9,707	3,257
Pre-payments and accrued income	78,555	23,453	-	-
VAT	47,642	44,175	35,995	23,041
Amounts owed by group undertakings	-	-	223,878	284,007
	194,705	176,349	269,580	310,305

5 Current Asset Investments

		£		£
National Savings	209,205	207,707	209,205	207,707
	209,205	207,707	209,205	207,707

6 Creditors: amounts falling due within one year

		£		£
Trade creditors	38,981	33,969	28,520	22,500
Deferred income and accruals	196,505	210,911	176,262	177,658
Other taxes and social security costs	-	-	-	-
Other creditors	203,448	169,520	32,221	31,612
	438,934	414,400	237,003	231,770

7 Creditors: amounts falling due after one year

	Consolidated 2019 £	Consolidated 2018 £	Charity 2019 £	Charity 2018 £
Deferred income	258,883	268,273	-	-

Representing the proportion of licence fees receive which will be credited to Income after more than one year.

8 Activities of IRSE Enterprises

	2019 £	2018 £
<u>Turnover</u>		
Donations	(10)	180
Proceeds - Conventions and Conferences	15,559	149,025
Proceeds - Dinner	51,466	51,947
Proceeds from Technical Visits and Seminars	35,453	37,829
Licences - Fees Received	194,322	229,343
Licensing - Appraisal Fees	56,022	20,367
Licensing - Assessing Agents Fees	62,564	84,101
Licensing - Technical Publications	10,546	17,947
	425,922	590,739
<u>Cost of sales</u>		
Opening Stock	4,721	546
Costs - Conventions and Conferences	4,801	113,750
Costs - Dinners	31,285	32,668
Costs - Technical Visits and Seminars	35,354	18,160
Costs - Engineer's fees	14,081	13,738
Licensing - IRSE Administration Charges	122,032	146,746
Costs - Appraising Engineers	58,825	65,773
Costs - Accreditation	10,980	10,427
Costs of Young Members' Seminars and Visits	1,104	810
Closing stock	(9,034)	(4,721)
	274,149	397,897
GROSS PROFIT	151,773	192,842
<u>Other income</u>		
Dividends receivable	6,413	8,029
Bank interest receivable	367	312
	6.780	8,341
	158,553	201,183
<u>Expenditure</u>		
IRSE Admin Charges	18,990	17,318
Telephone	7,033	4,918
Post and Stationery	6,441	15,779
Officers' expenses	-	33
Accommodation and Refreshments	3,584	3,260
Computer costs	34,522	31,487
Sundry expenses	2,975	2,820
Licensing - Treasurer's, Chief Executive's and Registrar's Fees	80,525	69,479
Investment Manager's Fees	3,421	3,346
Auditor's remuneration	4,000	2,750
Donations	-	45,029
Exchange rate variance	7	
Profit / loss on sale of fixed asset investments	-	11,122
	161,588	207,341
<u>Finance costs</u>		
Licensing - Bank charges	3,238	2,064
Net figure	(6,183)	(8,222)
<u>Gain / Loss on revaluation of assets</u>		
Gain on revaluation of investments	77,292	(16,283)
NET PROFIT	71,109	(24,505)

9 Donations And Legacies (Group)

	2019	2018
	£	£
Donations	41,708	1,763

10 Other Trading Activities (Group)

	2019	2018
	£	£
Subscriptions	404,989	407,876
Professional Reviews	915	833
Advertising	9,075	10,323
Booklets and text books	7,138	7,072
IRSE ties, badges & cufflinks	26	51
Examination Fees and materials	25,413	22,823
Sponsorship of charity event	-	557
Proceeds from members' lunch	707	800
Consultancy Income	-	1,700
	448,263	452,035
Trading income:		
Turnover of trading subsidiary - Note 8	425,922	590,739

11 Investment income (Group)

	2019	2018
		£
Equities and government stocks	29,958	24,030
Interest receivable	2,167	4,731
IRSE Enterprises Ltd	6,780	8,341
	38,905	37,102

12 Analysis of Expenditure

	Staff Costs	Depreciation	Other	2019	2018
	£	£	£	£	£
Raising Funds					
Other Activities	1,864	158	6,545	8,567	9,714
Investment	-	-	7,865	7,865	8,067
Non-ancillary trading - Note 8	104,357	7,178	327,349	438,884	562,274
Total raising funds	106,221	7,336	341,759	455,316	580,055
Charitable Activities					
Awards	7,455	631	16,443	24,529	32,102
Promoting best practice	177,061	14,981	342,737	534,779	557,098
Total charitable activities	184,516	15,612	359,180	559,308	589,200
Total Expenditure	290,737	22,948	700,939	1,014,624	1,169,255

13 IRSE Charitable Expenditure

	2019	2018
	£	£
Raising donations and legacies		
Fund raising dinners	4,190	3,729
Consultancy	-	1,360
Charitable activities		
Proceeding: editing and printing	4,517	7,173
Newsletter: editing and printing	94,728	96,438
Booklets and textbooks	5,773	3,540
IRSE ties, cufflinks and badges	1,295	45
Prizes	1,111	1,272
Awards	7,020	13,602
Activities funded by country subscription supplements	8,821	9,268
Professional review costs	2,682	-
Support costs		
Staff costs	191,176	219,788
Office rent and services	20,202	20,072
Fees and honoraria	71,070	51,388
Membership database	8,420	6,750
Other administrative costs	127,100	125,118
Investment manager's fees	7,865	8,067
Fixtures and fittings	15,770	36,269
Governance costs		
Auditor's remuneration	4,000	3,101
Total Expenditure	575,740	606,980

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Index of IRSE News Contents – May 2019 to April 2020

IRSE News 259 – October 2019 **Author/Presenter** **Page**

IRSE News 260 – November 2019 **Author/Presenter** **Page**

Summaries of IRSE Presidential Programme Technical Papers 2019-20

Each year the President of the IRSE invites keynote speakers to produce papers and presentations on selected topics. The papers for the Presidential Programme for April 2019 – March 2020 had the overarching theme of *Delivering Change* selected by George Clark for his Presidential Year.

In 2019-20 the papers and speakers were as follows (a summary of each appears on the following pages):

Delivering change through intelligent traffic management
by Andy Bourne on 1 October 2019
(Published in IRSE News, November 2019 – Issue 260)

Delivering change in Denmark: operational readiness of successful ERTMS programmes
by Jens Holst Møller, Ross Gammon & Ben van Schijndel on 5 November 2019
(Published in IRSE News, December 2019 – Issue 261)

Delivering CBTC in Hong Kong – carrying the changes
by Gordon Lam on 5 December 2019
(Published in IRSE News, January 2020 – Issue 262)

The race against obsolescence
by Wim Coenraad on 7 January 2020
(Published in IRSE News, April 2020 – Issue 265)

Future reference CSS Architecture
by Nicola Furness & Michael Ruesen on 12 February 2020
(Available as a video link at: https://irse.info/rxvl4)

Converting a GoA1 commuter railway to a GoA4 driverless Metro – the Sydney Metro experience
by Steve Allday on 5 March 2020
(Published in IRSE News, May 2020 – Issue 266)

Delivering change through intelligent traffic management

Andy Bourne, senior technical director at Arcadis
Presented in October 2019 in London
Published in IRSE News, November 2019 – Issue 260

Summary:

Taking up the 2019/20 Presidential theme of Delivering Change, this paper considers the experiences of the introduction and evolution of traffic management (TM) systems for Network Rail in the United Kingdom (UK). TM is a key component of the group of technologies and programmes that comprise the Digital Railway in the UK, aiming to bring a step change in capacity, performance, safety and cost efficiency to the main line railway network.

The first TM systems delivered as part of the Digital Railway are now in service in the UK, following the introduction of similar systems in other countries. Their introduction has been challenging, but key lessons have been learned along the way which are being fed into the next tranche of system deployments. This paper will share some of those lessons.

As well as telling the story of introducing a particular technology to a particular infrastructure, the paper aims to offer more general insights into delivering change in railway technologies which are new to a railway or other undertaking.

This paper also shares some of the thinking undertaken within the Digital Railway Programme about what national coverage of TM looks like in the UK and some of the developments being planned for the future.

What starts out as a discussion about introducing a technology inevitably ends up being a wider discussion about the people who use that technology and the processes they follow. Changes to culture and working practice within the constraints of organisational arrangements and precedent often prove to be harder to deliver than functional and operational system requirements.

Delivering change in Denmark: operational readiness of successful ERTMS programmes

Jens Holst Møller, chief engineer for the Danish ETCS Signalling Programme at Banedanmark, Ross Gammon, signal engineer at Rambøll & Ben van Schijndel, business development at Strukton Rail
Presented on 5 November 2019 in Copenhagen
Published in IRSE News, December 2019 – Issue 261)

Summary:

Much attention has been given during recent decades to the technical requirements of the new signalling projects in their diverse stages of roll-out across Europe. Delivering ETCS projects has proved to be complex and challenging. Experience shows that ETCS projects are not only about the technology. Many of the contributory factors to these difficulties can be traced back to the human and business change aspects of implementing new technology.

The capacity of the industry to deliver, the transfer of knowledge from projects to the people operating and maintaining the railway, and ensuring the receiving organisation is ready for the new system, are all challenges with the potential to result in change fatigue. In the context of the political wish to speed up deployment of ETCS, this paper attempts to cover these 'business change' or 'people and processes' aspects with reference to lessons learned on the Danish signalling programme.

The paper provides a short history of Danish signalling, the current status of the re-signalling programme, the human elements of delivering change, collaboration, project processes, configuration management, commissioning, and lessons learned.

Delivering CBTC in Hong Kong – carrying the changes

Gordon Lam, chief signal engineer at MTR
Presented on 5 December 2019 in London
Published in IRSE News, January 2020 – Issue 262

Summary:

MTR operates 11 domestic heavy railway lines and a light rail system and carries more than 5 million daily passenger trips on average in Hong Kong. In addition, we also operate high speed rail connecting Hong Kong to the high-speed rail network in China. Similar to other railway operators in the world, we are facing a number of challenges including Near Capacity Operation (NCO) and increasing demand for train service reliability.

To meet these challenges and further enhance the customer experience, a series of initiatives known as Rail Gen 2.0 has been launched which aims to upgrade and extend the existing network in order to bring superior connectivity, better facilities and services. One important mission is to upgrade most of the signalling systems in our network. The signalling upgrade will bring enhancement to 8 out of the 11 heavy railway lines and cover over 70% of MTR's existing heavy railway route length in Hong Kong.

The paper briefly describes the upgrade plans but focusses mainly on how the technology migration is being managed so as to minimise the impact on passengers. The migration plan has 12 steps, which includes shadow running, dual fitting of trains, and more.

The paper also reports on two software failures in 2018 and 2019, the first of which had a major impact on operations. The first problem was eventually traced to the differing behaviour of counters in two suppliers' systems. The second incident caused a collision involving a test train out of operational hours. It was concluded that the software implementation errors reflected inadequacies in the software development process with respect to software quality assurance, risk assessment and the extent of simulation of the software change.

The race against obsolescence

Wim Coenraad, senior signal engineer at Movares and a past president of the IRSE
Presented on 7 January 2020 in Utrecht, Netherlands
Published in IRSE News, April 2020 – Issue 265

Summary:

The world in which we do our signal engineering changes rapidly. We must deliver change more quickly as technology cycles speed up. However, the demands for assurance and certification of railway control systems slow us down, which causes inertia in the development and deployment of systems, products and processes, and can lead to obsolescence.

Obsolescence is usually thought of as technical systems becoming life expired, no longer maintainable or losing relevance for the required functions in their operating environment. It can also refer to engineering processes that become out-dated or no longer fit for purpose. And it can apply to people – either when the skills to maintain old systems are in short supply, or when the workforce does not have (and cannot acquire) the knowledge and expertise required for new systems. Even a profession can become irrelevant and outmoded.

This paper explores obsolescence in its many forms in the rail industry, and the impact of ever changing (and faster changing) technology. The author also challenges us about our burdensome engineering processes and asks how we as engineers (and IRSE members) can remain relevant as the industry changes.

Future reference CSS Architecture

Nicola Furness, Network Rail & Michael Ruesen, ERTMS User Group
Presented on 12 February 2020 in London
Available as a video link at: https://irse.info/rxvl4

Summary:
The presentation and paper described the current work in Europe to develop a reference architecture for future control, command and signalling (CCS) systems, which aims to standardise the interfaces and, to some extent, the functionality of the various sub-systems that comprise a signalling system.

Converting a GoA 1 commuter railway to a GoA 4 driverless Metro – the Sydney Metro experience

Steve Allday, executive director for ARCS (International)
Presented on 7 February 2020
Published in IRSE News, May 2020 – Issue 266

Summary:

The Sydney Metro is the first driverless passenger carrying railway to be built in Australia, the first stage having been introduced into service in June 2019 between Tallawong and Chatswood (Sydney Metro Northwest). The second stage of the project involves an element of new build railway and the migration of an existing Grade of Automation (GoA) 1 operated line from Sydenham through to Bankstown to a GoA4 operation.

The business requirement for the extension from Chatswood and the building of the Sydney Metro City & Southwest is multi-faceted. It is to provide greater connectivity into the city from the northwest, which is an expanding growth area, to alleviate existing traffic congestion in the south, thus enabling Sydney Trains to provide enhanced services on the City Circle line and at the same time increase economic development opportunities along the southwest corridor.

The Sydney Metro City & Southwest project has differing challenges. The City section involves the introduction of 'integrated station developments' and the Southwest section requires conversion of an operational railway, with a key objective being to minimise the time between the cessation of existing operations and introduction of the new GoA 4 operation.

This paper concentrates on the Southwest section and describes the systems engineering challenges of delivering the project. These challenges span the spectrum of time, logistics, design, integration, construction, assurance and not least innovation.

Summaries of IRSE International Technical Committee (ITC) Papers 2019-20

The mission of the IRSE's International Technical Committee (ITC) is to provide a multi-national and independent perspective on Railway Control, Command and Signalling (CCS) topics. Membership is by invitation, and comprises industry experts from both suppliers and operators, drawn from more than a dozen countries around the world. It aims to inform and educate both IRSE members and the train control and communications community worldwide, principally by the production of reports on selected topics.

Listed below are ITC papers published during 2019 – 2020 with the abstract on the following pages:

What constitutes good and acceptable practice in light rail signalling?
Rod Muttram
1 June 2019
(Published in IRSE News, June 2019 – Issue 256)

The use of formal methods in standardisation of interfaces of signalling systems
Maarten van de Werff, Bernd Elsweiler, Bas Luttik and Paul Hendriks
1 June 2019
(Published in IRSE News, June 2019 – Issue 256)

Human Factors and ethical considerations associated with automation
Rod Muttram
1 July 2019
(Published in IRSE News, July/August 2019 – Issue 257)

The use of formal methods in specification and demonstration of ERTMS Hybrid Level 3
Maarten Bartholomeus, Bas Luttik, Tim Willemse, Dominik Hansen, Michael Lauschel and Paul Hendriks
13 November 2019
(Published in IRSE News, October 2019 – Issue 260)

Automation of mining railways
Tony Godber
1 March 2020
(Published in IRSE News March 2020 – Issue 264)

What constitutes good and acceptable practice in light rail signalling?

Rod Muttram
1 June 2019
(Published in IRSE News, June 2019 – Issue 256)

Abstract:

After the decline and closure of many tram systems in the middle years of the 20th Century, recent decades have seen increased interest in, and the deployment of, light rail (or rapid) transit (LRT) systems around the world to provide higher passenger-carrying capacity and lower emissions than buses without the expense of heavy rail/metro systems.

This article was prompted by the derailment on the Croydon Tramlink, UK, on 9 November 2016 in which seven people died and over 60 were injured when a tram overturned due to entering a curve with a severe speed restriction at too high a speed. Trams differ from buses in several ways and one of the key differences is in the consequences and potential mitigations if a curve is approached at too high a speed. A bus has the option to ‘steer away’ if an alternate route is clear avoiding harm; a tram’s route is completely constrained (rail is a ‘one degree of freedom’ system) and even with secondary braking devices a steel wheeled tram will generally not match rubber-tyred road vehicle braking distances. Thus, if the speed exceeds a certain threshold approaching or within a curve it will inevitably overturn or at least de-rail.

The ITC therefore has similar concerns regarding the over-reliance on fallible human drivers for speed control as it has for main line railways. Our chair presented on this at the IRSE Convention in Dallas in 2017.

This paper explores how different light rail/tram systems around the world provide signalling and overspeed/train protection. A table provides information about various LRT systems in different parts of the world. The paper comments on the need to balance safety against affordability and explores what constitutes a sensible compromise.

The use of formal methods in standardisation of interfaces of signalling systems

Maarten van de Werff, Bernd Elsweiler, Bas Luttik and Paul Hendriks
1 June 2019
(Published in IRSE News, June 2019 – Issue 256)

Abstract:

This article describes the cooperation of Infrastructure Managers ProRail BV and DB Netz AG in paving the way towards the application of formal methods that can be used to prove the quality of software applied in signalling. As described later in this article, the scope of the work focuses on the interfaces within the signalling system.

This paper about interlocking interfaces is one of three ITC articles concerning formal methods. The second will address the use of formal methods in the certification process of Hybrid Level 3 ETCS, the third will deal with interlocking applications.

Many railways do not have a complete written set of signalling system requirements readily available. A lot of knowledge is still in the minds of a few specialists; technical solutions and schemes that are common to conventional technology are available; specialists know how to read their own documents. It is routine that in specification, review and validation specialists communicate in natural language. However, in the interlocking domain this information is incomplete and ambiguous.

Infrastructure managers DB Netz AG and ProRail together with Eindhoven University of Technology and the University of Twente have therefore decided to investigate the use of formal models in a research project called FormaSig. Formal models are models that are defined in a formal modelling language with mathematical semantics that can be fully understood by a computer. These two universities have developed a formal modelling language and a corresponding powerful tool set, which are particularly suitable for analysing the quality of the system designs. They will perform a mathematical proof that the interfaces behave correctly, based on the EULYNX SysML models, national knowledge and the typically used national specific subsystems of the two infrastructure managers. You can watch a presentation of this project on YouTube at irse.info/6dujm.

The main objective of the research project is to encourage the use of (formal) models in order to improve the quality of standards and tender documents in the railway domain. An explicit concern of the IMs is the traceability of requirements formulated in natural language. With the increasing complexity of today’s electronic signalling systems, it becomes increasingly difficult to verify that they meet their original requirements. However, the methods developed in this project will help to define test specifications that allow interfaces to be validated without full traceability to legacy requirements. The result will be that experts are exposed to a new way of working with regard to specification, testing and certification in the relation to market parties. As well as describing the research, the paper also charts the history of work in this field, from UIC in 1997 through the Euro-interlocking and INESS projects, and more recently EULYNX.

Human Factors and ethical considerations associated with automation

Rod Muttram
1 July 2019
(Published in IRSE News, July/August 2019 – Issue 257)

Abstract:

Automation and autonomous systems are currently getting a great deal of publicity. In road transport there is a lot of ‘work in progress’ on autonomous vehicles, and driverless technology ‘start ups’ have been snapped up by the new technology majors such as Google. In air, the recent tragic losses of two nearly new Boeing 737 MAX airliners with significant loss of life has generated a lot of attention. The update of a decades-old design relied on a degree of new control automation. In rail, metros are increasingly automated with fully driverless systems now common and main line rail is moving to implement systems such as Automatic Train Operation (ATO) to improve capacity and reliability.

Whilst these changes are driven by undoubted benefits there are also risks that need to be carefully analysed and managed. This paper explores some of the current developments in automation in air, rail and road transport, and the ethical and human factors issues associated with the various Grades of Automation (GoA).

The use of formal methods in specification and demonstration of ERTMS Hybrid Level 3

Maarten Bartholomeus, Bas Luttik, Tim Willemse, Dominik Hansen, Michael Lauschel and Paul Hendriks
13 November 2019
(Published in IRSE News, October 2019 – Issue 260)

Abstract:

Software has become an essential component in signalling systems. Writing clear, precise and accurate specifications is of course important for these systems. Can formal methods help in this process? An interesting case is the recent development of the Hybrid Level 3 for ERTMS/ETCS. This paper addresses the specification and demonstration of ERTMS Hybrid Level 3.

During development of Hybrid Level 3 it was realised that a pure functional specification did not provide enough insight into possible degraded scenarios and their impact on current operational processes. The list of generated scenarios kept growing and growing. A more precise method to specify the system behaviour on a functional level was required. For this purpose, a specification with state diagrams was developed describing the possible states of the track sections and transitions. This allowed the railway specialists to evaluate the operational impact and the system specialist to check if a system could be made according to these specifications.

The number of operational scenarios implicitly described by the state diagram is very large. Hence, there is a high risk that unsafe operational scenarios are missed in a review of the principles by railway experts. Using formal methods, computer tools can be used to exhaustively analyse all operational scenarios for a given track layout.

Formal methods are already well established to avoid errors in the software coding phase, but this does not guarantee that software safety requirements themselves are correct. The formal methods can also be used to prove that the software specification and its implementation satisfy the expected system properties.

The Hybrid Level 3 specification was selected as a case study for the formal methods conference ABZ. One of these cases was an implementation in a real-life test environment and was one of the successful demonstrators of Hybrid Level 3 in the UK on the ERTMS National Integration Facility (ENIF) test track in 2017. The Hybrid Level 3 specification was also analysed in cooperation with the University of Eindhoven. This paper reflects on these studies and the benefits of using formal methods in this project.

Automation of mining railways

Tony Godber
1 March 2020
(Published in IRSE News March 2020 – Issue 264)

Abstract:

For new construction and major re-equipping of urban mass transit railways, automatic operation has become the most popular mode of operation. Depending on the environment, this can range from unmanned or driverless operation (GoA 4 – no driver on the train) to some form of attended operation with staff present, who may have limited operational tasks, including driving the train in exceptional or emergency situations.

Applying unmanned automatic operation to mining railways has now been successfully demonstrated (by Rio Tinto in Australia), but there are many differences (some obvious, and some not so obvious) compared to operating a rapid transit or metro system. While the core principles of controlling and supervising an automated rail system are similar, these differences must be addressed when considering automation.

While automation is usually viewed as a means of improving capacity or productivity and reducing variability, there are other benefits of particular relevance in a mining railway environment, such as eliminating the need to change train crews at remote locations. As well as the unproductive time involved in getting drivers to and from changeover points, the time and fuel consumed in stopping and restarting heavy trains are saved and risks associated with driving road vehicles are also reduced. In addition, the skills required to drive heavy freight trains may take several months to acquire to an acceptable level and years to perfect. With automation, the lead time required to train new drivers to take account of growth and staff turnover is no longer a constraint on capacity.

This paper explores the challenges of designing and operating a fully driverless railway, with a particular focus on the challenges of doing so on a heavy haul freight railway. It includes consideration of human factors, the provision of train protection systems (and their limitations), network control, monitoring train movements, safety at level crossings, collision detection, telecommunications requirements, and more.

Results of the IRSE Examination – 2019

The IRSE is pleased to announce the results of the 2019 IRSE Professional Examination and to congratulate all those listed, especially those who have now achieved the IRSE Professional Exam. Currently there are seven exam modules and to pass the Exam as a whole candidates are required to achieve a pass or higher in Module 1 and three other modules.

Thank you to all those who have supported candidates through their studies by organising study groups, acting as sponsors and running the exam forum. Thanks also to exam facilitators and invigilators for organising the venues, running the exam day and collating the returning the papers, and of course the examiners for the considerable amount of time involved with setting and marking the papers.

The modules referred to in the table below are as follows:
Module 1 Safety of Railway Signalling and Communications (compulsory)
Module 2 Signalling the Layout
Module 3 Signalling Principles
Module 4 Communications Principles
Module 5 Signalling and Control Equipment, Applications Engineering
Module 6 Communication Applications
Module 7 Systems Management and Engineering.

Key:
P = Pass
C = Credit
D = Distinction

The table below shows the results for modules taken in 2019 which now means that those listed have now completed the IRSE Exam by achieving a 'pass' or higher in at least four modules:

Name	Modules: results
V Aviomoh	1:P; 7:P
A Azad	2:C; 7:P
M Bastow	4:P; 7:C
A Belson	1:P; 7:P
L Edwards	3:P; 5:P
A Farish	2:C; 3:P
B Gabai	2:C; 3:P
P Hobden	3:C; 7:C
R Hutchinson	1:C; 7:C
S Iqbal	1:C
G Larkin	1:C; 5:P
S F Lau	1:P

Name	Modules: results
M-A Lew	2:P; 3:P
A Love	3:C; 4:C; 6:P
M Neilan	1:P
Y Pathak	5:P
A Sawyer	1:P; 2:C; 3:P; 7:P
A Singh	1:C
D Srivathsan	1:D; 7:P
R Taylor-Rose	3:P; 7:P
P Tully	1:C
S Wallace	3:P
J Whyte	1:C

The table below shows those who have successfully passed modules in 2019 but have not yet achieved passes in the required four modules to complete the IRSE Exam:

Name	Modules: results
M Allen	2:P; 3:P
M Baporia	1:P
A Berridge	1:C
N Blakeley	1:P
J Bradley	1:P
E Bramble	1:D
J Calderwood	1:P
A Chauhan	3:P
S Chityala	2:P
P Chopra	1:P
B Christensen	7:P
W S Chung	2:C
J Cooper	2:P
A Courts	2:P
P Dakin	7:P
J Darlington	2:C
S Dowling	2:P
J Farrell	1:D
Z Feng	1:P
N Fernando	2:P
T Flynn	2:P; 3:P
J Francis	2:C
S Gorman	1:D
K Hadlington Needs	2:P; 3:P
S Hatton	1:P
K M Ho	3:P
M Navis Hussain	5:P
K Ismailjee	2:P; 3:P
A Jacob	2:P
C Jameson	5:P
E Jordan	2:P; 3:P
C Kerrigan	1:P
M Kingston	1:C; 2:P
H Kodam	2:P; 3:P
P Kokkonda	3:P; 5:P

Name	Modules: results
P Kumar	1:P; 3:P
D Lanlyan	2:P
B Law	3:P
A Laz	1:P
K C Li	2:C
Y M Li	2:D
J Lim	3:P
Y L Lau	1:P
H M J Ma	2:P; 3:P
G Marquis	1:P
A McConville	7:P
K McGuinness	7:P
R Mitchell	1:C; 2:P; 5:P
P Morgan	2:P
A Morrison	3:P
M Moyo	2:P
M Murphy	5:P
G Nemeth	2:C
T Parker	1:C
R Pesaramilli	2:P
A Plumb	2:C
H C Pun	2:P
M Pylyp	1:P; 5:P
S Saenthan	6:P
A Scaricabarozzi	2:C
M T Shum	2:P
V Silapasoonthorn	1:P
D Snelling	3:P
P Vakkantham	2:P
S Walker	3:C
M Williamson	6:P
L H Wong	7:P
R Wright	1:C; 5:P
H T Wu	1:P; 7:P
L C Yin	2:C; 3:P

Reports from Local Sections Non-UK 2019-20

The following reports were originally prepared by the UK's international (non-UK) Sections as a means of reporting their activities to the Institution's Council. The reports reflect the activities and plans of each section at the time they were submitted to Council. They have been edited slightly for the purposes of providing a permanent record as part of the Proceedings 2019-20.

The international Sections in existence in 2019-20 (in alphabetical order) were:

Australasia
China
France
Hong Kong
India – no Section Report for 2019-20 due to impact of Covid
Indonesia
Ireland
Japan
Malaysia
Netherlands
North America
Singapore
Southern Africa
Switzerland
Thailand

IRSE Australasia Section Incorporated Report: 2019 – 2020

Report produced by: Kaniyur Sundareswaran (Chairperson) and Les Brearley (Secretary)
Date: April 2020

1. Introduction

The Section has had a successful year in the past 12 months with the national technical meetings, local technical meetings and participation in a major rail industry conference where the IRSE managed a stream of the technical papers. This situation changed in early March 2020.

Due to the coronavirus pandemic and Government regulations, it was necessary to postpone the four-day AGM and technical meeting scheduled for Adelaide in late March 2020. The meeting has been moved to October 2020, and the situation will be monitored to determine if this is achievable.

It has also been decided not to hold the two-day Technical Meeting scheduled for Sydney in July, as a physical meeting combined with site visits as usual. Alternative arrangements are currently being investigated to hold this meeting as a webinar.

The AGM will now be held as a webinar when a suitable platform has been arranged. Use of the HQ licence for GoToMeeting in being investigated.

Steps are also being taken to hold some of the local technical meetings as webinars to gain experience prior to moving to a whole day technical meeting.

The Graduate Diploma in Railway Signalling course has been accredited with the Australian Skills Quality Authority (ASQA) and we have engaged a Registered Training Organisation, Competency Australia, to deliver the course and the first intake of 33 students commenced on 13 January 2020.

In spite of multiple reminders from the Section, a significant number (just less than 50) of IRSE members in the region failed to meet the 1 April 2020 deadline for payment of their subscriptions.

Steps have also been taken to increase the number of IRSE members residing in the region also joining the Section.

Please note that the Local Technical Meeting information in Section 3.2 covers the period from January 2019 until December 2019.

Date of last Annual General Meeting:	15 March 2019 (2020 AGM not yet held see above)
Were annual accounts presented at the AGM?	Accounts have been prepared for 2019 and will be presented in the AGM.
Were officers elected / re-elected at the AGM?	Nominations for vacant positions in 2020 have been received however the election has not yet been held.
Have minutes of the last AGM been produced?	Yes, 2019 AGM Minutes has been produced.
How many IRSE members are in the Section?	558 IRSE Australasian Section Inc members as of 1 April 2020

2. Section Officers (at the time of writing report)

Chairman	K P Sundareswaran
Vice Chairperson	G Hartwell
Secretary	L F Brearley
Treasurer	P Szacsvay
Country Vic President	R Baird
Webmaster	W Millburn

3. Main Activities During Past 12 Months

During the year, there has been two national Australasian Section technical meetings of the Australasian Section. In addition, 24 local technical meetings were held.

National Technical Meetings

These meetings are held in each state and New Zealand on a rotational basis. The AGM meeting (March or April) is held over three days. The other meetings are two days.

Ballarat 19-20 July 2019 – The two-day meeting had a theme of *Brownfield Rail Investment* with 117 Members and guests attending the Friday meeting and approximately 50 attending the site visits on Saturday. Site visits included the Ballarat Line Upgrade site visit and project information session as well as a visit to the Alstom rollingstock workshops.

Wellington, New Zealand 1-2 November 2019 – The final national technical meeting for the year had a theme of *New Zealand, New Generation, New Approach*. The Friday attendance 70 with 35 attending the Saturday site visits to Wellington 'A' Signal box and adjacent equipment as well as the Hutt signal equipment prefabrications workshops. There was a further 2-day optional extension to the overall program to visit the earthquake damage repairs at Kaikoura on the South Island which included 14 participants.

Local Technical Meetings in 2019

Local technical meetings are held in capital cities. Typically, they involve two 30-minute presentations followed by light refreshments and networking. Technical papers are not usually provided. Note this information is for the 2019 calendar year which is the most recent detailed information available. These meetings started in a similar pattern in 2020, however the meetings were then halted due to the regulations associated with the coronavirus.

Queensland:

30 April 2019, attendance 44. Evidencing Your Competency – Somnath Banerjee (Hitachi Rail STAF). AWS Then and Now – Howard Revell (Hitachi Rail STA).
15 October 2019, attendance 87. ETCS Level 2 in Aurison – Andrew Harvey & Robert Bragg (Aurison) and Gabor Nemeth (Siemens). Application of ETCS Baseline 3 Braking Curves in Heavy Haul – Geoffrey Voss (Aurizon) and Craig Cameron (Siemens).
11 December 2019, joint meeting with RTSA, PWI and RTAA, total attendance 85. Experience for first 100 days as EGM Network – Scott Riedel, EGM Network (QR)

South Australia:

5 September 2019, joint meeting IRSE, RTSA & PWI attendance 65. Gawler Line Upgrade – Emily Spudic (Siemens Mobility). Electronic Track Worker – *Pathway to Safer Work Outcomes in the Rail Corridor* – Stewart Haycock (ARTC).

Victoria:

20 February 2019, attendance 75. Development of the ESDS for the Mernda Rail Extension Project - Simon Lehman (MTP Rail Infrastructure Alliance). CBTC in Brown Field Sites (Ampang Line) - Ayya Viswanath (WSP)
12 March 2019, attendance 65. AC Track Circuit and Rolling Stock Interference Study for the High-Capacity Metro Train (HCMT) - Robert Baird (Rail Networks). SIL-4 is not always SIL-4 - Dr Markus Montigel (IRSE President)
17 April 2019, attendance 50. Requirements Definition and Signalling Projects in Victoria – James Scotter (PTV). Lakeside - An old approach to a new signalling scheme - Brett Cox (V/Line)
15 May 2019, attendance 55. Rapid Mechanical Product Development Using Modern Design Techniques - Ben Carey (Siemens). Reflections on AusRail 2018 - Joyce Pick (WSP) and Pesala Kahawita (PTV)
19 June 2019, attendance 75. The Purpose of Signal Sighting and the Signal Sighting Committee - Kasia Zawiazalek (Metro Trains). Integrating Asset Management, Engineering and Management - Amy Lezala (Metro Trains)
21 August 2019, attendance 130. V/Line Level Crossing Template Typicals - Charlie Turner (V/Line). Axle Counters within the MTM Network - Jim Warwick (Metro Trains)
18 September 2019, Joint meeting with RTSA attendance, 85. CSRs – Alex McGrath (VicTrack). Axle Counters within the MTM Network Part 2 - Liam Palmer-Cannon (Metro Trains)
16 October 2019, attendance 65. Data Analytics/Digitalisation within rail industry - Dr Martin Fankhauser (Siemens). Engineering Assurance through the Investment Lifecycle – Marc Chadwick (Rail Projects Victoria)
20 November 2019, attendance 75. Operational modeller + signalling engineer = awesome.- Arthur Bruce, (Rail Projects Victoria / DOT), Huw Hawkins (AECOM) and Philippa Thode (DOT). Railway Signalling Engineer Cadet Program 2019 – The journey so far - Sajitha (Saji) Sovis (WSP) and Venkateshwaran (Venk) Srinivasan (LXRA)

New South Wales:

24 January 2019, attendance 38. Railway Engineering – Working together as a system **–** Panel: Trevor Moore (JMDR), David Stuart Smith (Arup), Bruce Sismey (Sydney Trains) and Mike Hickey (Rail Planning Services)
28 February 2019, attendance 54. A Single Platform for Many Trains - Nellai Somasundaram (Ansaldo STS)
28 March 2019, attendance 39. The use of independent Safety Assessment in Railway Projects - Hugh Hunter (Certifer)
23 May 2019, attendance 35. Train Control – Rail Operations Centre, Sydney - Tony Eid (Sydney Trains)
13 June 2019, attendance 110. Joint meeting with PWI, NSW. On Track towards a faster future- David Ashby (WSP)
25 July 2019, attendance 55. Rail safety: the role of signalling asset management - Andrew Webb (Office of the National Rail Safety Regulator)
26 September 2019, attendance 55. Signal Design Process – Lessons Learnt - Trevor Moore (JMDR)
24 October 2019, attendance 53. TfNSW's ATP System - Frederic Tricoche (Transport for NSW)
20 November 2019, attendance 41. Cybersecurity for signalling Systems across the lifecycle and an update on ASA standards and evolving Transport changes- Peter McGregor (Asset Standards Authority, Transport for NSW)

Western Australia:

10 April 2019, Attendance 31. Surge Protection - Phil Jones (ERICO). Electrical Earthing & Bonding - Bill Schlesinger (ERICO)
15 September, 2019, attendance 25. Informal networking (BYO) event.

New Zealand:

A major technical meeting was hosted in Wellington in November. Local members attended some of the RTSA events, however no IRSE branded local meetings were held.

ARIA Awards Dinner, Sydney 17 July 2019. (attendance 500+)

A gala dinner evening was held in Sydney where the IRSE and the other rail engineering institutions of Australasia organise an event called the Australasian Rail Industry Awards (ARIA), where people were recognised for their contribution into the Industry. The IRSE chairman Kaniyur Sundareswaran presented an award for the Rail Signalling and Systems Engineering area, which was won by Frank Bartolo from FMB Signalling.

AUSRAIL Plus, Sydney 3-5 November 2019 (attendance 5000 approx.)

AUSRAIL Plus is an event held by the Australasian Railways Association (ARA) and is a three-day conference with more than 380 exhibitors with a theme in 2019 of *Delivering Growth; Creating Opportunity; Embracing Technology*. The IRSE participated with three streams of papers in the conference with a total of 12 papers presented. Average attendance at the IRSE papers was approximately 90.

Insight into Railway Signalling Courses

In conjunction with ARA, IRSE delivers Insights into Railway Signalling course in the various states of Australia. In 2019 courses were delivered in Brisbane, Melbourne and Sydney.

4. Plans for the Next 12 Months

Events
The program of technical meetings, both national and local, will be maintained as far as possible given the restrictions associated with the COVID-9 pandemic. It is proposed to hold the postponed 2020 AGM via a webinar in May 2020. The next national technical meeting is proposed to be a webinar to be held in July. The following national technical meeting will be held in Adelaide on 22-25 October 2020.

The Australasian Section is scheduled to host ASPECT in Melbourne in September 2021. This may have to be rescheduled based on the state of the 2020 International Convention.

Local technical meetings will continue to be arranged in the major capital cities where possible.

IRSE will be holding two streams of presentations in the AusRail conference to be held in Adelaide from 1-2 December 2020.

The biennial CORE (Centre on Railway Excellence) Conference scheduled for 2020 has now moved by a year to take place between June 21-23, 2021.

Joint delivery of the Insight into Railway Signalling courses with the Australasian Railway Association (ARA) have been put on hold until the end of July 2020. The Section will start delivering them in the later part of the year once the Covid-19 situation improves and the restrictions are eased.

Other Initiatives

One major focus is to continue setting up the processes obtaining feedback and reviewing the material for the Graduate Diploma in Railway Signalling as well as reinstating the 'Appropriate Equivalent Qualification' status from HQ for the course.

The Section's Professional Education Committee is back in full swing action with Phil Baker taking over as the Chair of the PEC committee. He is also participating in the E&PD committee meetings of the HQ. The Section was fully geared up to run our new Testing and Commissioning Seminar in conjunction with the AGM in Adelaide. It is now being planned to be delivered in October, with the rescheduled Adelaide meeting.

IRSE China Section Incorporated Report: 2019 – 2020

Report produced by:	Yinghong Wen
Date:	March 2020

1. Introduction

Date of last Annual General Meeting:	10 January 2021
Were annual accounts presented at the AGM?	Yes
Were officers elected / re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the Section?	95

2. Section Officers

Chairman	Yao Tang
Secretary	Yinghong Wen
Treasurer	Wei Jiang
Country Vice-President (if appointed)	Chaoying Liu, Yan Qin, Weizhong Huang, Weizhong Shi, Fang Ma
Webmaster (for updating IRSE website local Section page)	Kexin Liu

3. Main Activities During the Past 12 Months

IRSE China Section Executive Committee Meeting (10 Jan 2020)

IRSE China Section ECM was held in January 2020 in Beijing Jiaotong University. The new IRSE China Section committee was selected and approved. The list of the selected 3rd IRSE China Section committee members are:

- **Committee Chair:**
  Tao Tang (Beijing Jiaotong University)
- **Committee Vice-Chairs:**
  Chaoying Liu (China Railway Corporation)
  Yan Qin (China Railway Corporation)
  Weizhong Huang (China Railway Signal & Communication Corporation Limited)
  Weizhong Shi (China Railway Information Technology Group Co. Ltd)
  Fang Ma (China Academy of Railway Sciences)
- **Secretary General:**
  Yinghong Wen (Beijing Jiaotong University)
- **Executive Committee Members:**
  Yu Cao (China Railway Corporation)
  Zhisong Mo (China Railway Corporation)
  Yong Cui (China Railway Test & Certification Center Limited)
  Zhijie Yang (China Academy of Railway Sciences)
  Baigen Cai (Beijing Jiaotong University)
  Chunhai Gao (Beijing Traffic Control Technology Co. Ltd)
  Chunming He (Beijing HollySys Automation Technologies Ltd)

Wei Li (Beijing Jiaoda Signal Technology Co. Ltd)
Jiangtao Wang (Beijing Funenc Technology Co. Ltd)
Jianhua Jiang (CASCO Signal Ltd)
Wenhong Liu (Beijing Jiaxun Feihong Electrical Co. Ltd)
Lei Chen (Anhui-Birmingham International Research Institute in Rail Transportation)
Xiaohong Yu (Beijing MTR Company)
Min Zhang (Beijing Jiaoda Signal Technology Co. Ltd.)
Yang Zhao (China Academy of Railway Sciences)

- **Treasurer**:
  Wei Jiang (Beijing Jiaotong University)


Figure 1 IRSE China Section ECM 2019

2019 Chinese Railway Telecommunication and Signalling Technical Meeting – The 10th Anniversary of China High-speed Railway (10 October 2019)

The Chinese Railway Telecommunication and Signalling Technical Meeting was held in October 2019, the meeting was also held to celebrate the 10th anniversary of China high-speed railway's operation. The Vice-chair of IRSE China Section, Mr. Yan Qin, from China Railway Corporation hosted the meeting. Seven experts from Beijing Jiaotong University, China Academy of Railway Sciences, China Railway Signal & Communication Corporation Limited etc. made the presentations. More than 300 technical papers were collected and published for the technical meeting.

Figure 2 2019 Chinese Railway Telecommunication and Signalling Technical Meeting – The 10th Anniversary of China High-speed Railway

The 6th ZPW-2000 Track Circuit Technical Workshop (3-4 September 2019)

The 6th ZPW-2000 Track Circuit Technical Workshop was held with the assist of IRSE China Section in Beijing on 3-4 September 2019. The topic of the technical workshop is to summarise the development of Chinese track circuit technology in last 10 years, and communicate to overcome the last problem in production, maintenance, and operation. More than 100 delegates attended the workshop. A technical visit to the R&D Lab of China Railway Signal & Communication Corporation was also held.

Fig.3 The 6th ZPW-2000 Track Circuit Technical Workshop

2019 China Railway Technical Workshop (11-12 June)

2019 China Railway Technical Workshop was held with the assistance of IRSE China Section in Beijing on 11-12 June 2019. The technical workshop was hosted by the IRSE China Section vice Chair Mr.Yan Qin. Delegates from universities, research institutes and industrial corporations attended the workshop.

Fig.4 2019 China Railway Technical Workshop

Domestic Railway Signalling Training Project

With the support of China Railway Corporation, IRSE China Section approved the Domestic Rail Training Project, which aims to help improve railway signalling engineers' basic theoretical knowledge and operation safety awareness. IRSE China Section will organise the training process, including courses and theoretical exam. China Railway Test & Certification Center Limited (CRCC) will help the assessment process under the direction of the China Railway Corporation. The project is planned to be started at 2020.

Figure 5 Domestic Railway Signalling Training Project

IRSE Membership Application

In 2019, IRSE China Section considered and approved 57 membership applications and submitted to the IRSE Council, the current number of IRSE members in China is 95.

Figure 6 IRSE Membership Application

IRSE China Section also updated the application form and the membership routes flowchart in Chinese and submitted to IRSE committee. The translated version has also been uploaded to IRSE China Section website to help member applicants fill in the English/Chinese application form.

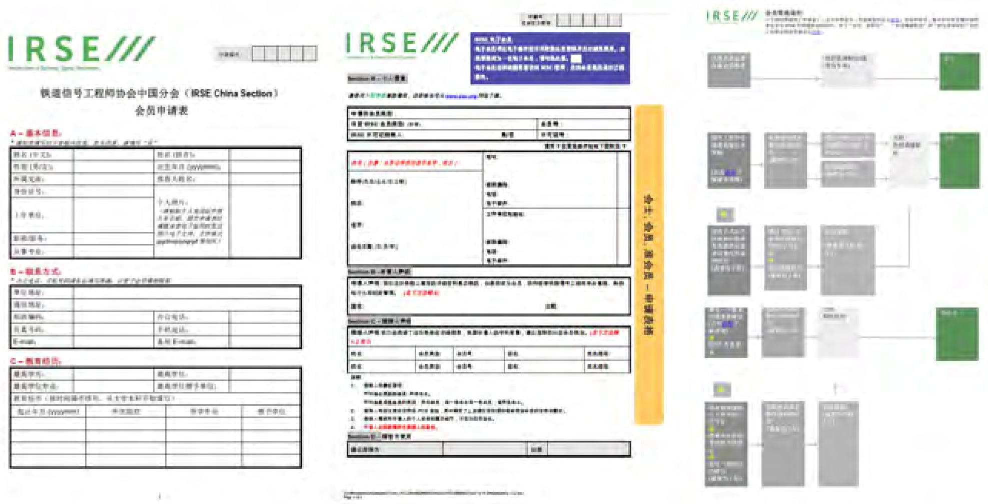


Figure 7 Updated IRSE membership application documents

4. Plans for the Next 12 Months

Annual General Meeting 2020

In 2020, IRSE China Section plans to conduct the Annual General Meeting according to the bye-law. The Annual General Meeting will be held in OCT, chaired by the President Tao Tang. The Annual Dinner will be held at Beijing, on October 2020, followed by the Annual General meeting. The IRSE China Section would invite President Tao Tang to give an annual report of IRSE China Section to all members.

Executive Committee Meeting 2019

The Executive Committee Meeting is planned to be chaired by the president Tao Tang in June, held in Beijing Jiaotong University. The meeting aims to discuss the membership application to IRSE China Section, and recommend the outstanding member to the IRSE council. This meeting is scheduled 3 weeks prior to the AGM, aims to prepare for the AGM 2019.

IRSE China Section co-hosts workshop “The 7th ZPW-2000 Track Circuit Technical Workshop” (September 2020)

IRSE China Section will co-host the local technical workshop “The 7th ZPW-2000 Track Circuit Technical Workshop” in Beijing with the support of China Railway Society. In this workshop, engineers from local railway corporations and research institutes are invited to attend and present. The workshop plans to last for two days, and open to all IRSE members. All related researchers and industrial companies are also encouraged to attend and communicate at the workshop.

IRSE China Section co-hosts workshop “Future development of Railway Telecommunication and Signalling System” (October 2020)

IRSE China Section will co-host the local technical workshop “Future development of Railway Telecommunication and Signalling System” in Beijing with the support of China Railway Society. In this workshop, the domestic and international technical experts are invited to present and discuss the promoting issue of the telecommunication and signalling technologies in next generation train control system in China. The workshop plans to last for one day, and open to all IRSE members. All related researchers and industrial companies are also encouraged to attend and communicate at the workshop.

IRSE China Section co-hosts workshop “Intelligent development of Railway Telecommunication System” (November 2020)

IRSE China Section will co-host the local technical workshop “Intelligent development of Railway Telecommunication System” in Beijing with the support of China Railway Society. In this workshop, the applications of cloud, internet of thing, big data and artificial intelligent technologies on railway telecommunication system will be discussed. The workshop plans to last for two days, and is open to all IRSE members. All related researchers and industrial companies are also encouraged to attend and communicate at the workshop.

IRSE French Section Report: 2019 – 2020

Report produced by: Mr. Hugh Rochford, Secretary
Date: 19 November 2020

1. Introduction

The local section is now three years old and the decision was taken that no Annual General meeting is to be organised as such.

Regarding financial matters, IRSE French Section has decided to organise free events (around 4 per year among which conferences and technical visits) each individually sponsored by companies who have members. All events are covered by an article in IRSE News as much as possible and recently the possibility to publish on an IRSE webpage to be discussed for articles exceeding IRSE News publication capacity.

The French section has been increasing its number of members from 45 (minimum for the creation of the section) to 86 members of the IRSE today. The Section also attracted the interest of 300 other professionals, potentially future members of the IRSE.

Minutes of all meetings are written and available in native language.

Date of last Annual General Meeting	None yet
Were annual accounts presented at the AGM?	NA
Were officers elected / re-elected at the AGM?	NA
Have minutes of the last AGM been produced?	NA
How many IRSE members are in the Section?	86

2. Section Officers (at time of writing report)

Chairman	Mr. SEVESTRE Christian
Secretary	Mr. ROCHFORD Hugh
Treasurer	NA
Country Vice-President (if appointed)	Mr. PORE Jacques
Webmaster (for updating IRSE website Local Section page)	Mr. ROCHFORD Hugh

3. Main Activities During the Past 12 Months

Meetings:

The French section has held 8 regular Committee meetings since April 2018. The committee meetings are well attended with physical or online presence of the Section’s 8 Committee members, namely Christian SEVESTRE (Consultant ex SNCF), Jacque PORÉ (Alstom), Hugh ROCHFORD (SNCF Réseau), Philippe LEBOUAR (SNCF Réseau), Gilbert MOENS (ex SNCF), Gilles PASCAULT (ANSALDO), Pierre Damien JOURDAIN (ALSTOM) and François Xavier PICARD (SNCF Réseau).

The agenda consists of decisions to be taken regarding the section’s development (visiting major railway companies for IRSE promotion) and preparation of events (contacts and coordination of the event).

Events:

The events attracted around 60 individuals at each conference (limitation of 40 for the technical visit in Bruges, Belgium), among which members and non-members.

Technical conferences:
The events focused on national and international signalling presentations such as:
7 February 2019 - Conference on FRMCS future railway telecommunication technology, presentation by Kapsch and SNCF Réseau

16 May 2019 - Conference on Automatic Pilot overlayed on the SACEM signalling system on RER A line by RATP and Alstom

9 April 2018 Technical visit of the Bruges OCC with the installation of a Siemens Simis W interlocking controlling the ERTMS line Bruges Courtrai

Conferences this year were hosted by SNCF Réseau and RATP, the technical visit by Infrabel (Belgium). Events end usually with an informal session around drinks and finger food. The interest and satisfaction of attendees is good and increasing in the number of attendees, experience shows that the answer rate is still high and fast after invitation.

As mentioned in the introduction, after each event, the Section plans to send an article to IRSE NEWS to increase visibility. There has been some difficulty experienced in getting 4 of the articles published in IRSE News, they were submitted to IRSE News and never published. An arrangement seems to have been reached by publishing on the IRSE Website.

4. Plans for the Next 12 Months

The IRSE French Section will organise new events towards the beginning of year 2019:
30 January 2020 - Conference on Technical visit on innovation in point machines
27 April 2020 - Conference on Experience return on Moroccan High Speed Line Signalling
September 2020 - Conference on SNCF RESEAU Signalling strategy for renewal in France

Feedback of events is always analysed during the meetings, and the Section already sees the fruit of its efforts to promote contacts and discussion across the French sector.

IRSE Hong Kong Section Report: 2019 – 2020

Report produced by:	YF Sung
Date:	5 February 2020

1. Introduction

The IRSE Hong Kong Section conducted an election during the 24rd AGM on 17 June 2019. 40 members attended the event. The organisation was put on the IRSE(HK) website and the Section launched one Basic and one Intermediate Signalling Course for MTR Academy in 2019.

Date of last Annual General Meeting	17 June 2019
Were annual accounts presented at the AGM?	Yes
Were officers elected / re-elected at the AGM?	No. Refer to the report submitted in June 2018.
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the Section?	218

2. Section Officers (at time of writing report)

Chairman	PANG Kwok Wai
Secretary	SUNG Yuen Fat
Treasurer	PANG Kwan Kin, Ken
Country Vice-President (if appointed)	LUK Kam Ming
Webmaster (for updating IRSE website Local Section page)	IRSE.org.hk

3. Main Activities During the Past 12 Months

- Committee Meetings – Normally bi-monthly meeting and to be held in MTR HQs.
- Technical forums – To invite Signal experts of MTR, Consultant firms in Hong Kong and China to deliver technical papers.
- Technical visit to local or overseas railway lines and local major utilities
- Participated in IRSE ASPECT 2019 in the Netherlands – IRSE(HK) Vice-chairman Henry Cheung delivered a paper and one member was sponsored and attended.
- Technical visit to Beijing Jiaotong University and China Railway Signal and Communication Company in November 2019 – 4 Committee members were sponsored and attended.
- IRSE(HK) collaborated with MTR Academy. Provision of one Basic Signalling Course and one Intermediate Course .

4. Plans for the Next 12 Months

- Committee Meetings
- Technical forums
- Technical visit to local or overseas railway lines and local major utilities
- Technical visit to the railway operators and suppliers in main cities of China
- Provision of basic signalling course and intermediate signalling course
- Provision of IRSE Exam Briefing for IRSE candidates
- Invite railway experts from China to give talks on new train developments

IRSE India Section Report: 2019 – 2020

India Section no report for 2019/20 due to COVID.

IRSE Indonesia Section Report: 2019 – 2020

Report produced by: Toni Surakusumah
Date: 15 June 2021

1. Introduction

Date when section was formed	4 April 2013
Date of last Annual General Meeting	2015
Were annual accounts presented at the AGM? (if applicable)	Yes
Were officers elected / re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the Section?	84
Is your page on the website up to date with contact details, etc?	No

2. Section Officers (at time of writing report)

Chair	Adi Sufiadi Yusuf
Secretary	Toni Surakusumah
Treasurer	Yunanda Raharjanto
Country Vice-President (if appointed)	
Communications / website (if appointed)	

3. Main Activities During the Past 12 Months

No.	Activity	Date	Remarks
1	Annual Meeting of IRSE HQ	13 March 2019	Joining the Annual Meeting at IRSE HQ
2	London Underground Visit	14 March 2019	Visit to Operation Center and Equipment room
3	Meeting with Birmingham University	15 March 2019	Discussing a partnership opportunity for opening Master Program of Train Control System
4	Trial Ride of MRT Jakarta Lines	20 March 2019	MRT Jakarta is a new line in Jakarta and they invited some related institutions to take trial ride before launching the commercial operation.
5	Participating as a speaker at the 19th Indonesian Scholars International Convention (ISIC)	23 June 2019	Nottingham University, UK
6	Coordination of IRSE Membership	24 June 2019	Taking discussion with Membership Department of IRSE HQ at IRSE HQ
7	IRSE Campaign for student in University	October 2019	Taking lecturer at Stadium General Program Telkom University

4. Plans for the Next 12 Months

No.	Activity	Date	Remarks
1	General Meeting of Committee Election	The end of September 2020	Reactivate the IRSE Indonesia Section, conduct new Committee Election of IRSE and open new membership.
2	Book Donation	April, June, August, October 2019	Plan to take book donation for several universities, Railway Industries and Railway Regulator.
3	IRSE Campaign and open recruitment for student in University	April, June, August, October 2019	Plan to take lecturer at Stadium General Program in several universities (ITB, Tel-U, Itera, API Madiun, UP)
4	IRSE Seminar	November 2020	The seminar takes the topic about the latest issue of signalling in the world.

IRSE Ireland Section Report: 2019 – 2020

Report produced by: Sean Burns, Chairman
Date: 1 November 2019

1. Introduction

2019 was the fifth year in existence of the Irish Section of the Institution. The Section continues to be in a healthy state, with membership climbing to over 100 and great interest shown in the many events organised throughout the year. There is an active and enthusiastic committee of eight members drawn from different railway administrations, suppliers and regulators and together they have run a wide-ranging and diverse programme of events throughout the year.

Date of last Annual General Meeting	7 February 2019
Were annual accounts presented at the AGM?	Yes
Were officers elected / re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the Section?	104

2. Section Officers (at time of writing report)

Chairman	Sean Burns
Secretary	Mark Neilan
Treasurer	Huw Bates
Country Vice-President (if appointed)	Peter Cuffe (vice-chairman)
Webmaster (for updating IRSE website Local Section page)	Peter Cuffe

3. Main Activities During the Past 12 Months

The annual dinner was held in the Radisson Hotel Belfast on 1 Dec and was deemed by all who attended as being a great success. The meal and the entertainment were excellent and the subsequent impromptu sing-along was hugely enjoyed by all. The traditional charity raffle raised over €1,000 for the mental health charity, Mindwise, an excellent result.

The AGM this year was held in the offices of Translink at York Road, Belfast on February 7 2019. 18 members attended. The Chairman's report highlighted the principal events held in the previous year and outlined the intended programme for the year ahead. Accounts were presented and the new committee was elected, consisting in the main of the previous year's committee with some roles alternated.

Following the section AGM Irish member Mark Neilan gave a presentation on the proposed IÉHS (Iarnród Éireann Hybrid System) currently under development in Irish Rail. The IÉHS Project is a form of Train Protection System which has both on-board and trackside elements. It is proposed to mix both traditional coded track circuits that currently provide in-cab CAWS and ATP with eurobalises that will add train stop and over-speed functionality at critical locations. The presentation discussed development plans, risks to the project, rollout program and budget.

Frauscher gave a technical paper followed by an axle counter demonstration at Irish Rail's training centre in Inchicore, Dublin on 16 April. The concept of an axle counter head being an intelligent sensor incorporating evaluation and opening up greater flexibility and reliability through a bus architecture was explored in depth. The event was well attended and received with a strong presence of young members.

The section annual golf outing was held at Nuremore Hotel and Country golf club, Co. Monaghan on 22 August. 18 players attended and all enjoyed the day, everyone who participated stayed for the dinner and prize giving.

On 11 September Alcatel Lucent Enterprises presented a technical paper in Inchicore, Dublin on the subject of Rail Safety & Communications Technology. The paper looked at connecting railway systems and subsystems with technology that supports passengers, employees and services. Examples of current application of using such intelligent interconnection to provide targeted information for staff and customers in station environs were presented and the audience of over 30 were impressed by the paper and a lively question and answer session on how and to what extent Artificial Intelligence would impinge on railway signalling followed.

On Saturday 6 October the Irish Section organised and supervised the Dublin exam centre for annual IRSE professional exams. 19 candidates sat a total of 21 modules.

4. Plans for the Next 12 Months

Having established an ongoing stream of candidates for the IRSE professional exams the committee are anxious that those with who have successfully completed the required four modules continue on to professional registration and efforts will be made during 2020 to progress this.

9 November	Limerick	Annual Dinner and Dance
6 February	Dublin	AGM & Technical Paper “Distributed Acoustic Sensing DAS”
16 April	Carrickmacross	Technical Day – Rail Forum An exhibition from a range of rail industry companies, product demonstrations and presentations
11 June	Belfast	Technical Paper “SN119 and its effect on the UK rail industry”
20 August	Mannan Castle	IRSE Irish Section social golf outing
17 September	Belfast	Technical Paper “From the Signal to the Ground”

IRSE Japan Local Section Report: 2019 – 2020

Report produced by: Yuji Hirao
Date: 20 November 2019

1. Introduction

Date of last Annual General Meeting	18 October, 2018 14 November, 2019
Were annual accounts presented at the AGM?	No. (Art 5: Members of IRSE JP shall not be required to pay an annual subscription to the Local Section. IRSE JP members who participate in technical and social events shall bear only the actual costs for each event.)
Were officers elected / re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the Section?	73

2. **Section Officers** (at time of writing report)

Chairman	Prof. Yuji Hirao
Vice-chairman	Dr. Masayuki Matsumoto
Secretary	Dr. Takashi Kawano
Treasurer	Hideki Komukai
Country Vice-President (if appointed)	-
Webmaster (for updating IRSE website Local Section page)	-

3. Main Activities During the Past 12 Months

General Annual Meeting (18 October, 2018 attended by 45 members and 24 proxies)

a. Report on local section activities after the Inaugural Meeting on 1 November, 2017
b. Approval of revision of articles of the local section - local committee members from 6 to 9 except for Chairman, Vice-Chairman, Secretary and Treasurer - (Proposal by Committee)
c. Approval of Committee Members (Proposal by Committee)
d. Approval of action plans 2018-2019 (Proposal by Committee)
   - Studies and their result presentations by five study groups which discuss the following subjects: (a) management and strategy, (b) technology in general, (c) technology in details, (d) cost and (e)certification and standards
e. AOB

Study Meeting (18 October, 2018 attended by 53 members)

a. Lecture on "Technical support for the Indian High-speed line project"
b. Report on activities of study groups *(see Study Meeting on 14 November, 2019)*
c. AOB

Study Meeting (7 March, 2019 attended by IRSE President and 53 members)

a. Lecture on "SIL-4 is not always SIL-4" by IRSE President, Dr. Markus Montigel
b. Interim reports by study groups *(see Study Meeting on 14 November, 2019)*
c. AOB

Study Meeting (17 July, 2019 attended by 42 members)

a. Lecture on "IRSE Licensing Scheme"
b. Reports on studies by study groups (see Study Meeting on 14 November, 2019)
c. Discussions on study results
d. AOB

Committee Meeting (7 August, 2019 attended by 10 Committee Members)

a. Inquiry results about section activities among younger and middle-ranking members
b. Proposal of action plans 2019-2020 on the basis of the inquiry results
   - Inquiry results about Japanese section activities among younger and middle-ranking members
c. Proposal of Committee Members
d. AOB

General Annual Meeting (14 November, 2019 attended by 40 members and 26 proxies)

a. Report on local section activities 2018-2019
b. Approval of Committee Members (Proposal by Committee)
c. Approval of action plans 2019-2020 (Proposal by Committee)
   - Publication of study results and restructuring of study groups
   - Lectures by experienced expert members: knowledge transmission to younger and middle-ranking members
   - Presentations of job-based topics by younger and middle-ranking members: share of experience
   - Technical visits
d. AOB

Study Meeting (14 November, 2019 attended by 53 members)

a. Reports on studies by study groups. Each study group has concretely studied the following topics and obtained results:
   - management and strategy - Competence of individuals in a project lifecycle
   - technology in general - Secondary systems and their adoption criteria
   - technology in details - DAS, safety technologies, cyber security, data redundancy and level crossings
   - cost - Software development cost influenced by incompleteness of requirements
   - certification and standards
   - Comparison of background and present situations between Europe and Japan
b. Discussions on study results
c. AOB

4. Plans for the Next 12 Months

Three or four study meetings are to be held.

IRSE Malaysia Local Section Report: 2019 – 2020

Report produced by: Ir. Sri Viknesh
Date: 25 January 2020

1. Introduction

Date of last Annual General Meeting	17 June 2019 (2020 AGM not conducted)
Were annual accounts presented at the AGM?	Yes
Were officers elected / re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the Section?	91
Is you page on the website up to date with your contact details, etc?	Yes

2. Section Officers

Chair	Ir. Shahrizaman Zamhury
Secretary	Ir. Sri Viknesh
Treasurer	Hazwan Rahman
Country Vice-President (if appointed)	Aniket Mukhopadhyay
Communications / website (if appointed)	

3. Main Activities During the Past 12 Months

Item	Date	Activity	Participants	Remarks
1	20 Jan 2020	Committee Progress Meeting & E\ Planning	6 members participated	-
2	19 Nov 2020	Evening Talk 1: 2 speakers on - Mainline FAO - Railway Operation & TCS	105 participants	Online

4. Plans for the Next 12 Months

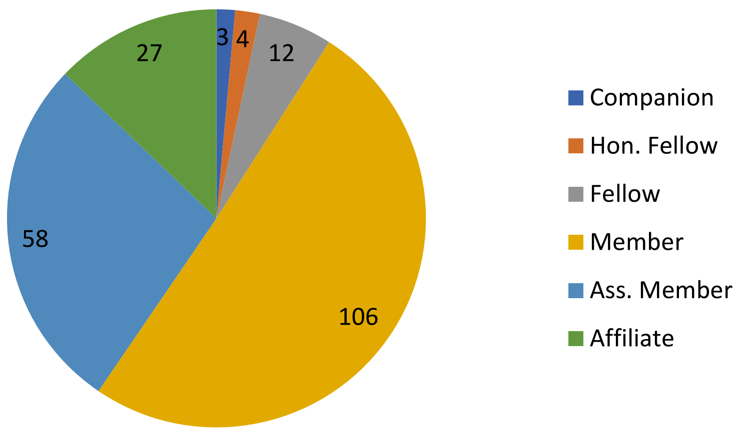
Item	Date	Activity	Participants	Remarks
1	Feb 2021	Evening Talk – Sharing session		Online
	March 2021	Partnering with C3 Rail : Command, Control & Communications (Asia Pacific) seminar		Online
2	May 2021	Evening Talk – Sharing session		Online
3	Aug 2021	Evening Talk – Sharing session		Online
4	Nov 2021	Evening Talk – Sharing session		Online

IRSE Dutch (Netherlands) Local Section Report: 2019 – 2020

Report produced by: Alwin van Meeteren (chair) & Ben van Schijndel (secretary)
Date: 31 January 2020

1. Introduction

Date of last Annual General Meeting	May 16, 2019
Were annual accounts presented at the AGM?	Yes (and approved)
Were officers elected / re-elected at the AGM?	3 officers re-elected
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the Section?	212 members @1 January 2019 215 members @31 December 2019 (incl. 5 YM)



2. Section Officers (at time of writing report)

Chairman	Alwin van Meeteren
Vice Chair	*Wendi Brandt - Mennen*
Secretary	Ben van Schijndel
Treasurer	Wilbert Eijsink
Webmaster	Wim Coenraad

3. Main Activities During the Past 12 Months

The main activities of the Section during the past 12 months both for members to attend and actions for the board are listed in the table below.

Activities for all Members

In 2018 the Dutch section celebrated its 10th anniversary and the year 2019 was mainly focused around hosting and co-organizing ASPECT 2019///
The Section also organized several other meetings and presentations for members, and is convinced that regular (smaller) technical and social meetings contribute to cohesion within the section.

Date (in 2019)	*Subject*	*Attendees*
February 28	Speech by Prof Rob Goverde	51 members
March 28	Technical visits Railcenter	49 members
May 16	ATO at Rotterdam metro	43 members
May 16	AGM and Presentations	49 members
June 19	Visit to Schiphol Airport	42 members
October 22	ASPECT 2019/// Introduction	Young members
October 23-24	ASPECT 2019/// Congress TUD	International IRSE members
October 25	ASPECT 2019/// Technical visits hosted by IRSE Nederland	50 memb. NZL 50 memb. RC
November 27	Future of Train detection Presentation with Railforum	80 members
November 28	ERTMS; We've started	59 members
December 10	Closing drinks and Pub Quiz	45 members

Significant changes; New changes in the Board
Only minor change in board members (re-elections).

Position	*Old*	*New or re-elected*
Chairman	Alwin van Meeteren	Alwin van Meeteren (re)
Secretary	Ben van Schijndel	Ben van Schijndel
Treasurer	Wilbert Eijsink	Wilbert Eijsink
Country Vice-Chair	*Wendi Brandt-Mennen*	*Wendi Brandt-Mennen*

New Strategy process

During several 2016 board meetings and evenings spend together; the new board elaborated a renewed strategy for the next 5 years. This process is known as OGSM - joint Objective, shared Goals and Strategy that are Measured - and is followed-up by an action plan for each strategy. Most board members are an owner of a strategy and have working groups around a specific theme.

In the first meeting of the year the OGSM strategy method was introduced to the members. After discussion and (smaller) adaption the Section has firmly presented this new strategy during the 2017 and 2018 AGM. All 5 strategy themes were presented by its non-executive board member to further adopt this item with AGM.

OGSM Outcome in brief:

Mission
To improve the safety and the increase of the capacity of rail-guided systems by the retaining and further development of the knowledge and practice of signalling.
Vision
By developing and bringing together professionals and knowledge in the field of the signalling, we propose and encourage them to realise solutions for the optimisation of the use of track.

The goals and strategies are defined in five major strategy items:

Strategy Theme	*Goal*	*Realised actions in 2019*
Knowledge Platform *JP van Hengstum*	Securing, deepening, and broadening of knowledge by bringing together knowledge and collaborations with knowledge sources.	See activities for members in paragraph 3.1 above. Focus is on sharing information not only in Rail sector, but also in the adjacent fields, like Airports (2019), harbours and new technology like unmanned driving and Hyperloop (2018).
Network *Paul van der Ven*	Developing knowledge and acquaintances by increasing and simplifying access to knowledge and acquaintances.	Discussing with IRSE UK the Section's internet platform and how to create a common, clear platform for members. Goal for the year 2020 is to integrate site with the IRSE UK one.
Involved Members *Fred Kossen*	Increasing the involvement of its members by mobilising the knowledge of its members.	Targeting younger members with specific meetings (see above) and making it easier for them to apply for a membership
Opinion making *Wendi Mennen*	The interpretation of the developments in the industry so that it can be practically applied.	What needs to be said more that the very successful event of the ASPECT2019/// and the hosting of Delft University of Technology
Image *Paul Hendriks*	Securing the continuity of knowledge of signalling by a relevant and contemporary knowledge platform	Helped by the new IRSE branding and organizing events that are out of the box, the Section received positive feedback about its image, which is perceived as more modern and better aligned with the present days. Especially younger (candidate) members are enthusiastic.

Other issues during 2019

The Dutch Section was happy to host and co-organize the ASPECT 2019 in Delft. This, combined with other activities, made it a busy two years for the Section. The Section has never been more challenged, and it was great fun!

4. Plans for the Next 12 Months

After ASPECT 2019 the main 2020 focus for IRSE Dutch Section will be (international) Growth, Diversity and Inclusion. Part of the financial resources coming from this event will be used to invest in these topics. The Section is investigating the possibilities to grow the number of members; not only in The Netherlands but also in the adjacent countries like Belgium and maybe even the Nordics, to be further examined. Visits will be organised in Belgium, Germany and/or Denmark in the coming period to assess this and to see what the possibilities are.

The Section will be stronger ad much more relevant as an organisation when it has a more diverse membership, not only in gender or nationality but also in cultural background, education/experience, etc. The Section should be more open for people who think differently and therefore Inclusion is as important as Diversity. It is about getting the right mix AND getting the mix right.

Current Plans for 2020

Month [planned]	*Subject*	*Date*
January	Presidential Visit Netherlands Incl Presentation Obsolescence	January 7
January	Visit of the IRSE CEO Including visit to ProRail	January 8
March	Visit EMC Lab Dekra Arnhem	Tbd
April	ATO/ERTMS L3 Wuppertal Germany By ALSTOM	*Trip with members*
May	AGM + lecture cyber security	May 14
September	Visit LWR Rotterdam Harbor by Siemens	
October	Visit to Infrabel incl presentations. Antwerp Central station	Tbd
Autumn	Lecture on GSM-R / GPRS Nyenrode University	
December	Close-out IRSE-NL year Networking event	
Spring Special: Diversity	*Diversity event*	*Spring 2020*
Autumn Special: Inclusion	*Inclusion event*	*Autumn 2020*

IRSE North America Local Section Report: 2019 – 2020

Report produced by: Rob Burkhardt
Date: 16 November 2019

1. Introduction

The NAS conducted its AGM at the Interchange Conference in Minneapolis September 24. Following the AGM a technical visit was held at BNSF's Northtown Hump Yard. The Toronto CBTC conference will be held November 28 and 29.

Date of last Annual General Meeting	September 24, 2019
Were annual accounts presented at the AGM?	Yes
Were officers elected / re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the Section?	107

2. Section Officers (at time of writing report)

Chairman	Rob Burkhardt
Secretary	Ray Rizman
Treasurer	N/A
Country Vice-President (if appointed)	Dave Thurston
Webmaster (for updating IRSE website Local Section page)	Rob Burkhardt

3. Main Activities During the Past 12 Months

The NAS AGM was held in conjunction with the Interchange Conference in Minneapolis on September 24th of this year. Because Interchange hosts AREMA's presentation of papers and technical committee meetings no papers were presented at the AGM. A technical visit to BNSF's Northtown Hump Yard was held following the AGM. A total of 12 members attended the technical visit and were provided.

The next activity was the annual Canadian meeting held in Toronto, Ontario on November 30, 2018. This is more a conference with presentations for members and guests and is held immediately before the Toronto Railway Club holiday dinner. This year, over 90 were in attendance at the meeting.

The last activity was the annual CBTC conference held in Toronto on November 29/30, 2018 at the Fairmont Royal York hotel in Toronto, Ontario. This event sold out at 115 attendees and was considered a very successful event for IRSE.

The NAS Committee met via teleconference throughout the year.

4. Plans for the Next 12 Months

For 2019, the NAS plans to help organise the annual Canadian meeting as well as the annual CBTC conference in Toronto, Ontario. The AGM will be held in Minneapolis, Minnesota. As this year is a Rail Interchange Event (this is the North American equivalent to Innotrans), the traditional mini conference will not be held.

The Section will also advance the proposed licensing scheme for the North American Market. It is anticipated that there will be additional interest from the major railroads and transit agencies for this.
There are several officers' positions scheduled for election as well, and this will be processed in the second quarter of 2019.

IRSE Singapore Local Section Report: 2019 - 2020

Report produced by: M P White
Date: 6 November 2019

1. Introduction

During 2018/2019 the Section held three presentations. These are typically attended by around 25 to 60 people.

Date of last Annual General Meeting	5 November 2019
Were annual accounts presented at the AGM?	Yes
Were officers elected / re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the Section?	59

2. Section Officers (at time of writing report)

Chairman	Robert Cooke
Secretary	Lim Chee Siong (Elected at 2019 AGM).
Treasurer	Ian Tomlins
Country Vice-President (if appointed)	Mark Appleyard
Webmaster (for updating IRSE website Local Section page)	Lim Chiau Koon

3. Main Activities During the Past 12 Months

During the period November 2018 to November 2019, the following presentations were facilitated by the IRSE Singaporean Section:

Date	Title	Presenter
25 June 2019	A legacy in Signalling Interactivity	Ethan Chia
27 August 2019	Crossrail Signalling Co-promoted by IES Singapore under the IRSE/IES MOU	Tom Godfrey
8 October 2019	Advancing SCORES-Signalling Simulator to Training Tool	David Dobson

In addition to the above presentation, the Section hopes to have a presentation by the IRSE President, Mr George Clark in March 2020, when he will be en route to attend Australasian Section AGM and Technical meeting.

The Section's presentations are open to both IRSE Members and non-Members.

In December 2018 an annual lunch was held for members of the IRSE Singaporean Section Committee. The Annual lunch for 2019 will take place on 30 November.

4. Plans for the Next 12 Months

The Section plans to continue to hold presentations at approximately bi-monthly intervals over the next year.

IRSE Southern Africa Local Section Report: 2019 - 2020

Report produced by: Ryan Gould (Hon. Secretary)
Date: 17 November 2020

1. Introduction

As would be expected for the IRSE Head Office as well as all the Local Sections of the IRSE, this past year has been truly different. Not so much in terms of the established processes and procedures, but rather in terms of the processes and procedures specific to the day to day running, format of events, activities and operation of both the Head Office and the Local Sections. Most of this is as a result of the sudden occurrence of the Covid 19 epidemic.

The signalling industry in the Southern Africa Region remains depressed, with a further decline in specifically the amount of new works planning and implementation.

The activities within specifically the South Africa signalling industry during this period has focused on the following:

- The ongoing re-signalling project in the Gauteng, Durban and Cape Town metropolitan areas. This remains the most significant project in progress. Meaningful further progress has been achieved during the past 12 months, but with the extent of the progress varying from region to region.
- The planning and implementation of signalling changes to various selected freight rail corridors, to either increase or in some cases decrease (typically associated with theft and/or vandalism) the infrastructure and capacity of the general freight network.
- Efforts to combat the occurrence and impact of what appears to be a more rapidly growing trend in theft and vandalism, especially in certain areas of the metropolitan infrastructure. The levels of theft and vandalism has further increased in the past 15 months and is having a significantly greater negative impact on the commuter and freight rail service quality and projects, with the commuter rail sector being more affected.
- Essential train control system developments, enhancements, maintenance and repair to ensure, as far as possible, continued train operations on existing commuter and freight rail networks.

As reported last year, the IRSE Local Section was granted Voluntary Association Recognition by the Engineering Council of South Africa (ECSA) in August 2018. Significant progress has been made in the past 15 months regarding the processes and procedures required for IRSE Local Section members to claim continuous professional development (CDP) points from ECSA for attending the Local Section Technical Meetings and any other qualifying events. These CPD points form part of the requirements for re-registering every five years with ECSA as a Professional Engineer. Some of the IRSE members have already been successful in logging these events with ECSA.

Financial support from the local industry players for the IRSE Local Section remains a mixed bag, with good support from some industry players and limited to no support from others. Despite this, the SA IRSE Section has improved on its financial reserve during this period.

Unfortunately, some difficulties were experienced regarding the regular inclusion of the IRSE colleagues from Botswana in the South African events. Efforts to resolve these problems were unsuccessful. The need for us to change to virtual technical meetings, as dictated by the Covid 19 epidemic, now creates the opportunity for the Botswana members to dial into the Local Section meetings. Initiatives to achieve this are currently under way.

Date of last Annual General Meeting		10 October 2019 (*the most recent AGM relative to the reporting period of September 2019 to August 2020*)
Were annual accounts presented at the AGM?	Yes	The accounts as presented were approved.
Were officers elected / re-elected at the AGM?	Yes	
Have minutes of the last AGM been produced?	Yes	
How many IRSE members are in the Section?	57	Member numbers as per our local records. Comparison with the Head Office records is still to be done by the Secretary.
Is your page on the website up to date with contact details, etc? https://www.irse.org/Get-Involved/Near-You	No	Still to be done – set as a priority.

2. **Section Officers** (at time of writing report)

Chair	Nikesh Hargoon
Secretary	Ryan Gould
Treasurer	Johan van de Pol
Country Vice-President	Louis Beukes
Communications / website (if appointed)	Selection still to be finalised – shared role currently.

3. Main Activities During the Past 12 Months

On 19 September 2019, at the 8th Technical Meeting of 2019, Nkululeko Gobhozi from Transnet delivered a presentation titled *Artificial Intelligence and Machine Learning in context for Railway Engineer*s. He postulated that the Fourth Industrial Revolution (4IR) is characterised by an emergence of various technologies that have become accessible to industry. The actual value however that can be realised in the short term is dependent on the maturity of the environment within which it is explored. His paper sought to demystify one of the technology areas that are in the forefront of the 4IR, namely Artificial Intelligence, and more particular, Machine Learning for advanced analytics.

On 22 October 2019, at the IRSE 2019 Annual General Meeting (AGM)and 9th IRSE 2019 Technical Meeting, the AGM focused on the report of the Chairperson and the report of the Treasurer for the 2018-2019 session, the election of members to the General Committee for the 2019-2020 session and any other matters relating to the IRSE AGM.
The Technical Presentation title *Electronic Interlocking Development and Application – the Actom Approach* was delivered by Leon Pienaar from Actom. The presentation focused on a comparison between existing versions of relay interlocking and electronic interlocking as well as the advantages and disadvantages of each type. He also addressed the reasons why IVPI was chosen by Actom as the basis for the interlocking development, the different configurations that can be used with the IVPI, the improvements and additions developed locally to enhance the IVPI application and the performance of the system over the last four years.

On 26 October 2019, relating to the presentation of 22 October 2019, the IRSE Local section arranged a Technical Visits to the Actom IVPI installation that they had installed approximately 4 years back. The focus was on viewing and learning more about the electronic interlocking, the diagnostics and the interfaces to the adjacent stations.

On 14 November 2019, at the 10th Technical Meeting of 2019, a Technical Presentation was delivered by Kameshini Pathar (Kamy) of Transnet. The presentation related to a subject pertaining to signalling/train control systems within Transnet. A constraint was placed on further distribution of the detail.

On 20 Feburary2020, at the 1st Technical Meeting for 2020, the presentation took the form of a brief feedback for each of the two technical visits that took place towards the end of 2019 (one in Johannesburg and one in Cape Town), followed by a discussion. The intention was to expose a wider group of the membership to the feedback and discussion re the two 2019 Technical Visits (as referred to above and the other in Cape Town (not reported on)). It was hoped that doing this would whet the appetite of more members and guests for future technical visits.

For March, April, May 2020, in the advent of Covid 19, it was initially decided to suspend both the committee and technical meetings. We then discovered the world of virtual meetings.

On 18 June 2020, the IRSE local section held its 1st virtual meeting and 2nd Technical Meeting in 2020. The topic was presented jointly by Berend Ostendorf and Johan Todkill and was titled *Testing of Electronic Interlocking*. The testing of an electronic interlocking is significantly different to that of an electro-mechanical interlocking, although they both largely perform the same function. It also requires different test methods. The presentation outlined the methodology used to test electronic interlockings. It addressed two examples of electronic interlocking used for the new PRASA systems in Gauteng and Western Cape respectively.

On 16 July 2020, the 2nd virtual and 3rd Technical Meeting was held. The topic pertained to the PRASA ETCS Pilot installation and was presented by Athanacious Makgamatha from PRASA. PRASA has embarked on a modernisation programme comprising a re-signalling system, train communications systems and new rolling to improve asset life cycle, safety and capacity for commuter rail services. The Pilot is setup to test and commission all systems and subsystems within Signalling, Rail Bound Telecommunications and Trains. The Pilot involves validation of trackside equipment and on-board in-CAB signalling based on the European Railway Train Management System (ERTMS)/ETCS System. The technical presentation was followed by a discussion session.

On 20 August 2020, the 3rd virtual and 4th Technical Meeting, the current IRSE President, Daniel Woodland delivered to us his Inaugural Presidential Address, *Update slightly based on how things had emerged subsequently*. The South Africa Section again expresses its thanks to Daniel for a very interesting and relevant presentation. The Section did not foresee such a successful event happening at the start of the Covid 19 challenges.

4. Plans for the Next 12 Months

The current focus areas for the Southern Africa Section for the balance off 2020 and for 2021 are captured below. These will however be reviewed and refined at and after the AGM in October or November 2020 and when the newly elected committee for 2020-21 is in place. Accordingly, these focus areas/plans may change later.

- To inform of and promote to the South Africa IRSE members the processes required to fully and successfully implement and benefit from achieving ECSA recognition as a Voluntary Association.
- To promote this as a tool to persuade non IRSE members in the industry to become members and thereby be able claim ECSA CPD points for IRSE events attended.
- Strive to further identify possible approaches and enhance ongoing efforts to encourage our guests and others in the train control systems arena to become IRSE members.
- To strive to provide the best possible programme for the 2020-21 session.
- As an ongoing effort, finding more innovative ways to approach the captains of the railway and signalling industry in South Africa to promote the IRSE and to provide a better understanding of how the IRSE can contribute to the success of the industry. Conversely, to also promote the concept that the industry can in turn support and assist the IRSE. There is still meaningful room for improvement in this regard.

IRSE Switzerland Local Section Report: 2019 - 2020

Report produced by: Daniel Pixley, Chairman
Date: 13 January 2020

1. Introduction

This report covers the complete business year 2019 of the Swiss section.

Date of last Annual General Meeting	8-March-2019
Were annual accounts presented at the AGM?	Yes
Were officers elected / re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the Section?	67

2. Section Officers (at time of writing report)

Chairman	Daniel Pixley
Secretary	Henrik Roslund
Treasurer	Rolf Seiffert
Country Vice-President (if appointed)	Rolf Seiffert
Webmaster (for updating IRSE website Local Section page)	Beatrice Müller and Henrik Roslund

3. Main Activities During the Past 12 Months

Events

During the calendar year 2019, the section organised the usual 4 events: 3 technical visits and 1 paper session. In addition to that, three get-togethers were organised.
Overview:

Date	Topic	Type
1 February 2019		Get-together
8 March 2019	Harbour Railway, Kleinhünigen, Basel	Technical Visit
8 March 2019	AGM in Kleinhünigen, Basel	AGM
13 May 2019		Get-together
21 June 2019	Managing Multilateral Traffic in Different Sectors	Paper Session
6 September 2019	Tunnel Cinema Weissenstein and City of Solothurn	Technical Visit
22 October 2019		Get-together
15 November 2019	Chemin de fer du Kaeserberg, Swiss model railway	Technical Visit

All events were well attended, generally by close to half of the section members. Reports of the events have been submitted to the IRSE News. The selection of interdisciplinary subjects demonstrates once again one important element of the strategy of the section.

As a trial the Section organised three get-togethers this year which were each attended by about a dozen members. Based on this success, it will be suggested to the AGM that this is continued this.

For organising the events and get-togethers the Section has continued to utilise the online scheduling service of doodle.com, so that all participants could sign up and see who else was joining. Although for most events not mandatory, this was well utilised. It has proven to be a very lightweight but powerful way to organise events.

AGM

On 8 March 2019 the 8th regular AGM was held together with a technical visit. The annual accounts 2018 and the budget 2019 were approved.

Dr. Marco Lüthi, the secretary of the section, was elected as CEO of the Sihltal Zürich Uetliberg Railway and therefore resigned from the committee of the Swiss local section. As his successor Henrik Roslund was elected as new member of the committee.

All other members of the committee were re-elected.

Participation at the international level

The Swiss section remains involved also at the international level:

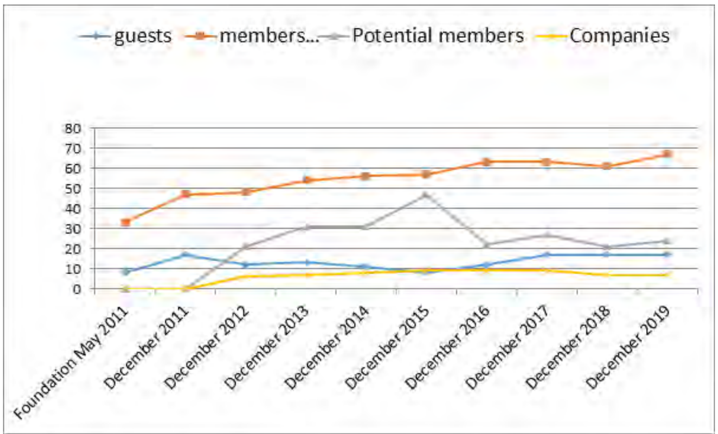
- With Dr Markus Montigel as the past IRSE president and Xiaolu Rao as council member the Swiss section is well represented in the governing body of IRSE.
- Two active members of the Swiss section, Beat Keller from Siemens Mobility and Jens Andreas Schulz from the Swiss Federal Railway SBB, are members of the International Technical Committee (ITC).
- One member visited last year's IRSE Aspect.
- The section chairman joined the IRSE AGM in London.
- Companies becoming increasingly restrictive on travel has been compensated by the well-received possibility to join many IRSE sessions by video link.

Committee

The committee met four times during the year and treated strategic subjects, the organisation of the events, membership and other matters. This year's priority was to develop a communication strategy for the local section.

Development of membership

The Section was able to increase the number of members by 10 % to 67 members.
There are a number of guests that have been actively participating in the section events, so it is hoped that they will join as member this year. Also, the smartrail 4.0 programme of the Swiss railways is creating additional opportunities and interest for an IRSE membership. The potential to grow to 100 members remains, given the number of guests and prospective members. The largest obstacle remains filling in the application form in English correctly and completely.
The Section has therefore assigned a member of the committee with the specific experience to motivate and coach prospective members individually when filling in the application form. This has proven valuable and necessary.



4. Plans for the Next 12 Months

For 2020 the committee has set the following priorities for the Swiss section:

- Organise the usual 4 yearly events:
  Q1: technical visit and AGM
  Q2: paper session
  Q3: technical visit
  Q4: technical visit
  The events will be published on the irse.org web site as the dates are defined and we very much welcome international participation.
- Hosting an additional paper session in Q4 as part of the presidential program.
- After the success with the get-togethers the Section plans to continue with them in 2020.
- It remains the Section's goal to grow the number of members and develop membership.
- Finalise and begin to implement the communication strategy for the local section. The Section plans to improve the communication between members of the Swiss section by taking advantage of state-of-the-art social media tools.

IRSE Thailand Local Section Report: 2019 - 2020

Report produced by:	Mr.Vasuwee Euanchita/Dr.Wichai Siwakosit
Date:	22 September 2020

1. Introduction

IRSE Thailand section was opened in the inaugural meeting on 27 July 2016. Currently there are 3 fellows, 9 members, 7 associate members, and 4 affiliate members in the section with 8 committee members.

Due to the global pandemic situation, the activities for 2020 had been greatly affected since March 2020 according to Thai government restrictions. Thailand is still not opening its borders and international travel restrictions are enforced. Mass gatherings and conferences are generally adapted to social distancing norm and the emergency law is still in effect.

Asia Pacific Rail 2020, an international event planned in Bangkok with IRSE TS involvement was postponed twice and finally cancelled. However, the annual general meeting for IRSE TS was held on 29 January 2020 just before the pandemic and it was the only event held by the section this year. An on-line technical meeting is planned in early November this year and IRSE TS will present at Rail Asia 2020 event on 27 November 2020.

The section is hopeful that the situation will be improved due to the availability of mass vaccination, and next years' activities are planned accordingly.

Date of last Annual General Meeting	January 29, 2020
Were annual accounts presented at the AGM?	Yes
Were officers elected / re-elected at the AGM?	No
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the Section?	23
Is your page on the website up-to-date with contact details, etc?	No. The contact email needs to be changed

2. Section Officers (at time of writing report)

Chair	Associate Professor Wichai Siwakosit, Ph.D.
Secretary	Mr.Vasuwee Euanchita
Treasurer	Mr.Vasuwee Euanchita
Country Vice-President (if appointed)	Mr. Paul Harland
Communications / website (if appointed)	Mr.Vasuwee Euanchita

3. Main Activities During Past 12 Months

Due to the global pandemic situation, IRSE Thailand Section achieved only an AGM held on 29 January 2020 at Bombardier Transportation Thailand head office. There were 33 participants in the event. Presentation topics were CBTC technologies applied to MRTA monorail lines in Bangkok, WiFi 6 protocol with applications to signalling and telecommunications, and roles of safety assessment in railway projects.

Figure 1 AGM 2020 event held on 29 January 2020 at Bombardier Head Office in Bangkok

Figure 2 Presentations at AGM 2020 for IRSE TS:

4. Plans for the Next 12 Months

The section expects that the pandemic situation in Thailand will be markedly improved without a substantial recurrence wave of infection, hence the plan will be as follows:

Tentative Date	**Activities**	**Target Group**
2nd week of November 2020	IRSE TS Technical Meeting	IRSE members and interested audiences
25 November 2020	Rail Asia 2020 Conference and Exhibition at SRTET Makkasan Station	General audiences
1st week of March 2021	Annual General Meeting 2021	IRSE members and interested audiences in Thai Railway industry
3rd week of May 2021	Asia Rail Summit Presentation by IRSE TS	Conference audiences
3rd week of July 2021	IRSE TS Technical Meeting	IRSE members and interested audiences in Thai Railway industry
2nd week of September 2021	IRSE TS Committee Meeting	IRSE TS Committees

Reports from Local Sections in the UK 2019-20

The following reports have been received from the IRSE's UK Sections to report their activities over the Presidential Year 2019-20. They have been edited for consistency and to provide a permanent record for the 2019-20 Proceedings.

London & South East Section
Midlands & North-Western Section
Minor Railways Section (submitted in non-UK Section format)
Plymouth Section
Scottish Section
Western Section
York Section
Younger Members' Section

IRSE London South East Section Report: 2019 – 2020

Report produced by:	Mick Ward
Date:	29 May 2020

1. Introduction

As you will read about below, with have had an interesting second year. Some of our speakers had to withdraw at the last moment, which lead to some last-minute substitutions from the committee members. Unfortunately, our family day was significantly less supported than we had planned and so ran out a substantial loss.

With the COVID-19 outbreak we have moved to using GoToMeeting for our technical papers. This is a situation which we envisage will continue to at least end of the year.

I wish to thank HQ for their continued support and helping us make the transition to GoToMeeting as smooth as possible.

Trevor Foulkes, Chairman L&SE Section

Date of last Annual General Meeting	21 May 2020
Were annual accounts presented at the AGM?	Yes, from the formation of the LSE section until the AGM on the 21 May 2020. These were audited by Keith Walter and no objections were received from the members at the AGM.
Were officers elected / re-elected at the AGM?	Yes, all current members returned with no proposals from the membership for new members.
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the Section?	700+

2. **Section Officers** (at time of writing report)

Chairman	Trevor Foulkes
Secretary	Mick Ward
Treasurer	Adrian Vyse
Country Vice-President (if appointed)	Jerry Morling
Webmaster	All updates now done by HQ

3. Main Activities During the Past 12 Months

These are the events from our first AGM and cover from May 2019 to May 2020 as reported at the AGM. In the majority of cases, we have submitted a report to the IRSE News of our activities.

21 May 2019 Short papers given at the AGM

The 43 attendees at the AGM listened to 3 short papers from members – Richard Stokes on the driver's point of ETCS cab displays, Judith Ward and Polly Whyte on the IRSE HQ organisation, licencing and CPD, and a final talk from Blane Judd getting information from other institutions.

Richard chatted about the origins of the ETCS Standards and how the CENELEC Standards were initially developed and how they changed since the installation of ETCS in Germany and France and the Cambrian lines in the UK. Richard went on the chat about the driving display icons that the driver sees and how these needed to be standardised across the manufacturers in order to keep displays consistent. Richard explained that some trains had up to 9 different types of train control equipment which is confusing for the driver.

Judith and Polly described the organisation and roles within head office. Judith then gave us an overview of the licencing scheme and how this was being aligned to registration. Polly followed this with a description of the levels of membership and how members can gain Engineering Council registration through the IRSE. Judith then delivered a talk on professional development and how events can contribute to CPD. Finally, Judith gave an overview of how the professional examination is to change in the near future.

Blane described how he thought an Engineer, although he/she might be a member of the IRSE, should be able to get information from any Institution. Signalling today is not an isolated skill but needs to integrate with many other disciplines to deliver projects. This developed into a general discussion on system engineering within the meeting.

25 June 2019 HackPartners

Our members were invited by HackPartners to talk to us about innovation in the rail industry. River Tamoor-Baig, HackPartners' co-founder, told us about how, a delay in his train journey as an IT consultant led him to create a business aimed at bringing innovation to our industry.

HackPartners told us about their three core activities: Hackathons, Consulting and Product development. HackTrain is the hackathon that they run to try and solve industry problems in 48 hours over a weekend of madness and fun. In 48 hours, teams of hackers come up with prototypes that can solve real industry issues.

Another example River told us about was how they developed an image processing solution that helped Network Rail to save millions in brick crack identification. And HackPartners most used solution is busybot, which helped 9.5 million passengers to find a place to seat on trains. Members were energised by HackPartners leading to many discussions after the presentation.

25 July 2019 Acoustic Monitors - Trackside Monitoring systems

The London and South East Section invited Nicholas Kay, operation director of Track IQ Wabtec to present on a subject a little outside normal signalling matters, trackside acoustic monitoring systems for train axle journal bearings.

Many railway engineers and operators are familiar with the Hot Axle Box Detector, This system relies on the detection of heat, which means something is going wrong and so is a reactive response to a developing failure and action is needed quickly.

The HABD technology does not lend itself to third rail systems and requires significant equipment both within the track structure and lineside. We heard that the commercial demands of the heavy-haul railway that have developed in both Australia and America with long trains of roller bearing fitted wagons with only a 'head end' operator drove the demand to develop a monitoring system that was far more predictive.

From this a product emerged in the form of the Rail Bearing Acoustic Monitoring (RailBAM) now Track IQ and part of Wabtec.

The principle is simple and uses a microphone array which 'listens' to each bearing as it passes. With RFID (radio frequency identification) readers identifying the rolling stock and rail mounted sensors detecting the position of each wheel, each vehicle and axle bearing can be identified accurately and repeatably.

26 September 2019 NetworkRail FTN and GSM-R Implementation

Unfortunately, the planned presentation to the London & South-East Section on HS2 could not go ahead so instead Trevor gave a presentation to 20 members on how the FTN / GSM-R programme came about.

Trevor explained that when he joined the project, the national provision of Global System for Mobile Communications – Railway (GSM-R) for Great Britain had been authorised but there was no approach agreed on how to connect the component parts of the GSM-R system together.

Trevor explained how the feasibility study showed that the best option was to build Railtrack's own network the Fixed Telecom Network (FTN).

Trevor then went on to explain the different layers of the FTN network from SDH STM-16 at the top for national circuits to copper cables at the bottom for local phones, etc. Trevor finished the talk saying how proud he was to be given the opportunity to be part of the programme which has made a real difference to the Railway.

28 September 2019 Great Cockrow Family Day

50 people made up of members and their families enjoyed a day on the Great Cockrow Railway. People enjoyed unlimited train rides and had the opportunity to watch the operation of the railway in signal boxes and some were able to experience pulling levers. It was a nice day weather wise and the BBQ went down well.

Unfortunately, we had planned to breakeven on 100 members and guests attending. The lower-than-expected numbers lead us to subsidise this event from the section's funds.

24 October 2019 The wheel rail interface

Regrettably the planned speaker for the evening was unable to attend and so one of the section's Committee members agreed to stand in with a personal talk on his career and the unintended course it took.

Paul Baker joined the Signal Engineers section of London Underground in September 1973. He reflected on how he got there, with an interest in trolleybuses he originally intended to join LT's bus division, which resulted in meeting an LU signal engineer, attending a "run through" at Epping at which a pep talk from a Chief Inspector resulted in ending up on a 4-year sponsored "thin" sandwich course and the rest, as they say, was history.

Paul eventually moved into operational line-based engineering management becoming involved with the performance impact of the “wheel-rail interface”. This developed into a topic of great interest and the subject of a Rail Systems Master’s Degree based on the extensive research he was doing, and the worldwide contacts made. Direct involvement in the Hatfield crash, a section of railway he was responsible for managing until a few weeks prior, brought the subject of the wheel rail interface into sharp focus and became the basis of much of his work for the following 20 years.

The wheel is supported by the rail on a contact patch of the size of around a 10 pence coin. This carries the weight and absorbs the forces for support and steering of the wheel and, rather than being a “solid” area, does have a very small degree of deflection and elasticity. The forces, and resultant damage that arise, if unmanaged, can lead to such features as degradation of the wheel and rail profile, damage to both surfaces, rail vehicle damage due to corrugation and broken rails to name a few and all potentially resulting in severe service availability, and worst case, loss of life and business.
Prior to Hatfield there had been specialised “pockets” of research around the world based primarily on commercial railroad operations and supported by a handful of research centres and eminent scientists. With the focus that came with Hatfield it brought a wider recognition of the issues and acceleration in research into the problem that included organisations from Canada, America and other overseas resources. Work demonstrated that the damage mechanisms can be measured, modelled and explained and through this controlled by rail material development, friction management, better detection, active intervention and developing understanding in staff of the tools available to them. Many are being applied today.

The presentation is available on the LSE page of the IRSE website.

28 November 2019 Brighton Mainline Resignalling

85 people listened to Paul Percival and Anil Rana talk about the challenges of Resignalling the Brighton main line which carries around 300,000 people every weekday. We heard of the many different types of existing equipment which had been installed over many changes over the years.

The challenges faced included Victoria RR relock with SSI to interfacing with existing track side equipment then Gatwick station redevelopment followed by Victoria Resignalling and recontrol to three bridges.

We finally heard of the many changes to improve the line for the Thameslink network and make the infrastructure more resilient.

The full set of slides can be found on the IRSE website.

10 December 2019 Joint meeting with Midland and North West section
Beyond a 20/20 Vision by Blane Judd

December's meeting was a joint gathering with the Midlands & North Western section in Milton Keynes. Blane Judd, IRSE CEO, joined us to layout the latest vision for the IRSE and discuss with us how our local sections can assist the institution achieve the vision of developing safe and sustainable global railways.

Blane described how the key pillars of the vision Engage, Grow, Network, Develop and Assure link into local section's work, for example through "preventative maintenance" of speaking up about issues early and "acceptance testing" of checking reactions to new concepts.

23 January 2020 Timetabling by Kris Alexander, Network Rail's Programme & Support Services Director

The first meeting on the new year was held at TfL's offices in Stratford where Kris Alexander gave a talk on delivering better timetables. He started by explaining how the process was defined by the "Network Code" which was set up when British Rail was split up. It defines the regular cycle of requests for timetables and how these are combined to produce the timetable, normal 13 weeks ahead. Kris explained that the process was incredible manual with TOCs using a variety of ways to submit information, the information on the track layouts being a separate document as are details of planned engineering activities. Thus, the timetablers are pulling the information together on their screens to produce a timetable. He explained that there was very little opportunity to model the timetables as the time to load the data was almost as long as they had to generate the timetable. Kris then went on to explain how he wants to modify the computerize the process. Kris also offered members a visit to Milton Keynes to see the work going on.

11 February 2020 Joint meeting with TfL's Technical Society
Open Train Times by Peter Hicks

This meeting was undertaken jointly with TfL's Technical Society and was a presentation by Peter Hicks on how he has set up the web site Open Train Times. Peter explained how he has always been interested in trains and timetabling so that when Network rail said it was making train position information available to the public he thought he had to ask. He was stunned to be given access. Peter explained how he had to develop each of his map by hand from available information. He also explained how the data was different for different areas due to the data provided by the information feed from the signal box. Peter also explained that running the web site was not his main job but that it had opened the doors to many opportunities where an understanding of the data is required e.g., in Digital Railway work.

26 March 2020 Crossrail Signalling

This meeting had to be cancelled because of the COVID-19 lockdown. It will be presented instead following the AGM in May.

30 April 2020 Minimising Safety Risk. What is Grossly Disproportionate? by David Crawley

This meeting was delivered by webinar using GoToMeeting. The presentation was recorded by David Crawley and presented to 103 people who had joined the webinar online. This was followed by questions raised by the audience using chat and answered by David live after the presentation. It was a first for LSE and seemed to be successful.

The talk itself considered six examples where the safety of the public was put at risk that required mitigations put in place to minimise that risk to below a reasonable level. David discussed the costs and processes that needed to be put in place for each example from being proportional to the risk through to being potentially grossly disproportionate to the risk.

The talk was thought provoking and judging by the questions a very welcome subject. The presentation and questions has been made available on the IRSE Vimeo site.

4. Plans for the Next 12 Months

Below are our current plans from the AGM in May.

25 June 2020	Docklands Light Railway with Geoff Mitchell
23 July 2020	Industry 4.0 - Delivering digital transformation for a transport revolution for the next decade by Mike Hewitt
27 August 2020	No Meeting
24 September 2020	Compass with Chris Fulford
22 October 2020	Certification of interoperable systems by Pradip Roy
26 November 2020	How it works ETCS with Aiden McGrady
Dec 2020	No Meeting
28 January 2021	London managed stations information systems improvements by Steve Peckham
25 February 2021	4G mobile coverage on the Jubilee line
25 March 2021	Safer and smarter isolations of dc lines by Neil Clegg
29 April 2021	Croydon Area Redevelopment
27 May 2021	AGM & Westrace Trackside System by Daniel Hill

IRSE Midland and North Western Section Report: 2019 – 2020

Report produced by:	Paul Darlington
Date:	April 2020

1. Introduction

The Midland & North Western Section holds regular meetings in various locations in the Midlands and North West parts of the UK between September and April, along with technical visits and a steam lunch on a heritage railway during the summer. In February 2020 the Section celebrated its 50th anniversary.

Date of last Annual General Meeting	10 April 2019
Were annual accounts presented at the AGM?	Yes
Were officers elected / re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the Section?	783

2. Section Officers (at time of writing report)

Chair	Paul Darlington
Secretary	Bill Redfern
Treasurer	Clive Williams
Webmaster (for updating IRSE website Local Section page)	Ian Fury

3. Main Activities During the Past 12 Months

The M&NW Section covers a large geographical area and has always visited different locations throughout the year. This year was no different with meetings and visits organised in Preston, Manchester, Derby, Crewe, Southport, Milton Keynes and Liverpool with an average attendance of 30 members. Since the last AGM in 2019 the Section held its annual technical visit and steam lunch at the Churnet Valley Railway on 29 June 2019. Lunch was served on a steam hauled train along with visits to three signal boxes. The excellent sunny warm day out was enjoyed by 40 members and guests and the Section were very grateful for the generosity of the sponsor for the day, Haywood & Jackson Fabrications Ltd together with the hospitality of the guides from the railway.

The season's technical talks made an excellent start on 25 September 2019 in Preston when Claire Beranek, route asset manager signalling for Network Rail in Manchester explained the Network Rail digital rail long-term deployment plan. In common with many other railways Network Rail is faced with maintaining a large and complex network while introducing ETCS to improve operational performance and asset condition. Claire explained the background to this challenge and the current approach in relation to the immense amount of work involved within the constraints of the industry. The talk was well received by 32 members and quests who left with a good understanding of the challenges ahead, an appreciation of the timescales for ETCS in the UK and the requirement to keep existing signalling systems operational until ETCS deployment is achieved, both nationally and within the M&NW region.

The Manchester 17 October meeting on the Trans Pennine upgrade project got off to a rousing start with a promotional video entitled "The North shall rise again", publicising investment in new trains and infrastructure across the north of England. James Hodge and Gregor Dowdy explained the project they are working on to modernise the infrastructure of the main route between Manchester and Leeds via Stalybridge and Huddersfield. A large number of potential interventions were explained, with the final solution comprising remodelling of the junctions at the west end of Stalybridge, remodelling and new platforms at Huddersfield, and an additional pair of tracks between Huddersfield and Ravensthorpe. An interesting point made by the speakers was that the biggest improvements in journey time comes from focusing on low speed areas – the time saving for improving a 500m stretch from 25-30mph is the same as improving 8km from 105-110mph. The meeting was exceptionally well attended with 46 members and visitors. The Section was very grateful for Network Rail for providing the room and the Transpire Alliance (Amey, Arup, BAM Nuttall and Network Rail) for the speakers.

The November 18 meeting took place in Derby, with a talk about a radio based in cab signalling system that had been in operation for many years. Radio Electronic Token Block (RETB) was introduced in the 1980s for signalling single lines using SSI and VHF base stations and on-board radio equipment on four schemes in the UK. Two of these schemes have subsequently seen the RETB replaced. The Cambrian Line system in Wales was replaced with the ETCS in 2011 and the East Suffolk Line system was replaced with conventional multiple aspect signalling in 2012. In Scotland RETB has been retained and enhanced as the method of working on the West Highland Line and the Far North Line. The re-engineering of these systems to produce what has been named RETB Next Generation (NG) was the subject of the talk by Lee Clinton, senior operations manager, Telent. Lee enthusiastically explained the re-engineering and potential enhancements that may be implemented. These include: reducing the time taken for token exchange from 9 seconds to 2.8 seconds, facilities to notify passenger request stops from stations, automated train describer, token operated points, semi-automatic signaller cautions to trains, resilient positioning to support automated loop clear notification, automated operation at the fringes between interlockings, collapsing ‘super’ long token Sections, and enhancements for train service intensification with additional passing loops. The work has been recognised in a number of industry awards including two Rail Staff awards, two IOSH awards and the M&NWS chairperson’s award last year. The meeting was attended by 28 members and guests.

10 December saw the Section meeting at the Network Rail HQ in Milton Keynes with a joint meeting with London South East Section with 23 members attending to hear Blane Judd talk about the “IRSE Beyond 2020 Vision”. Blane explained the development and implementation of the IRSE strategy for the future after 2020. The meeting was attended by the Network Rail professional heads for both signalling and telecoms, and while the numbers attending from two Sections were low, this was attributed to the location being too far north for LSE members and too far south the M&NW members. For example, one committee member from Manchester could not attend as it would have cost him over £100 and required several hours of travelling. This reinforces the Section policy to hold meetings and talks in different locations to ensure as many members as possible have the opportunity to attend events.

The 10 January meeting was slightly different to a normal presentation as it focused on the civil engineering requirements for signalling and telecoms structures. Paul Mansell, general manager of Haywood & Jackson gave an interesting talk to 17 members and guests about his personal experiences from the past 25 years delivering complex signalling structures and the foundations they require, and the everyday challenges faced in planning large and small installations. Paul explained the helical pile technique and the part he played in the development of the strategies for the choice of foundation type, delivery and erection of such structures. He also covered how life extension requirements for signalling structures are driving further innovation in maintaining structure foundations until the introduction of ETCS.

In conjunction with the Minor Railways Section a technical visit was organised on 22 January for 20 members of the M&NW and MRS to enjoy an interesting and informative technical visit to Unipart Dorman in Southport. Unipart Dorman are a supplier of LED signals to the UK, Middle East, Australasia and North America markets. During the visit we learned of the history and development of LED signals together with presentations from other Unipart Rail companies.

On Friday 31 January the current and next year's M&NW Section chair's, along with UK and Ireland Sections (but excluding York and Plymouth Sections) met with Blane Judd, Judith Ward and Polly Whyte for an IRSE Sections networking event at the National College for Advanced Transport & Infrastructure in Birmingham. The objective of the day was to explore synergies and to discuss the challenges of running a Section, and to share best practice in organising and running events/technical visits. Other topics discussed during the day were maximising collaboration opportunities, developing recruitment strategies, improving the engagement of Section members and how to implement Section committee succession planning. In the discussions social events and networking dinners were identified as positive initiatives, and that events and visits involving local projects were always well attended.

The Section held its very first event on 4 February 1970 in Crewe. To mark and celebrate the occasion the Section held an anniversary dinner in Crewe exactly 50 years to the day. All members of the Section past and present were invited, with the menu a classic 1970s selection of prawn cocktail, chicken dinner and Black Forest Gateau. Unlike in 1970, a vegetarian alternative was also available. The Section committee were delighted to welcome past committee members, speakers, a number of past and future presidents and former chief executive Colin Porter to the dinner. Among the guests were past president Peter Stanley who was one of the very first committee members in 1970. Current chair Paul Darlington and past chair Peter Halliwell summarised the last 50 years, highlighting key moments and mentioning a number of members who had filled a number of roles on more than one occasion over the years, including secretary, treasurer and committee chair. It was reflected that the Section had delivered in the order of 400 events, both technical and social over the years to inform, debate and develop members of the institution. Ties and badges were produced to celebrate the anniversary and are available by emailing acw-57@ntlworld,com at a cost of £15 plus postage.

On 19 February a presentation of the Manchester Thales Tram Management System (TMS) was delivered by Stephen Corlett of Thales at the Arup offices in Manchester. 30 members and guests attended to hear the history and development of the Manchester Metro, the design and implementation of the TMS system, and the expansion of the Metro - which is now the largest in the UK. One unique feature of the Manchester system is that the trams operate on a number of ex heavy rail lines which means the trams doors are at a 'high level' and have to use raised platforms, including the newer city centre station platforms. We learned of the principles of tram signalling and that the design of any system is heavily influenced by road signage principles and the highway code. The TMS also controls customer information and SCADA systems. Stephen explained that each metro signalling system is different so that it is not easy to transfer trams between systems. The Section was most grateful to Thales for the presentation and Arups for the room and buffet refreshments. Arups also produced a video of the talk synchronised to the slide presentation, unfortunately we were unable to obtain permission from Thales to host it on the IRSE website.

The final two talks planned for the 2019 / 2020 programme were a talk in March on the Merseyrail new Class 777 fleet to replace the Class 507/508 fleet and the oldest operating on the main line (excluding Isle of Wight), and the April AGM and a talk by Tony O'Brien of his career as a signal engineer and infrastructure manager. Following the outbreak of the COVID-19 infection the Section took a quick decision on the 10 March to defer these to the 2020/2021. This turned out to be the right decision as the UK commenced its 'lockdown' with no essential travel from 23 March.

4. Plans for the Next 12 Months

In addition to the deferred 19/20 AGM and Merseyrail Class 777 talks we have the following plans, but all subject to change and confirmation.

September / October East Lancashire Railway steam lunch on a Sunday
16 September 2020 Preston – On-board 5G connectivity McLaren Applied Technologies.
13 October 2020 Manchester joint with IMechE. – Obsolescence Stuart Broadbent, Alstom.
18 November 2020 Derby Signet – LX risk assessment. AEGIS.
9 December 2020 Liverpool – Liverpool Central station redevelopment speaker TBC.
13 January 2021 Crewe – HS2 / main line interface Claire Hulstone? TBC.
10 February 2021 Derby – ETCS speaker TBC.
17 March 2021 Birmingham High Speed College – Better Timetables, Kris Alexander.
21 April 2021 Manchester – AGM and Christian Whyte my life on the railway.

IRSE Minor Railways Section Report: 2019 – 2020

Report produced by: Dominic Beglin
Date:

Whilst 2020 has prevented the Institutes Minor Railways Section from visiting our colleagues, their signalling and telecommunications and operational railway infrastructure, the section has not been sat still.

During August, the section had its 2020 AGM, whilst the physical ability to meet had been curtailed via the pandemic, the opportunity was undertaken to facilitate this via the medium of the internet and so the section sent out invites to interested attendees of the section to attend virtually.

The AGM went reasonably well, with some learning curves made from the perspective of digital technology and online meetings, how to access this and holding virtual Meetings with questions and answer sessions.

For our Section's first online AGM this went reasonably well.

Following the AGM, it is usually the Section's time to visit an operational signalling or telecommunications installation and again the section proposed to undertake a virtual visit to the Churnet Valley railway's project at Cheddleton, with Emma Haywood the railways head of signalling undertaking the first portion of the virtual visit giving a brief upon the project itself.

This was then followed up by me giving the second portion of the virtual visit on site with a walk around of the works being undertaken.

From the reports back, this virtual visit appears to have been received well from all the online attendees.

The section has also regularly been undertaking to add to its Facebook pages regular updates on the various members signalling projects, other museums and railways signalling projects of which many railways signalling departments have started regular updates on their respective works for all to see, we have also managed to provide some small how it works videos to the pages bringing regular interest to the section.

As part of this we will try to keep this regularly updated and certainly would like to see more telecommunications-based updates as well as signalling from the minor railways section, as well as bringing the wider world of minor railways Worldwide into the Pages if possible.

Many of the Section's members update these pages and the availability to all the minor railways to be part of this information exchange is desired.

Lastly, I would like to thank Ian Allison, our outgoing chairman, for all his hard work and input over the last few years. Ian is a driving force in many fields, and I hope to follow in his footsteps with as much fervour."

Dominic Beglin
Chair, Minor Railways Section.

IRSE Plymouth Section Report: 2019 – 2020

Report produced by: Dave Came
Date: 26 November 2020

1. Introduction

This report covers the period from after the 2018-2019 Annual General Meeting until the present day.

Normally this report would end with the Annual General Meeting for the period in question (2019-2020 in this case), which would have been held in May 2020. However, as a result of the COVID-19 pandemic all section activities ceased in March 2020. As a result of this, Section officers have remained unchanged from the previous year with the proposal to keep it that way until the end of the 2020-2021 period in order to maintain some continuity.

Included within this period was to have been the celebration of the 50th anniversary of the formation of the section. At the above AGM it had been agreed that the Section should celebrate this occasion, but no detail had been discussed except at a general level.

Further detail is included in the sections below.

Date of last Annual General Meeting	15 May 2019	
Were annual accounts presented at the AGM?	Yes	The bank balance at the date of this AGM was £368.16. The current balance at the date of this report is £783.41. See further detail later in this report.
Were officers elected / re-elected at the AGM?	Yes	
Have minutes of the last AGM been produced?	Yes	
How many IRSE members are in the Section?		At the time of the meeting it was estimated that there were approximately 20 members local to Plymouth. This did not take into account many who reside in Devon and Cornwall but whom do not attend meetings except on rare occasions.
Is your page on the website up-to-date with contact details, etc?	Yes	However, the secretary notes that an update is necessary to include email addresses.

2. Section Officers (at time of writing report)

Chair	Richard Belli
Secretary / Treasurer	Dave Came

3. Main Activities During the Past 12 Months

Proposed programme.

Further to the actions identified at the 2018-2019 AGM, the committee met regularly in order to take the programme forward. The intention was to hold the following:

- Two technical presentations (one or both in cooperation with the IET). Unfortunately, one of the presenters had to withdraw his offer quite late on due to other commitments, resulting in there being only one technical presentation.
- Technical visit
- Social event
- 50th Anniversary celebration event
- Annual General Meeting

The resulting events were as follows:

Technical Presentation.

In recent years it has been found beneficial to hold joint meetings with the IET (Plymouth branch of the South West area). Both the local IET and IRSE organisations suffered from low attendances at their individual meetings but this solution has proved to be successful. The IET provides lecture facilities and refreshments and the IRSE arranges the speaker plus associated expenses, if any.

On 16 October 2019 Ian Allison presented his paper entitled "Innovations in the Era of Industry 4.0". The lecture took place in the Babbage Building of Plymouth University, where an audience of 38 engineers and students attended. Unfortunately, as a result of work commitments, only 6 IRSE members were present. Plymouth IRSE Chairman Richard Belli shared chair duties with the IET representative.

Industry 4.0 is the term applied to what is considered to be the fourth industrial revolution, and Ian described various developments that fit into this category, especially those relating to railway matters.

Technical Visit.

On Saturday 16 November 2019 members enjoyed a rail excursion with pub lunch experience. Gathering at Plymouth station participants boarded the 10.54 to Gunnislake, travelling via local stations within Plymouth plus Bere Ferrers, Bere Alston and Calstock. It is a picturesque journey, especially the Calstock viaduct which spans the River Tamar and takes travellers from Devon into Cornwall.

Along the way, as well as seeing how the line is operated, the procedure for traversing gateless road crossings etc. there are locations displaying signalling hardware from days gone by.

Lunch was taken at the White Hart CAMRA award winning pub at Chilsworthy. (Recently featured on the Tom Kerridge TV programme about saving the British pub).

There was excitement on the return journey when the train was brought to a halt by cows on the line near Bere Ferrers. The train was delayed while the driver plus local farm workers dealt with the cattle.

Social Event

The annual Beer and Curry night was held on Friday 21 February 2020, with members assembling in the well-known Plymouth Barbican pub the Dolphin.

The group of approximately 16 then proceeded to the Himalayan Spice restaurant for an excellent convivial meal.

50th Anniversary Celebration Dinner

Following several committee meetings, it was agreed that the preferred way to celebrate the 50th anniversary of the section would be to hold a formal dinner. After much deliberation taking into account expected numbers, availability of guests, size of venue plus menu choice etc., it was confirmed that the event would take place on Friday 20 March 2020 in the Green Room of the Boringdon Park Golf Club, Plympton. Guest of Honour was to be IRSE Vice President Daniel Woodland.

Unfortunately, the corona virus intervened causing the section to postpone the event. Every effort was made to carry through with the dinner but it got to the stage where two key members of the planning were forced to withdraw, and many other members were willing to go ahead but felt uncomfortable, thus the event was postponed. With hindsight it turned out to be very much the correct and wise decision.

The venue was very understanding and following two further attempts at postponements, with it being obvious the virus was here to stay, it is left that the section will contact the golf club as and when we plan to go ahead.

4. Plans for the Next 12 Months

There have been no meetings of any sort during the various lockdown periods, thus no plans are in place, except that the 50th anniversary celebration will go ahead when possible.

IRSE Plymouth Section Report: 2019 – 2020

Report produced by: Gerry Loughran
Date: 27 January 2020

1. Introduction

This year's session has been on par with last, with lectures that were arranged for 2019 being well attended at the Sloan's function room venue in Glasgow.

The Section's 2019 Dinner was gratefully sponsored by Thales, with 365 guests present. With the surplus accrued from the various dinners, the committee will continue providing funding for training session days for younger members, bursaries to allow members to attend the IRSE Exam study groups organised at Derby, as well as subsidised events such and visits to Bo'ness & Kinneil Railway for the section family day and AGM at West Brewery.

Date of last Annual General Meeting	9 May 2019
Were annual accounts presented at the AGM?	Yes
Were officers elected / re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the Section?	130

2. Section Officers (at time of writing report)

Chairman	Frazer Howie
Secretary	Gerry Loughran
Treasurer	Brian McKendrick
Vice-President (if appointed)	N/A
Webmaster (for updating IRSE website Local Section page)	Gerry Loughran

3. Main Activities During the Past 12 Months

January Lecture – 'Signalling Within S&C' – Stephen Paul – S&C North Alliance

The first lecture of 2019 was given by Stephen Paul, with a strong local attendance. Stephen explained the sources of information required from the sponsor/client prior to work commencing, and the challenges faced when interfacing with other disciplines, and carrying out the works, with most 'simple renewals' turning into minor remodelling works.

Stephen then discussed some successful local works completed, with examples of Polmadie & Rutherglen Renewals (PARR), Larbert North Junction and Blackford Highland Spring Depot. Lessons learned and cost saving methods (plug n play vs conventional) during these projects were a key highlight to round the presentation off.

(Attendance: Members 21, Guests 4)

March Lecture – 'RETB Developments' – Dr Paul Clark – Comms Design Ltd

The telecoms lecture of the session was delivered by Paul Clark of Comms Design.
Paul began with discussing the challenges of network coverage vs geography of usual RETB areas, and then explained how, with Comms Design, 'RETB Next Generation' provides many advantages over previous RETB systems including improved coverage and lower driver workload and adds highly efficient remote management.

He then discussed the development of on-train equipment, fixed radio base stations, portable support equipment, signalling desk interfaces and remote asset monitoring software, and the training and in-field support services that provide a full turnkey signalling solution.

(Attendance: Members 15, Guests 8)

April – Family Day – Bo'ness & Kinneil Railway

The section organised a visit to Bo'ness & Kinneil Railway for the members and their families. Frazer and Neil and were on hand as committee reps, and from feedback from the members following the event, everyone had a great time.

(Attendance: Members 11, Guests 29)

May – AGM – West Brewery

The 2018/19 session ended in May with the AGM. This was held in West Brewery with a tasting tour of the facilities and buffet provided for all attendees.

(Attendance: Members 19, Guests 2)

September Lecture – 'Waterloo Incident' – Paul Tickner – RAIB

The first lecture of the 2019/20 session was delivered by Paul Tickner of the RAIB on the incident at Waterloo in August 2017.

Paul began with discussing the events which led up to the collision between the passenger train and the stationary engineering train, with 1524 points which being positioned incorrectly as a result of uncontrolled wiring added to the signalling system during the commissioning of a project to increase station capacity.

He then explained the RAIB observed that there are certain similarities between the factors that caused the Waterloo accident and those which led to the serious accident at Clapham Junction in 1988.

One lasting statement from Paul was that the RAIB has expressed concern that some of the lessons identified by the public inquiry following the Clapham accident, may be fading from the railway industry's collective memory.

(Attendance: Members 25, Guests 3)

November Lecture – 'Training & Development for Signalling, Control and Communication Engineers – Dr Daniel Woodland – Ricardo / IRSE

Daniel Woodland of Ricardo Rail agreed to present the lecture preceding the dinner. Following a brief background to his career, Daniel discussed the historical approaches to Training and Development for Signalling, Control and Communication Engineers, then considering how the engineering 'environment' has changed since he began his career to today.

These changes, which cover both technology and the role of engineers, impact on how we as engineers need to look at the subject of our own professional development, take a more active role in identifying and pursuing training and development opportunities and consider readiness for the future, not just skills for today.

Daniel also presented the IRSE's 'Route to CPD', using it as a guide to consider the needs and opportunities for professional development in the modern rail industry and the importance of developing a career plan if you want to achieve the most out of your personal development efforts.

(Attendance: Members 39, Guests 23)

4. Plans for the Next 12 Months

It is intended that the 2019-2020 season takes a similar shape to the season just gone, with various presentations already confirmed into 2021.

The Section has also arranged Younger Member events, such as technical visits and tours.

Daniel Woodland, who was kind enough to present for the pre-annual dinner lecture in November, has suggested an IRSE Presidential lecture for this coming programme as part of his tenure in 2020, with various topics being discussed for the presentation.

The date for the section's annual dinner has been brought forward from the usual November slot to Thursday 29 October. This is to avoid a UN climate conference in Glasgow which has resulted the City's hotels being very busy and expensive.

There is a tentative agreement for the section to visit Shields Depot for its technical visit, and will continue to support any section members undertaking the IRSE exams by subsidising travel to the Exam workshop weekend in Derby.

The section will also be preparing for the planned 2022 IRSE Convention in Glasgow.

IRSE Western Report: 2019 – 2020

Report produced by:	Sam Loveless
Date:	31 August 2020

1. Introduction

The 2019-2020 season was a troubled one for the Western Section. Meetings were subject to frequent cancellation and/or last-minute alteration due to problems with external stakeholders. As this happened frequently, and with most committee members occupied with high workloads in their day jobs, meetings ended up being arranged on a meeting-by-meeting basis. Plans for new summer activities were abandoned due to the COVID-19 pandemic.

Date of last Annual General Meeting	2 October 2019	
Were annual accounts presented at the AGM?	Yes	
Were officers elected / re-elected at the AGM?	Yes	
Have minutes of the last AGM been produced?	Yes	
How many IRSE members are in the Section?	375	
Is your page on the website up-to-date with contact details, etc?	No	Secretary's e-mail address/company needs updating.

2. Section Officers

Chair	Simon Cooper
Secretary	Sam Loveless
Treasurer	Andy Scarisbrick

3. Main Activities During the Past 12 Months

October Debate: 'Competency Management'

This was the second time the section had used the debate format, following the successful debate on the Digital Railway the previous season. This session focused on the competencies used in the signalling industry.

The session began with an exploration of how competencies had originated, developed over time and what keeps them relevant. Ownership of competence management was discussed as a collaboration between companies and individuals to reflect what each party needs from the system. The comments then proceeded to reflect that individual companies drives what competencies are needed, and although the IRSE licence has an underpinning commonality it is not an equivalent system. There was also concern raised that the existing competency systems were suitable for conventional signalling systems but were not ready for ETCS-style systems.

The debate then moved onto the differences between jobs/roles and competencies, and as an extension how Network Rail's changing processes changed the relevance of mainline competencies, especially in maintenance. Supplier company's management systems were discussed and by extension how the continual addition of new technologies placed pressure on the competency system. Concerns were also expressed at the difficulties involved in some colleagues switching between licensable and non-licensable work, and the associated degradation in competency. It was observed that the different company systems could be translated by qualified individuals without difficulty.

Technology was a key issue, with the introduction of technologies and revolution of systems creating knowledge obsolescence amongst the key items. The use of technology to keep people off track also led to discussions about rounded experiences in engineers, and whether a fragmented industry was leading to a shortage in multi-disciplinary skills sets. The evening concluded on discussions predominately centring around the licence complaints process and whether it was being used effectively.

Attendance: 16 Members, 2 Guests

November Lecture: 'The Waterloo Incident' – Richard Brown, RAIB

An inspector from the RAIB walked the section through one of its most recent reports. He focused on the lead-up to the commissioning, including the complexity of the project, an incomplete design process and a late change to the possession arrangements. The immediate cause and underlying issues as described in the report were then walked through, including an extraordinary section on comparisons with previous incidents. The evening ended with a spirited Q&A.

NB. This event was very popular: there were requests afterwards for the RAIB to conduct more presentations on major incident reports. This will be followed up for future seasons.

Attendance: 45 Members, 14 Guests

December Lecture: 'Developing Cyber Resilience Together' – Alexander Patton, Siemens Mobility

The presentation for this session was an extended and updated version of the ASPECT 2019 paper of the same name. Throughout the evening, he described the problems with cybersecurity on an international level, and what must be done by railway suppliers to make signalling systems resilient to the modern environment. A general conclusion drawn is that whilst physical security is at a reasonable level, network security is still not very understood, with too much emphasis on products and not enough on process. This was followed by information on what can be done to improve on this state of affairs.

An informative Q&A focused on migration strategies and the risk-reward balance in availability.
Attendance: 10 Members, 3 Guests

March Lecture: 'The Obsolescence of GSM-R and Other Telecoms Updates' – Paul Darlington, IRSE

The session served as a history of telecoms development and what might come next. The speaker covered the use of GSM-R, and it's use in the context on going telecoms development, and its predicted remaining lifespan. This segued into explanations of successor technologies, with a focus on 5G as the most likely long-term replacement candidate. The importance of spectrum was raised throughout the talk, as was the protracted development time of GSM-R and any replacement system. This was followed up on in the Q&A, where questions were asked concerning the use of obsolete technologies in planned projects and the risks involved in the current planned timescales the UK are working to.

Attendance: 20 Members, 2 Guests

Abandoned Activities

The February presentation was intended to be a joint session with a local branch of the IET, the arrangement for which has been in place for some years. This season, the quality of response communication from the IET was poor, culminating in the section being informed of the cancellation of the speaker at the last minute.

The annual pub quiz/social event was also abandoned due to issues with the venue.

The April session was planned as a series of short presentations conducted by younger member of the institution. This was cancelled due to the pandemic. The pandemic also resulted in the abandonment of plans for a technical visit and social event in the summer.

4. Plans for the Next 12 Months

The current pandemic means that, in the view of the section committee, the vast majority of meaningful events the section can put on are not viable. The current plan is to put on a couple of presentations in 2021 using the HQ GoToMeeting licence and gauge the reaction to them. It is currently too early to tell if a full programme can be planned for 2021-2022.

In the absence of activity, there is work in the background to create new ties with other local institutions, so that more joint events can be held when we are able to resume normal service.

IRSE York Section Report: 2019 – 2020

Report produced by: Richard Storer
Date: 12 May 2020

1. Introduction

York Section has continued its activities throughout the year with a variety of topics discussed during our lecture programme. It was unfortunate that following record bookings for recent years the Annual Dinner on 12 March 2020 was impacted by several corporate guests who were unable to attend due to the COVID19 crisis. The Annual Dinner was however able to go ahead where the approximate 110 guests present addressed by Jon Shaw, Network rail Chief Engineer.

Unfortunately following the lockdown on 23 March 2020, the planned Annual General Meeting on 2 April was unable to proceed and it was decided to defer it to 10 September before the winter Lecture Programme commences.

Rhiannon Jones will at that point take up her appointment as Chair. Rhiannon is currently the Assistant Signal Maintenance Engineer at Leeds for Network Rail and has been a member of the Section Committee during the last 12 months. At the same time Rebecca Radnage will become the committee secretary taking over from the long serving Tony Pinkstone. Both are great ambassadors for young women in Signal Engineering getting involved with the Section.

Date of last Annual General Meeting	11 April 2019 Planned meeting 2 April 2020 postponed to 10 September 2020 (will go ahead virtually if required)	
Were annual accounts presented at the AGM?	No	Accounts are ready to present but no due to above.
Were officers elected / re-elected at the AGM?	No	Nominations for offices have been received but not yet elected due to above. Nominees are: Chair – Rhiannon Jones Secretary – Rebecca Radnage
Have minutes of the last AGM been produced?	No	Meeting not yet held
How many IRSE members are in the Section?		
Is your page on the website up-to-date with contact details, etc?		Details are current until election of new above at AGM but could be updated now

2. Section Officers

Chair	Richard Storer (Rhiannon Jones from 10 Sept)
Secretary	Tony Pinkstone (Rebecca Radnage from 10 Sept)
Treasurer	Anthony Kornas

3. Main Activities During the Past 12 Months

York Section started the year by attending the North East Railway Engineers Forum at the National Railway Museum where a variety of subjects were presented including the future of rolling stock including hybrid and hydrogen cell development, Leeds station redevelopment and a presentation on the effects of Electro-Magnetic Interference. A series of Section Lectures followed during the autumn and winter period held at York ROC Auditorium with a variety of speakers as follows:

24 October 2019 – Becky Radnage – Resilience – focusing on the effects of mental health
14 November 2019 – David Jones (NR LX Engineer) – Obstacle Detection at level Crossings (at GSH)
5 December 2019 – Rhiannon Jones + Guests - Signalling Maintenance – Plan v's Actual!
15 January 2020 – Tony Kornas – Engineering Safety and Safe by Design
12 February 2020 – Mark Marridge, Arentis – Operational applications of HD Video
5 March 2020 – Craig Donald, NYMR – Maintaining and Replacing Level Crossing Equipment and level Crossings on the North Yorkshire Moors

The Lecture programme was followed with the Annual Dinner on 12 March 2020 where our speaker was Jon Shaw, Network Rail Chief Engineer.

Unfortunately, the AGM planned for 2 April 2020 had to be cancelled due to the lockdown on 23 March 2020 and has been re-scheduled for 10 September 2020 when on-line access will be made available if required.

4. Plans for the Next 12 Months

Provisional plans have been made for the lecture programme next year which we are looking to make available on line as a contingency to the continuing impact of the Coronavirus crisis which could result in arrangement changes. Current dates planned are:

17 September 2019 – North East Railway Engineers Forum at National Railway Museum
15 October 2020 – Joint Event – Institute of Engineering Technology – Trans Pennine Route Upgrade at York ROC
19 November 2020 – Daniel Woodland Presidential Address given by Rod Muttram at York ROC
10 December 2020 – Signalling Maintenance Paper

Further Lectures will be added to the programme once confirmed in 2021.
The Annual Dinner will be held on 1h March 2021.

IRSE Younger Members Section Report: 2019 – 2020

Report produced by: Aaron Sawyer
Date: 19 November 2020

1. Introduction

Following the successes of 2019, including the attendance of many Younger Members (YMs) to ASPECT 2019, the YM Section experienced a significant and positive reorganisation of the committee in February 2020. The introduction of new members within the committee and the revised energy imparted by its members has enabled the expansion of the Section's activities over the past 12 months; however, it is noted that in person activities have been prohibited due to the global pandemic and government restrictions. The committee is comprised of 15 YM delivering content for the community.

Date of last Annual General Meeting	3 March 2020	
Were annual accounts presented at the AGM?	Yes	
Were officers elected / re-elected at the AGM?	Yes	
Have minutes of the last AGM been produced?	No	
How many IRSE members are in the Section?	~980	General members under 35
Is your page on the website up-to-date with contact details, etc?	Yes	

2. Section Officers

Chair	Aaron Sawyer
Secretary	Robin Lee
Treasurer	John Chaddock

3. Main Activities During the Past 12 Months

The previous Younger Members' Section Committee conducted a survey of the Younger Members, to identify what they want their committee to focus on. The results of this survey were analysed by this year's committee. Based on this feedback the YM section committee developed ideas for new events, to facilitate more participation and networking with the wider IRSE. A focus on international responses was also made, and in combination with the new requirements driven by Covid-19, study days were held online, with material then made available through the IRSE's Vimeo channel.

This year the IRSE YM committee developed a strategy which focused on five focus areas:

- Flagship Competition;
- Attract & Expand;
- Digital Initiatives;
- Support Development; and
- Sustain & Improve.

Flagship Competition

The Flagship Competition was an initiative that has seen many of the YM committee planning a competition event targeted towards giving its committee the opportunity to compete in a signalling related design competition. The specifics of the event are still in their infancy; however, it is hoped that the event would grow into a large annual event targeted specifically at our YM community.
Out of this workstream, the committee founded another initiative. An initiative which was not appropriate for a flagship competition; however, worth developed for the benefit of the Section. This initiative is the Accident Investigation event whereby attendees are invited to a heritage railway to conduct a railway accident investigation into a mock scenario. The scope of this event has been set and the team is working to form strategic partnerships to deliver the event.

Attract & Expand

Attract & Expand saw the delivery of the IRSE STEM programme. This saw four members of the YM committee produce an IRSE STEM workbook – titled “IRSE Super Train Challenge: A Journey Around the World” – and associated online webinar. The event followed the fictional character Prerna the Great Inventor and her quest to build a Super Train. The webinar was attended by 30 participants in which the YMs introduced themselves, their careers, the Super Train challenge and hosted a quiz. The event also featured within the IRSE magazine. This was a brand-new initiative created by the committee, the second event is in development.

Following feedback provided to the YM committee expressing a desire for more international input within the YM activities, the committee has a dedicated International Outreach role. The aim of which is to move away from a UK centric operation. We have been working closely with key younger members of the IRSE around the world allowing for collaboration with future event planning. In 2020 we now have representation from both the Swiss and Netherland Sections. The advent of remote working and virtual events has allowed the IRSE to offer many events from around the world to all members regardless of geographical location. We are currently working closely with Australia as pilot region to coordinate future events and advertisement. We are also utilising the advertisement outreach of the UK section to help promote younger sections to a wider reach of members across the globe.

The committee’s interaction to the wider Sections has further increased with active YM interface with the International Technical Community.

We are further supporting Railway Control and Digital Systems course at Birmingham University. It is hoped that through our visibility at such events and audience targeting, we will create greater exposure and attract new volunteers and members into our community.

Digital Initiatives

Due to prohibition of in-person events, all IRSE YM events occurred on a digital platform. Beyond this, saw the creation and active management of IRSE YM social media platforms. This enabled increased communication channels between the committee and its members, contributing to the advertisement and positive attendance of events of interest to our members.

Support Development

The section increased their presence across the institution, including its active relationship with E&PD committee through a permanent YM/E&PD interface role. The development of this interface was considered a key priority as many of the committees' initiatives are aligned to YMs of the institution. Beyond providing updates and input within discussions, representatives from the YM Section led two collaborative projects between the committees.

Firstly, the YM Section has developed and is working to rollout a new automated mentoring scheme that connects mentors with mentees in a simple self-managed system that reduces administration overheads and ensures low maintenance. Regaining access to the mentoring IRSE email address was a positive first step.

The second activity has seen the YM Section conduct a review of the “Maintain you Competency” system. This work is identifying and proposing updates to the website to improve the navigation of the site to simplify the information provided to Chartership candidates and improve the MyCareer-Path system. The YM section is working to define the full scope of the improvements and produce and implementation plan.

Sustain & Improve
This focus area covered activities already delivered under previous YM Sections or the wider institution. These include ASPECT, IRSE Exam Study Days and the YM Conference.

Following ASPECT 2019 in Delft, Netherlands, and the attendance of many Younger Members from around the world, the YM Section further developed its relationship with the event providing active YM representatives at the ASPECT organisation committee. It was the roles of these individuals to speak on behalf of the YM Section and represent our community to the organising committee.

The section has always been committed to supporting the preparation for the IRSE exams; however, 2020 saw a significant increase the support provided by the YM Section. Several members of the Section played lead roles in the organisation and logistical planning of the events. Following the Exam review in March, online exam preparation events were held with the assistance of the normal tutors:

- Telecommunications day
- Modules 2, 3, 5 & A preparation day
- A series of three Module 2 events
- Safety & Systems Engineering day
- Signalling Equipment (Module 5) event

These were recorded and now form a permanent study resource, consisting of over 24 hours of content: irse.info/oxp03

A 'Cyber Academy' was run consisting of a small group working through the CompTIA Security+ textbook practise questions.

4. Plans for the Next 12 Months

The YM section committee intends to run a survey again early in the new year to attain general feedback on the activities of the committee in 2020 and what improvements could be made for 2021.

The following events are planned:
- Exam Review & AGM (following exam results)
- Online YM conference, planned for 13 March 2021 (a series of YM papers)
- Further exam study events
- STEM
- Cyber Academy

The goal is to further increase international presences outside of the UK within the YM committee and intend to continue a close working relationship with the Australia section as a pilot region to coordinate future events and advertisement.

Planning is to continue for the Flagship Competition and Accident Investigation Events.

The Section will continue to develop relations with other IRSE Sections and deliver improvements in collaboration with E&PD committee.

It is also the intension to develop improved committee handover documentation to aid future committee changes.

The Institution of Railway Signal Engineers

Proceedings for the Year 2019-20

IRSE News issues May 2019 to April 2020

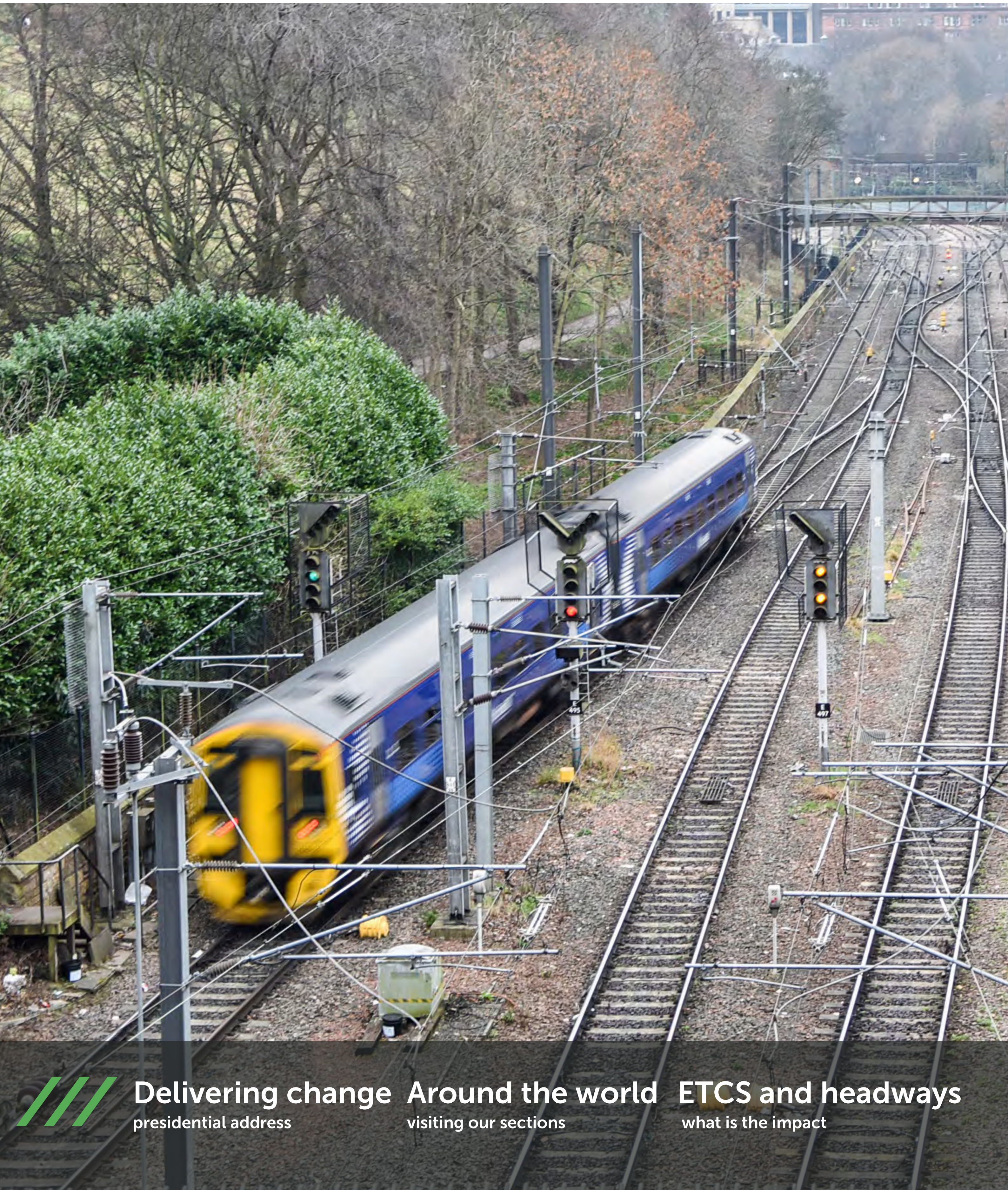
The IRSE News issues that follow (issues 255 – 265) are available in the archive on the IRSE website www.irse.org

Please visit irse.info/newsarchive

IRSE News

Institution of Railway Signal Engineers

May 2019



Delivering change
presidential address

Around the world
visiting our sections

ETCS and headways
what is the impact

Global reach, local focus

It has been a great experience for me over the last year to begin engaging as junior vice president with some of the local section committees and attending local section meetings. Throughout my membership of the IRSE I have been actively involved in a variety of committees, but being London based never had the opportunity to get involved in a local section committee. Indeed, it has been a rare occurrence that I have been in the right area, at the right time, to attend a local section meeting. During 23 years of membership I had only actually attended a handful of local section presentations with the Scottish, Midland & North Western and Singapore sections – in most cases when I was the presenter!

One of the things that has struck me whilst visiting local sections is the variety, interest and quality of presentations given. The organising committees, all volunteers, put in a huge amount of effort to find speakers, venues and sponsorship that enables a fantastic offering to their local members. However, given all of the previous IRSE News editorials on the topic of Continuing Professional Development CPD (that is, maintaining and developing one's professional competence) I have been left wondering why more members aren't taking advantage of this by attending their local events?

The IRSE Articles of Association state the objectives of the IRSE as "The advancement for the public benefit of the science and practice of signalling* by the promotion of research, the collection and publication of educational material and the holding of conferences, seminars and meetings...."
* which means in all the equipment and systems (electrical, electronic, mechanical or software-based) methods, regulations and principles whereby the movement of railway or other traffic is controlled. This includes associated telecommunications systems.

I have been truly delighted to find that the sample of local sections I have visited so far are leading the way in delivering this objective. As I move into my year as senior vice president, and now have access to the recently formed London and South East Section, I intend to continue visiting local sections – and hope to meet with many more IRSE News readers when I do.

Daniel Woodland, senior vice president

Cover story

Our cover shows a ScotRail service in Princes St Gardens, part of Edinburgh Waverley Station signalling controlled locally from the BR 1970fs Edinburgh Signalling Centre. This replaced an LNER pre-war power signalling scheme with a GEC Geographical Interlocking which by the Railtrack era was suffering from rampant wire degradation, which was resolved in January 2004 when new 2MHz SSI interlockings were commissioned. Subsequent remodelling of the west end of the station resulted in an extension to the building and the commissioning of a Classic IECC in December 2006, which was subsequently extended to cover the entire control area of the original 'Edinburgh and East of Scotland Resignalling'. The final stage in 2010 being the re-opening of the Airdrie to Bathgate Rail Link, resulting in the Edinburgh IECC being connected to Yoker IECC at Drumgelloch, just to the East of Airdrie.

Words Steve Muirhead.
Photo Paul Darlington.

In this issue

From the IRSE and its sections

Presidential address: Delivering change

George Clark
Director of Engineering, Transport for London, UK

The inauguration of our new president for 2018-19, George Clark, took place during the Annual General Meeting of the IRSE held in April. IRSE News is pleased to share George's Presidential address with you in this issue.

It is a great honour for me to serve as your president and to write this article. This institution continues to play a significant role in a modern railway industry that is facing huge challenges and exciting opportunities. At the Institution's digital railway seminar last year, many were envious of those joining the profession now as it sees so many developments across the world. It is only right that this institution inspires, informs and develops engineers globally.

This is a year when change features large on the agenda of so many countries and major cities. In the UK whilst we debate the form of our future relationship with Europe, we have a transition from one national rail five-year plan to the next with over £50bn (€58bn, $66bn) to be invested in maintaining and upgrading our main line railway. Network Rail also embarks on a period of radical organisational change to 'put passengers and freight users first' and to address concerns about poor operating performance. Closer to home for me personally, in today's economic climate, Transport for London faces unprecedented pressures to modernise and deliver ambitious transport strategies cost efficiently.

This is a global trend. In Sydney we see the arrival of the metro as this form of railway expands further around the globe. It has been over 20 years since my mentor and guide Eddie Goddard led the institution into the world of the metro and focussed on the challenges of providing an integrated high capacity railway system. I recall he often said the "S" in IRSE should be for "System", these challenges are still just as evident on railway delivery today as all too often railway systems (be they for railway, train or station control) and their complex interfaces are overlooked until too late in major infrastructure projects. This can often feel like they are a cause of failure, when in fact these systems are at the very heart of the railway and must be given adequate focus throughout the whole lifecycle to bring it to life, and deliver the major social and economic changes that transportation enables.

My career has been focussed on the world of metros and these intensive high-capacity railways have never been in more demand. The world-wide growth of cities has pushed so many to forge ahead with bold plans for metros, whilst those who already have them are driven to upgrade capacity. We have never faced higher social expectations and economic challenges, with global technology giants investing furiously in a race to bring transformational robotics, automation and artificial intelligence technology to everyday consumer products that must surely disrupt our traditional railway world.

In his presidential address last year, Markus Montigel clearly articulated the "Winds of Change" and how these will likely revolutionise the transportation system as a whole: calling us to "find an appropriate balance of 'walls' (maintaining the tradition of high safety standards) and 'windmills' (harvesting opportunities and increasing efficiency) in times of uncertainty".

So, the theme of my presidential year in this changing world is "Delivering Change" and how this institution, with its thousands of dedicated professional members, can rise to meet the challenges and enable the opportunities ahead.

George led the delivery of moving block train control on London Underground's Jubilee and Northern Lines. *Photo Transport for London.*

My career

A great pleasure of becoming president is the opportunity to reflect and reminisce on my career, and the many occasions where the work and opportunities offered by this institution have played a role. As is common in our industry, my journey started early as part of a transport industry family and formally began in 1976 with my signalling technician apprenticeship at London Transport. I was sponsored for my degree in electronic engineering and joined the Computer Development Section of London Underground where I first met my mentor over many years, Eddie Goddard.

Throughout 1980s I worked on programming the latest mini-computers in assembly language (efficient code as memory was a premium), delivering systems and initially training of the Piccadilly Line signal operators on powerful timetable editing and train control (a major change to many, including the use of qwerty keyboard entry) which used my first live real time signalling control systems software. Moving onto the Jubilee and Metropolitan lines, I progressed from coder to system designer/tester.

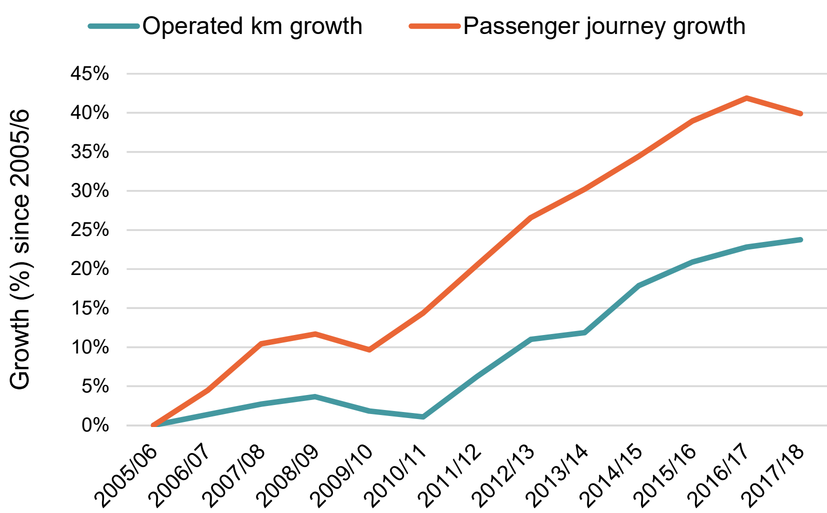
I then moved into specification and assessment of new solid-state safety systems and their design acceptance by engineers and operators who were used to mechanical and deterministic machines. I also focussed on such specifications as part of a European initiative to harmonise interlocking principles across Europe, working with senior signalling engineers (two of whom are today IRSE council members) which was a great opportunity for my own development in learning signalling principles of all the major European main line railways. This illustrated the similarities as well as the challenges still facing Europe today as we seek to achieve the benefits of more standardised signal and control system products.

Delivering new technology into the railway was always a theme for me, so I leapt at the chance to join the Jubilee Line Extension Project in 1996, when it was at the heights of its challenges. Working with a small group of similarly minded delivery engineers led by David Waboso, I spent a very challenging four years in establishing and then delivering the systems needed to open the railway for the new millennium – a major project that provided many lessons in Systems Integration and railway systems delivery, that unfortunately we often see recurring today.

'Delivery of Change' is my presidential theme, and the new millennium saw me leading the delivery of the first moving bblock signalling system for London Underground's Jubilee and Northern Lines. I had, I believe, a unique series of roles over seven years that began with adding my signature to the contract award recommendation, through its application design and finally to be the legal entity under UK law to authorise its use for public transport which was quite a journey.

Part of that journey for me was about responding to the change in demand which continues today (as shown in the graph below), albeit slowed by the current economic uncertainty. That could be a picture from many major cities around the world and shows why the institution has such a

On London Underground, as with many other railway systems, the rate of growth of demand for passenger journeys significantly outstrips the rate of growth in supply. The data for this chart comes from London Underground's performance almanac.



Before and after, left the 'industrial archaeology' of Edgware Road signal box, still in use today. Above the Hammersmith service control centre which will assume control from the Edgware Road signal box later in 2019.
Photos Transport for London.

key role in expanding the profession, creating a greater more effective community of engineers and unlocking resource constraints.

This brings me to my current role as TfL's director of engineering, where I am proud to lead a fantastic team of over 1400 engineers who form a unified engineering function to efficiently serve all the delivery businesses of TfL (from roads to rail, from buses to ferries). It is an exciting opportunity to make a real difference to all forms of transport across London, whilst meeting that ever increasing demand for mobility.

Part of that team has delivered the first phase of the biggest ever moving block signalling project in London – the modernisation of the Hammersmith, Circle, District and Metropolitan Lines which entered passenger service in March 2019 between Hammersmith and Latimer Road, bringing the new signalling into the latest, and largest control centre on the Tube at Hammersmith.

It seems my whole career has been about delivering change.

Engineers of change and innovation

As engineers, we are catalysts and agents for the delivery of change and our skills have never been in more demand than they are today. We deliver new tools, techniques and technology systems to colleagues (e.g. fellow engineers in other disciplines, signallers and operators).

We lead in so many areas: data analytics, human factors and design, safety assurance and integration/ commissioning. Today IRSE members and licence holders around the world are introducing the latest technology systems from Sydney to Copenhagen, Toronto to Hong Kong. In the UK we have seen the ERTMS solution with world leading ATO being introduced on Thameslink and increasingly across London Underground we are benefiting from technology delivering up to 36 trains per hour.

New technology is a key enabler to delivering change and always comes with its own inherent challenges and risks, but so often the wider people, process and interface changes are even more significant and the root cause of delays and cost. Not only must we deliver the required functional performance enhancements for system capacity and asset availability, but also significantly reduce the whole life cycle costs through radical changes to maintenance (e.g. through digital and virtual data driven approaches) and operation (e.g. GoA4 fully automated operation).

Of course, the unique challenges inherent in most railway upgrades is that they start from a base state that most other industries would class as 'industrial archaeology', with complex legacy interfaces that are rarely adequately understood, multiple party interfaces, all intricately interwoven with deeply established organisations, culture and processes. Invariably this all needs to be changed, whilst continuing to deliver intensive operational services with minimal disruption to the system being upgraded. Many industries face huge technical complexity and challenges, but few, if any, must contend with the full range of challenges faced by railway system engineers.

Increasingly the once clear lines between main line and metro control systems are blurring. Whilst there are common requirements to increase capacity on constrained infrastructure, traditionally a main line system would have one set of characteristics with fixed block multiple aspect colour light signals and the metro would have another with continuous ATP/ATO. But today we increasingly see mass transit rail, such as Thameslink or areas around Waterloo, but with main line technology. Crossrail is fundamentally a mass transit railway in the centre but operates on legacy main line systems on the outer areas. ERTMS and CBTC use common components and whilst both in high levels of performance are very similar, they have different requirements (e.g. interoperability for ERTMS or optimisation of capacity for CBTC). From a supplier perspective, each CBTC supplier is seeking to optimise with their own commercial edge and adapt to the specific application whilst ERTMS drives a standardised approach.

Communications technology is fundamental to train control systems and evolves rapidly. Railways are not the first to implement this and should be able to learn the lessons from others who have gone before us, but equally rarely seem to. We need to break the pattern of current technology solutions by pushing at the door of concepts such as common shared networks and industrial clouds, with primary aims being quality of service, affordability and 'cultural' change to maintain pace with our travelling customer's growing demands. This will be the subject of my first thought provoking seminar in September 2019, harvesting the open and frank opinions of the railway signalling industry which is vital to gaining traction on the rail operator's future strategic direction.

Delivering change – the need for a business case

Last year Markus clearly illustrated for us how the cost of public transportation in Switzerland had increased at almost double the rate of consumer goods and almost triple the rate of road transportation.

Technologies such as ATO have been in use for decades on metro railways, but are now revolutionising service on main line services, such as London's Thameslink project.
Photo Siemens Mobility Limited.

But despite the powerful cost pressures on railways today and the disruptive potential of autonomous vehicles, data analytics and artificial intelligence to challenge fundamentals of the railway position in an integrated transport system, there is little evidence that the cost and time to deliver railway control systems and the transformational changes they enable is responding as quickly as is needed.

This is summed up by the journal headline "Affordable trains, expensive infrastructure" (Rail Engineer, 2018) [6], which describes how over 7000 new rail passenger vehicles are to enter service between 2014 and 2021, representing more than half the UK fleet. These orders are due to a combination of factors including cheap finance, lower manufacturing costs, franchise quality requirements and new trains having lower operating and maintenance costs. Over the years, the price of new trains hasn't changed significantly (at today's prices) but signalling costs have continued to rise with signalling renewal costs (signalling equivalent unit) having more than doubled over 10 years.

The barriers to entry and change for rolling stock and 'walls' of safety standards are high, but perhaps seem relatively manageable when compared to the challenges railway control systems and their intricate interfaces are to operating railways and organisations. Professional engineering and innovation has an opportunity to deliver the improvements to create a more compelling business case for change, by challenging standards in organisations and exploiting newer technologies before implementation is overtaken by obsolescence. This is not only a challenge for client organisations, so many of our suppliers are global businesses working across industries, innovating and racing to market with the very same technologies that might disrupt rail's traditional dominant position.

Delivering the future engineers of change

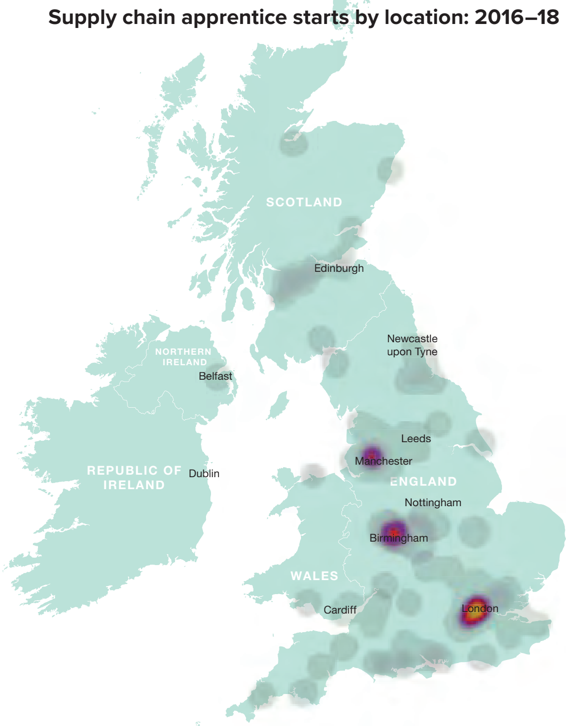
As an institution our challenge is to set our strategy to successfully respond to this changing environment, and whilst every president brings his or her own focus and emphasis to their presidential year, the president also provides continuity of purpose, and that is encapsulated in our five-year strategy (2015-2020) which is nearing its end. If you are not familiar with it, you can find it on the IRSE website, and we must now build upon this strategy, "The Winds of Change" and "Delivering Change" to feed into our new strategy. The existing strategy and its supporting implementation plan address key issues, including:

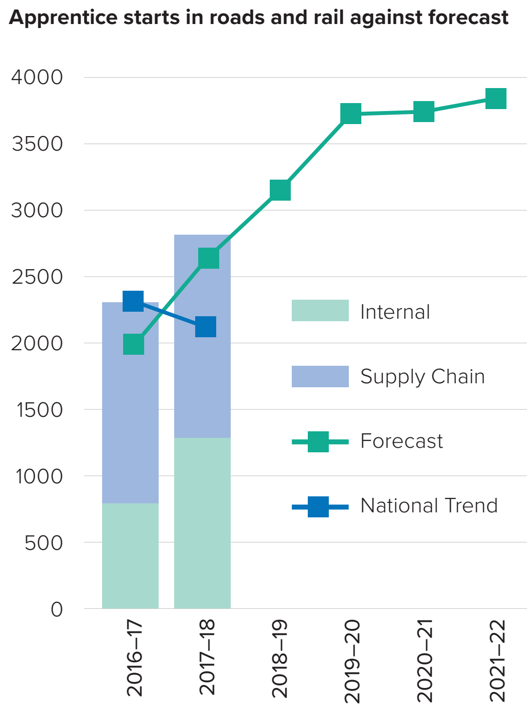
- Tackling the skills gap facing railway signal, control and communications engineering in many countries.
- Encouraging employers' support for IRSE activities to help ensure that the Institution's activities align with the needs of the wider industry.
- Enabling growth of the IRSE as a global Engineering Institution, to promote professional standards throughout the world.

These themes all remain highly relevant to today's challenges and since the last strategy was set there has been a step change in the awareness of the role of diversity and inclusion. The diversity of our members roles is greater than ever before, as is the diversity of our skill sets and solutions we deliver. The moral imperative for diversity and inclusion is compelling: "People matter, and we all should have equal opportunity to develop, progress, and be rewarded and recognised at work. Organisations must ensure that their people management practices champion this fundamental principle" (CIPD, 2018) [5], but as our industry and the challenges it faces change, its stands to reason that diversity of thought and approach, and hence our people and membership, will be increasingly critical to generate the creativity and innovation required to face the future. But the challenge starts early as illustrated in "Engineering and Economic Growth: A Global View" (Cebr for the Royal Academy of Engineering, 2016) [4]:

In the UK engineering graduates make up only around 0.1% of the population and women only make up 22% of engineering graduates. We cannot expect a diverse workforce solving our future challenges unless we can attract a diverse range of children from all corners of the talent pool into subjects that will inspire and equip them to go on to be the engineers we need to tackle future challenges.

A great example here in the UK is The Transport Infrastructure Skills Strategy, the "Two Years On" report (Strategic Transport Apprenticeship Taskforce, 2018) [7] shows we need 50 000 people in rail by 2033.As shown in the figure overleaf, taken from that report, in the UK we have seen rising numbers of apprenticeships from transport employers, in contrast to the wider national trend in apprenticeship





UK apprentice starts in road and rail 2016-18 [7].

numbers this year, a trend we need to ensure is generally continued and specifically for railway control. The report notes that "existing staff will need greater systems engineering, advanced telecoms, software programming and crucially business change skill sets to help fully realise the benefits of a digital railway. Successful development will build upon the industry's existing capability, and give the opportunity to boost exports". Engineers delivering change.

But just attracting the people will not be enough and we also need to change the way we are working. We must expect that the way that engineers need to organise to deliver, and hence the skills they need to be equipped with, are also changing. Themes that I am sure will be explored through my coming technical lecture programme including the Danish lecture: Delivering change through the National ERTMS programme in November 2019 and Australian lecture: Delivering metro travel in Sydney in 2020.

Journey into the future

Another great pleasure of being president is the opportunity to recognise and thank all those who have inspired, guided and supported me in my career. There are too many to name everyone, but I am particularly grateful to Eddie Goddard and David Waboso CBE for their inspiration and wisdom as mentors and Mike Brown MVO for his constant support.

I have benefited from a hugely varied career and have taken the opportunities given to me, I am proud to have the opportunity to lead engineering across Transport for London having started there as an apprentice.

The world has always changed relentlessly, but it seems to me that the pace is accelerating. When I started my apprenticeship in 1976, the idea that railways could ever be challenged by other modes on cost, capacity or environmental impact seemed hard to imagine, however today it feels not only possible, but increasingly likely. If we stand behind the traditional walls of safety standards and do not harvest the opportunities that these winds of change present, there is a risk that railways could be rendered obsolete as technological and social transformation goes on without us.

So, our role as engineers is to deliver change as never before and there are so many good examples of engineering stepping up to this exciting challenge. To name but a few examples, we have the UK's Year of Engineering, the Strategic Transport Apprenticeship Taskforce, the National Skills Academy for Rail, the Women's Engineering Society, the Future Engineers exhibition at the London Transport Museum (**irse.info/a0idv**) and indeed my presidential year's programme of events on Delivering Change. Please get involved and don't forget the website, live streaming and international lectures as well as your local section.

At the IRSE we have a key role in promoting our profession and in providing the opportunity for those in it to develop their skills, harness the winds of change and continue to deliver change which will benefit society for decades to come. This is a truly worthy cause and one I am honoured to lead this year as your president.

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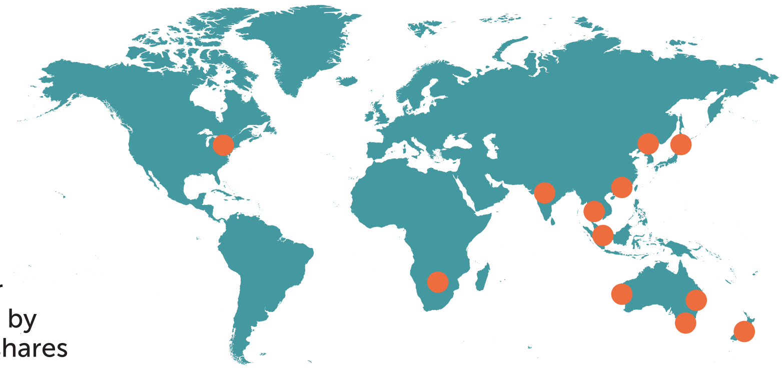
IRSE///
Institution of Railway Signal Engineers

The 2018-19 President's world tour

Markus Montigel



Map (c) Free Vector Maps

During the course of his 2018-19 presidential year Markus has made a point of attending events held by IRSE sections around the world. In this report he shares some of the highlights of his whistle-stop travels.

Toronto, Canada
29-30 November 2018

Representatives met: Yousef Kimiagar, conference chair, North American Section officers, and many industry representatives.

Topics discussed at meetings and site visits

- CBTC developments and lessons learnt world-wide, but particularly in the USA and Canada.

With IRSE colleagues at the CBTC conference in Toronto.

Meeting at the Ministry of Railways.

Delhi, India
24-25 February 2019

Representatives met: Mr N Kashinath, director general (S&T), Ministry of Railways and team, Anshul Gupta, secretary IRSE Indian Section.

Topics discussed at meetings and site visits:

- India wants to deploy ETCS L2 on their entire network of 60 000km.
- Education, training in new signalling technologies for the adoption of a digital train control system, ETCS L2, for Indian Railways facilitated by IRSE, London.
- Collaboration in the area of IRSE licensing for competence development.
- India's largest relay interlocking at New Delhi main station.
- Metro Delhi Education and Training Centre.

Bangkok, Thailand
27 February 2019

Representatives met: Wichai Siwakosit, Kasetsart University, Gregory Enjalbert, vice president Asia Pacific, Bombardier.

Topics discussed at meetings and site visits

- "Winds of Change" implications for the rail industry.
- MRTA Blue Line Extension: using an upgraded version of LZB.
- BTS Sky Train re-signalling using a completely new CBTC system without any interface to the old signalling system. This will require many sophisticated migration steps.
- Plans for high speed lines in Thailand.
- Problems created by the obsolescence of GSM-R.

Thailand Section meeting.

Meeting the transport minister of Malaysia.

Kuala Lumpur, Malaysia
28 February 2019

Representatives met:

Anthony Loke Siew Fook, transport minister of Malaysia, Satyamoorthy Ponnudrai, Aniket Mukhopadhyay and board (IRSE).

Topics discussed at meetings and site visits

- Application of the IRSE licensing scheme in Malaysia.
- The insight of the meeting: the IRSE's licensing scheme would fit in His Excellency's plans of setting up an independent authority for the safety assurance and education for all railways in Malaysia, to ensure a consistent level of safety and quality.
- Future signalling system possibly ETCS L1/L2.
- Communication infrastructure for L2.

Hong Kong
1 March 2019

Representatives met: K W Pang, section chairman, Gordon Lam, chief signal engineer of MTR, members of the section committee.

Topics discussed at meetings and site visits

- Migration strategy for the current project for the re-signalling of several lines of MTR with a modern CBTC system, including the commissioning of new Chinese trains.

Hong Kong Section dinner.

A different kind of signalling system, once used to warn to use the population of Hong Kong about approaching typhoons.

The President travelled on the remarkable Hong Kong to Beijing high speed train. Covering 2439km in just under nine hours, the train averages 273km/h including stops!

Beijing, China
4 March 2019

Representatives met: Ning Bin, president of Beijing Jiaotong University and chairman of the IRSE China Section and his team.

Topics discussed at meetings and site visits

- Achievements of Chinese Railways, for example their 30 000km of high-speed railway lines.
- Strengthening the cooperation between the IRSE in China and other IRSE sections.
- GoA 4 (UTO) CBTC train simulator, this time driven manually by the IRSE president.
- New train control system, almost purely based on train-to-train communication.

Prof Ning receives Markus at the Beijing Jiaotong University.

Manual driving on the CBTC train simulator.

Meeting of the Japan Section.

Tokyo, Japan
6-7 March 2019

Representatives met: Yuji Hirao, section chairman and his team; many relevant representatives of various railways, RTRI, and suppliers.

Topics discussed at meetings and site visits

- Review of results of subgroups working on several interesting current topics, including ATO and cost.
- Various research topics in the RTRI.
- Operation of several railway companies.
- L3 system without any trackside equipment.
- Rides on high-speed and suburban lines.

Experiencing travel by Shinkansen.

Auckland, New Zealand
11 March 2019

Representatives met: Todd Moyle, CEO and John Skilton, chief engineer both KiwiRail and team, Noel Burton, engineering manager, Siemens.

Topics discussed at meetings and site visits

- The enormous growth of Auckland metro area and resulting rise of demand.
- Status and future plans of KiwiRail, including strategy for future signalling systems.
- Special prevention measures for natural disasters.
- Cab ride on Auckland suburban network.

Auckland suburban train.

Metrotunnel's CBTC lab.

Melbourne, Australia
12 March 2019

Representatives met: Robert Braid, Country vice president and team.

Topics discussed at meetings and site visits

- Operation centres of Metro Trains Melbourne and V-Line.
- CBTC lab of new Metrotunnel project.
- AC track circuit and rolling stock interference study for the high capacity metro train.

Brisbane, Australia
14 March 2019

Representatives met: Management team of IRSE Australasia, various representatives at management level of QR, Aurizon and WSP.

Topics discussed at meetings and site visits

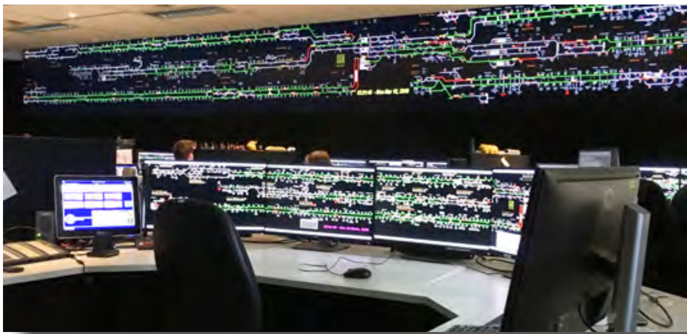
- Operations of QR and Aurizon.
- New tunnel line in Brisbane, to be equipped with ETCS L2 and ATO.
- Australasian annual conference, including Presidential paper "Human factors in cockpits: lessons learnt in the light of ATO" by Michael McNamara.

Perth, Australia
18 March 2019

Representatives met: Arvind Maharaj, Perth subsection chair.

Topics discussed at meetings and site visits

- Rio Tinto train and mining operation centre.
- TransPerth train operation (pictured opposite).



Gautrain in Johannesburg.

The President provided the section secretary, Ryan Gould, like all the sections before, with a token of appreciation for the hard work of organising the presidential visit, a vital Swiss tool for calling meetings to order or lure people back from the tea break.

Johannesburg, South Africa
20-22 March 2019

Representatives met: IRSE Southern Africa Section officers.

Topics discussed at meetings and site visits

- CPD point allocation for IRSE technical offerings.
- Transnet technology research (CTC system, onboard computer, TMS, data analytics and research in protection of susceptible equipment from the strong and frequent lightning strikes).
- Gautrain and Metrorail operations and maintenance.
- Siemens assembly factory and sophisticated testing facility.
- IRSE section meeting.

Markus says: "Thank you to everyone who contributed to my world tour. I am infinitely grateful."

Repoint – the future of track switching?


Sam Bemment and Tim Harrison
University of Loughborough, UK

Researchers at the University of Loughborough have developed an innovative point operating equipment with multi-channel redundancy to achieve very high levels of availability. A prototype installed on a UK heritage railway was recently demonstrated to stakeholders and the university is now looking for an industry partner to take the project forward.

Introduction

This article follows on from earlier project updates published in IRSE News. The February 2013 issue described the Engineering and Physical Sciences Research Council (EPSRC) funded Repoint Phase 1, which ran from 2011-2013, and examined track switching practice from first principles, under the research question "Could a fundamental re-think of railway track switching not only ease some of the current route-setting constraints to provide higher capacity, but also provide a significant reduction in operational unreliability arising from points failures?". A series of switching concepts were developed as part of this work, and one of these was selected for laboratory-scale demonstrator construction. This represented a technology readiness level (TRL) of 1-3.

Demonstrator construction through TRL 4 and 5 formed the core of Repoint Phase 2, funded by the UK Rail Safety and Standards Board (RSSB) 'Future Railway Enabling Innovation' fund. This demonstrator is described in the July/August 2016 IRSE News, and indeed is pictured on the front cover. The article described the general arrangement of the Repoint actuators, and the engineering reasons for this. This design, and the enhancements since, is recapped below. The article in that issue closed by stating that the following 30 months were to see a complete prototype installation with triplex redundancy at a suitable test site, and the 30-month journey through Repoint Phase 3 forms the subject of this article.

Repoint Phase 3 follows on from this earlier work, and takes the 'Repoint' switching concept to around TRL 7 – 'technology demonstration in a representative environment'. The project was funded and supported by RSSB, with significant funds from Network Rail and the Department for Transport.

If you didn't read those earlier articles, then you may be wondering, "what is this Repoint thing?" Well, it's nothing to do with bricks and mortar, though you may be forgiven for thinking so if you Googled it. Repoint was originally the name of a project to re-engineer track switches for enhanced RAMS (Reliability, Availability, Maintainability and Safety) performance, but by extension the name is now applied to the point operating equipment (POE) which has been created as a result of that project.

The original goal wasn't to add a few years to MTBSAF (mean time between service affecting failures) or shave a few delay minutes off each yearly total. We set out on a fundamental re-engineering to see where we could get to performance-wise. This included reviewing over 20 000 points fault and failure records from UK infrastructure to see where improvements were necessary. Previous publications[1] highlight both the opportunity for improvement, and the level of improvement possible. Existing UK installations achieve between 3-7yrs MTBSAF, and any maintenance beyond a brief visual inspection generally requires a possession. Historically, there was plenty of time for these possessions, but a pattern repeated worldwide is increasing capacity utilisation. Networks are under more capacity pressure than ever before, and with the ever increasing reliability and availability of other assets, the contribution of POE to overall unreliability has been increasing. Modelling suggests that the multi-channel redundancy introduced with Repoint opens up MTBSAFs over 60 years; the limiting factors are listed below. Maintenance, even in the most modern designs, must be undertaken in situ by removing the covers on the track. We examined a LRU (line replaceable unit) architecture, with each channel monitored and every component lifed, in order to reduce annual maintenance downtime to around 3 minutes.

Operation

As originally envisaged, Repoint was a stub switch arrangement. Three actuators are provided to give redundancy in case of individual actuator failure. Locking is "passive", i.e. any operational actuator can release the locking function of a failed actuator (Figure 1).

The mechanism uses cams to lift the switch rails out of one locked position,

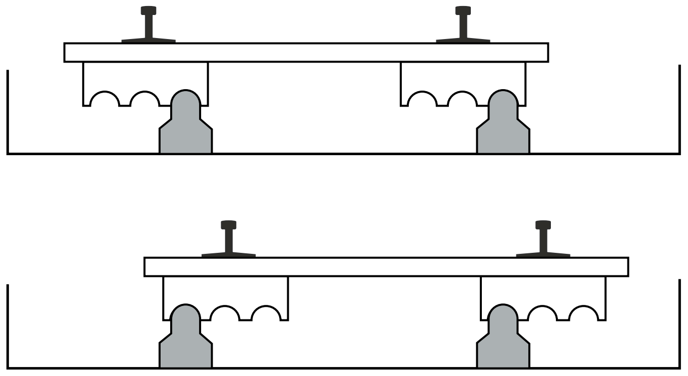


Figure 1 – Repoint locking mechanism.

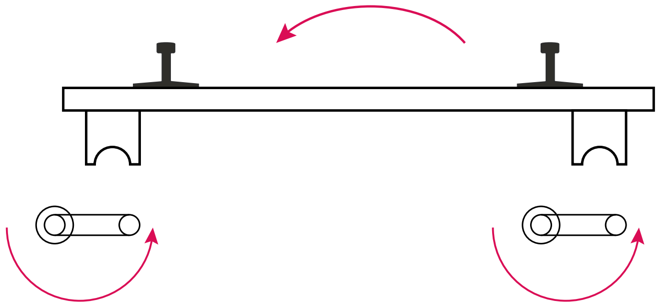


Figure 2 – Repoint actuation mechanism.

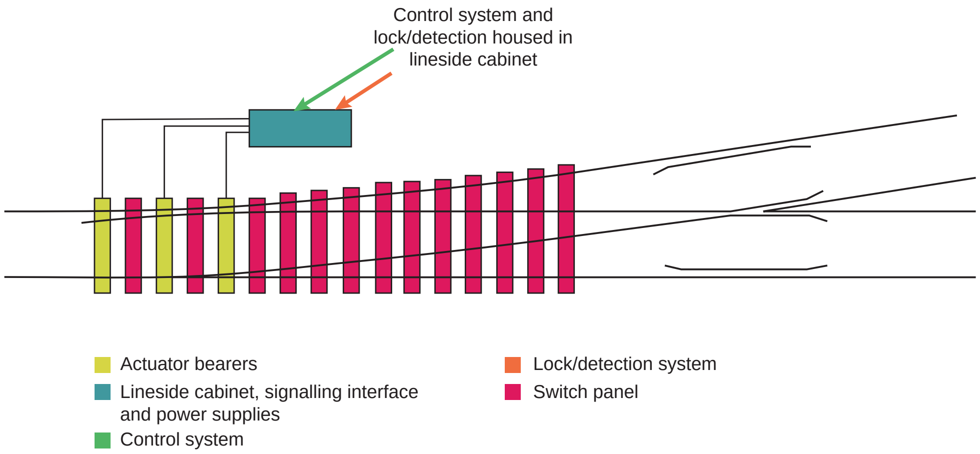


Figure 3 – Repoint Light sub-systems.

translate them across and drop them into the opposite locked position (Figure 2). The switch rails and the "hopper" part of the actuator follow a semi-circular arc. When in the lowered position, the switch rails rest on "locking blocks" and cannot move laterally. Any one of the actuators is capable of lifting the hopper and switch rails out of the down and locked position, translating them across and dropping them into the down and locked position on the opposite side.

After discussion with railway infrastructure owners and potential funding bodies regarding further development, it was felt that the redundant actuation and passive locking are a positive step, but that the stub switch element was perhaps too big a step to be taking in one project. Repoint "Light" was initiated, to develop a bank of actuators to use the lift-move-drop actuation and passive locking on a conventional switch arrangement.

For the Repoint Light design, the actuators have been adapted to function with an existing switch rail arrangement. These actuators can be isolated individually when faulty, and the switch operates using the remaining channels until repair is possible, without a reduction in system performance.

The main design change from a conventional switch actuation mechanism is that the Repoint Light actuators operate the switch rails through a two-dimensional arc, lifting them out of register before traversing them and then lowering them in the opposite register.

The Repoint Light programme is divided into five sub-systems, shown in Figure 3:

1. Actuator bearers – the mechanical design of the bearers, including the operating mechanism and locking provisions.
2. Lineside cabinet, signalling interface and power supplies.
3. Control system –motor control at the bearer level and the higher level logic concerning normal operation, maintenance mode and provision for hand winding.
4. Lock/detection system – independent of the control system, taking the outputs from sensors in the bearers and providing the system level normal/reverse position output.
5. Switch Panel – the rails, (non-actuating) bearers and associated components.

Actuator bearers

There are three actuator bearers in the Repoint demonstrator. The actuators are positioned at bearer positions 1, 3 and 5 from the switch toe. The three actuator bearers are similar, with alternative assembly of the cam mechanism to provide differing cam lengths in each of the three bearers which give the differing throw length moving back down the switch rails. The entire operating mechanism is housed within a hollow bearer. There is no equipment beyond the ends of the bearer, nor any equipment above the bearer top between the rails. The Repoint bearer uses off the shelf half baseplates for securing the stock rails.

The switch rail mounting is a cradle design, positively holding the rail in the lateral sense. The cradle design allows for the changing radius and position of the switch rail in all axes through the motion of the switch. The rail is clamped down into the cradle with allowance made for thermal expansion. The switch rail cradles are an integral part of the "hopper". This component provides the function, provided by the stretcher bar in conventional designs, maintaining the open switch rail position. The hopper also transfers the train loads through the

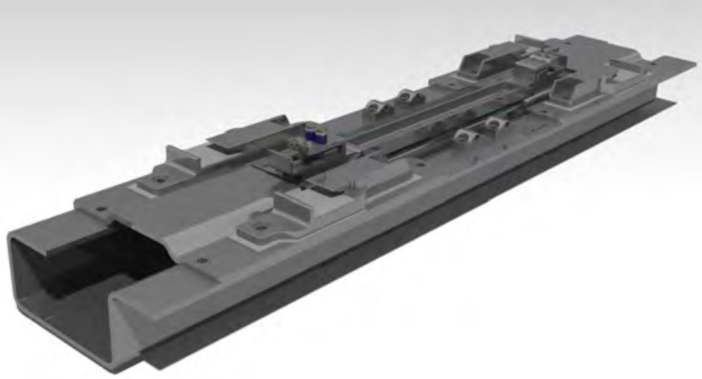


Figure 4 – Repoint bearer.

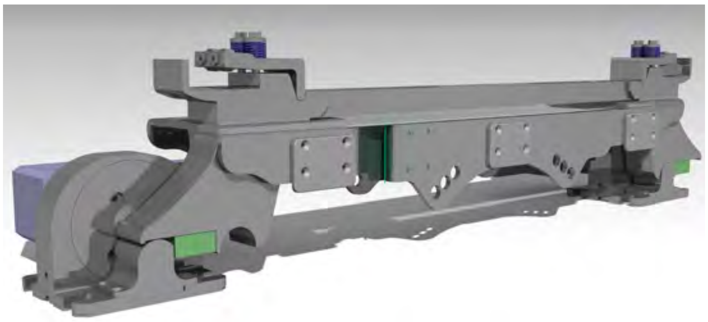


Figure 5 – Repoint bearer internal components.

locking blocks to the bearer base when the switch is in either the normal or reverse positions. It is the hopper that is lifted and translated by the cams to provide the switching motion.

There are two motor/gearbox/cam assemblies in each bearer, situated below the stock rails, each independently driven by an electric motor. Switching time is approximately three seconds. Cam position sensors are fitted to each cam, both to ensure synchronous movement, and to allow recalibration and self-checking following power outage.

There is a separate hand wind mechanism installed in bearer 1 only. Removing the central cover of the bearer allows access to fit a 0.5-inch drive ratchet bar to the hand wind mechanism and set the ratchet for the desired direction of movement. 12 to 15 swings of the ratchet bar are needed to lift the switch to the top-dead-centre position, after which it falls under gravity to the opposite side. If power is available, the detection system continues to operate when the hand wind is used.

Lineside cabinet, signalling interface and power supplies

A full width location case is provided at lineside to house power supply, signalling and control systems. All circuitry has been designed to Network Rail codes of practice – Lineside and On Track Equipment Typical Circuits. DEG Signal, now part of Ramboll, designed the signalling interface and the lineside cabinet for us.

Local controls are installed in a lockable box installed on the outside of the lineside cabinet. These consist of; a normal/reverse selector switch and a mode change switch to change mode from normal operation to maintenance mode. Normal and reverse indications are fitted.

The following circuits are required for point operation:

- Normal and reverse point operation relays – double cut, fed by the normal/reverse rotary switch.
- Latch lock relays.
- A single contactor to isolate the motors.

Detection is fed back to the signalling logic over a two wire polar circuit from normal and reverse contacts in the lock/detection subsystem. Relays are single cut. Normal contacts are closed when detected in the normal position, reverse contacts closed when detected in the reverse position.

Power supply to the lineside cabinet is 240V 50Hz single phase AC. Transformers and transformer/rectifiers within the lineside cabinet provide the following:

- 240V AC to the motor controllers.
- 110V AC for lineside cabinet lamps and heating.
- 24V DC for detection and signalling relay logic, indicator lamps and control electronics.

Control system

The control system is implemented on a National Instruments CompactRIO FPGA (field programmable gate array). The main objective of the controller is to move the actuator bearers as specified by the input from the signalling system. After reading the input, the Central Processor Unit (CPU) sends the command to the six motor controller units to run the motors. Cam position is fed back to the CPU. The 'Lock/Detection concentrator' block continually checks the status of the switch rails. When the actuation is completed a detection signal is sent back to the central processor unit and to the signalling system.

As shown in Figure 6, the motor control consists of three cascaded loops. The outer loop position controller runs on the CompactRIO to synchronise the motors in driving to the commanded position. The two inner loop controllers run on the six motor controllers and regulate motor velocity and motor current. There is no mechanical clutch – the motors drive until a current limit is reached.

The control system has three working modes,

- Service: To move the switch rails as commanded between the normal and reverse positions using the operational bearers.
- Maintenance mode: Allows the operational bearers to be used to bring the switch to the top-dead-centre position to allow access to maintain a non-operational bearer.
- Hand wind: Isolate the bearers from the power source and open the option for hand wind.

Lock/Detection system

The project team could have chosen a conventional detection system, adapted for the motion of the Repoint switch, however, the opportunity has been taken to design a detection system with fault tolerance built in. Each actuator bearer has Hall Effect, non-contact detection sensors. Signals from these are combined and processed by hard wired logic circuits using 4000 series logic chips to give a single normal/reverse output.

In each of the three actuator bearers there are four sensors, two for each of the two switch rails. One sensor detects the rail in its closed (against the stock rail) position, the second detects the switch rail in its open position. Four sensors per bearer and three bearers gives a total of twelve sensors. The lock/detection concentration logic takes inputs from these sensors and consolidates those inputs to provide an output to the signalling system. To allow a degree of fault tolerance, 2-out-of-3 voting will be used for the logic combining information from the three bearers. The arrangement is shown in Figure 7.

Each bearer will only output a 'normal' indication when the normal switch rail is closed against the stock rail and the reverse switch rail is open. Similarly, the bearer will only output

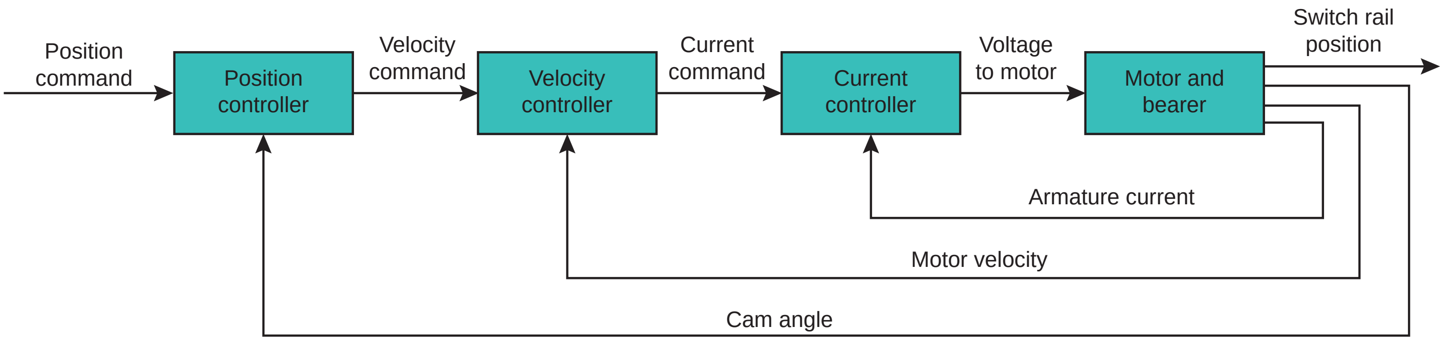


Figure 6 – Control system block diagram.

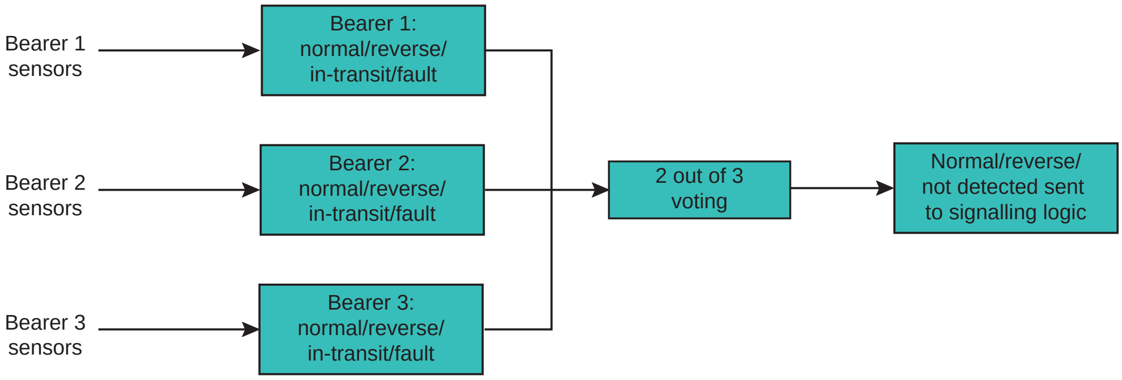


Figure 7 – Detection system overview.

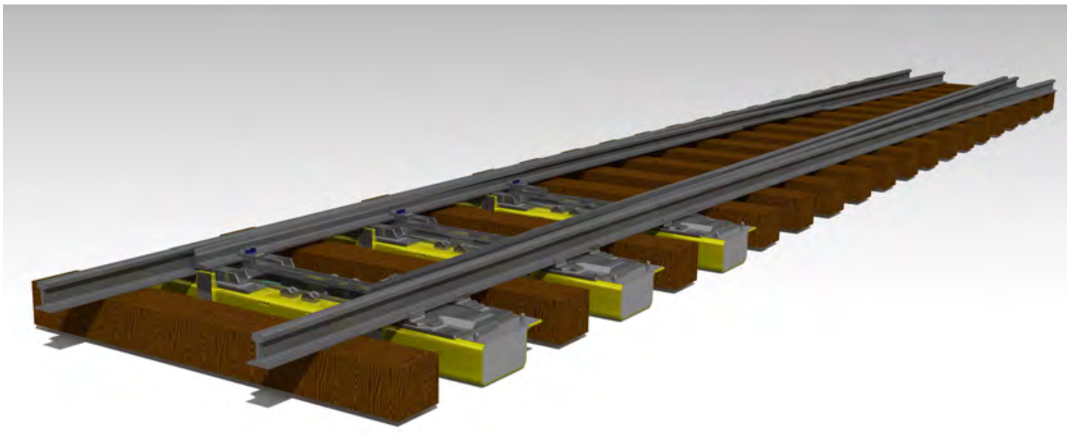


Figure 8 – Switch panel.

a 'reverse' indication when the normal switch rail is open and the reverse switch rail is closed against the stock rail. There are two other possible outcomes; the switch is moving between the normal and reverse positions, i.e. 'in transit', and conditions that can only occur if a fault occurs, for example, the switch rail is detected in two positions simultaneously, or both switch rails are detected closed simultaneously.

To allow fault tolerance in the detection system, a form of two out of three voting is used. If all bearers agree that the switch is on the normal or reverse position, then the switch is detected normal or reverse as appropriate.

If one of the bearers remains in transit, or is in the fault condition, and the other two agree on normal or reverse, then the in-transit or faulty bearer is outvoted, and the switch is detected normal or reverse as appropriate.

If one bearer shows the opposite state to the other two, then the voting does not apply and the switch cannot be detected.

Repoint Light switch panel

The switch panel is a standard switch panel using CEN56 section stock rail, as shown in Figure 8. There are no modifications to the switch panel, except for removing the standard concrete bearers at positions 1, 3 and 5 and replacing them with the Repoint actuator bearers. Progress Rail have been very supportive of the project and supplied the switch panel and the hollow bearer shells. The Repoint Light architecture does not include conventional stretcher bars. The hopper components take on the role of maintaining correct switch rail lateral position. As the switch rail tip position must be controlled, it was assumed that the first actuator bearer should be at the bearer 1 position. Based on an even bearer spacing, possible locations for three actuator bearers are: 1-2-3, 1-3-5 and 1-4-7.

Using bearers at positions 1, 2 and 3 would not provide sufficient lateral support to maintain the minimum flangeway throughout the length of the switch panel. With actuator bearers in positions 1, 4 and 7, it would not be possible for the actuator bearer in position 7, acting alone, to lift the switch rail toes sufficiently to pass over the locking blocks at position 1, in case of failure of the other two actuators. Hence, the remaining configuration, with actuator bearers at positions 1, 3 and 5 is the preferred solution for a switch of this length – a trade-off between having the third actuator bearer sufficiently close to the switch rail toe to lift the position 1 actuator bearer over its locking blocks, and sufficiently far from the toe to provide lateral restraint to the open switch rail.

This is a pragmatic design decision, considering the limited number of possible locations for three actuator bearers in the length of a C switch. A rail bending analysis was performed in order to provide bearer position, cam torque and cam length as inputs to the Repoint Light actuator bearer design.

Repoint test programme

The test programme grew alongside the switch system hardware. It began in the Loughborough University labs, with control system development on the motor controllers, before the first of the bearers was assembled. Further bearer level testing was followed by full system test once the location case was available. We then moved to Progress Rail's Sandicare site to integrate the bearers into the switch panel. Here the complete switch was operated for the first time.

Latterly, the complete Repoint system has been installed in the south yard at Quorn & Woodhouse station on the Great Central Railway, shown in Figures 9 and 10. The location was chosen so that the switch sees some traffic, but we can get access for testing without interrupting normal operation of the railway. The Great Central Railway has been very accommodating and supportive of the project. Testing of trains, on-track plant, and railway equipment is a growing part of their business.

Testing is almost complete. Functional and requirements testing completed to date has shown that the system meets our requirements set. The total number of cycles is building. Some of the potentially damaging test scenarios, such as blockage between the switch and stock rails, have been left until last. We only have one switch – we wouldn't want to break it before we've completed everything else!

Maintenance and condition monitoring

Should a conventional switch machine fail, personnel must go lineside to secure the points before a train can pass. Until that occurs, delays will build and knock on to the point where the timetable could be disrupted for a significant time. Repair, set-up and maintenance work is all carried out trackside, exposing staff to all the associated dangers.

Should one of the bearers fail on a Repoint switch, the condition monitoring system would isolate the faulty bearer and the switch can continue to operate and trains can continue to run. The intention is that this process is transparent to the signaller and the train driver. Neither would need to know that a bearer has failed and there would be no reduction in safety margins.

Maintenance personnel would be informed by the switch condition monitoring system that it was now operating with one of the actuators failed. Plans can then be made to attend and switch out the faulty component. That could be done in quieter time, at night, at the weekend, or even in the next planned possession.

The Repoint switch is intended to be maintained on a line replaceable unit (LRU) philosophy. Faulty or life expired units are exchanged lineside with a known good unit. Repair, maintenance and refurbishment activities are then moved off-track. The Repoint motor/cam/gearbox assembly is designed as an LRU. These can be removed and replaced with a minimum of adjustment.

Drawbacks, pitfalls and things we haven't solved

Of course, no new technology is without its drawbacks, no matter what the salespeople say! Repoint is no exception, and indeed as a university it would be unprofessional of us to pen an article to the signalling community which does not highlight these.

Foremost is the loss of positive vertical restraint of both switch rails via the removal of the kicking strap, necessary to enable the vertical switch rail motion. We are less concerned about the switch unlocking under a train as over 65mm of vertical lift is necessary to achieve this, requiring a vertical force component of many tonnes, and indeed significantly greater than that specified for overcoming traditional FPL arrangements. However, this lack of restraint may allow the switch rails to vibrate under dynamic loads potentially leading to chipped toes or accelerated wear of locking elements on poor track. These effects remain to be fully investigated as part of the next phase

Figures 9 and 10 – A Repoint switch in use at Quorn & Woodhouse on the Great Central Railway.

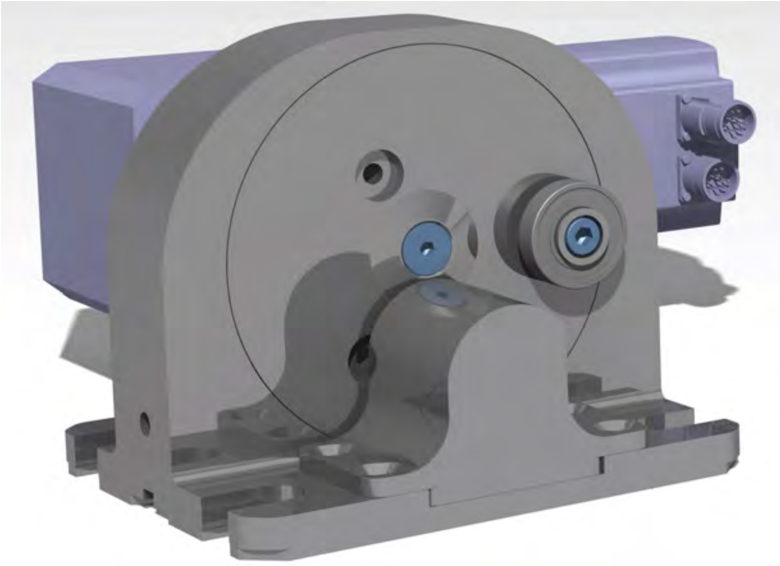


Figure 11 – Motor/gearbox/cam line replaceable unit.

of testing. In any case, wear components have been designed to be as quick and easy to replace as possible.

Secondly, whilst the individual components are simple, the whole system is more complex due to the integration of redundancy and monitoring. Failures caused by human factors are infrequent but nonetheless present with existing designs. If we are eliminating many other operational failure causes at the same time as making the system more complex, then it is reasonable to assume the portion of human errors with Repoint will be higher. This needs to be carefully managed to ensure safety through training, design and monitoring.

Lastly, whilst mean power use is on a par with existing designs, if the switch is set to actuate very quickly, for instance to enable closer headways, the peak power consumption during the first half of the swing can be higher than that of traditional POE. It is worth noting that our average power use is very low and we could actually dump power back onto the DC bus as the rails are braked during the second, 'falling' phase of motion.

Introducing redundancy of key subsystems does not eliminate the risk of blockages between switch and stock rail. All significant blockages would be caught by the detection system, just as in existing designs, but may still represent an operational failure requiring intervention. In fact, for as long as ballast, coke cans or rabbits exist this problem will remain upon any switch design with an opening and closing gap between switch and stock rail.

Blockages form a large part of the remaining 'unsolved' failures, alongside human errors. Some future work may concentrate on redesigning the slide chairs to reduce their surface area, the area where foreign objects generally become trapped. After all as the rails are lifted during motion, the slide chairs are no longer in use for their original purpose of sliding! Inboard of the switch rails is another area where foreign objects could prevent the rails dropping into the locating blocks. This would be managed with simple flexible covers, omitted from the demonstrator.

There is also the potential for common mode failures across software or hardware which negates the use of redundancy, though efforts have been taken to eliminate these too. Though not a feature on our demonstrator, dual incomers and transformers are already used in some locations.

A common-mode example was discovered in our redundant servo motor drives which, it transpired, perform a safety shut-down in extreme temperatures. This was discovered the hard way just before launch day in a late January chill. In that case it was nothing a fan heater couldn't solve, but it is good to learn such lessons on the first prototype and obviously there is a lot of development work and testing between here and deployment.

Future plans

The project, design and engineering has come a long way since the thought exercise was initiated in 2011. Normally, universities don't lead projects beyond around TRL4-5, instead pushing technologies to market by acting as consultants or advisors in one of a range of technology transfer arrangements.

The next steps are production engineering and product acceptance. Loughborough University does not have the expertise to take a system such as Repoint through railway product acceptance, and by its very charter, the university is not legally able to be a point machine manufacturer, and nor does it wish to be! From here onwards, the two obvious routes to market are to form a spin-out or to licence to a manufacturer. Whilst a spin-out is attractive to the engineering team, the commercial reality is that the scale of investment required for testing, our lack of experience in navigating product approvals processes coupled with the potentially long gestation to first sale mean that this is unlikely to succeed without significant backing from a partner with industry understanding, and probably quite a lot of patience. Licensing to an existing manufacturer with the correct resources and drive is therefore the preferred option, and the university are in talks with a number of potential partners with an interest in taking the project forward worldwide.

The team is in no doubt that once the first few units are in service and the benefits begin to reveal themselves on the operator's balance sheets, there will be few remaining reasons to purchase a legacy solution. The idea is a potential world beater, invented, developed, first in track and hopefully soon commercialised from a little town in the East Midlands of England.

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Institution of Railway Signal Engineers

Critical doors

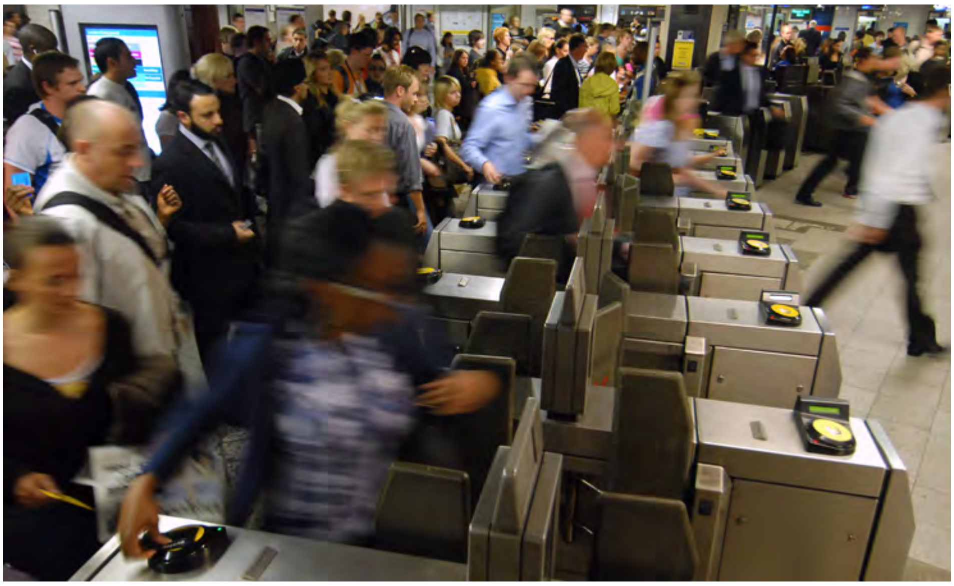
Clive Kessell
Past President, IRSE

Much has been written and said in recent times about efforts to improve the throughput of trains on metro and inner suburban railways. The development of CBTC technology is widely applied on such lines, and on London Underground's Victoria Line it has enabled a 36 trains per hour (tph) timetable to be achieved in each direction.

A dramatic improvement to passenger comfort has resulted and much of the severe overcrowding has been eliminated. Similar predictions are made for other LU Lines and also the Thameslink and Crossrail (Elizabeth Line) services when they reach full fruition.

However, a crucial factor in all of this is the 'dwell time' at stations to allow travellers to alight and board the trains. If the time taken for this is more than a few seconds, then very quickly the delay to following trains builds up and the intended throughput becomes unachievable. A service gap of more than three or four minutes means that crowds increase on the platform such that dwell time is extended at every station and the worsening effect is compounded. Although in theory drivers are not supposed to initiate door closure until everyone is safely on board, in practice they occasionally have to start the closure process whilst people are still squeezing in, otherwise the train would never get underway.

A further factor is now influencing the process, this being to take account of the needs of disabled people, with legislation potentially increasing the dwell time period. Whilst the Rail Vehicle Accessibility Regulations (RVAR) of 2010 (its forebear being the Disability Discrimination Act) is intent on allowing additional time to board, the basis of this prescription may not have been scientifically derived with perhaps a less than optimum situation developing. London Underground was concerned that a negative impact could result and initiated a trial to establish exactly how passengers behave when boarding tube trains.



As footfall increases on urban railways there is increased pressure to provide more and more trains. The number of trains per hour is not just a function of headway and train performance, but of dwell time – the length of time that a train needs to remain in the platform to allow passengers to leave and join the train.
Photo Transport for London.

The door closure sequence

When a train arrives at a station, providing it is proved stationary and at the right location, door opening is initiated by the driver. After passengers have alighted and boarded, a door closure alert signal (known as a chime) sounds for a period before the doors begin to close. Providing nothing is trapped in the doors (see later paragraph), the driver's door close pilot light illuminates and the train start buttons can be pressed for ATO equipped lines or the driver engages traction power if driving manually.

The chime signal time is crucial: the LU standard is 1.75 seconds $\pm$ 0.25 seconds whereas the RVAR (aligned to the Equality Act) requirement is three seconds. This difference, whilst small, can accumulate to several seconds for an end to end train journey and if applied to every train can significantly reduce the overall service throughput. More importantly however, does changing to three seconds make any detectable difference to either non-disabled or disabled passenger behaviour?

One important element is the 'hustle' effect. When the door chime sounds, a regular occurrence is for passengers to hurry into a nearby door so as to avoid waiting for the next train. Regular commuters are adept at knowing which door is nearest the exit at their destination station so will not always board a train straight away when it arrives and instead walk along the platform to the preferred door. Equally, travellers who are not regular underground users and who may be tourists from another country, on hearing the chime will rush to the nearest door often with large amounts of luggage. Any instance of incomplete boarding will result in a door obstruction situation and potential train delay. Any door obstruction takes a minimum of five seconds to resolve so the delay impact can be significant if compounded along the route. Any door obstruction incident is automatically flagged within the train software and sent by WiFi to the server, available for review by engineers within 20 minutes.

Different types of London Underground train have differing solutions to this situation. The most modern trains (Victoria and the S stock on the Sub-Surface Lines) have obstruction detection so that, should an obstruction occur, the door will reopen part way to allow the obstruction to be pulled clear. They also have sensitive door edges where any deformation of the door edge will cause an emergency brake application should the train have started to move. This deformation can be caused by even very thin items which, when caught, would be pulled on as the train begins to move. Older trains are designed to ensure doors are fully closed before traction power can be applied. The latter is not foolproof and items such as bag straps or coat belts can be trapped between the doors and are not always detectable. Unfamiliar users often expect the doors to re-open if an obstruction is detected much as they do on lifts but this is not true for Underground trains or indeed any UK train with sliding doors.

All of this presents a complex set of circumstances which, when combined with the differing views on chime time, meant that a comprehensive trial was necessary to understand more completely the impact of passenger behaviour and minimising the ensuing risks.

The trial

To be meaningful, any trial must know what it sets out to do, the way it will be measured and how the results will be analysed. The intent of this exercise was to assess the impact of different door chime timings with respect to the following aspects of door usage and passenger behaviour: safety, accessibility and capacity (in that order). The trial, which took place on the Victoria Line, consisted of a number of investigations within the context of both a 1.8 seconds and 3.0 seconds chime duration, comprising:

- Door obstruction data, collected from the rolling stock.
- Platform observations.
- Reported safety incidents.
- Passenger survey.
- Service data (dwell times, lateness).

The door obstruction data was the most meaningful in terms of assessing safety: it was used as a proxy for the number of passengers being hit by the doors, an indication of items that could be trapped (risk of dragging), and an indication of the number of passengers running (risk of slips and trips). If LU's concerns about the hustle effect were correct, an increase of door obstructions would be observed.

To be effective, the trial needed to ascertain the before and after situation so data and observations were obtained prior to August 2017 after which the chime duration was changed to three seconds for a duration of six months. The whole Victoria line fleet of 47 trains, each of eight cars, were altered so as to get consistency and accurately observe passenger behaviour. The results have proved interesting.

The door open and close sequence is well disciplined at peak hours with regular travellers standing clear of the doors before getting on to allow passengers getting off to disembark more quickly. This discipline is less well followed during off peak periods when unfamiliar travellers tend to block the door egress thus slowing the whole process. A longer chime duration did allow more time to get out of the way of the doors but equally gave more time to try to board.

The sounding of the chime has always been known to prompt late boarders to run for the nearest door. With 1.8 seconds, the time was insufficient for this to be successful unless very close to a door. Extending the time to three seconds saw an increase of the hustle factor with the result that noticeably more door obstructions occurred. This worsened the safety risks as more doors were striking or trapping passengers, the numbers of trips/falls increased and more pushing/falling of other travellers took place. Clearly there is a linkage between door obstructions and passenger demand with the number of obstructions using a 1.8 seconds chime remaining fairly constant throughout the year, rising slightly between October and the year end. Introducing the three seconds chime saw a marked increase in obstructions during the lead up to Christmas, during the January sales and at public holiday weekends. The overall finding is that off peak, more people run for a door once the chime sounds as the platforms are less crowded, whereas in the peak more people try and squeeze in.

Not surprisingly, the highest number of door obstructions happen at the busier stations. The northbound platform at Victoria was by far the worst with an average of 245 obstructions happening each day during the three second chime period, an increase of 60 (32%) over the 1.8 seconds time. Oxford Circus and Kings Cross also recorded high numbers of around 150, in all cases the longer chime time being marginally worse. At less busy stations the effect was more prominent; at Highbury & Islington southbound in the morning peak, the obstructions rose 80% with the extended chime time and indeed a worsening was noticed right throughout the day. The door obstructions are also markedly different down the length of the train. At Oxford Circus the doors in the second and third rear cars, close to where the interchange for the Bakerloo and Central lines takes place, the number of door obstructions are significantly greater and made worse with the three second timing.

Analysing the trial

Clearly the increase in chime time had a detrimental effect on obstruction occurrences and, due to the safety impact, the Victoria line fleet has since reverted to a 1.8 second timing. That said, it has been necessary to submit the findings to vested interest groups. Presentations have been given to London Underground (DRACCT – Director's Risk Assurance Change Control Team), to Transport for London (TfL) and to the Department for Transport (DfT, in effect the government). The DfT have forwarded the results to the Disabled Persons Transport Advisory Committee (DPTAC). A passenger questionnaire has been conducted in an attempt to establish what passengers believe are the safety risks associated with their journey. Approximately 150 responses

The use of platform screen doors, in this example during a particularly quiet period at Canary Wharf station, allows trains to enter crowded stations at full speed with no safety risk, and also can lead to changed passenger behaviour. System integration is however necessary to ensure optimisation of dwell time.
Photo Westinghouse Platform Screen Doors.

were received, which is considered sufficient to gain some understanding but is a very small sample compared to the approximate 75 million passenger journeys made on the Victoria Line during the period of the trial. Of the 150 responses, 60% considered themselves to have a disability. Oddly the time to board and door closure time feature less than the fear of interaction with other passengers who might in their urgency to board could push people both on the train and on the platform. There was little difference in the result from both disabled and non-disabled passengers.

Overall the trial findings have been well received since there is now hard proof that the three second chime offers no betterment and has a negative impact on safety. The recommendation from LU is that the standard should remain at 1.75 ± 0.25 seconds and this is being considered by the aforementioned organisations. London Underground stress that they are totally committed to improve accessibility across the entire network with step free access being provided at an increasing number of stations and large projects underway to improve accessibility in rolling stock features.

Factors for the future

It may be asked how this trial impacts on other metro/light rail operators and indeed mainline suburban services. Since Docklands Light Railway is part of TfL, the same criteria will likely apply whatever the final outcome. Main line operation is different in that it provides timetabled departures rather than a high frequency, turn up and go service, and as such passengers have more time to plan their journey and associated timings at a station. That said the likes of Thameslink and Crossrail in the central London sections, may be more akin to LU operation.

The eventual adoption of fully automatic trains (Unattended Train Operation – UTO) may well become reality. They exist already in locations worldwide, and for instance on the Paris Metro (Lines 1 and 14) where door operation is programmed automatically dependent on the particular station and the time of day. When the programmed time has elapsed, the doors will begin to close regardless of whether boarding is still taking place or not. Centralised CCTV monitoring of conditions takes place both on platform and train so that remote intervention can happen should anything untoward occur. Travellers have got used to this and it is now part of normal life. The current modernisation of the Glasgow Subway will adopt UTO when completed in the early 2020s.

So, a fascinating subject with many complex interactions. As the population of London increases so the pressure to provide more and more public transport services will mount and the need to be up to speed with technology and optimum routines will become ever more vital.

Thanks are expressed to Zoe Dobell from LU for the information given and who was the project engineer for the trial.

This article was originally prepared for Rail Engineer magazine and is reprinted in IRSE News with the kind permission of the Rail Media Group.

What do you think?

What do you think of the points raised in Clive's article? How relevant is this sort of system-wide thinking to your role in command, control or communications? Is it your experience that the issues raised just apply to metro railways, such as London Underground's Victoria Line, or are you experiencing similar issues with a project you are involved in?

How has your railway overcome these issues, and what learning would you like to share with others?

Would you like to read more articles like this one? Let us know what you think as we value your feedback. You can contact us at **editor@irsenews.co.uk**.

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Headways – what effect does ETCS have, and how do we know?

Darren King, William Barter, Olga Garzon Guinea, Kelvin Yeung and Jelena Jovanovic

WSP, United Kingdom

The authors of this article have reviewed the implications of European Train Control System (ETCS) Level 2 for line headways and other planning margins associated with a high-speed rail project. By developing modelling methodologies based on train movement simulation and using spreadsheet techniques to forecast them, they identified where further signalling scheme development is required in order to achieve acceptable values.

The classic method for calculating a headway is set out in the IRSE's Railway Signalling textbook, summarised as:

T = (xD + O + L)/V + 10, where:

- T is the headway time (in seconds).
- D is the required braking distance (in m) from the full permissible speed.
- x is a factor depending on the number of signal aspects, equal to 2 for 3-aspect signalling, 1.5 for 4-aspect signalling, and by extension to 1.33 for 5-aspect signalling.
- O is the length (in m) of the overlap of the danger signal.
- L is the length (in m) of one of the trains.
- V is the train speed (in m/s).
- 10 is the Sighting Time in seconds (other values may apply).

The 'x' factor reflects that one more section is needed for trains to run on clear aspects than is required for braking distance, and, although 'x' reduces as the number of aspects increases, it is clearly subject to diminishing returns.

There are limitations to this classic method, particularly because signals are assumed to be located optimally for headways, which is almost certainly not the reality, especially with the sighting issues inherent in lineside signalling. In addition, trains are assumed to run at constant speed, ignoring factors such as permanent speed restrictions below the line speed, and gradients that may both prevent trains reaching line speed and influence the braking distance element of the formula.

More complex cases call for modelling which uses computer simulation of train movements. With data on actual signal locations, route alignment and rolling stock capabilities and constraints, the passage of a modelled train can be tracked. The headway at each signal can be found simply by comparing the time at which the train passes it with the time at which the train then releases the overlap that restores the signal to green. Thus the effect of gradient on train movement is implicitly captured, as signals, we assume, will have been located in accordance with the braking curves appropriate to the alignment.

What difference, then, does ETCS make to headways, and how does this affect modelling methodologies?

Decoupling Movement Authorities from block sections

Some factors in the headway are equivalent in Multiple Aspect Signalling (MAS) and ETCS Level 2. The overlap in MAS is equivalent to distance in ETCS from End of Authority (EoA) to Supervised Location (SvL). Train length is common to both, whilst Sighting time is replaced by system response times, likely to be of a similar magnitude. in both systems, one 'signal' section in addition to braking distance is required between trains to allow 'free flow', that is, running on green aspects/ unrestricted movement authorities

The key issue with ETCS is that an updated movement authority (MA) can be received at any point on the route, and not just when a train is within sight of a signal. Section length, other than the 'free flow' section, therefore becomes irrelevant, and the calculation can rely directly on braking distance. So the effect of gradient on braking distance can no longer be assumed from the signal spacing and must be captured in the modelling.

For the same simplistic assumptions as to gradient and speed, an arithmetic calculation can be undertaken by adjusting the 'textbook' formula to:

T = (D + S + O + L)/V + 10, where:

- D is the required braking distance (in m) from the full permissible speed.
- S is the length of the 'free flow' block section (in m).
- O is the distance (in m) from EoA to SvL.
- L is the length (in m) of one of the trains.
- V is the train speed (in m/s).
- 10 is the system response time in seconds.

Figure 1 shows the headway/speed graph calculated in this way for speeds up to 360km/h, breaking down the calculated headway into the contribution of each factor. Just as with the

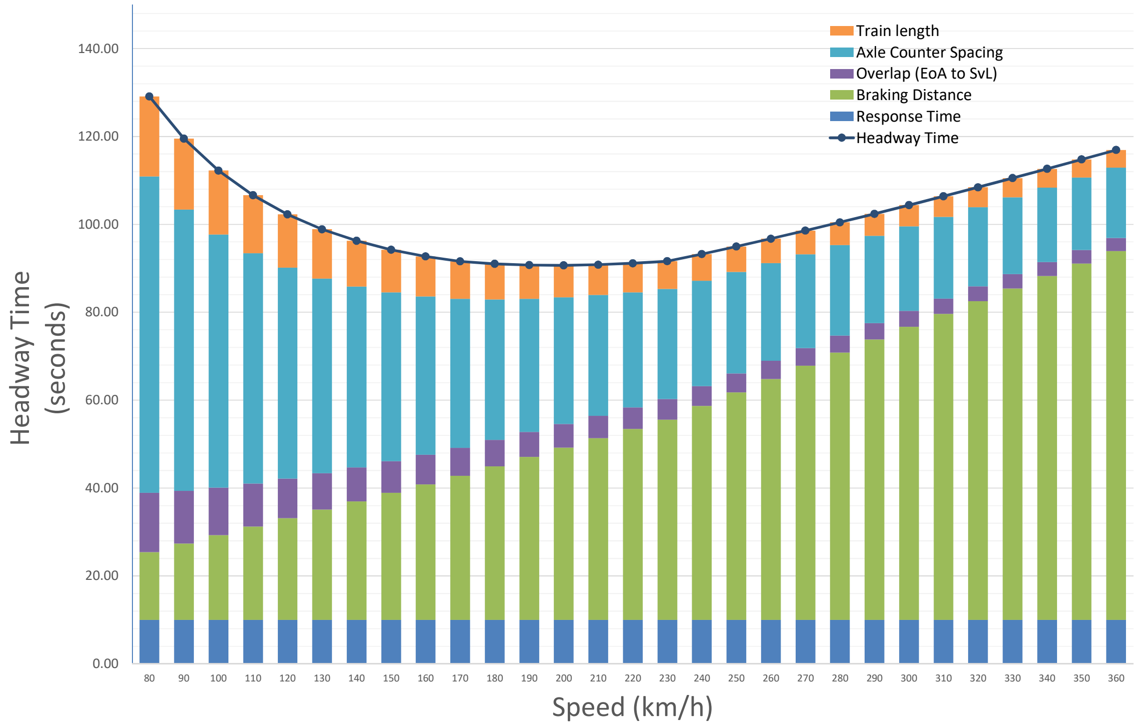

Figure 1 – Headway/Line speed chart for ETCS encompassing high speed operation, identifying components of the headway.

Block section (between axle counters)	1600m
EoA to SvL	300m
Length of trains	400m
System response time	10 seconds
Gradient	Level
Braking rate of trains for seeking movement authorities	360 to 230km/h, 0.54m/s^2
	230 to 170km/h, 0.68m/s^2
	170km/h to 0km/h, 0.72m/s^2

Table 1 – Input parameters for Figure 1.

classic headway: speed curve for MAS, an optimum speed for minimum headway is apparent, not now at 45mph (approx 60km/h) but around 200km/h.

It is possible to make an approximation for the effect of gradient, simply by adjusting the input braking rate by the gradient percentage of G, e.g. adding 0.0981m/s^2 for a train on a falling 1% gradient. However, this has limited value as gradient is unlikely to be consistent throughout a headway distance.

More likely a route will have varying gradients, such as the short but sharp, and frequently-changing gradients that characterise a high-speed line. Here, calculation shows that the negative effect on headway of a falling gradient outweighs the benefits of a rising gradient. For more realistic cases involving switchback routes, more sophisticated modelling is called for.

Refining the analysis to reflect the reality

For train movement simulation, WSP uses the RailPlan system, marketed by Signature Rail of York (UK). RailPlan models movement of trains from data on the route alignment (speed limits and gradients); train mass, tractive effort and braking capability, plus data on the signalling system describing block sections and overlaps.

Having created a simulation in which realistic train speed:/distance behaviour is captured, and block boundaries are identified, the initial process to find the ruling headway on a route is to run a pair of trains at progressively decreasing intervals, until signal checks are encountered. Simulation output can be interrogated to identify which train is being checked where, but a simple and effective check is to inspect the output speed/distance plot for the second train and note when its natural behaviour is interrupted by out-of-course braking. Figure 2 shows a speed/distance plot showing a train checked by signals (green) compared with the free-flow speed/distance behaviour (blue). Projecting the braking profile of the signal check to a stand (red) identifies the section into which a movement authority has been refused, in this case a long section encompassing an OHLE neutral section, also subject to am extended transit time due to speed restrictions approaching a complex junction. Gradient is shown in purple and can be seen to be influencing train speed.

In this case, on a 360km/h route, the train separation identified to just avoid signal checks is 129 seconds, to which an allowance for system response needs to be added. The ruling headway derives from a long section (encompassing an overhead line neutral section), exacerbated by being traversed at limited speed by the previous train thus further delaying release of the section.

This 'Train 1/Train 2' method can be made sensitive to the effect of gradients on braking distance, if the train braking capability is entered as a force/speed characteristic. It is appropriate to find the ruling constraint on headway on a route, but needs an iterative process to identify the longest headway, mitigate it, then repeat the process to find the next.

An alternative method to expose the range of headways along a route was therefore developed. Whilst on a conventional railway the longest headway at any one point is regarded as setting the headway for a route, advanced train control systems may make it possible to take advantage of short headways where they exist in order to separate trains optimally where they do not.

Figure 2 – Speed/distance plot showing a train checked by signals (green) compared with the free-flow speed : distance behaviour (blue).

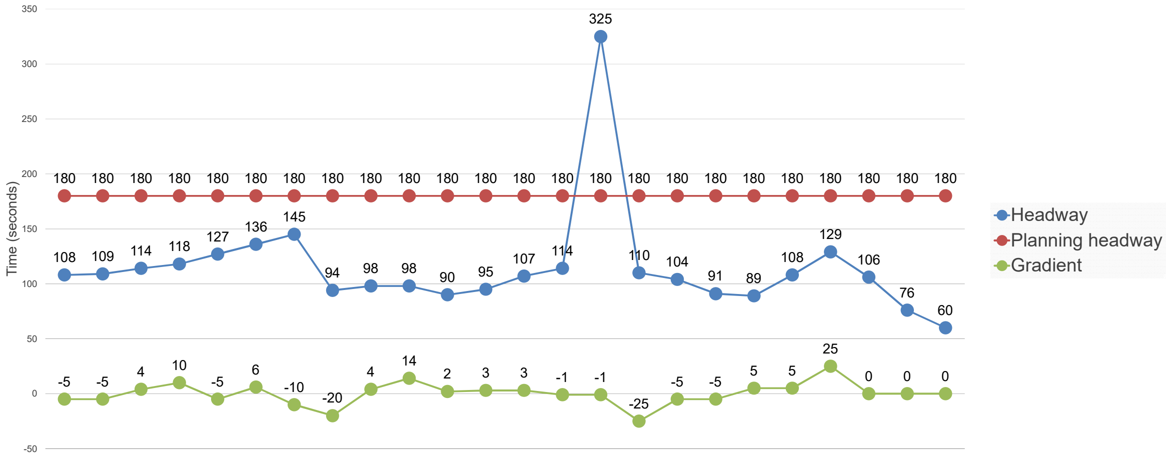

Figure 3 – Example of EBA plot for a section of 230km/h route, showing headways at each block boundary.

Headways along a route

One of RailPlan's outputs is a "Tripwatch Listing" – a detailed statement of a train's journey, giving lines of data at frequent intervals including where route characteristics, such as speed limit or signal section, change. The data reported at each line includes the time, the train's current location and speed, the signal section in which it is moving. Crucially, a change of gradient generates a line of data, and the gradient applicable up to the next line is recorded.

This Tripwatch Listing is the basis of a post-process function termed (for historical reasons) the Emergency Braking Analyser (EBA).

The EBA will, for each line in the listing, read forward to the next, and from the reported initial speed and a user-defined set of braking rates adjusted for the reported gradient, calculate the end speed at the next line. The process is then repeated through subsequent lines until zero speed is reached. So, for every line in the listing , the point at which the train would come to a stand is known, and the difference between the initial location and zero speed location is the braking distance.

From this starting point, we realised that the key to a headway assessment is to select the lines of data at which a train is just making the move from one block section to the next, then read back to find the location associated with the last line of data from which a train can just stop short of the released section. The difference between the times for these two locations, with an adjustment for train length, EoA to SvL and system response time, becomes the headway time.

Our spreadsheet methodology processes the EBA output, identifying, for every ETCS marker board along a route, the headway that leads to it. This way we reflect the actual speed of trains rather than an assumed maximum and capture the effect of intervening gradient on braking distance. Not only is the ruling headway found, but the variation along the route is exposed, so that odd peaks in headway can be reviewed for mitigating action, such as adoption of reduced section lengths. This is shown in Figure 3, an example of EBA plot for a section of 230km/h route, showing headways at each block boundary. The spike to 325 seconds arises at a station where trains dwell for 2 minutes; clearly alternating use of platform faces is necessary if trains are to run at the 3-minute planning headway.

The lesser peaks are attributed to a combination of gradient and section length, and shortening of block sections may be needed to improve them. The gradient data is simply a snapshot at each block boundary rather than the full profile but can still be related to headway outcomes.

The method has proved particularly valuable at locations where there are complex interactions between the factors influencing the headway, so that the location of the ruling constraint may not be obvious and may even be counter-intuitive. Often such locations will be tunnels, which to avoid surface features may present sustained severe gradients, together with section lengths dictated by the spacing of ventilation shafts.

Beyond plain line

The EBA, however, is limited in that it is based on the run of a single train. This is fine for finding headway between trains of the same capabilities that run on the same route and share the same stopping pattern. However, it cannot be applied to interactions between trains on different routes, for instance, for finding platform reoccupation times at a terminus, or where flows converge at a junction. In such cases, we have also utilised RailPlan.

The RailPlan model can be enhanced by adding data on the track layout and the axle counters or track circuits marking fouling points of critical turnouts. The method for identifying, for instance, a reoccupation time at a terminal platform is simply to set up one train leaving the platform, followed by another approaching it. The timing of the second train is then adjusted until signal checks are just avoided, and the reoccupation time is the difference between the departure of the first train from the platform, and the unchecked arrival of the second.

Some conclusions

There does not seem to be a single universally-applicable method for identifying headways and other technical margins. Arithmetic can deal with simple or ideal cases, but such cases rarely apply. The EBA method is excellent for headways along a route, in particular reflecting the impact of varying gradients on braking distance. However, it is not suitable for conflicting routes in complex areas. The 'Train 1/Train 2' method identifies the ruling constraint within a compact, complex area but requires repeated trials to fully understand constraints on plain line.

By applying this range of methods, however, we have gained a practical understanding of the impact of ETCS on planning margins, and thus on the capacity of a rail network. ETCS Level 2 can reduce the plain line headway, principally by decoupling receipt of MA from sight of lineside signals, and even at high speed (360km/h) very low technical headways can be achieved, robustly supporting a planning headway of three minutes.

But we are not just dealing with plain line headways in the open air; in reality routes can include long tunnels with severe gradients that dip below surface features, and a one-train-between-ventilation-shafts rule can extend headways in long tunnels further still. This effect is exacerbated where the release of sections bounded by ventilation shafts is delayed by the slowing of trains to stop at a nearby station.

Moreover, where a railway is characterised by intensity of operation, its terminus is likely to be the key constraint on capacity, rather than the route leading to it. It has been suggested that ATO would allow zero overlaps, thus significantly reducing reoccupation times, but there is no sign of this becoming reality yet.

Our conclusion from all of this is that technology on its own is not enough; the traditional common sense of the signal engineer in 'chasing seconds' by carefully locating block boundaries and overlaps in critical and complex areas must not be underestimated or neglected.

What do you think?

Do we always get the right mix of new thinking and the benefit of experience? Do we make enough use of simulation and analysis? Let us know, email **editor@irsenews.co.uk**.

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The ‘10/16’ incident on four MTR urban lines

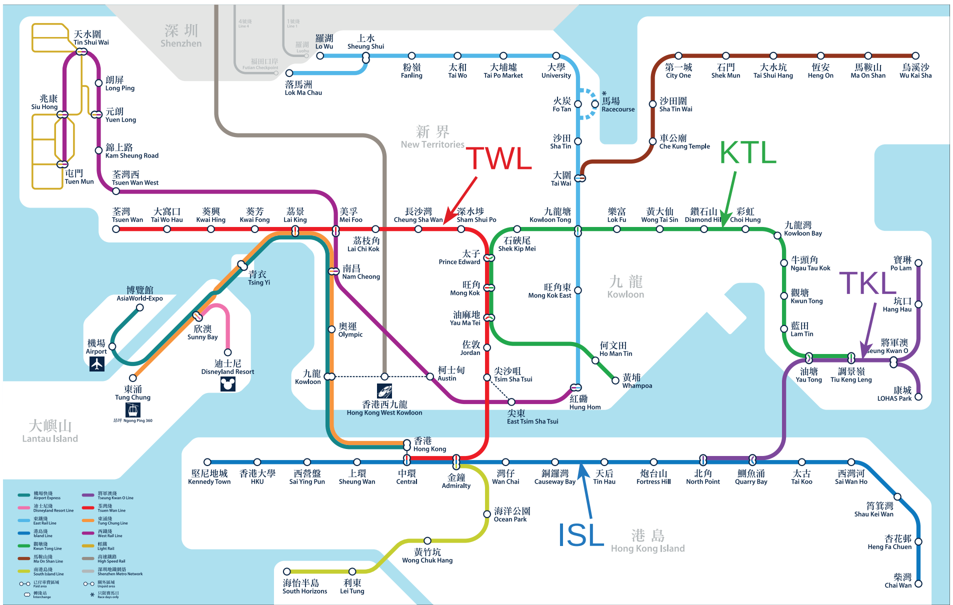
Gordon Lam
MTR Corporation, Hong Kong

The MTR network in Hong Kong was affected by a signalling system failure on 16 October 2018 that was unprecedented in scale as the failure involved four of MTR’s urban lines.

From 0528hrs on that day, the Operations Control Centre started receiving reports that trains on three lines were receiving unstable train control commands. The trains could only be operated in manual restricted mode (RM) during train deployment and preparation before the start of revenue operation. Subsequent to that, about five hours later while recovery on the three lines was underway, trains on a fourth line were reported to be losing train control commands which also resulted in manual RM operation.

Normal service on all four lines was resumed progressively from 0920hrs onwards to 1145hrs. During the incident, all trains in revenue service on the affected lines were operated at low speed with overspeed protection, with all train movements to be authorised by a traffic controller according to procedures. With such an extent of failure, the general public in Hong Kong experienced massive delays and inconvenience in their journeys. Other public transport operators were coordinated to provide emergency support.

This paper aims to share the cause of the incident in relation to a software counter as revealed after investigation. The recovery approach during the incident was praised in the investigation report as inspired despite the huge logistical challenge to an operating railway. The importance of continuous and successful risk control of brownfield signalling replacement work in not affecting normal asset performance was again highlighted throughout the incident and investigation afterwards.

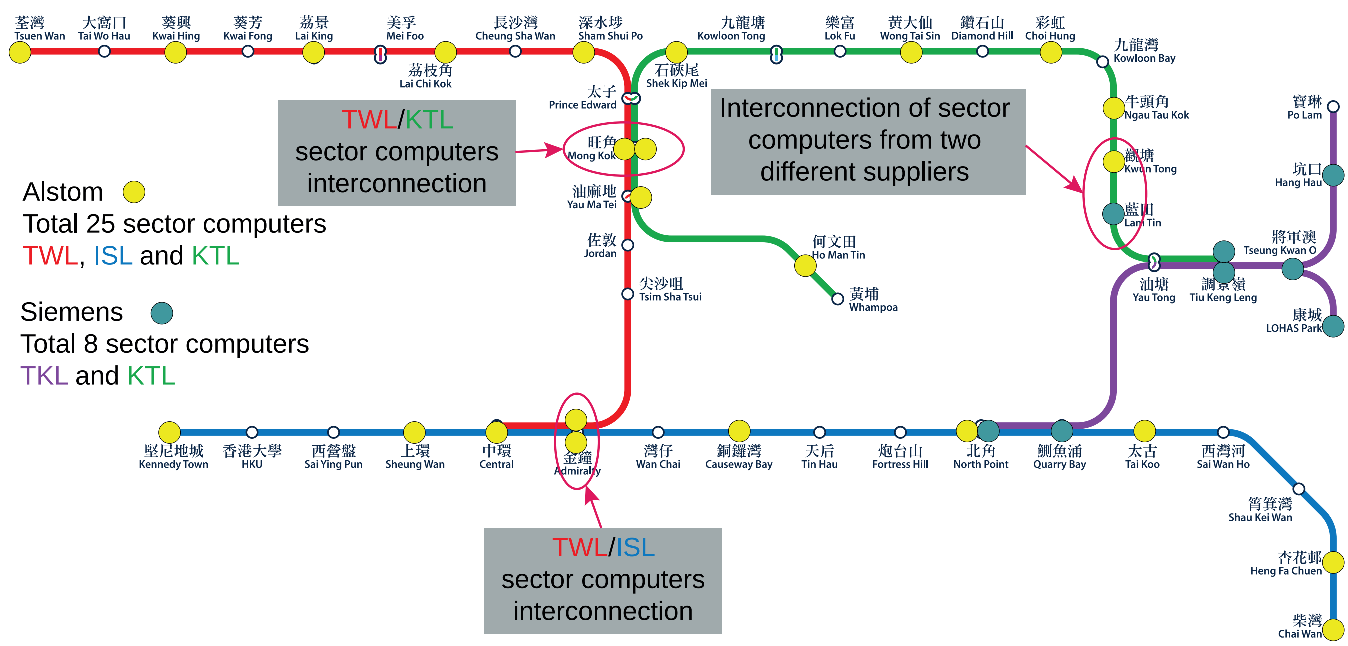


MTR network which includes the Tsuen Wan Line (TWL), Island Line (ISL), Kwun Tong Line (KTL) and Tseung Kwan O Line (TKL). *Image MTR Corporation.*

All the four lines involved in the incident use SACEM systems. The equipment on the TWL, ISL, and most of KTL was supplied by Alstom, and that for the rest of the KTL and TKL by Siemens. The Alstom system is equipped with 25 SACEM sector computers and has been in use since 1996. The Siemens system with 8 SACEM sector computers has been in use since 2001/2002 . Both Siemens and Alstom equipment were provided at different times and differ in detail; however all of the equipment was designed to meet SACEM functional system standards and has achieved operational compatibility during operation in the network.

Sector computers are located in equipment rooms at stations. They serve to deliver train control commands via continuous transmission loops to all trains in each respective sector. Adjacent sector computers are connected to each other by inter-sector links to manage smooth train running between sectors. Inter-sector links also exist between lines to allow trains to cross between lines to ensure operational flexibility and resilience in case of need.

The two suppliers’ sector computers are linked between Kwun Tong (KWT) (by Alstom) and Lam Tin (LAT) (by Siemens) which represents the physical boundary between the two supplied SACEM systems.



The location and suppliers of sector computers on the lines affected.
Image MTR Corporation.

Incident recovery and findings revealed from investigation

At the outbreak of the incident, rebooting SACEM sector computers was the first logical step to be done according to maintenance procedures as used in the past two decades, yet this normally would involve one, or two at maximum, individual sector computers. With failure of four complete lines during the incident, simultaneous rebooting of 33 sector computers with deployment of professional staff to 33 sites across all four incident lines and the time taken in executing coordinated rebooting based on a prudent logical deduction process presented unprecedented challenges to the team. However, the first few attempts of rebooting with the inter-sector links remaining were unsuccessful. Coordinated rebooting was swiftly deemed necessary on site, i.e. with inter-sector links disconnected and re-connection one by one for root problem location identification. After the interconnections between the respective four lines were isolated and all sector computers were effectively rebooted, the signalling systems of the four lines gradually resumed.

An immediate review of the system failure was conducted with both suppliers. Failure scenario simulation was attempted in non-traffic hours and further analysis was carried out shortly thereafter. It was revealed that data transmission between sector computers is always synchronised through an internal software counter in each sector computer. These internal software counters have commenced incremental counting since deployment for revenue operation. Once any individual sector computer is rebooted, its counter will be re-initialised and will immediately synchronise to the higher counter figure for the whole synchronised network. Given this principle, when Siemens sector computers were commissioned and put into revenue operation in 2001/2002, the relevant counters were synchronised to the Alstom sector computers with a higher counter figure, which were installed in 1996. If the counter reaches its ceiling figure, which is bounded by its allocated number of bits, the associated sector computer will halt and need to be re-initialised. However the re-initialisation arrangements for the two suppliers' sector computers are different.

The Alstom sector computers are re-initialised automatically once their counter reaches a built-in re-initialisation triggering point approximately 5 hours before reaching the ceiling figure. However the operators and maintainers had not been made aware of this internal software function. The Siemens ones do not have an automatic re-initialisation function and therefore need to be manually re-initialised through rebooting on site by maintenance staff.

The investigation found that at around 0526hrs on the incident day, the Alstom software counters reached the built-in triggering point for automatic initialisation while the Siemens software counters continued counting up, creating an inconsistent re-initialisation situation between the two sector computers at the aforementioned KWT and LAT boundary between Alstom and Siemens. This resulted in repeated execution of re-initialisation in the Alstom sector computer at KWT followed by re-synchronisation with the higher counter figure from LAT, hence the KWT sector computer became caught in an endless loop causing corresponding instability in all 25 Alstom sector computers connected in the system.

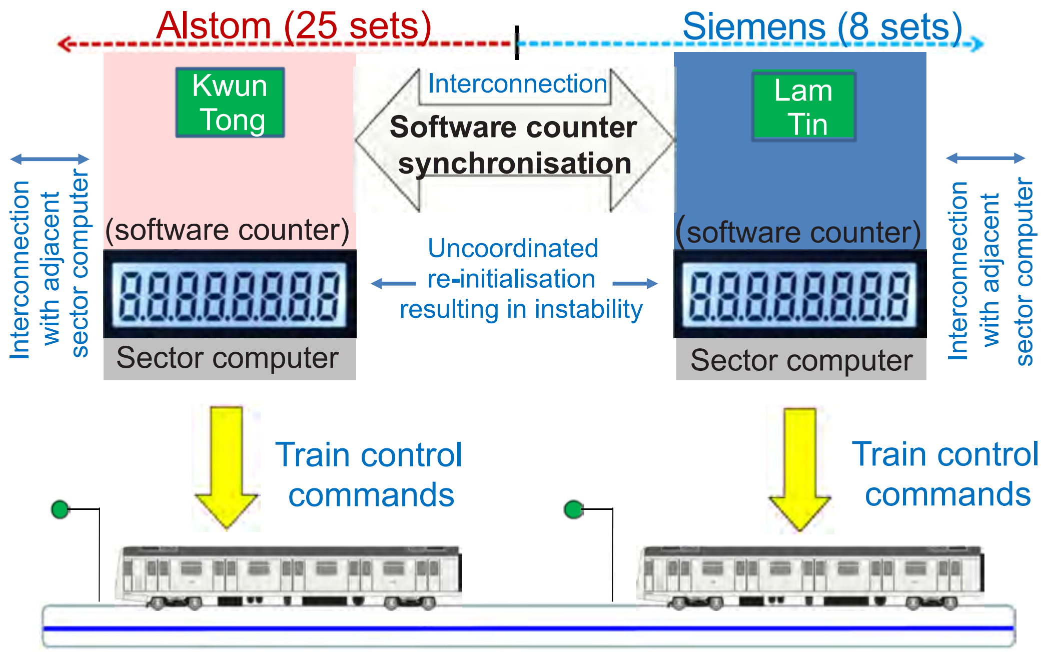
When all the Siemens software counters reached the ceiling figure at around 1022hrs, about five hours after the Alstom software counters first passed their automatic re-initialisation triggering point, the eight Siemens sector computers halted as designed.

After disconnecting the interconnections between the signalling systems of the incident lines and the Alstom and Siemens boundary links, all sector computers were effectively rebooted to complete the entire re-initialisation process and the signalling system for the four incident lines resumed normal.

Simulations during non-traffic hours were able to reproduce the same fault.

Conclusion of the incident and experiences to bring forward

In view of the severity of the service impact, MTR commissioned an executive review panel to establish the facts and identify the root cause(s) leading to the incident, and review the timeliness and effectiveness of the incident response and recovery process. The panel concluded the root cause of the incident was the inconsistent software counter re-initialisation arrangements of the two types of signalling equipment.



Meanwhile it was worth noting that an upgrade project to install a new communications-based train control (CBTC) signalling system has been underway on TWL, ISL and KTL since early 2015. Non-traffic hours train testing on TWL using new CBTC with over-and-back facilities had been conducted the night before the signalling system incident occurred. Immediate focus was given on whether the incident was caused by the testing of the new CBTC system. It was also one of the mandates of the Panel to review the relationship between the CBTC testing and the incident. The Panel, based on the signalling data records and analysis of the events, confirmed that the incident occurred only after the signal replacement project testing work on the TWL had been completed. The signalling system had been switched back to the existing SACEM system around 50 minutes before the incident and trains had operated normally for some time using the legacy system. This timely and clear-cut conclusion was substantiated by solidly established risk mitigation measures applied on daily implementation and testing of the CBTC which aimed to prevent interruption to the existing service. Implementation of such brownfield risk control in the signalling replacement project underway in MTR has been an important focus of recent asset replacement activities. Indeed, similar replacement works on different lines were underway concurrently every night within the MTR network.

Considering the severity of the incident, the results of the Panel review have been communicated to the public. It was concluded in the report that train service was maintained in a safe manner despite operating at reduced capacity during the recovery process. Considering the lack of awareness of the underlying software counter re-initialisation issue, MTR was faced with a multiple line event of unprecedented scale with no easily identifiable cause or source. In these circumstances, the site decision to attempt a whole line coordinated restart was correct but presented an extreme level of logistical challenge, which was finally overcome.

Among a series of recommendations from the Panel, actions completed include regular checking of software counter figures for all relevant lines, and implementation of a maintenance programme for manual re-initialisation of all the software counters in the signalling systems at relevant lines before the software counters reach the relevant triggering or ceiling figure. It was also recommended that a dedicated team with advisors from academia should be established as and when required to ensure the integration and performance of new and modified software-based systems are well controlled.

The four-line incident also posed a more far-reaching question to us – as signalling practitioners, how do we face the challenge of knowing in-depth coding and its behaviour within the system itself, and also consider its interfaces to connected systems? The assurance mechanism to enhance software performance and integration, in view of the deployment of more and more software-based CBTC systems, inevitably turns out to be one of the keys to sustainable and successful operation in the future.

About the author ...

Gordon Lam is the chief signal engineer (operations) overseeing resignalling works and overall signalling development for MTR in Hong Kong. He is a railway signalling engineer with over 29 years' experience covering design, installation, integration and commissioning. He has managed MTR signalling projects in Hong Kong including the Lantau Airport Railway, Tseung Kwan O extension, and Disneyland Resort Line, and also spent over 10 years working in MTR's Mainland China hubs including Shanghai, Hangzhou and Beijing covering implementation of CBTC in hubs, E&M project management, operations management and joint venture company management.

Gordon is a Fellow of the IRSE and serves on the Education & Professional Development Committee and the Executive Committee of the Hong Kong Section.

Industry news

Alstom-Siemens merger prohibited

The European Commission has decided to prohibit the proposed merger of Siemens Mobility and Alstom. The decision means that two companies will continue to work separately and the proposed new railway company will not be established.

The main reason for the verdict was the Commission's concerns over competition in two areas of railway industry – signalling systems and very high-speed trains. The UK Office of Rail and Road (ORR) welcomed the final outcome of the competition review of the merger – "the very significant competition concerns that were identified would have been a bad deal for passengers, freight companies and the taxpayer and ORR have been active in opposing the merger".

French ATO

France: Chairman of France's SNCF group Guillaume Pepy has announced that his company will introduce "semi-autonomous" trains by 2020 and fully-automated ones within five years. The French national operator plans to launch self-driving freight trains by 2021, while the automated passenger service will start in 2023 on the RER network in Paris and its suburbs. The self-driving TGV high-speed trains will run in 2025.

Russia to test self-driving tram

Russia: PC Transport Systems and Cognitive Technologies are working together on the development of a fully autonomous tram. Two-months of trials of the self-driving vehicle are planned for Moscow, with regular service of the automated tram scheduled for 2021.

The self-driving tram is equipped with a computer vision system of up to 20 video cameras located around the perimeter of the vehicle, with up to 10 radars, GNSS sensors and high-precision cartography. The tram driver will be inside the cab during the test rides.

The combination of sensors, cameras and radars is designed to ensure an accurate and reliable detection of road scene objects in any weather conditions (night, rain, fog, snow, blinding light etc.). "The technology allows the computer vision system to efficiently use all the combined 'raw' data coming from cameras and radars", said the chairwoman of Cognitive Technologies, Olga Uskova.

The first Russian self-driving tram is based on the Vityaz-M (literally 'Knight-M') modification of the type 71-931 'Vityaz' developed jointly by PC Transport Systems and Tver Carriage Works (TVZ), part of Transmashholding.

Driverless metro train video

Australia: Transport for New South Wales has released a video documenting the first complete driverless metro train journey in the country, undertaken on the soon-to-be-opened Sydney Metro. See **irse.info/f9eob**.

The network is the largest public transport infrastructure project in Australia's history at a cost in the region of AUD 8.3 billion (£4.4bn, €5.2bn, $5.9bn) and will enter operation later in the year.

The Sydney Metro will allow for a metro train to travel every two minutes in each direction, targeting capacity of approximately 40 000 customers an hour .

Paris metro driverless train testing

France: Alstom has commenced dynamic testing of the MP14 driverless rolling stock on Line 1 of the Paris metro at night and out of normal passenger service running, with testing continuing until summer 2019. The dynamic testing in checking the train's performance in terms of braking, traction, electromagnetic compatibility, acoustic comfort, and climate comfort. The driverless electric multiple units will ultimately run on Paris's Line 14.

The new trains, part of Alstom's Metropolis platform, are two cars longer than the rolling stock they will replace on the line (six-car MP05 trains). 72 new trains will be delivered over a period of five years at a cost of just over 1 billion euros. Like their predecessors, the trains will be rubber-tyred.

The MP14 rolling stock will reduce energy consumption by 20 percent compared to the previous MP05 rolling stock. These new trains will also be more comfortable for passengers with for example the noise levels inside the cars reduced 40 percent. The seating design is more ergonomic and there are also seats specifically for passengers with reduced mobility.

The MP14 rolling stock will in time also run on Line 4 in a six-car configuration in 2021 and on Line 11 in a five-car configuration with driver in 2022 respectively.

The operator, Régie Autonome des Transports Parisiens (RATP), re-signalling programme was initially called Offre Urbaine Renouvelée et Améliorée Gérée par un Automatisme Nouveau (OURAGAN), which means a renewed, improved, automatically controlled urban offer, but was later renamed as the OCTYS system. The signalling system of the metro is based on OCTYS-CBTC (communication-based train control).

Train testing of track circuits

Australia: Sydney Trains has engaged ERTMS Solutions to deliver their TrackCircuitLifeCheck system mounted on one of the Mermec Roger 800 MTP vehicles to cover the network every eight weeks. This is to assist predictive maintenance of track circuits to prevent delay causing failures.

The track circuit measurement instrument can be installed on diagnostic (or commercial) trains, to perform an automatic diagnosis of AC and DC track circuits to implement a preventive maintenance strategy, based on multi-data of the same track circuit in time and deviation analysis.

New SSI Technician's Terminal

UK: Park Signalling Ltd has received full and final product acceptance from Network Rail for their MT04 -Technician's Terminal, for the replacement of the original Solid-State Interlocking (SSI) Technician's Terminals.

The MT04 has been developed using standard Commercial Off-The-Shelf (COTS) components and is directly compatible, replicating the feel and functionality of all original and existing equipment. USB pen drives have been provided for event logging and event data recovery in a controlled manner.

A user group is planned for the product to increase and add to the existing functionality, and to meet the requirements of the maintenance areas across the UK.

Japanese high-speed train 5G trial

Japan: Japanese company NEC Corporation has undertaken a high-definition video transmission test utilising 5G connected to a high-speed train. The test was conducted by compatriot firms NTT Communications Corporation, NTT DoCoMo and Tobu Railway. NEC provided a 5G base station.

This 5G test was conducted in Kasukabe City, Saitama, Japan, using a train on the Tobu Skytree Line from 17 – 21 December 2018. NEC said that 4K and 8K high-definition videos were transmitted from a 5G base station installed along the railway, using the 4.5GHz band and 28GHz band, to a 5G mobile station located inside a train running at approximately 90km/h and projected on a large display in real time. In addition, the videos were transmitted to 40 smartphones on the train via wireless LAN.

NEC, KDDI and Obayashi had already carried out a successful field trial in remote construction using 5G and 4K 3D monitoring in Japan in February 2018. The companies say they aim to realise advanced construction technologies utilising 5G through a number of field experiments.

Irish rail new train protection system

Ireland: Currently, over 50% of the Irish network has no automatic train protection, and the existing train protection systems in operation – Continuous Automatic Warning System (CAWS) and Automatic Train Protection (ATP) – are nearing the end of their life expectancy.

Irish Rail (Iarnród Éireann) has appointed Turas, a joint venture between CPC Project Services (CPC), Deutsche Bahn and Egis, to deliver a new train protection system across its network. This will deliver safety and reliability improvements for the 45 million passengers travelling on the network each year. The new Train Protection System (TPS) will be deployed over the next seven years and will be a hybrid system based on the existing CAWS and ATP systems and ETCS (European Train Control System) Level 1. It will provide automatic train stop, set train-regulated line speed and ensure compliance with speed restrictions.

RailWorx 2019

UK: RailWorx is a new-for-2019 outdoor exhibition for the rail engineering and systems industries. Co-located with PlantWorx, the Construction Equipment Association's biennial show, the new joint show will take place at The East of England Arena, Peterborough, on 11-13 June 2019. See irse.info/6ubm1.

RailWorx features will include: The Drone Zone – drones are increasingly over the railway; Dedicated 'InnovationWorx' area showing the latest developments by the Network Rail Signalling Innovation Group SIG and in the fields of electrification and telecommunications; Major civil engineering contractors, Live demonstrations of machinery and plant used for railway engineering, including piling, reinforcing, access, lifting, surveying and monitoring and 'Consultants Row' to meet the industry's designers and consultants.

IRSE
Institution of Railway Signal Engineers
MIDLAND & NORTH WESTERN SECTION

Midland & North Western Section technical visit and annual luncheon

With the kind assistance of Haywood & Jackson Fabrications Ltd and the Churnet Valley Railway (CVR), the 2019 technical visit and steam lunch will take place on Saturday 29 June at the Churnet Valley Railway, Staffordshire. The programme is: 10:30 arrive for a briefing of the re-signalling and tours of signal boxes, 12:46 the luncheon train departing Consall station to Ipstones Loop and back. The visit will conclude at 15.50 and members and guests may attend just for the lunch should they wish.

A three-course meal will be provided and menus are currently being prepared. The cost of the event, including train tickets and luncheon (excluding beverages) is £45 per adult and £35 per child (aged 5-15). All children attending must be supervised individually by an adult.

To confirm your attendance, please email acw-57@ntlworld.com and ian.james.allison@sky.com. Payments can be made electronically to sort code 09 01 51 account 09065506 (preferred), or cheques made out to "IRSE Midland & North Western Section" sent to Clive Williams at 4 Mill Rise, Kidsgrove, Stoke on Trent, ST7 4UR, no later than 1 June 2019. For any further details, please contact Ian James Allison on +44 (0)7794 879286.

News from the IRSE

Blane Judd, Chief Executive

Blane's World

Engagement with other organisations is gathering momentum as I continue my mission to raise awareness of our Institution and encourage stakeholders to see the importance of professional registration in our shared safety critical environment.

At the IMechE annual luncheon I sat next to the CEO of Network Rail, Andrew Haines, where we discussed the Waterloo incident and IRSE engagement with the Network Rail team. At a later meeting of Engineering Council licensed institutions chief executives, I discussed closer working relationships with other similar bodies, including the new CEO at the Permanent Way Institute. To further this objective I also met with Darren Caplan, CEO of the Rail Industry Association to lay the foundations for collaboration on future signalling projects.

The nominated charity for this year's AGM was RedR, an international engineering charity that trains and supports aid workers and humanitarian organisations (see IRSE News March 2019 issue for a feature about their excellent work.) Together with now IRSE president (then SVP) George Clark, I attended the charity's annual reception where we had the honour of being presented to its patron Her Royal Highness The Princess Royal.

I co-hosted the well-attended joint IRSE/INCOSE workshop on 11 April with outgoing president Markus Montigel which gave delegates the opportunity to be involved in a simulated digital signalling upgrade.

As an institution, the IRSE recognises outstanding performance and achievement through presenting a series of annual awards. It was my pleasure to join John Penny, the chairman of Signet Solutions, to interview this year's winner of the IRSE-Signet Award. The award is presented to the candidate who obtains the highest marks in any single module of the IRSE examination. The result of this year's award was announced at the AGM on 26 April and will be covered in a future IRSE News. You can read more about this award and other IRSE awards in the 2018 Annual Report which was posted to members with the April IRSE News.

In the London offices of the IRSE we continue working with Acuutech on our IT modernisation programme and are overseeing the final stages of the new website development project with Cantarus. Staying on the digital theme, I met with IET.tv to discuss future arrangements for live streaming and broadcasting of IRSE events. Live-streaming has to be of a standard commensurate with the professionalism of our Institution and IET.tv has the expertise to deliver this.

AGM and Annual Dinner

The IRSE's Annual General Meeting was held on Friday 26 April 2019 at the IET, Savoy Place, London, following which our president for 2019-20, George Clark, delivered his Presidential Address (which you can read elsewhere in this edition of IRSE News).

Council members for 2019-20

The result of the ballot for the election of IRSE Council members to serve in 2019-20 was announced at the AGM on 26 April. The Council now comprises:

IRSE Council 2019 – 2020	
President	George Clark
Vice presidents	Daniel Woodland, Ian Bridges.
Members of council from the class of fellow	Jane Power, Peter Allan, Rod Muttram, Ian Allison, Pierre-Damien Jourdan, Steve Boshier, Yuji Hirao, Andy Knight, Bogdan Godziejewski, Gary Simpson.
Members of council from the class of member	Rob Burkhardt, Martin Fenner, Ryan Gould, Lynsey Hunter, Cassandra Gash, Paul McSharry.
Members of council from the class of associate member	Keith Upton, Xiaolu Rao.
Co-opted past presidents	Markus Montigel, Peter Symons, Charles Page.
Chief executive	Blane Judd

International members welcomed by Council

The Council was delighted to welcome members from the Indonesian, Japan and Netherlands sections at its March meeting. While he was visiting the UK, Toni Surakusumah also took the opportunity to present senior vice president George Clark with a traditional Indonesian folklore statue.

Annual Lunch London

The 21st IRSE Annual Members' Lunch will take place at the Union Jack Club, Sandell Street, Waterloo, London, SE1 8UJ (near Waterloo station) on Wednesday 12 June 2019.

A three-course lunch with wine and coffee will be served at 13.00 hours and tickets for the event can now be purchased. Please note that the Lunch is for IRSE members only. This event is for all members, regardless of age or employment status. It's a great way of networking and meeting up with both current and former colleagues in an informal social setting. Our president, George Clark, will be speaking.

For more information, and to book, please visit the IRSE website (irse.info/914jd).

Presidential Programme 2018/19

The first event of the Presidential Programme 2018/19 will take place on 18 September in London. This is a seminar on future railway mobile communications systems (FRMCS) being held at 1 Great George Street which will be an excellent opportunity to debate and contribute to the industry's thinking on what takes over from GSM-R. For more information, and to book, please visit the IRSE website.

Midland & North Western Section

ElectroLogIXS introduction to service

Report by Paul Darlington

For the February meeting Ian Bridges and Peter Harbottle welcomed 30 members and guests for an update on the production and introduction to the UK market of SNC-Lavalin Atkins' ElectroLogIXS electronic interlocking. The ElectroLogIXS, is a flexible ladder logic driven device that deploys software written using the Atkins Signalling Method (ASM). The talk covered what the hardware looks like, how the data is produced and how it is supported by the telecoms network.


All trackside equipment is contained in a smaller number of location cubicles with no equipment buildings required, thus saving both cost and space.

After a demonstration of the system under test it was explained that the introduction of the ElectroLogIXS interlocking in the UK is intended to remove reliance on existing interlocking products and solutions, with the system enabling the rationalisation and reduction in the quantity of trackside cabling. Standardisation of equipment and lower number of trackside equipment location cases is another benefit, which should deliver significant CAPEX and OPEX savings. There will also be no reliance on bespoke software languages used in previous electronic interlocking technologies, with the system designed to be future proof, scaleable and ETCS compatible.

Repeatable data modules

It was identified some time ago that the industry could only supply a limited number of interlocking solutions for UK market and more suppliers were needed to provide additional capacity. There were also limited design resources available to design and verify existing solutions. The solution developed by Atkins is to use readily available non discipline specific software engineers, rather than scarce signalling designers. This allows signalling engineers to focus on the core functional signalling requirements. With traditional SSI interlockings there was a disproportionately large number of data errors leading to wrong side failures, so new methods of new data production and testing methods using defined mathematical proving processes were needed.

Designing and testing of interlocking data was taking a long time so one requirement was for repeatable data modules, designed and tested once and used many times. Some current interlocking technology, SSI trackside functional modules for example, are reaching the end of their life, so new equipment solutions are required. Not all UK systems are capable of migration to ETCS, so an interlocking capable of communicating with a Radio Block Centre (RBC) was required. Network Rail's Technology Strategy requires new interlocking technology to comply with the EN50128 data development process, so the ElectroLogIXS interlocking creates a new solution that is designed from the start using EN50126, EN50128 and EN50129.

The ElectroLogIXS hardware is manufactured by Alstom (formally GE) and is a Vital Logic Controller (VLC) using internet protocol (IP) communications and advanced diagnostics via the Scaleable Remote Condition Monitoring system and a common hardware platform for both trackside and control.

Application data is written in ladder logic, with the ElectroLogIXS chassis-to-chassis communication using RP2009 (SIL4) protocol with no safety reliance on the network i.e. SIL0. The equipment product acceptance has been developed to cover 'interlocking' and 'level crossing controller' applications.

The compliance with EN50128 is considered a step change improvement in safety when compared to SSI data software with automation of the design process along with the production of the ladder logic, which is tested mathematically. This enables far more testing to be done automatically.

The interlocking is provided in three sizes, with either a one, four or nine slot capacity. New input/output cards have been designed for the UK that are 'hot swappable' with personality modules provided to ensure their correct location in the chassis. The hardware is designed to work reliably between -40°C and +70°C. The power supply requirements are only 70W with an internal 5V supply derived from a 12V external feed. The processor is a two-out-of-two arrangement that can handle 10 000 vital equations with a MTBF of 1.3 million hours. Up to 32 interlockings can be multi-dropped together if required, making it truly scaleable.

Top left: Far left are two control centre cubicles, coloured red and yellow, and to the right Multi Service Network (MSN) interlocking and MCB-CCTV cubicles.

Left: Location case suite arrangement with Functional Supply Point FSP, SIG2 and SIG1 and telecoms copper and fibre cross connect cabinet.

Above: Interlocking cubicle containing ElectroLogIXS and network switches.

The lineside network consists of Layer 2 network switches (housed within each signalling location case) and the control centre network consists of Layer 3 switches (housed within each cubicle). The Network Rail telecoms network FTN/FTNx is used to 'bridge the gap' between the lineside and control centre elements of the network.

Atkins Signalling Method

A significant change in approach to the design of a scheme has been the introduction of the ASM. This is intended to maximise overall efficiency across the design (including interdisciplinary design interfaces), procurement, installation, testing and commissioning. Deviations from the ASM are prohibited without the formal agreement of the ElectroLogIXS Technical Authority group, to avoid changes that appear to give a benefit (e.g. less materials) but actually cause inefficiency on the scheme, or to Atkins' business as a whole. The ASM also allows the use of another programmable logic controller (PLC) hardware platform in the future far more easily than was the case with previous bespoke designs

The lineside fibre solution uses a 24 fibre to NR/PS/TEL00014 between FTN access nodes to form a sub access layer to the telecoms network. This is supplemented with a two fibre pre-terminated fibre cable provided by CommScope to the lineside equipment.

Future enhancements may include integration with Intelligent Infrastructure, IP enabled barrier machines, IP enabled signals, integration with ETCS and level crossings, VoIP telephony, replacing ElectroLogIXS VLC with a commercial off the shelf PLC product and radio-based communications between lineside 'Objects'.

Level Crossing in a Box

The 'Level Crossing in a Box' (LCiaB) as a concept arose from the idea of delivering a complete crossing in a container ready for installation. This has now evolved to an element of 'just in time' delivery, but the concept of a complete and ready to install crossing is now available.

Currently LCiaB is specified for MCB-CCTV (manually controlled barriers with closed circuit television), but it has been designed so that is can easily be configured other types of MCB. A similar miniature stop light (MSL) crossing system is currently in development.

The barrier machine, supplied by Newgate, is also new to the UK signalling market and is 110V AC powered, with the boom driven by a three-phase inverter and motor through a gearbox. Angular detection of the barrier is by factory set rotary blades detected by proximity sensors. There are a pair of industrial safety switches which mechanically detect the drive spindle when it is in the lowered position.

A small safety controller (PLC) provides machine control via a set of 24V DC control and indication lines connected to the Level Crossing Controller (LXC) case. Manual operation is achieved with a small hydraulic pump and cylinder system. A machine has already completed 3 000 000 fault free operating cycles, and the testing continues at the factory.

The presentation from Ian and Peter was very comprehensive and the audience were very engaged. Questions from the audience were competently answered. The choice of a two-out-of-two processor was questioned and it was identified that a three-processor configuration was only required for reliability purposes, and that the two-out-of-two ElectroLogIXS processor design has an acceptable MTBF specification. Other members questioned if the +70°C level was adequate for within a trackside location, especially with global warming and last year's hot summer. Atkins believed it was, but would keep the issue under review and the use of another hardware processor solution using ASM, or to retrofit of forced air cooling are two options available for tomorrow's engineers.

The M&NW Section would like to thank the presenters for their excellent talk and to SNC-Lavalin Atkins for their hospitality and the opportunity to look at the equipment under test conditions.

London & South East Section

The application of digital technologies on Thameslink

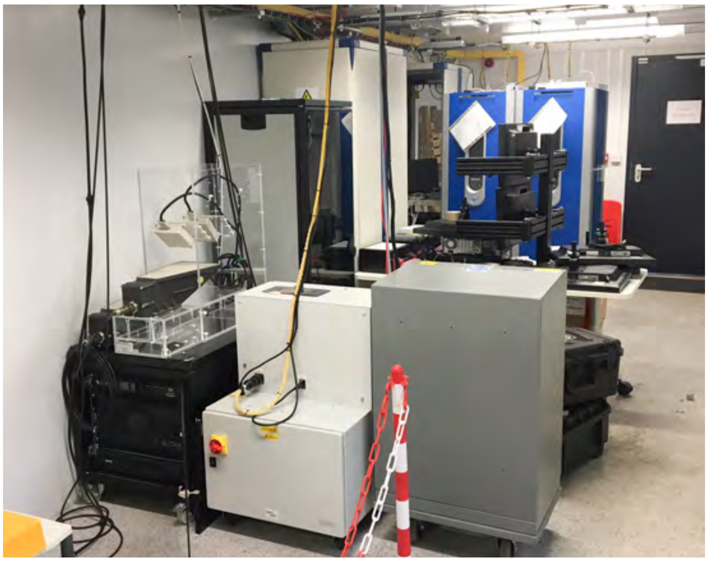
Report by Trevor Foulkes

On Thursday, 24 January 2019, 66 members and 38 visitors attended a very interesting lecture on the application of digital technologies on the Thameslink project, at Transport for London's new headquarters in Stratford, East London. The lecture was given by two principal programme engineers from the project: Tom Chaffin (telecoms) and Stephen Brown (signalling).

The Thameslink route is a main line railway through central London linking St Pancras to Blackfriars. This allows services from Bedford, Peterborough and Cambridge in the north to Horsham, Brighton, Caterham, East Grinstead, Tunbridge Wells, Maidstone East and Ashford International in the south. Tom explained that the Thameslink Programme is a UK Government funded scheme with three main parts: a £4.6bn infrastructure investment led by Network Rail; a £2bn rolling stock delivery consisting of new Siemens Class 700 electric units (55 x 12-car and 60 x 8-car), which work on 25kV AC overhead and 750V DC third rail; and the creation of a new train operating franchise covering all of these services.

The aim is to run 24 trains of up to 12-car length through the core in each direction every hour. In addition to the extensive work on the signalling and telecommunications systems, there has also been a substantial amount of civil engineering work to provide grade separated junctions and additional lines undertaken. The Thameslink operation is complicated, as most of the lines also have traffic from other operators into other London terminals.

The signalling system in the core is designed to support an operational headway of 120s so they can recover from perturbations. To provide a consistent train performance, this is provided by ETCS Level 2 with Automatic Train Operation. There are conventional signals, but a train operating under ETCS can make use of smaller blocks, which are normally shorter than a train length. The communications to and from the train are provided by Network Rail's GSM-R network. The network had originally been provided only to support voice communications, so it had to be enhanced significantly to provide the required data capacity, improve the availability and provide the enhanced coverage levels required for ETCS. As the ETCS system uses circuit switched data, extra base stations had to be installed and additional frequencies allocated. Although this was a challenge in London, which already uses the majority of the available frequencies, interference issues only occurred on the approaches to the core section, this being underground. Once all the work had been done, the first ETCS test train was run through the core and it worked on the first attempt.



The use of system integration has been at the heart of the Thamesilnk project, as shown here in the laboratory where a range of test equipment can be tested as a complete system.

To achieve this the Thameslink project had set up a system integration laboratory, comprising of a signalling interlocking, a radio block centre, three GSM-R base stations (from Network Rail's reference network), train equipment and simulation equipment. This proved to be invaluable in testing and debugging the complete ETCS system, as well as for the development of operational rules and procedures, prior to, and also during, testing in the core.

Tom then went on to explain that, in addition to GSM-R, the project also had to support the Airwave (TETRA) and Fire Ground UHF systems in the core tunnels to support the emergency services.

One of the main challenges of Thameslink is to operate the railway so that trains arrive at the entrance to the core at the right time. This is being addressed by a traffic management system from Hitachi Rail Systems Europe called Tranista. It is deployed in two modes 'interfaced', where the system directly calls the routes, and 'isolated', where suggestions are given to signallers to implement. The system receives the expected timetable and real time train describer data and uses these to identify conflicts. If found, it offers suggestion to the controller on how they may be overcome. The system also provides outputs to Darwin, which feeds the national rail enquires system and customer information systems at stations.

Stephen then talked about the signalling private network. The network is designed to support signalling and ETCS and covers the London Bridge equipment room, the radio block controller, ten remote relay rooms and the Three Bridges Rail Operating Centre (ROC) from where the core is controlled. The network is completely Internet Protocol (IP) based including interfaces to the Trackguard Westrace Trackside System components. The network was developed jointly by the Network Rail part of the Thameslink Programme, Network Rail Telecom (NRT) and Siemens Mobility Limited. Following much discussion, the system was managed from NRT's network management centre NMC, with NRT managing the network. The network was also given a new name: the Thameslink Signalling Private Network (T-SPN) or teaspoon! The network will be expanded to support future signalling stages. One issue which had occurred was that technicians and installers were not used to working on a managed system, and their activities caused many alarms to be displayed at the NMC. To avoid these being managed as faults, stickers were provided at all locations to remind staff to phone the NMC before taking any action.

Tom then talked about a further use of IP, this time to support the public address, closed circuit television, customer information systems, electronic access control, building management systems, lighting control and disabled toilet alarms within London Bridge station. Block wiring and dark fibre connectivity to the retail units in the station was also provided by the scheme. This involved the use of power-over-ethernet cameras and, during the stage work, converting analogue camera pictures into digital format for recording and remote surveillance.

The customer information displays at the Thameslink stations are provided at intervals along the platform to avoid crowding round the displays. They provide clear information on station stops for both next train and following train plus the destination of the six subsequent trains. This helps to allow passengers to board the correct train quickly (with a requirement of 42 seconds for everyone leaving and joining at a station). To maximise this use of this time the trains have wide quick-acting electric sliding doors, which open automatically in the underground core section when the train stops at the platform. The dwell time and any station congestion is monitored at the Three Bridges ROC, so issues are quickly bought to the operators' attention.

At the conclusion of the talk, there were interesting questions raised which were ably answered by Tom and Stephen. Trevor thanked them for their very informative presentation. Slides of the presentation are available at irse.info/3dvf2.

Radio equipment in the Thameslink system integration lab.

The Thameslink signalling private network or T-SPN has been nicknamed 'teaspoon'.

The IRSE Audit Committee needs you …

One of the many important things any business must do to ensure it is working as intended is to carry out periodic audits. The IRSE is no different and has an Audit Committee to undertake this activity. The Committee targets undertaking two audits per year across most aspects of its business, including local sections, Council, and the various other committees that undertake the Institution's business. They aim to meet four times a year, either face to face or by video conferencing, to plan the upcoming audits and review findings. Once complete, a short report is composed, which the chairman presents to the auditee and to Council. Any corrective actions or recommendations identified in the audit are discussed with the auditee and agreement reached on a way forward.

The Audit Committee consists of a chairman, currently Ian Bridges, and four auditors, currently Jane Proc, Keith Walter, Pradip Roy and Paul Darlington, who have all covered their roles for the last five years. However, some members are standing down to take on other IRSE activities and it is now time to start the process of finding new auditors.

This is an interesting way to learn about how the institution works and supports its 5000+ members across the globe. By being a member of the Audit Committee, you will be contributing to the continuing development of the IRSE and ensuring the organisation complies with its processes and regulations. It will also assist your CPD. If you believe you are inquisitive, able to analyse processes and can contribute to improvements in systems, then this may be an excellent opportunity for you.

If you would like to volunteer to chair the Audit Committee or be a member of the audit team, please get in touch with the IRSE office, hq@irse.org.

York Section

Institution of Railway Signal Engineers
YORK AND THE NORTH EAST SECTION

Section Dinner 2019

Report by Paul Darlington

The York Section dinner was held at the National Railway Museum York on Thursday 21 March. Sponsored by Siemens Mobility Limited, guests enjoyed a splendid evening at the world-famous museum which captures two centuries of railway history.

The chosen charity was Railway Children and £1983 was raised by the event. Rob McIntosh, the Guest of Honour and Network Rail's route managing director for London North Eastern and East Midlands, gave a well-received talk on the challenges facing the industry, and the opportunities being presented by the Network Rail reorganisation with further devolution and more focusing on the customer.

Past president Colin Porter presented an IRSE merit award to Ian Moore on behalf of Markus Montigel current president. Colin said "Ian has been nominated primarily for his long service to the Institution and in particular the York Section. As we have seen tonight, he has organised these dinners in York for some years, and with 190 attending, this has been the best supported dinner in recent times. As his nominator said in the citation to Council 'it is also noting that not only is Ian a very dedicated enthusiastic railwayman with a terrific knowledge in numerous areas of signalling, but he is also a great guy in his manner, decency and helpfulness' which I think we can all here tonight only echo."

Photos, clockwise from top right:

Ian Moore, with his wife Lynda, receiving the Merit Award from Colin Porter (right).

Our Guest of Honour, Rob McIntosh.

The venue allowed guests to get up close and personal with some valuable, and beautiful, UK railway heritage.

The event was very well attended.

Book review

The railway signalling of Portugal (Volume I) – Electrical and electromechanical systems

Nuno Barrento

The book provides a technical and historical account, in Portuguese, of the signalling systems installed in Portugal. Published in collaboration with APAC – Portuguese Association of Friends of the Railways (a non-profit organization) the book by IRSE member Nuno Barrento is the first book published in Portugal about the subject and fills a gap in the available railway literature.

The first major technological leap in the Portuguese railways occurred during the process of electrification of the national rail network in the fifties/sixties of the 20th century. Electromechanical and electrical relay technologies were introduced, replacing the rudimentary mechanical signalling.

The book addresses the technical aspects (and some curiosities) depicting a scenario very typical of the Portuguese railways, where technology has assumed a preponderant role in the operation of the railway system. The particularities of the technologies provided by Jeumont (electromechanical), Alsthom (electrical), Ericsson (electrical) and Siemens (electromechanical and electrical) are described in detail.

Further volumes are planned in future years and the cost of volume one is €39 see **irse.info/0yw54** or email **apac@net.sapo.pt** for further details.

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at irsenews@irse.org.

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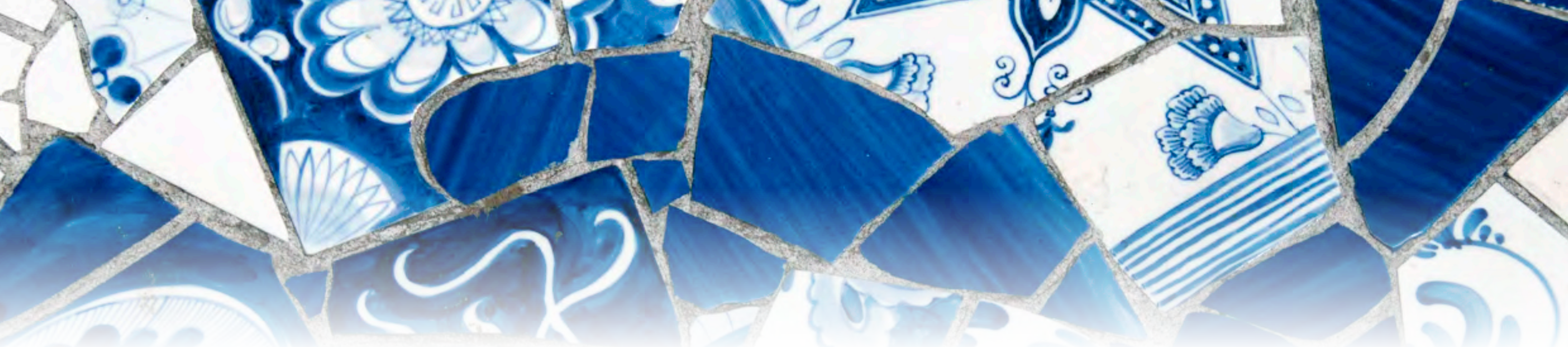

IRSE News

Institution of Railway Signal Engineers

June 2019

Standards
what, when and why?

Light rail signalling
what is good practice?

Formal methods
standardising interfaces

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Raising the Standard in Development

International experience

The IRSE's International Technical Committee (ITC) is a collection of eminent professionals from all corners of the signalling and telecommunications world. There are representatives from many European countries, Canada, Singapore, Japan and Australia. There is a broad cross-section of backgrounds, covering research institutes, universities, operators and suppliers. The expertise and experience of the group include both metro and main line signalling, telecoms and other specialised areas. Its collective knowledge of railway signalling is one of the best in the world.

Its mission is to share knowledge across the industry and the world. The main output of the committee is a series of articles, which are published in IRSE News. In this issue there are three articles provided by the ITC, including "Reflecting on the IRSE ITC" by Clive Kessell which provides the history and further details of the group.

There are normally four meetings held each year in different countries. Topics are suggested and the lead person develops a 30 second message, which outlines the proposed article. The topic is debated at the committee meetings where the direction and focus is agreed. There are many interesting and lively debates in the meetings as well as via email. The topic leaders then write the article which is circulated for comment by the committee.

Each meeting is hosted by one of the members and it is traditional to organise a technical visit for the meeting, sometimes to coincide with an event of interest. For example, last year one was held in Lugano, Switzerland at the start of the IRSE convention, and one in Berlin, Germany to coincide with Innotrans. We were also fortunate to visit the Railcenter at Amersfoort and see the ETCS test suites and many railway innovations like virtual reality headsets for asset identification.

The topics range widely in subject matter including "Achieving high levels of signalling system availability" (IRSE News September 2018) and 'Track worker safety' (IRSE News May 2018).

One of my favourites last year was "Why do signalling projects fail?" (also IRSE News May 2018) which was a fascinating article by Alan Rumsey. The contributions from all over the world showed how much we have in common rather than highlighting our differences.

Jane Power FIRSE, secretary ITC

Cover story

This month's front cover is Urlay Nook level crossing at Eaglescliffe, Stockton-on-Tees, England. The Network Rail infrastructure projects signalling York project team recently converted the crossing from manual controlled gates to manually controlled barrier with obstacle detection (MCB-OD) monitored from the York rail operating centre Bowesfield work station. This allowed the closure of Bowesfield signal box.

The upgrade and recontrol followed a proposal by Network Rail to permanently close the crossing. Unfortunately, a potential diversion of up to 2.5 miles (4km) would have been created, causing local objections to be raised. The closure would have affected access to the Cleveland Police Tactical Training Centre and their ability to promptly respond to incidents. Such is the difficulty in closing crossings.

Photo by David Shutt

In this issue

From the IRSE and its Sections

IRSE

Institution of Railway Signal Engineers

Standards for control, command & signalling systems – what, when and why?

Richard Barrow

Principal CCS Engineer, Railway Safety & Standards Board

This article is inspired by my (almost) forty years' experience of standards applicable to main line railway signalling systems in Great Britain (GB). It all started in York on day one of my signal engineering career, when I was presented with a heap of British Rail (BR) Eastern Region S&T instructions and procedures, together with the Rule Book, and was encouraged to read and absorb their contents. Looking back this was a strange instruction as, during the next two years of my training placements with maintenance and installation teams, I don't recall standards being used very much; signalling technicians applied their knowledge and experience to work practices and passed it on to others. The standards were kept in the locker and only brought out when revisions needed to be inserted.

The only standards briefing I experienced was being told to read any updated rules. However, before attending an interview, it was necessary to rehearse the content of key standards. I still recall that instruction 'ME12' was the BR standard on relay base pin codes!

Within the signalling design and testing departments, the standards describing the basis of signalling system design practice were referred to more frequently, for example: signal aspect sequences, approach locking controls and level crossing circuits. Some of the detail in these standards differed between BR regions, depending on historical regional practices, however the principal requirements were eventually standardised by the BR Board.

This attitude towards standards existed for many years within British Rail. It was sustainable because decisions were taken by experienced managers and practitioners who had clear roles and responsibilities within a single organisation with a top-down command structure, maintaining a strong corporate memory. Later, as the GB railway industry structure started to change and become more fragmented, people's roles and responsibilities changed more frequently, and the rationale behind decisions were forgotten.

An adverse consequence of this became all too apparent in 1988, when at 08:10 on 12 December, 35 people lost their lives and 100 were injured as a result of a three-train collision at Clapham Junction. The Hidden inquiry into the collision said the primary cause was "wiring errors" made by a technician who had had one day off in 13 weeks and that British Rail work practices were to blame. It made 93 recommendations for safety improvements, and as a result, BR initiated various workstreams to introduce more discipline into the signal engineering domain. These workstreams included the development of a series of S&T handbooks – aimed at the workforce – containing standards for design, installation, testing and general engineering practices, and the eventual adoption of standardised quality system processes, including auditing. This was part of a significant culture change within the signalling domain, which underpins good practice to this day.

What is a standard?

"Something used as a measure, norm, or model in comparative evaluations"

Oxford English Dictionary

"An agreed way of doing something ..... the distilled wisdom of people .... a reliable basis for people to share the same expectations about a product or service"

British Standards Institute

"The aim of standards is to support a compatible, cost-effective, safe and efficient railway system. To meet this aim, standards define and record what must be done, or how something needs to be done. This avoids 're-inventing the wheel' each time the same situation occurs"

RSSB

Ask ten people the question, 'what is a standard?' and you are likely to get ten different answers, depending on the context in which they live and work.

On the GB main line railway, a 'standard' is a formally published set of information about a defined topic area, that is available to support the decisions people take. There are a myriad of standards and topic areas, with different provenances, authorities, status and audiences. This means there are also different levels of prescription; many of which overlap, but some are contradictory. Most standards are well written and understood, although there are still some that are not. Many engineering standards are no longer written with the workforce in mind and have to be interpreted by professionals. The standards world can be difficult to navigate, confusing,

EU-wide legislation - EC Directives	Approved Codes of Practice (ACoP)	Rail Industry Approved Code of Practice (RACOP)
EU-wide legislation - EU Regulations	National Operations Publications (NOP)	Codes of Practice
UK legislation - Acts and Regulations	British Standards (BS)	Company Standards
Railway Group Standards (RGS) (containing GB national rules)	British Standard Euronorm (BS EN)	Project Standards
Rail Industry Standards (RIS)	International Standards (including IEC/ISO)	Guidance

Figure 1 – Examples of the 'standards' commonly applied on the GB main line railway.

and hard to understand; even professionals sometimes find it hard to decide which standards to follow. Figure 1 gives some examples.

Scope and force of standards

I have witnessed many discussions about which standards are 'mandatory' and which are not. There is a misconception in some parts of the GB rail industry that Railway Group Standards (RGS) are 'mandatory' and must be followed, whereas Rail Industry Standards (RIS) are 'voluntary' and can be ignored. This over simplistic view reveals a misunderstanding of the role of different types of standards and how they inform good decision making, irrespective of whether they are mandatory or not. This is explored further in the case study at the end of this article.

It is a fact that all standards can be mandatory – it is the force behind a standard that makes it mandatory, not the standard itself. All standards have scope and force; understanding this can help people decide what is achieved by compliance. It is also worth noting that no standard, regardless of its scope or force, should be a barrier to progress or innovation and all standards should allow a level of challenge, otherwise we would still have people walking in front of vehicles and waving a red flag.

'Scope' refers to the applicability of a standard, for example ISO standards are internationally recognised; RGSs and RISs apply to the GB main line railway; other standards may be written for a specific project and have very limited application.

'Force' refers to the compulsion to comply with a standard, for example, some standards are enforced by law; other standards are mandated in contracts or safety management systems (SMS) and other standards are advisory. It is misleading to describe some types of standards as being 'mandatory' and others as being 'voluntary'.

Figure 2 illustrates the current scope and force of requirements contained in the standards shown in Figure 1.

Standards containing legal requirements

In the UK, the decisions and actions people take in their work are bounded legal requirements, which are set out in the Acts and Regulations (standards) passed by the British and European Parliaments. Relevant extracts of legal requirements include:

Health and Safety at Work etc Act 1974

"It shall be the duty of every employer to ensure so far as is reasonably practicable the health and safety and welfare at work of all his employees".

Railways & Other Guided Transport System (Safety) Regulations 2006 (ROGS)

A transport operator shall: (1) make a suitable and sufficient assessment of the risks ...... (2) When carrying out an assessment or a review under paragraph (1) ... a transport operator shall apply the Common Safety Methods to the extent that the operation is carried out on the main line railway.

Railways (Interoperability) Regulations 2011 (RIR)

.....Subsystem is required to conform with all or part of a TSI, the procedures specified in the TSI or part of the TSI with which that subsystem is required to conform.....

Commission Regulation 352/2009: Common Safety Method on Risk Evaluation and Assessment

The CSM on risk evaluation and assessment shall apply to any change of the railway system..... which is considered to be significant.... Those changes may be of a technical, operational or organisational nature.

Clearly, legal requirements are mandatory; in these cases, their scope is GB national (or European Union wide), and failure to comply with them in the UK might lead to a prosecution, punishable by a fine or a prison term.

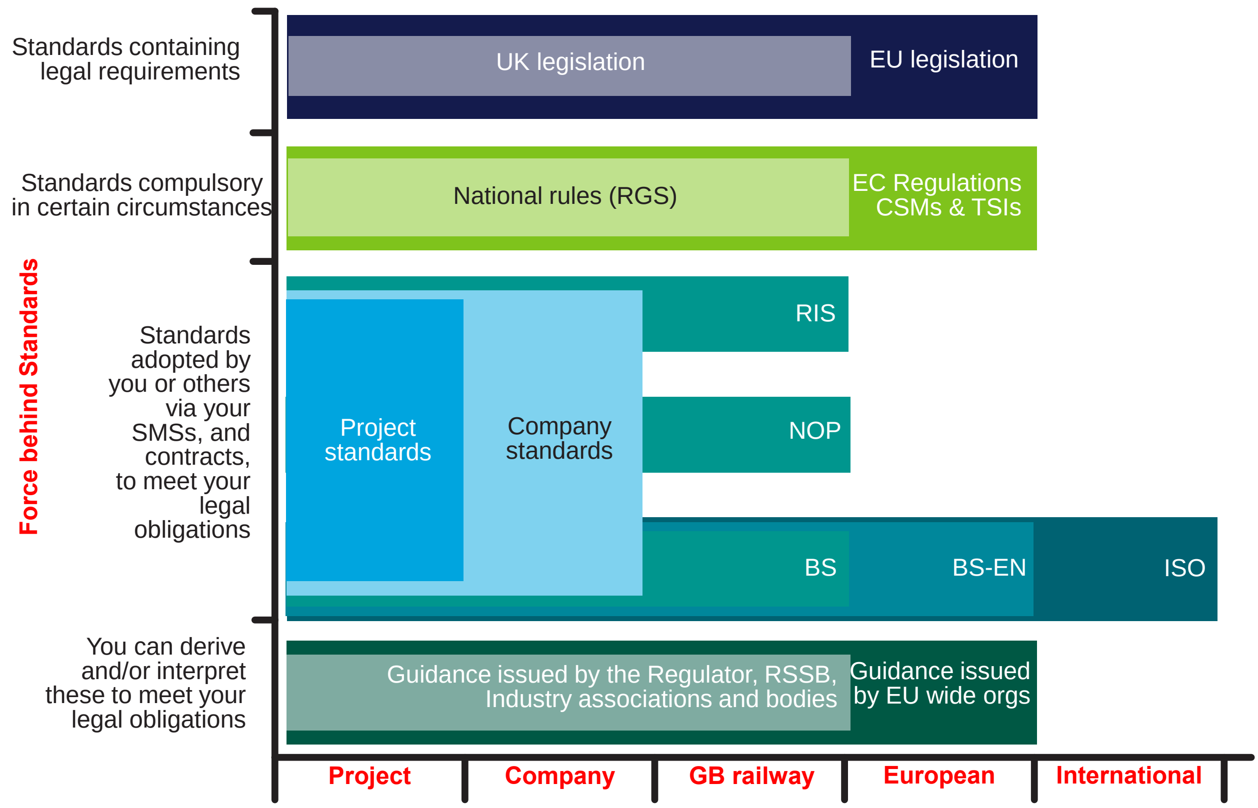

Figure 2 – An illustration of current force and scope of the standards shown in Figure 1.

Standards compulsory in certain circumstances

Conformity with some other types of standards is made compulsory by law. For example:

a) ROGS contains legal requirements for duty holders to apply EC Regulations – Common Safety Methods (CSMs).

b) RIR requires conformity with EC Regulations – Technical Specifications for Interoperability (TSIs) and national rules (published in RGSs), if the change is within the scope defined in the regulations. TSIs may require conformity with certain BS-EN and ISO standards. Therefore, in the same way as the law is compulsory, the requirements in RGSs and some other standards are compulsory in certain circumstances, and failure to comply might also result in a prosecution.

Adopted standards and requirements

Just because some standards are not made compulsory by law, this does not mean that the requirements they contain should not be followed; non-compulsory standards contain good requirements to help people meet legal and contractual obligations.

Most of the signal engineering standards applicable to the GB main line railway are now published in RISs rather than RGSs. The applicability of RISs is not well understood; some people think that requirements published in a RIS do not need to be followed, and that alternatives can be applied. This is only true if the decision to follow alternative standards is consistent with the duty holder's responsibility to comply with legal requirements.

The following requirement to display a cautionary aspect sequence is an extract from RIS-0703-CCS Signalling Layout and Signal Aspect Sequence Requirements. This is a standard not made compulsory by law. The rationale explains how following the requirement helps to control the risk of a train passing the end of its movement authority.

2.7.3 Location of first cautionary aspect

Requirement

2.7.3.1 The first cautionary aspect shall be presented at least signalling braking distance (SBD) from the main stop signal denoting the limit of movement authority (MA).

Rationale

G 2.7.3.2 SBD provides enough distance for the train to stop at the limit of MA if the brakes are applied before the train passes the signal presenting the first cautionary aspect.

G 2.7.3.4 This requirement can be applied to control the driveability hazard precursor: Insufficient time for the train driver to comply with the operating requirement.

Guidance

G 2.7.3.5 This requirement is always applicable to the following cautionary aspects, which are specified in RIS-0758-CCS:

a) 3-aspect caution.

b) 4-aspect first caution

c) The outermost distant ON aspect.

G 2.7.3.5 etc...........

Most standards within the railway signalling domain are relevant to meeting the legal requirements set out in ROGS and the CSM-RA because they set out methods that can be applied to control hazards and manage risk to an acceptable level, if the requirements are applied in the way they are intended.

RGSs and RISs are managed by the RSSB in accordance with the Standards Code [1], which is endorsed by the UK industry regulator (Office of Rail and Road – ORR). The RSSB Standards Manual [2] sets out the processes for developing and authorising these standards, and for authorising deviations from the requirements in RGSs. In this way, RGSs and RISs contain the requirements that are the industry agreed and endorsed ways of doing things on the GB main line railway.

RISs could be considered as the normative standards for the GB main line railway, in a similar way that BS-EN standards are applicable throughout Europe, irrespective of whether they are specified in European law.

Transport Operators adopt RGSs because their licence conditions require them to do so. They may also choose to adopt RISs because that helps them comply with the law, either directly or through their contractual arrangements with others. If an organisation does not follow requirements in a RIS that provides a method for discharging its obligations, it would need to identify a suitable and robust alternative method and consult with any affected parties.

What is a RIS?

A Rail Industry Standard (RIS) is a document that codifies a set of requirements and guidance as GB rail industry agreed good practice, where standardisation is considered beneficial for the industry.

The requirements in a RIS can fit one or more of the five categories:

1. As a 'code of practice' to address a safety hazard when applying CSM RA or another suitable and sufficient risk assessment approach.
2. A common application of a risk management or assessment approach.
3. An agreed approach for two or more industry parties to cooperate, coordinate and collaborate.
4. A common approach to discharge specific legal obligations beyond risk management.
5. A common approach which provides economic or other benefits across the industry.

How and when a specific RIS becomes compulsory is determined by:

- The safety & quality management system to which an organisation's employees and projects are bound.
- The contractual specifications and agreements to which an organisation, its employees and projects are bound.
- The assurance policies, specifications and other company documents, such as company standards and guidance, to which an organisation's employees and projects are bound.
- The proposer's specific CSM RA implementation and acceptable conformity assessment approach/strategy, if used as a 'Code of Practice'.
- Any specific obligations placed on the organisation by third parties, if compliance is part of conditions of inclusion and exemptions.

Company standards and Project standards

A robust set of company standards, or project standards, provides a framework of requirements that helps people take good decisions. It also provides: a means of identifying and managing derogations and deviations, a means of measuring conformity, a basis for managing change control and a means of demonstrating that a reasonable approach to managing risk has been taken.

Company standards set out the way in which a business operates in order to meet its legal obligations and business objectives. Company standards may describe specific ways of doing something; they may also reference or amplify other standards, by setting out how conformity is achieved.

Network Rail company standards set out how the infrastructure part of a signalling system is designed, installed and tested. This includes the standards setting out interlocking requirements. All these standards exist within the framework in Figure 1, so they do not exist in isolation. Conformity with Network Rail standards should support conformity with the RISs for integrating lineside signalling systems with train operations, which is relevant to controlling operational risk and therefore relevant to complying with ROGS and the Health and Safety at Work etc Act 1974.

Project standards set out bespoke requirements that describe what needs to be done to deliver the intended business and commercial benefits of undertaking a specific project. These standards might be restricted by time and geographical boundaries and typically include a: system capability statement for example:

- What signalling system provision is needed to support the planned train service; performance specification.
- Reliability and availability targets, design specification.
- The characteristics of a signal that supports the required reading time; methods of stakeholder cooperation and interworking; and the project delivery process.
- How the project will be operated to meet company standards.

Requirements, rationale and guidance

Requirements

It is the content of each standard that really matters, not the identity of the standard. Most standards set out requirements, which may be amplified with supporting guidance. All requirements set out one of three things:

1) A state to be achieved (e.g. necessary conditions for clearing a signal).
2) A process to be followed (e.g. signal sighting assessment).
3) An action to take (e.g. replace a signal to danger).

Requirements in standards usually provide good answers to many of the questions that people are faced with, but only if they are applied in the way they are intended. Most people take decisions as part of their normal work activity; their decisions can be routine or ad-hoc and may be related to simple tasks or complex problems, however they are all relevant to answering one or more questions. These questions usually fit into the following list:

a) **What** needs to be done?
b) **Who** is responsible for doing something?
c) **When** does something have to be done?
d) **Where** does something need to be done?
e) **Which** method needs to be followed?

Rationale and guidance

Publishing the rationale with each requirement helps the user to understand 'Why' the standard says what it does. In my experience, answering the 'why' question is one of the most difficult – and interesting – tasks faced by the standards setter. A good rationale captures corporate memory; making this information available provides real benefits to the user.

Some standards contain guidance, which is a type of informative text that helps the user to understand 'How' to use requirements in the way that they are intended. Good guidance helps users: understand the context of requirements and their background, interpret the intent of the requirements or specifications, apply the requirements, comply with the requirements by setting out what the industry 'normally' does, find other sources of information and understand why doing something in a certain way is beneficial.

Conformity vs deviation from standards

Conformity

It is important to understand what is achieved by conforming with each requirement or set of requirements. Misunderstanding the rationale can lead to assumptions and decisions that might not be supportable.

Some standards set out clear and concise rationales, that help the user to understand what is achieved by conforming with each requirement, and importantly, what else might be needed to achieve the desired outcome.

The requirements in RGSs only cover technical compatibility of infrastructure with rail vehicles at network level, which is relevant to safety but might not be enough to confirm technical compatibility or safe integration of a change on a specific route. Other types of standards contain requirements that inform decisions beyond the scope of technical compatibility at network level.

The following extract from RIS-0797-CCS ERTMS/ETCS Baseline 3 Onboard Subsystem Requirements: Retrofit Part 1 describes the rationale underpinning the requirements contained in that standard:

a) **Technical compatibility**; necessary to support technical compatibility with the GB main line railway network or the route(s) on which the rail vehicle(s) will be operated. Further requirements for route technical compatibility assessment are set out in RIS-8270-RST.

b) **Integration with train operations**, the rail vehicle or another CCS system; so that the rail vehicle is capable of being operated as part of a train on the GB main line railway, including the interfaces with the train driving task.

c) **Performance**; necessary to support the overall performance of the railway system in the operational context.

d) **Safe integration**; necessary to control one or more of the hazards listed in Appendix A.

e) **Economic**; necessary to realise cost efficiencies.

f) **Reliability**; necessary to meet reliability targets.

g) **Availability**; necessary to meet availability targets.

h) **Asset management**; necessary to support rail vehicle asset management processes, including maintenance, repair and faulting tasks.

i) **Efficiency**; necessary to reduce waste and support future rail vehicle or CCS subsystem enhancements

j) **Train driver learning**; necessary to support migration to an ERTMS/ETCS railway.

Achieving conformity with all relevant standards does not necessarily mean that your work will be safe enough or that you have met the essential requirements. By their nature, standards can only describe a defined system under specified conditions and an assumed operational context. If your work exactly fits that system definition, set of conditions and context, then conformity might be enough. However, the responsibility for complying with the law rests with the party making the change, not the standards setter.

Non-conformity

Unquestioning conformity with 'all relevant standards' will sometimes result in an undesirable outcome. RSSB has provided the opportunity for deviations and a route to propose changes to standards, open to all for many years. In 2017, Network Rail issued a 'Standards Challenge' to encourage challenges against standards considered to be obstacles to innovation, creativity or efficiency. The UK's Railway Industry Association (RIA) is supporting Transport for London (TfL) in a similar standard challenge process.

A deviation usually needs to be obtained from the body that made the standard compulsory or the body that authorised the standard. A decision to deviate from a Network Rail company standard or adopted RIS would need to be supported by the relevant Network Rail professional head; a decision to disapply a requirement in an RGS would need permission from RSSB.

A proposal to change a standard could provide a long-term benefit to the rail industry if the system it describes has changed since the standard was published. More localised benefits may arise by developing a bespoke standard; with the condition that the proposed alternative solution is consistent with meeting legal obligations and that any necessary deviations are obtained from the relevant authorities.

The CSM RA (risk acceptance) principles provide two paths to identifying alternative risk controls that do not comply with a code of practice – comparison with a similar reference system and explicit risk estimation – both of which require an assessment that risk is controlled to an acceptable level. Where a potential code of practice is available (for example, a RIS), it might be necessary to obtain authority from a standards body to deviate from the standard. The risk assessment developed to fulfil the risk acceptance principle can be reused to support the case for deviation. The output of a deviation can be implemented as a Project standard, or Company Standard, within the framework shown in Figure 2 above.

The RSSB deviation process is easy to follow; the applicant is requested to provide the following supporting evidence:

- The scope of non-compliance.
- The reason for the non-compliance.
- A description of the alternative requirement being proposed.
- Evidence that the alternative requirement is supported by a suitable and sufficient risk assessment.
- Evidence of stakeholder consultation with no objections.

The RSSB deviation process takes decisions by consensus using industry representation at standards committees. Two deciding factors are:

1) Has the applicant provided evidence of suitable and sufficient risk assessment?

2) Is the alternative provision consistent with the best long-term interest of the GB main line railway?

Most deviations submitted to RSSB are authorised, and certificates are usually issued within ten working days of the decision being taken. Delays to approval can arise if the application for deviation does not provide the information needed by the committee to take a decision.

Case study: RGS or RIS

Since 2017, RSSB has been reviewing the content in RGSs to confirm the applicability of the requirements as GB national rules. This is consistent with implementation of the 'technical pillar', of the 4th Railway Package, which was adopted by the European Parliament and the Council in April 2016 with the aim of boosting the competitiveness of the railway sector by significantly reducing costs and administrative burden for railway undertakings wishing to operate across Europe.

This RSSB standards review has resulted in the withdrawal of many of the signalling system requirements from the scope of RGS because they are not relevant to technical compatibility of infrastructure with rail vehicles, GB specific cases, or a TSI open point where the detail of a requirement is not yet fully specified.

In most cases, the withdrawn content contains good requirements and so was republished in RISs to keep it within the standards catalogue maintained by RSSB. It soon became apparent that the review process was leading to some misunderstanding, particularly about the continued applicability of the requirements withdrawn from RGS and transferred to RISs. A lot of work was done with RSSB standards committee members to help them understand the reason for the review and the impact of the outcomes in terms of the compulsion to comply with the law – needless to say, there were some initial objections to be overcome.

In fact, there is real benefit in providing better clarity as to which requirements are compulsory and which other requirements are also available to inform good decisions. What is lacking in some areas is a good understanding of how the standards framework should be used to good effect.

A particularly contentious example was the review of GE/RT8075 issue two, on the subject of AWS and TPWS Interface Requirements, which identified that the requirements specifying the AWS/TPWS onboard driver-machine interface (DMI) were not within the permitted scope of national rules and therefore needed to be withdrawn from the 'mandatory' RGS. The implication that these requirements were no longer mandatory caused understandable concern that rail vehicle manufacturers would supply trains with alternative DMI interfaces, resulting in an increased risk to train operations. As described earlier in this article, the compulsion to comply with a standard does not come from the identity of the standard but from the force it is given. In this case, the force could not be given by the RIR, however ROGS requires duty-holders to cooperate and to follow the CSM-RA process to identify risk controls.

The requirements for the AWS/TPWS DMI have been updated to set out the GB main line rail industry agreed and endorsed requirements, and given the status of a Rail Industry Standard, being published in RIS-0775-CCS AWS and TPWS Application Requirements Part 5. The introduction to this standard includes the following statements:

1.1.2 Conformity with the requirements in this document can be used by infrastructure managers (IMs) and railway undertakings (RUs) in discharging their obligations under the Railway Safety Regulations 1999 (RSR 99).

....

1.1.5 This document includes the TPWS Driver-Machine Interface (DMI) requirements, which have been developed to control the risk of a driver incorrectly resetting the TPWS and restarting the train after a train protection system intervention. This is sometimes referred to as 'TPWS reset and go risk'. These requirements support the design of a TPWS DMI which will provide operational functionality consistent with the requirements set out in the Rule Book GE/RT8000 and the supporting handbook RS522 that all GB main line train operators have collectively agreed to mandate on themselves.

1.1.6 The requirements in RIS-0775-CCS are available to both suppliers and train operators as widely accepted codes of practice which can be used as a means of applying the CSM RA risk acceptance principles to the hazards of a train passing the end of a signalled movement authority and a train exceeding the permissible speed, in order to control collision risk and derailment risk. They also provide suppliers of rail vehicles and onboard CCS subsystems with a specification of a system which is capable of safe integration into the GB main line railway.

Conclusions

People take decisions throughout the whole lifecycle of a system. Understanding and having access to a complete, correct and relevant set of requirements is a good place to be to inform those decisions.

The standards framework has slowly and subtly changed over time and, in a fragmented industry, there is no longer a standardised solution the workforce can apply, without a project-specific interpretation. This can result in continually reinventing the wheel with associated escalating costs; there is a conflict between templated designs to reduce costs and the competency of staff to understand the true meaning of standards.

It is important that we do not forget the comment in the Clapham accident report that "Deficiencies have been established in the workforce's understanding of their instructions". People need to understand which standards are applicable to their work, the compulsion to comply with them, what compliance means and where the standards sit in the standards framework.

It is important to comply with the standards that are applicable, however meeting unsuitable requirements can stifle innovation or creativity and add cost. If the available requirements are unhelpful, it is worth considering the benefits of proposing a change to a standard or obtaining an authorisation to be non-compliant. Following the deviation process is the right thing to do in certain circumstances. In such cases, follow the correct process and make sure that you provide relevant supporting evidence to justify the alternative approach.

System safety is a given and is required by law; many standards contain safety related requirements, however achieving safety on its own might not realise the intended performance benefits. Consider how conformity with standards can help with decisions about other essential requirements.

If an essential requirement is not specified in a standard, there may be a benefit in writing a bespoke specification; this might be particularly beneficial when agreeing system capability with project stakeholders.

References

1. Standards Code: RGSC01, Issue 4, RSSB.

2. Standards Manual: RGSC02 issue 3, RSSB.

The RSSB website provides guidance on how to propose changes to, and deviate from, the standards published by RSSB (**irse.info/ahx78**).

The Network Rail website includes a link to their Standards Change Application Form (**irseinfo/az841**).

IRSE
Institution of Railway Signal Engineers

Watching for weak signals

Greg Morse
Rail Safety and Standards Board

The Rail Safety and Standards Board (RSSB) is a British independent company which supports the rail industry in achieving its objectives of improving safety and performance. It guides and manages the maintenance of railway standards, industry research and innovation programmes, and facilitates collaboration to drive improvement. Greg Morse, lead operational feedback specialist RSSB, reminds us why root cause data, investigations and accurate daily reports help to create safety improvements.

Every morning at six o'clock it comes, popping into the inbox. We click, we open, we read. We read of SPADs (often), fires (sometimes), train divisions (less often) and 'operational incidents' (all the time). Here is where we confirm that we can't be complacent, can't believe that – just because the numbers say we have the safest railway in Europe – we can sit back and crack open the champagne. We all know that, if we do, our oil rig is sure to explode (to allude to the Texas City disaster of 2005).

The NOC – Network Rail's National Operations Centre log – is a daily download of incidents recorded almost in real time. It's news 'hot off the press', and as such won't give us the causes like an investigation report. But it isn't meant to. It's meant to give an early warning of what's going on out where people get their hands dirty. It's meant to help us stop near misses from becoming accidents involving harm or loss of life, by helping us keep a watch for anything that doesn't look quite right.

At RSSB I produce a weekly digest of the NOC, taking some of its key incidents, which are edited down to be shared with members and colleagues who don't have time to read the whole thing. Within RSSB's offices, the document aids learning, and can act as a check that incidents have been recorded in the industry's Safety Management Intelligence System (SMIS). Recently something happened which hadn't, and the weekly summary played a part in putting that right. More specifically, the NOC showed that self-evacuation seemed to be on the rise since the Kentish Town incident of 2011, in which a number of people detrained in the Thameslink core section after they'd been trapped for the best part of three hours. Matters came to a head at Lewisham last year, so we took a closer look and found that – in SMIS – some incidents were being recorded as dewirements, traction failures, fires or whatever had caused the delay that led people to get out and onto the track. The trouble was, the self-evacuation element wasn't being recorded with them.

The NOC summary also provides source material for RSSB's papers to the cross-industry groups it facilitates. Of course, by the time this information – which gets coupled with recent overseas incidents, and the latest in-scope investigation reports – reaches these groups, it can be a little out of date. Nevertheless, the NOC was used successfully by the Rail Accident Investigation Branch (RAIB) to produce its report on protection irregularities, and was used by RSSB's Operational Feedback function to highlight the 'trains being signalled into blocked lines' issue that went on to be taken up by the Infrastructure Safety Leadership Group (ISLG), and is now the subject of another RAIB 'class investigation'. (The latter will also consider incidents of pedestrians being trapped on CCTV crossings and other error types, with a view to understanding common factors, the effects of reorganisation, and so on.)

Going back to the NOC, there's an argument that, had such low level incidents been fed to industry in the same way back in 1988, then the collision at Clapham in the December of that year might not have happened. Clapham resulted from a wrongside failure. The resulting public inquiry – led by

Texas City, 2005

On 23 March 2005, a hydrocarbon vapour cloud was ignited and exploded at BP's refinery in Texas City, Texas, killing 15 workers, injuring over 180 more and severely damaging the refinery itself. An independent panel – led by former US Secretary of State James Baker III – considered the wider implications of the accident. The resulting report cited a weak safety culture, suggesting that cost-cutting and production pressure from BP executives may have resulted in a lack of necessary safety measures across the board. Furthermore, safety improvements between 2002 and 2005 were 'largely focused on personal safety – such as slips, trips, falls, and vehicle accidents, rather than on improving safety performance'. Moreover, managers and their ilk generally had a more positive view of the process safety culture compared to those on the 'shop floor'. The Baker Panel report may still be viewed online.

Clapham, 1988

On the evening of 27 November 1988, a technician left a bare live wire dangling in a relay room at Clapham Junction 'A' signal box. Two weeks later, further work jolted the wire, causing it to touch a terminal, make a connection and prevent a signal from returning to 'danger' after the passage of a train. Just after 08:00 on Monday 12 December, a commuter service passed that signal at green before colliding with another that was blocking the line ahead. The collision forced the leading coach to the side, where it struck an empty unit passing on the opposite line. Thirty-five people were killed and almost 500 were injured.

Anthony Hidden QC – suggested that British Rail had become almost blind to the risk from wrongside failures, contrasting it with a focus on SPAD risk. BR was probably right to put proportionately more focus on SPAD risk in the late 1980s, but not to the exclusion of wrongside failures (or any other hazard, come to that). In fact, there had been a 'cluster' of wrongside failures in Oxted, Northfleet and East Croydon in November 1985, during the installation of new signalling.

Of these, the Oxted incident was the most worrying, as a signal had shown green when it should not have, because a relay had been energised irregularly – a fault which would have been discovered by a wire count, but (as with Clapham three years later) no such count had been undertaken. Worse still, the resulting 'flurry of paperwork' provided important information, but was shared with very few people and therefore did not feature in anyone's thinking during the Waterloo area resignalling scheme . If that wasn't enough, a similar wrongside failure occurred at Queenstown Road on 14 June 1988, in which a signal cleared to green instead of yellow. In this case, there'd been a design error (a drawing being issued which omitted a track circuit from the signal's controls). The error was not picked up by the Design Office, nor during the testing of the signal on the ground.

It's totally rational to put most risk reduction effort into the areas where risk is highest, or where there's the most scope for risk reduction, but it's vital that risk assessments are kept fresh. It's also important to avoid being blinded by solid trend lines and look sometimes at the outliers, the "weak signals", where perhaps the data points are fewer, but where the consequences might be great if the situation is allowed to persist. There is no better argument for taking such a holistic view of risk than Clapham.

We all know that we can increase the accuracy of our risk picture by collecting, analysing and learning from information, not just about accidents but also their precursors and the activities that prevent them. Hidden was damning about BR's failure to collect information on wrongside failures systematically. After Clapham, though, it tightened up its safety arm and centralised recording by bringing together previously disparate sets of information into its British Rail Information Management System – a computerised database and the forerunner of SMIS.

The thing is (as I've said elsewhere) the corporate memory exists only while we remember it, and over the Christmas and New Year period of 2016/17, we seemed to forget. Extensive resignalling and track remodelling work was being carried out in and around Cardiff Central at this time, some of the new layout being brought into use on December 29. At 08:37 that day, the driver of a Treherbert service noticed that the points his train was about to take were not in the correct position. He stopped the train just before reaching them.

RAIB concluded that the points had been left in this 'unsafe condition' because they hadn't been identified as needing to be secured by the point securing team. Furthermore, no one had checked that all the points that needed to be secured during the works over the Christmas period had actually been secured. Route proving trains had also been cancelled, and a work group culture had developed between long standing members of the project team that led to 'insular thinking about methods of work and operational risk', meaning that team members 'relied on verbal communications and assurances'.

Simon French, RAIB's chief inspector, drew a clear line from Cardiff back to Clapham, pointing out 'how easily things can go wrong when railway infrastructure is being upgraded and renewed,' pointing out the importance of managing the working hours of people doing the job 'when organising intensive periods of commissioning work'. The events at Cardiff, he went on, showed 'how easy it is to forget the lessons of Clapham and slip back into those habits under the time pressures of a big commissioning'.

A few months later – in August 2017 – a train departed Waterloo on a green aspect, but was incorrectly routed and collided with an engineer's train on the adjacent line. Luckily the driver saw the way the points were set and managed to brake, meaning the collision occurred at low speed and resulted in no injuries. Modification to the wiring of the point detection circuits meant that a 'desk' set up to aid testing no longer simulated the detection of the points in question correctly, because it hadn't been modified to account for changes made to the detection circuit.

On the weekend of 12-13 August 2017, while trains had been stopped from running on the lines leading to the points, a temporary wiring "mod" was made in the relay room in an attempt to restore the correct operation of the relevant switch on the test desk. But the mod wasn't reviewed by a signalling designer and was wrongly left in place when the railway was returned to operation on the morning of 14 August.

Cardiff and Waterloo remind us that we need the numbers, need the investigations too. But we also need the daily reports to help us understand the complete picture of safety.

So, the NOC? Don't knock it...

RAIB's reports on the Cardiff East, Waterloo, Kentish Town and Lewisham incidents may be found on its website. The Hidden Inquiry may be downloaded free of change from **www.railwaysarchive.co.uk**.

About the author ...

Born in Swindon to a railway family, Greg Morse is RSSB's lead operational feedback specialist. This means he considers not only lessons learnt from accidents and incidents that occur on railways worldwide, but also lessons learnt in the past. With this partly in mind, Greg has also written many 'corporate memory' articles for RAIL, along with a book, Railway Accidents (Shire, 2014), which is a summary of lessons learnt on Britain's railways since 1830 and is a set text on the accident investigation course run by Arthur D Little.

IRSE
Institution of Railway Signal Engineers

What constitutes good and acceptable practice in light rail signalling?

Prepared on behalf of the International Technical Committee by Rod Muttram

The IRSE's International Technical Committee (ITC) provides a multi-national and independent perspective on Railway Control, Command and Signalling (CCS) topics. Membership of the ITC comprises industry experts from both suppliers and operators, drawn from countries around the world. It aims to inform and educate both IRSE members and the train control and communications community worldwide, principally by the production of reports on selected topics. In this issue of IRSE News we have two reports from the ITC, demonstrating the breadth of the work they carry out.

After the decline and closure of many tram systems in the middle years of the 20th Century, recent decades have seen increased interest in, and the deployment of, light rail (or rapid) transit (LRT) systems around the world to provide higher passenger-carrying capacity and lower emissions than buses without the expense of heavy rail/metro systems.

So what do we mean by 'light rail' in this context? The UK ORR defines 'Light Rail' as follows:

"Light rail is an urban rail transportation system that uses electric-powered rail cars along exclusive rights-of-way at ground level, on aerial structures, in tunnels, or occasionally in streets. The operation is under full signal control and the current UK systems have full automatic train protection.

As the name suggests, the term light refers to operations carried out under a less rigorous set of regulations, using lighter equipment at lower speeds than those used by heavy rail, such as services provided by train operating companies.

A tram system, tramway or tram is a railway on which streetcars or trolleys run. It is typically built at street level, sharing roads with traffic, but may include private rights of way especially in newer light rail systems.

Many older tram systems do not have platforms, which enables integration with other forms of transport and pedestrians making simultaneous use of the streets".

The ITC finds these definitions somewhat unsatisfactory in that the distinction between 'Trams' and 'Light Rail systems' is not clearly made, indeed it even talks about 'newer light rail systems' in the paragraph about tram systems. In our view this matters because it is misleading; the first paragraph says, "The operation is under full signal control and the current UK systems have full automatic train protection". Mixing the terms, without saying what is expected of tram systems specifically, creates the impression that they have a level of protection that in most cases they clearly do not. Better definitions developed by IRSE past-president Clive Kessell are given in the panel below.

Metros

- 'Heavy Rail' mass transit in city centres and out to suburbs.
- Dedicated track, often underground.
- High capacity, frequent train intervals.
- Power supply usually 3rd or 4th Rail.
- Usually long trains, up to 12 cars.
- Mandated automatic train protection.
- Often automatic, sometimes driverless, using communications-based train control (CBTC).

Light Rail

- A development of the past 30 years
- Dedicated tracks usually at ground level.
- Often built on 'stilts' as elevated railway.
- Cheaper construction for suburbs.
- Often a 'take over' of former main line rail lines.
- Power from overhead wires or 3rd rail.
- Lightweight trains up to three units of two cars.
- Usually automatic operation with CBTC.

Trams

- A resurgence of 19th Century transport.
- Combination of dedicated track (often former rail lines) and street running.
- Limited signalling for junctions and road Intersections but mainly 'drive on sight'.
- Sharp curves and steep gradients allowed.
- Overhead power supply.
- Single unit articulated vehicles, sometimes with several sections.
- Current generation trams often 'low floor' to facilitate passenger access.

The accident on the UK's Croydon Tramlink system in 2016 resulted from overspeeding into a sharp bend.

Photo Crown Copyright, from the RAIB report into the accident.

The reality is that trams are generally driven on 'line-of-sight', with drivers expected to drive at a speed which will enable them to stop the tram in the distance that they can see ahead, like the drivers of road vehicles. Light-rail on the other hand tends to have more sophisticated signalling and control systems similar to those found in the metro domain. There are systems which mix both operating modes and that introduces certain risks.

This article was prompted by the derailment on the Croydon Tramlink, UK, on 9 November 2016 in which seven people died and over 60 were injured when a tram overturned due to entering a curve with a severe speed restriction at too high a speed. Trams differ from buses in several ways and one of the key differences is in the consequences and potential mitigations if a curve is approached at too high a speed. A bus has the option to 'steer away' if an alternate route is clear avoiding harm; a tram's route is completely constrained (rail is a 'one degree of freedom' system) and even with secondary braking devices a steel wheeled tram will generally not match rubber-tyred road vehicle braking distances. Thus, if the speed exceeds a certain threshold approaching or within a curve it will inevitably overturn or at least de-rail.

The ITC therefore has similar concerns regarding the over-reliance on fallible human drivers for speed control as it has for main line railways. Our chair presented on this at the IRSE Convention in Dallas in 2017 (see **irse.info/itc43**)

The UK Rail Accident Investigation Board (RAIB) report into the Croydon accident (**irse.info/nzyec**) third recommendation was that "*UK tram operators, owners and infrastructure managers should work together to review, develop, and provide a programme for installing suitable measures to automatically reduce tram speeds if they approach higher risk locations at speeds which could result in derailment or overturning*". The ITC is somewhat surprised that this makes no mention of targeting these measures to be cost effective in the way that target cost was a key part of the specification and development of TPWS for the main line railway in the UK. A low cost system that reduces the risk will most likely deliver a lot more benefit than one that effectively eliminates it but represents gross disproportion in terms of cost and therefore achieves only limited deployment.

Whilst the severity and nature of the Croydon accident made it inevitable that Transport for London (TfL) would implement some form of speed control on the Tramlink, whether other operators do so will be highly sensitive to system cost and that will be driven by system complexity and the level of safety integrity demanded.

An international perspective

LRT systems are being implemented in many different forms around the world. At one end of the spectrum are driverless systems operating on exclusive rights-of-way that can be at-grade, underground, or elevated. At the other end of the LRT spectrum are manually driven systems, operating at-grade, that share the right-of-way with other road traffic users. In addition, we increasingly see examples of LRT systems with a mix of both dedicated and shared-use rights-of-way.

A good example of a mixed system is Metro do Porto in Portugal which includes street running, dedicated alignment (some of it along old heavy rail routings), an 8km in-tunnel section and a 100km/h tram train service to Póvoa de Varzim in the north all integrated into a single network. Other examples of LRT systems operating in ATO on sections of dedicated (grade-separated) alignments and operating manually on sections of shared-use (street-running) alignment would include the new Eglinton Crosstown Line in Toronto, Canada and the Red Line in Tel Aviv, Israel.

All of these LRT applications have to consider the risk of collisions (as a result of inadequate safe train separation assurance) and the risk of derailments (as a result of inadequate interlocking protection and/or inadequate overspeed protection). Risk levels will vary depending on the level and type of service being provided and the nature of the right-of-way. Risk levels can be different in sections of the right-of-way with differing characteristics. These risks can be mitigated through fixed block or moving block signalling systems, simpler control equipment or through reliance on operating procedures alone.

For some LRT applications, a conservative (but more expensive) approach is taken to install the same signalling system everywhere, as dictated by the highest risk section. In other LRT applications, it is argued that no signalling system is necessary (with associated cost-savings) on the basis that the LRT is simply being operated as a 'bus on rails'. A sample of different systems provided by ITC members is shown in Table 1.

Examination of Table 1 emphasises an issue; what is considered as 'light rail' covers a wide range of system level options. At one end of the spectrum a full control system applied over the whole line clearly poses no safety

Table 1 – Information on a selection of LRT lines worldwide.
All of the examples are steel-wheeled and standard gauge, unless noted otherwise.
Note that Japan also has three lines it considers 'light rail' but these are closer in nature to a metro system. Two are fully automatic (UTO) and the other has full ATP.

System	Key Characteristics	Length	Era	Control technology
Tampere raitiotie (Tampere tram) Finland	20% street, 80% dedicated. 70km/h.	15km then 26km.	2012	Lineside signals with PSR enforcement.
Metro de Malaga Spain	20% street running, 80% dedicated underground. 50km/h street, 70km/h dedicated.	11.3km	July 2014	Alstom Urbalis. ATO/ATP in tunnel section. Line of sight (LOS) with speed supervision only in street running.
Manchester Metrolink UK	33% street running, 67% dedicated alignment. 80km/h.	92km	1992 with extensions in 1998 and 2011-14	Manual LOS, Trams signals and point indicators. PSR by procedure, extended warnings.
Tyne and Wear Metro UK	5% dedicated underground, 78% dedicated, 17% shared running with heavy rail. 80km/h.	77km	1980, with extensions in 1992 and 2002.	Lineside signals with Indusi train stops. Mixed with TPWS for heavy rail trains on shared sections. Main line style approach locking.
Erasmuslijn Netherlands	Segregated.	5.9km	2006	Colour light signals and ZUB222 ATP.
Hoekse Lijn Netherlands	Segregated. Speed 100km/h.	24km with 2km extension planned	2018	Full ATP (BT CF150).
Sneltram Utrecht Nieuwegein (sun) Netherlands	Street and segregated. 80km/h.		1983	Colour light signalling based on axle counter blocks. Some level crossings (AHB).
Metro do Porto Portugal	Street and segregated and tunnel. Tram train high speed service to Pova.	Circa 67km (five lines with common core).	2002	Bombardier Citiflo 250 balise based ATP.
Al Sufouh Dubai	Mostly on-street, some elevated. 50km/h.	15km	2014	Alstom Urbalis CBTC.
Qatar tramway	Street, tunnel and elevated. 50km/h.	55km (four lines)	Planned 2019	Alstom Urbalis CBTC.
Reims France	Street running. 50km/h.	11km (two lines)	2011	Lineside signals with priority at road crossings.
Regional traffic Bern Solothurn (RBS) Switzerland	Dedicated alignment and underground. Track gauge 1000mm. 90km/h.	45km	1912	Lineside signals with continuous ATP (ZSL90).
Eglington Crosstown Line Toronto, Canada	Dedicated (underground) and street running.	10.2km underground 9.5km street running.	Planned 2021	Bombardier Citiflow 650 CBTC synchronised with road signals. Mix of GoA 1, 2 and 4 depending on area.
Confederation Line Ottawa, Canada	Dedicated underground and surface.	2.5km	2019	Thales Seltrac CBTC. Mix of GoA 2 and 4 depending on area.

A modern low-floor light rail vehicle, in this case a Bombardier vehicle for the Gold Coast in Queensland, Australia.
Photo Bombardier.

Heritage vehicles are in common use on densely used systems such as this example in Hong Kong.
Photo Shutterstock/Glen Photo.

concerns. Where no system or only simple lineside signals are applied but system characteristics pose additional risks then problems could arise, and as always, change can introduce risks. This goes to emphasise the need to be more disciplined in defining what is light rail and what is a tram.

Discussion

As the title of this paper states the ITC's intention was to survey a range of these systems to determine what constitutes 'good practice' and hopefully recommend what should be considered the minimum standard of control system to be applied. In practice the diversity of such systems and the blurred boundaries between trams, light railways and the bottom end of metros and automated people movers makes that quite difficult.

So, to offer an informed opinion of what the minimum standard should be means going back to an assessment of the risks in such systems.

In common with other rail systems the most significant 'top level hazards' are collision and derailment, particularly derailments at a speed or of a nature that may lead to vehicles overturning. So called 'second generation' trams are normally fitted with enhanced braking devices such as track brakes which give them stopping distances similar to if not the same as equivalently sized road vehicles. Treating trams as equivalent to a 'bus on rails' in terms of SPAD and collision risk may thus be considered not wholly unreasonable. Tram track structures often use spring loaded and trailable points such that controlled and facing points are relatively rare. 'Routing error' derailments are thus also likely to be rare and largely confined to low speed areas. That brings us back to speed related derailments on curves of a radius that it is not safe to transit at the maximum system line-speed; very much the scenario that applied in the case of the Croydon derailment and at least two others on other systems within the last year. Whilst there are many other contributing factors particularly if there are tunnels and/or elevated sections this is the key risk issue for simpler tram systems.

It seems to us that having a tight curve at the end of a long straight section (even without the potential disorientation of a tunnel at night) such that failure to control speed will result in derailment is a wholly foreseeable accident which, given the human propensity for distraction, and or other loss of attention, demands some form of automatic control or automatic warning not just lineside signs. Such speed control and/or warning systems exist, so the only possible argument against fitment can be that the cost is grossly disproportionate to the benefit.

We were therefore somewhat surprised that Recommendation 3 of the RAIB report into the Croydon derailment, regarding speed enforcement, was not more strongly worded to create the expectation that a cost-effective solution (and not just a solution) should be found.

It is the ITC's belief that any track layout which includes curves which it is possible to approach at above the derailment speed should be protected by some form of 'speed trap', 'speed control', or at the very least, a very marked audible or 'unmissable' visual warning in the cab if the tram is approaching at excess speed to reduce the risk of derailment ('Speed trap' is the term used for the main line Train Protection and Warning System [TPWS] in GB to describe a device which measures the speed of the train at a single location and enforces a brake application if a defined speed is exceeded). This will still leave many tram systems and parts of tram systems where 'line of sight' driving is permissible without such controls because the curve radii are such that an overturn is extremely unlikely. Thus, for most trams, a truly intermittent 'TPWS like' device seems likely to be the most cost-effective solution.

The cost conundrum

It seems to the ITC that the big problem with the application of control systems to trams has been an element of 'the best being the enemy of the good'. The number of new tram systems being built represents relatively low volume so in many cases the fitting of control systems that are (perhaps slightly modified) versions of heavy metro solutions as a 'dedicated' development cannot be justified. If the owner and operator are prepared to pay the up-front and on-going maintenance costs for such a system then from a safety perspective this is good, but many tram systems are very budget dependent in terms of whether they get built at all, and reference to the risks above would indicate that such a solution represents 'gold plating' for many trams that are mostly street running and/or at grade tracks with large radius curves.

We also recognise that trams are at the 'sharp end' of competition with road and that the factors that led to a revival could reverse with the increasing adoption of autonomous and zero emission road vehicles. Any guidance must remember that in terms of added costs, and in particular regarding the issue of required safety integrity and validation for tram control and signalling systems, the requirements must be addressed pragmatically.

For speed control/warning alone something much simpler than the existing systems should be possible and if it provides an underlying monitoring and intervention/warning function normally unseen to the driver it should be possible to avoid needing a high level of safety integrity with its associated high validation and approval costs.

Many systems deployed on trams, even those purporting to be tailored or specifically designed for the application are advertised as being designed and validated to CENELEC SIL 4. But if we consider a truly intermittent 'TPWS like' speed trap which intervenes only if the approach speed to a restricted curve is too fast then this is an 'on-demand' or 'low demand mode' function under the core IEC61508 standard. That is a much less onerous design requirement and it should be possible to meet it with a single channel 'commercial off the shelf' solution.

It also seems entirely feasible that a 'no SIL' system that measures speed continually and aligns this to the geographic whereabouts of a moving tram but has no interface to the tram braking system, merely giving an urgent vigilance alert to the driver, could well be an acceptable solution in terms of reducing this risk ALARP. This should be the very minimum that would be acceptable to the safety authorities beyond the provision of additional or re-positioning of fixed lineside signs for layouts with this type of derailment risk.

So the challenge to those implementing recommendation 3 should be to come up with a 'cheap and cheerful' intermittent speed control or warning solution. The challenge to the regulators is to accept the deployment of something that significantly reduces risk, even if it does not meet the 'normally expected' standard of integrity for main line or heavy metro railway signalling. Such a solution would then be available as a cost-effective risk reduction for other systems with similar derailment risks.

Current status and conclusion

Transport for London has made good progress on a number of the RAIB recommendations including improving situational awareness for drivers and managing driver alertness. Temporary lighting has been installed on the approach to Sandilands Tunnel and tunnel lighting is planned for this year. Additional speed signs have been added and a network wide maximum speed reduction from 80km/h to 70km/h implemented. An innovative new 'Driver Protection Device' has been installed which detects and manages fatigue and distraction. That system uses advanced, safety-verified sensors that track eyelid closures and head movements so that when fatigue or distraction is detected an in-cab alarm is sounded and the driver's seat vibrates to refocus the driver's attention. The new iTram information system planned, based on proven technology from the bus industry, will provide an in-cab alert if the speed limit at any location is exceeded.

Despite the unquestionable reduction in risk that the above measures will have brought, TfL is still (perhaps unsurprisingly) responding to recommendation 3 by installing an automatic speed control system. The contract has now been placed with ESG (a DB company) with the main component parts of the system supplied by Sella Controls and their sub-contractor EKE of Finland.

For a full description of the system please see Clive Kessell's excellent article in the April 2019 edition of Rail Engineer (**irse.info/86m4s**) but in summary it is, as we postulated above, a 'TPWS like' speed trap which will be applied at the vulnerable locations and directions (some curves are only a risk from one direction of approach). Like main line TPWS, it has its origins in a right-side door enable system but by using more modern communications technology and digital messaging needs only one beacon per 'speed trap' operating in the unlicensed 865.7 to 867.9 MHz band, rather than the two low frequency analogue loops of main line TPWS. The positioning of the beacons is not critical although they do need to be known as the system uses them as Absolute Position References (APRs) or Norming Points (NPs) like many metro CBTC solutions to accurately locate tram position. The beacons are 'telepowered' by the passing tram and answer back with the start and end of a zone and the maximum speed allowed within it. An on-board computer then uses the existing odometry to measure to the start of the zone and will initiate a brake application if the speed goes above the permitted maximum at any point within it. Graduated speed reductions can be enforced using multiple beacons, which can be placed together or separated depending on need and other track features since the distance to the zone start is calibrated but not determined by the beacon position. We understand that for Croydon between 2 and 4 beacons will be used at each 'control zone' depending on location. The on-board computer automatically communicates an incorrect beacon sequence to a central control station if a beacon is faulty or missing (the latter by knowing the sequence of beacons in a route) via public 4G. Should an over speed be detected, then the brakes are automatically applied and the tram is brought to a stop. It is understood that there will be an override which will allow a driver to reset the system and proceed (but only after getting permission from control) in the event of either a trip or a system fault.

In the opinion of the ITC there is little doubt that technically this system will do the job and reduce what is already a very low risk firmly into the 'broadly acceptable' band. The key question as far as we are concerned is what is it going to cost? At present both TfL and ESG are being 'tight lipped' about the contract value so we have little idea of the recurring and non-recurring costs and which of the non-recurring costs are true 'one-off's' and which are Croydon specific. In our view that will be critical in determining whether the system is more widely adopted or remains unique to Croydon. The system has been specified by the client as 'SIL 2' which is undoubtedly 'overkill' at the level of risk involved for this 'on-demand' system. However, it is clearly necessary for the system to have some defined integrity to allow an overall case to be made and it is likely that specifying SIL1 or SIL0 would not save much, particularly if the system components have already been assessed to SIL2 for other applications.

The ITC is very supportive of this project, which looks like a pragmatic technical solution given the circumstances of something having to be adopted. If the costs can be controlled to a reasonable level, wider adoption by other tram operators seems likely. Since this is a public procurement contract, sooner or later the contract value and its make up should eventually emerge. As and when that happens, we will issue an addendum to this article.

What do you think?

What is your experience of light rail signalling? Have you delivered a light rail speed control system? Has your railway authority tackled these issues in a different way? We'd love to hear from you, email **editor@irsenews.co.uk**.

The use of formal methods in standardisation of interfaces of signalling systems

   

Prepared on behalf of the International Technical Committee by Maarten van der Werff, Bernd Elsweiler, Bas Luttik and Paul Hendriks

Like other infrastructure managers (IMs), ProRail BV and DB Netz AG are responsible for the safe and efficient running of trains; their signalling systems play an essential role in this task. That is why they have to convince themselves of the correct level of safety of the technology used. This article describes the cooperation of these two IMs in paving the way towards the application of formal methods that can be used to prove the quality of software applied in signalling. As described later in this article, the scope of the work focuses on the interfaces within the signalling system.

This paper about interlocking interfaces is one of three ITC articles concerning formal methods. The second will address the use of formal methods in the certification process of Hybrid Level 3 ETCS, the third will deal with interlocking applications.

Signalling domain specific requirements

Many railways do not have a complete written set of signalling system requirements readily available. A lot of knowledge is still in the minds of a few specialists; technical solutions and schemes that are common to conventional technology are available; specialists know how to read their own documents. It is routine that in specification, review and validation specialists communicate in natural language. However in the interlocking domain this information is incomplete and ambiguous.

A complicating factor is that the signalling requirements include the operational rules of railway undertakings. In the course of time, this has been implicitly assessed by the agreement of the captured requirements for conventional interlockings. For a correct interpretation needed in the digitalisation of signalling and communications technology the implicit operational background must be made more explicit. The analyses of use cases based on railway operations should lead to an unambiguous description of functionality and behaviour of the system to be designed. An unambiguous description cannot be achieved using natural language, on the contrary, the development of reliable computer technology in the modern signalling environment requires the use of state-of-the-art methods and tools. Tooling is often associated with high investment costs. It is, therefore, preferable to collaborate on an international level and use standardised methods and techniques tailored for the signalling industry.

History of formal methods in signalling standardisation

In 1997 the UIC published the report of the European Railway Research Institute (ERRI) project A201 proposing to harmonise functional conditions of signalling systems. For the first time in signalling history the functional rules of interlockings were exchanged and analysed on a very broad basis. This was supposed to be a future proof approach, because even if new signalling technology were to appear, the basic vital functionalities would continue to exist. A more formal way of describing the interlocking functional requirements was sought, but this could not be found. In those days no cost-effective common approach was applied across the railways or in industry. This is still what we do, but we are far better at analysing state-transition diagrams nowadays, and we have higher-level languages to describe them.

As there was not much experience with formal and semi-formal methods many new methods were developed. In the UIC working group UIC 7A/16 a method called EURIS (European Railway Interlocking Specification) was developed. The EURIS method is a semi-formal method that defines building blocks (e.g. Signal, Track, Point). For each building block, operations are defined and these operations are described using flow charts.

In the UIC-project EURO-INTERLOCKING (1998-2008) for one of the first times ever a systematic approach was exercised for translating the captured requirements into a model, and that model was visualised with a tool. It appeared that both the skills of a signal engineer and a modelling specialist were needed to do this work. Besides this, during modelling it was experienced that in an iterative process the requirements needed an extra quality step both in verbal language and in completeness.

Based on the EURO-INTERLOCKING experience, in INESS (Integrated European Signalling System, 2008-2011) it was decided to define work for universities both for modelling and for exercising consistency checks. The objective of INESS was to develop specifications and associated material for the development of a European interlocking standard based on common requirements, including ways to verify models for interlockings. Tools to be used were defined, taking into account that there was a limited budget, that needed to reuse and modify existing tools, rather than develop new ones. The result of INESS contained a verification tool chain in the form of a research prototype, which could lead to a modelling and verification environment. However the model became available only towards the end of the project, when there was no time left for in-depth verification activities.

Model based system engineering

An important development evolved in EULYNX (project phase 2013- 2017, continuing organization from 2017 onwards **www.eulynx.eu**). In EULYNX the European infrastructure managers standardise the interfaces between signalling subsystems of different suppliers. The adoption of EULYNX will reduce both life cycle costs and time-to-market by preventing repetitive industrial developments of interface technology. EULYNX has developed a reference architecture, including how subsystems interact across the interlocking interfaces. EULYNX uses model-based system engineering (MBSE) which means that the functional behaviour of the interfaces is defined through unambiguously semi-formal, executable models. This complies with the CENELEC standard EN50128, which states that semi-formal methods are highly recommended for the specification of software requirements.

EULYNX is an innovative way in comparison with specifying requirements in natural language. The (semi-) formal method can be understood by people, and offers the user multiple views of the system to allow a clear understanding. Using the SysML modelling method, the infrastructure managers have defined the appropriate use case descriptions based on their knowledge of both national signalling principles and the non-harmonised operational requirements.

Following the experience from EURO-INTERLOCKING and INESS, in this phase modelling and system engineering expertise is combined with railway expertise. In recent years modelling has been accepted in various fields, such as the chemical, automotive, aerospace and telecom industries. This method includes the test domain by introducing model based testing. The method for modelling interfaces in combination with model based testing and generation of automatic test cases will be crucial for maintaining the standard. Early feedback that the standard is compliant with the automation of test execution will increase the level of sustainability. This is a prerequisite for keeping the standardised interfaces alive.

Implementation phase at IMs

A feasibility study conducted research on EULYNX models and the specifications that were available at ProRail. It included reviewing the modelling domain. This led to the conclusion that the EULYNX form of modelling can be useful for ProRail. It helps to understand the interface communication between interlocking and its subsystems. For example, EULYNX requirement specifications contain the main information in the form of models, while ProRail does not have models that describe these requirements.

DB Netz has already gone one step further in applying standardised interfaces in signalling projects. Starting with a national specification project some years ago, DB adopted the first European specifications in their latest projects and will use the European specifications for their roll-out programme. This approach delivers clear added value with respect to life cycle costs, innovation and performance objectives of future signalling systems.

Since EULYNX uses the concept in which the model is the main container of the requirements, the validation process is mainly the validation of models. It is the basic task of each IM to create a validation and testing approach to ensure that all requirements are included for implementation. With the already published baseline EULYNX has taken an important step towards formulating a stable standard. This result is sufficient to enforce an unambiguous interpretation by various suppliers. Validated SysML models provide useful guidance when testing the conformity of delivered components to the IM.

Current initiative of ProRail and DB Netz

Infrastructure managers DB Netz AG and ProRail together with Eindhoven University of Technology and the University of Twente have decided to investigate the use of formal models in a research project called FormaSig. Formal models are models that are defined in a formal modelling language with mathematical semantics that can be fully understood by a computer. These two universities have developed a formal modelling language and a corresponding powerful tool set, which are particularly suitable for analysing the quality of the system designs. They will perform a mathematical proof that the interfaces behave correctly, based on the EULYNX SysML models, national knowledge and the typically used national specific subsystems of the two infrastructure managers. You can watch a presentation of this project on YouTube at **irse.info/6dujm**.

The main objective of the research project is to encourage the use of (formal) models in order to improve the quality of standards and tender documents in the railway domain. An explicit concern of the IMs is the traceability of requirements formulated in natural language. With the increasing complexity of today's electronic signalling systems, it becomes increasingly difficult to verify that they meet their original requirements. However, the methods developed in this project will help to define test specifications that allow interfaces to be validated without full traceability to legacy requirements. The result will be that experts are exposed to a new way of working with regard to specification, testing and certification in the relation to market parties.

The results of the project can support the EULYNX standardisation process in the entire chain from users to equipment, including the approval processes for interfaces to supplied components. The development of the EULYNX standard provides an excellent opportunity to investigate how this approach based on semi-formal and formal models can further improve the applicability and the scalability of methods applied in the railway domain, as well as industrial verification and testing of state-of-the-art academic technologies.

We know from the past that development of a formal method requires a lot of resources (time, money). This experience was built on interlocking modelling in INESS. By limiting the scope to interfaces, which contain much less functionality compared to a complete interlocking (even with a limited number of field elements), it is expected that the project ambition will be achieved within the foreseen period of four years and for acceptable costs.

Benefit for the interlocking domain

The use of formal methods in the standardisation of interfaces of signalling systems is a continuation of long-term use of knowledge of (semi-) formal methods. This had already begun with the introduction of the Vital Processor Interlocking of General Railway Signalling in the Netherlands in the 1990s. This knowledge has been an input for the European standardisation projects mentioned above. It has been shown that many experts and students involved have found their careers in the field of railway signalling.

Formal methods will help to accelerate innovation processes and establish standards at a European level. In particular formal representations of real systems help to develop and test new functions applying state of the art engineering tools. For industry as well as for IMs formal methods are the basis for the automation of test procedures and are therefore helpful means to maintain international standards.

By continuing the cooperation between IMs and universities the circle of knowledge carriers will receive a new impetus. As was seen in the 1990s it can be expected that the initiative of ProRail and DB will also result in more activities in the combined knowledge domain of electronic interlockings and modelling, both for the railways and for market parties. In future a new generation of signalling experts working in the signalling domain will apply the results of the initiatives described. These experts will be exposed to a new way of working with regard to specification, testing and certification in relation to market parties. Suppliers already have their own system design processes and all these known and unknown steps need to be linked in the right way. Railways must invest resources in this type of activity. Consultants and engineering services in the area of (semi-) formal specification and universities can work on that task in order to get sufficient state-of-the-art skills in the process.

Conclusion

The characteristics of railways have made it necessary to introduce complex systems for signalling to avoid essential hazards. The aim is to improve the competitiveness of the railway business. The formal methods developed in the research project will help to define test specifications with which signalling systems can be validated without full traceability to legacy requirements. The initiative of ProRail and DB shows that 25 years of effort in the area of standardisation offers advantages in the field of effective and efficient quality improvement in the specification, realisation and validation of signalling systems.

All the IMs involved in EULYNX can benefit from the results by using the methodology and tools in their own quality assurance processes.

The ITC and the authors thank ProRail, DB, and the involved universities that contributed to this article.

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So, you don't have time for CPD?

Continuing professional development is an essential part of being a professional engineer and a member of the IRSE.

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Reflecting on the IRSE International Technical Committee

Clive Kessell
Past President, IRSE

Past president and member of the International Technical Committee (ITC), Clive Kessell has recently stood down from the ITC as he claims to be 'long in the tooth', although he will remain a corresponding member to offer his experience for the time being. In this article Clive reflects on the history of the ITC and its valued contribution to the industry and the IRSE.

Amongst the smaller UK professional engineering institutions, the IRSE is certainly one with a large contingent of members not having a UK address. The Institution, since its conception in 1912, has always had international connections, mainly associated with the need to signal railways in the then British Empire. Sections in Australia were followed by Hong Kong and more recently South Africa. India had a section for many years, which was then abandoned but has revived in more recent times. Links with Europe have strengthened since the 1950s (we now have sections in France, Switzerland and the Netherlands) and an IRSE section in North America. Latterly, sections have been formed in Malaysia, Singapore, Indonesia, China, Thailand and Japan.

That said, the IRSE has been UK orientated down the decades with its membership gaining knowledge of signalling in other places through the annual International Convention. Photographs of members in hats enthusing over a point machine or signal head may be found in the Proceedings of the Institution and the occasional London paper by a non UK author was about as far as it got to the IRSE acting in a truly international manner.

Origins of ITC

All this changed in 1990 when the president Jacques Catrain, the deputy managing director of GEC-Alsthom, realised that the profession needed a far greater technical input of signalling systems across the world, if it was going to achieve its objectives of being the focal point of signalling technology for all countries. His programme of papers was dominated by European speakers with subjects ranging from French railway telecoms. Italian railway signalling, a Swiss railway microcomputer interlocking, signalling technology on the German Federal Railways and a French review of signalling safety and progress

More importantly, Jacques initiated a Technical Committee comprised of senior IRSE members in European countries from both the railway technical departments and the supply industry. At that time, European railways were vertically integrated organisations, most being state monopolies and the supply industry was a handful of major companies. Jacques realised that the industry was changing and the competition for business by every supplier having different products, with only loose standards to bind systems together, was not going to be sustainable in the longer term. The first subject for discussion was system safety validation followed by track to train protocols

By 1991, with Jim Waller as president, also from GEC Alsthom, the group had become the International Technical Committee (ITC) with 16 members from across the industry participating. One of its first reports on the subject of cross acceptance of vital signalling systems was presented as a London paper in March 1992 by Eddie Goddard from London Underground and Charles Zufferey from SFF-FFS in Switzerland. This set the scene for the work of the ITC in the coming years, not only by introducing a strong European dimension into the work of the IRSE but also embracing metro as well as main line signalling practice. Cross acceptance was a subject that was to re-appear on the ITC agenda as something that everyone sees as highly desirable but with certain vested interests making it difficult to implement across national boundaries.

ITC initial reports and strategic guidance

With the senior level of representation on the ITC, it was well placed to debate and report on the issues dominant at that time. The result was a series of formal reports that gave strategic guidance to the signalling industry and that would hopefully become reference documents into the future.

- No 1 – Safety System Validation with Regards to Cross Acceptance of Signalling Systems by the Railways – January 1992.
- No 2 – Operational Availability of Railway Control Systems – December 1993.
- No 3 – The Influence of Human Factors on the Performance of Railway Systems – May 1996.
- No 4 – Implications of Applying Transmission Based Signalling – January 1998.
- No 5 – The Contribution of Signalling to the future of Rail Traffic Management and the Economics of Rail Transportation – November 2000.

- No 6 – Proposed Cross Acceptance Processes for Railway Signalling Systems and Equipment – April 2003.
- No 7 – Quality of Services in Railway Traffic Management Systems – December 2004.

Other publications with strong ITC influence emerged during this time, including The Role of Notified Bodies (NoBos) in 1999 and European Standards, also in 1999.

Re-reading some of these reports some 20 years later is an interesting experience. The rail industry was changing, firstly by European directives that infrastructure should be split from train operations (at least in financial accounting terms) and secondly the advent of privatisation led by Sweden and Great Britain, both of which created many questions as to how the signalling and telecoms functionality would fit into and serve the new organisational structures. The ITC reports attempted to tackle some of these issues, the conclusions from which might be regarded as blindingly obvious at least for some of them when viewed in 2019, but in others the challenges remain as pertinent and difficult today, e.g. cross acceptance. Just how much notice was taken of these reports when first published is difficult to ascertain but it is suspected few people took note of the conclusions and recommendations, with most recipients of the reports consigning them to the bookshelf to gather dust.

The change in rail organisation had implications for ITC membership with the captains of the rail and supplier organisations being replaced by technical experts, these being in the majority from the supply industry with a decline in the number of people from the rail infrastructure organisations. Partly this was due to 'signalling' being absorbed into the new and generalised 'asset management' departments, where in some organisations signalling regrettably lost some influence as to how the railway should be managed and operated.

Directed or self-determination

The ITC has always valued its independence in that it set its own agenda, the subject matters to be studied or debated and the way it which its output would be delivered. This had both advantages and drawbacks. The plus side was that the ITC would not be constrained by IRSE processes (some would say bureaucracy) and could proceed without undue outside interference to look at the areas of concern within the signalling profession that it determined were controversial or difficult. The downside has been that the output from the ITC has been somewhat side lined in terms of its visibility to the wider IRSE membership and more importantly to the global signalling profession.

In 1999, following the Ladbroke Grove accident when a suburban train from London Paddington passed a signal at red and collided head on with a high speed train as it was approaching the terminus resulting in 31 fatalities and many people injured, a judicial inquiry into the deployment of train protection systems was initiated. The IRSE was inevitably involved in the inquiry and in anticipation of this, the Institution initiated a 'Signalling Philosophy Review' to study not only the requirements and implications of providing an automatic train protection system but also the impact of human factors in a modern signalling system.

The ITC was asked to provide an overview of signalling practices in Europe and North America that could be compared with the then current UK situation. Strangely, some members of the ITC resisted this request on the grounds it would undermine the ITC independence, but the majority were in agreement especially in view of the circumstances. The IRSE Signalling Philosophy Review was published in April 2001, with the ITC element forming a significant part of this, containing details of German, French, Dutch and American signalling practice, all of which were duly taken into account. It is probably the most important piece of work that the ITC ever engaged in.

The changing railway and ITC reaction

With the dismemberment of the rail state monopolies, finding people to sit on the ITC who were the 'directing minds' in how signalling was organised within the new 'asset' organisations proved to be increasingly difficult. Thus the ITC has gradually become populated with people with significant engineering knowledge both from the railway and supplier sides of the industry. As such, the subject matter has gradually moved towards engineering type challenges faced by signal engineers rather than commercial or managerial matters. The international scope of the committee increased at the same time with members from America, Canada, Japan and more recently Australia joining. The ability to participate at meetings by video link has made it easier for people in far off lands to play a full part

In parallel, it was recognised by the ITC that the formal reports prepared by the committee were taking considerable time to research, agree and publish (often in excess of two years) by which time the subject under discussion may well have changed in scope and/or importance. A means of speeding up the process was deemed necessary and from 2007 onwards, the ITC output has been in the form of shorter 'articles' that would be offered for publication to IRSE News and other rail technical magazines. These are also available on the IRSE website.

This has had two effects; firstly the number of subjects studied has increased significantly and secondly the information is made available to a much wider audience. Every article is assigned a 'champion' (usually the person who suggested it in the first place) who then prepares a 30 second message setting out the objectives of the article and the broad order information it should contain. With the advent of email and group addressing, agreement for the article content can be achieved much more quickly whence the serious writing can begin. Depending on the simplicity or more likely complexity of the subject, the article will normally be finalised within a year and published soon after. Since 2007, some 38 articles have been produced and represent a significant part of the knowledge base that the IRSE has assembled down the years.

The one downside to this approach is that the articles are just that – an article in a magazine that sits alongside many other articles. It is to be hoped that people will read it but with the risk that the chances of it remaining in the memory diminish over time.

Subject matter

Looking at the subject matter of the 38 articles, some stand out from the list as recognisably difficult right across the globe. These are:

- ERTMS/ETCS and its progression from Level 2 to Level 3.
- Safety Integrity Levels (SIL) and understanding what they mean.
- Cyber Security.
- CBTC and its application both on metros and main line.
- The shortage of signalling engineers and associated recruitment and training.
- The relevance of standards and how to promote Innovation.
- How signalling impacts on safety beyond the engineering elements of the profession.
- Speed control measures to ensure some recent accidents do not re-occur.

Even on a coach transfer, the ITC discussions never stop. Three past presidents of the IRSE and Mrs Kessell on the bus, from left to right, Francis How, Clive, Penny Kessell and Peter Symons.

The attendees at the 2016 ITC conference in Japan, Clive is second from the left.

Other subjects are more mundane: level crossing technology, combating cable theft, managing obsolescence, ATO application, understanding signalling failures and such like. Important as they are, these tend to be of a tactical dimension rather than the important strategic direction

The ITC has struggled with some subjects, for example the future of GSM-R and its replacement and the impact of Internet Protocols (IP) in signalling systems, both of which are significant for the associated telecommunications discipline, the technology for which tends to be determined by the global telecom industry and which moves a lot faster than signalling.

There are also subjects that are proposed that fail to reach a consensus for discussion and are quietly dropped. It's all part of the collaborative process. In all of these, if the original wording is prepared by someone who does not have English as his/her first language, then it is the duty of the English speaking members to ensure that the final text is grammatically correct with no spelling errors. The working language of the ITC is English (as indeed it is for all IRSE correspondence) and it is with admiration that we from the UK, Australia and America compliment our overseas colleagues for being so fluent in our native tongue

Some thoughts for the future

So where does the ITC go from here and what should it concentrate on? The present chair, Frans Heijnen, has announced his intention to step down at the end of this year and is seeking a successor. Other than Wim Coenraad who has been a member of the ITC since its earliest days, none of the present members have been chair so the opportunity is there for one of them to step up to the challenge.

Frans has done a good job in bringing more focus to the subjects under discussion and the production of articles has accelerated during his time in office. For the IRSE membership in general, the ITC is still shrouded in something of a mystery and it is hoped that through this article some of the mystery has been revealed.

Some thoughts on how the ITC might operate differently are set out below:

- Become more integrated into mainstream IRSE policy with the chair having a permanent seat on Council.
- Present at least one of the recently produced articles as a paper during the president's year of office and at any convention or international seminar organised by the Institution. (This already happens to a degree but it is not always recognised as an ITC effort).
- Be open to ideas from the Institution as to subjects that the ITC could usefully contribute to in the furtherance of signalling technology internationally.
- Give increased consideration to commercial and managerial aspects of signalling that potentially have worldwide impact. An example would be the proposed merger of Siemens and Alstom (now abandoned) although it is recognised that some members would have vested interests and might have to disassociate themselves from any conclusion.
- Strengthen the telecommunications participation on the ITC as data and comms will be so important in the future structure of signalling systems.

In turn, the IRSE management should be prepared to put more resource into ensuring the continuing success of the ITC. Currently, ITC members cover their own costs to attend meetings often at considerable expense and it is a measure of dedication that they are prepared to do this. Some members have the benefit of expenses being covered by their employing company but for those who do not have this facility, they have to pay their own costs. Surely the IRSE has some duty to financially assist those who struggle to afford attendance

The role of secretary to the ITC is potentially career-advancing. Hugh Rochford from SNCF carried out this duty for many years and benefited accordingly. The present secretary, Jane Power, is enjoying her exposure to international signalling debate and will hopefully reap rewards in due course

It has been a privilege for me to have been a member since 2000 and I have gained many international friendships from this. I have also gleaned an immense amount of knowledge just by being part of the discussions, and being primarily from a telecom background, have often acted as some kind of 'wild card' by asking the occasional awkward question. I have recently stepped down from being a mainstream participant but I will remain a corresponding member at least for the time being. If nothing else it keeps the brain in gear and is good for the CPD record.

May the IRSE ITC continue to flourish in the future.

IRSE
Institution of Railway Signal Engineers

ETCS L2 and CBTC over LTE

Rodrigo Alvarez
Rail Systems Australia

In October 2013, the author and his colleague presented a white paper to the IRSE Perth Technical Meeting entitled "ETCS L2 and CBTC over LTE – Convergence of the radio layer in advanced Train Control System". The paper described the trends towards using increasingly similar hardware platforms to implement different train control system applications, and how that trend could affect the radio component of those same train control systems. This paper, first presented to the Australasian Section in Brisbane in March, will re-visit the postulates presented back in 2013 and review them against the actual technological evolution of the last five years, by drawing a picture of the current state of this area.

The paper identified 3GPP defined Long-Term Evolution (LTE) as an emerging radio technology that could act as a common train-to-trackside transport layer that replaced the existing radio layers of the main automatic train control applications of the day, European Train Control System (ETCS) and Communications-Based Train Control (CBTC).

Half a decade has passed since that paper was first presented, and natural passage of time begs the question: what has been the evolution of automatic train control systems since then? Have our 2013 predictions proved accurate? And what can be said about what is likely to happen in the next five years?

Introduction

The last five years have seen a continued expansion in the deployment of the two automatic train control (ATC) technologies we discussed back in 2013. Both ETCS and CBTC have continued to evolve and improve, while the number of deployment references has continued to climb.

The following sections kick off by covering the evolution that ETCS and CBTC have experienced since 2013 and by concentrating on the trends and developments seen in their radio layers. References to our 2013 white paper will be made where necessary to provide further details.

ATC system evolution

ETCS developments 2013-2019

In 2013, most (if not all) ETCS deployments in the world had followed version 2.3.0.d (also known as Baseline 2) of the ERTMS System Requirement Specifications (SRS) issued by the European Railway Agency (ERA). The much-anticipated Baseline 3 (whose first published version was SRS 3.3.0) was finally accepted by the European Commission in November 2012.

The changes since 2013 include a change of name for the authority that issues ETCS specifications – now the European Union Agency for Railways, although its acronym is still maintained as ERA – but the uptake of Baseline 3 has been fairly limited. Baseline 3 tests took place in Denmark in 2016, but no Baseline 3 compliant systems have yet entered into service.

Amongst the differences between Baseline 2 and Baseline 3, we can find additional operating modes – such as Limited Supervision (LS) and Passive Shunting (PS) – as well as improvements in other technical aspects, such as braking curve optimisation.

Baseline 2 deployments, however, have continued to grow in the last five years in Europe, with further implementations along the strategic Rotterdam to Genoa corridor being key examples.

Outside Europe, new ETCS systems have been put into service in Morocco, Israel and Turkey. China has seen the continued deployment of its domestic version of ETCS, branded Chinese Train Control System (CTCS).

ATO over ETCS Level 2

Our 2013 paper described automatic train operation (ATO) as a functionality of CBTC systems that was becoming more and more attractive for rail operators to provide automatic traffic management and an optimisation in travel time and energy resources.

We also predicted that, since ATO was a non-safety-critical application, its implementation over an ETCS Level 2 (L2) system acting as the equivalent of a CBTC automatic train protection (ATP) function would be feasible, and very desirable for rail operators.

The paper highlighted how this ATO over ETCS L2 trend was part of a more general trend within each application market, effectively steering ETCS L2 to converge with CBTC, as seen in Figure 1.

Back in 2013, the emphasis seemed to be in the development of a future Level 3 for ETCS. A standardised Level 3 which incorporates ATO functionalities and true moving block is

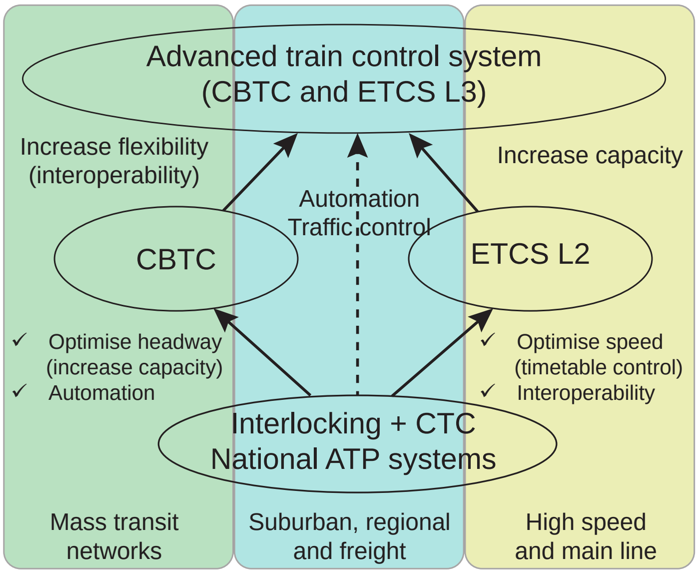


Figure 1 – Requirements for CBTC and ETCS convergence.

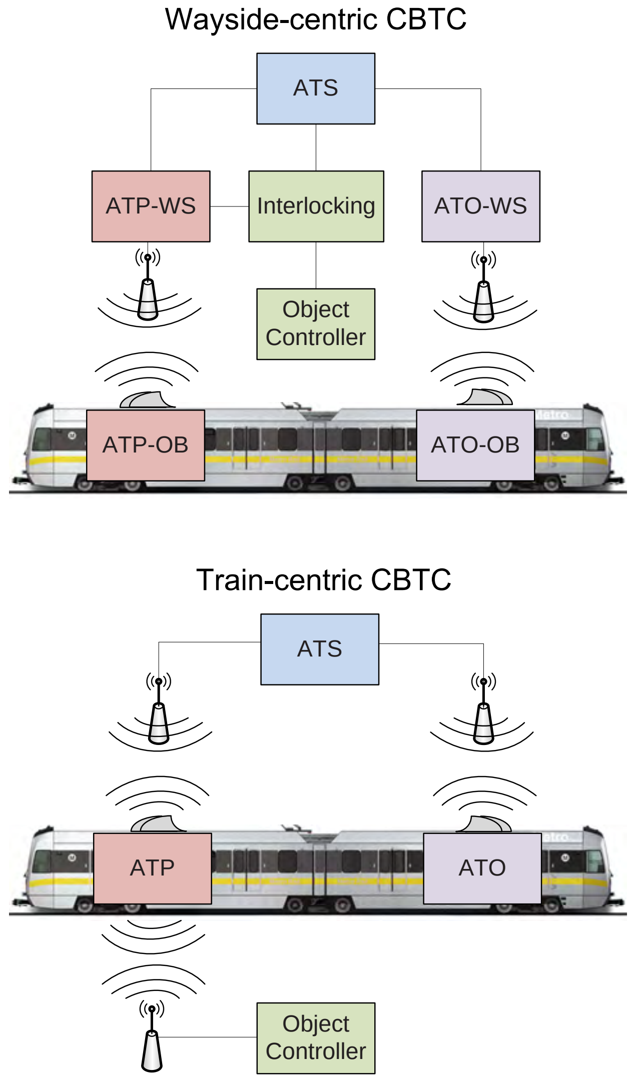


Figure 2 – Wayside-centric vs train-centric CBTC architecture.

not yet a reality, but bespoke ATO integrations over ETCS L2 certainly are.

Our paper already indicated that the Thameslink project in London (UK) was the first planned attempt to implement ATO over ETCS L2. Govia Thameslink Railway (GTR) ran the first train in passenger service with ATO over ETCS L2 service in the world in March 2018, with full peak period operation scheduled for December 2019.

Down Under, Rio Tinto has announced completion of its AutoHaul project in January 2019 in the Pilbara (Western Australia). AutoHaul, a proprietary driverless ATO+ATP system heavily based on ETCS L2, could be to a certain extent counted as an additional implementation of ATO over ETCS L2.

Therefore, ATO over ETCS L2 is now a reality. Other projects around the world are getting ready to follow suit, most notably the Transport for New South Wales Digital Systems project, which plans a staged roll-out of ETCS L2 with an ATO component over the Sydney metropolitan railway network across the next few decades. The Cross River Rail project in Queensland is also planning a Grade of Automation 2 (GoA2) ATO over ETCS L2 implementation, so it is fair to say that a significant part of the evolution of ATO over ETCS L2 in the next few years will take place in Australia.

CBTC developments 2013-2019

Our 2013 paper identified interoperability as a significant trend in the future of CBTC systems, since it was one feature where ETCS proved superior to CBTC at the time.

We must recognise that this prediction did not work out as well as others. Although interoperability is indeed an attractive feature for rail operators willing to expand their supplier base, typical CBTC mass-transit applications are mostly self-contained, segregated operations, and do not generally require interoperability with freight trains or medium to long-distance trains entering CBTC territory.

Because of this, and in spite of the significant amounts of time and money invested by some operators, such as New York City Transit and the US Federal Railroad Administration, mainstream CBTC interoperability is not currently on the horizon.

Bespoke CBTC deployment, however, has mushroomed in the last five years. No less than 70 separate CBTC deployments have entered into service between 2013 and the end of 2018, with a significant percentage of them taking place in mainland China. CBTC in its different implementations and variants is now, without a doubt, the most prolific automatic train control system in the world.

A fascinating development that did not seem obvious in 2013 has been the trend towards train-centric CBTC systems. Both Alstom and Hitachi have presented CBTC-lite products oriented towards the growing light rail market, where most vital functions are located in train-borne equipment – see Figure 2. It is still to be seen if these systems will at any point represent a significant market segment, but the parallels with autonomous road vehicles are evident and could generate unexpected opportunities.

Radio system evolution

Radio sub-systems in 2013

While ETCS and CBTC have been slowly converging at a functional level, the evolution that is currently taking place in their radio sub-systems is no less interesting, even if less visible, and could have significant consequences.

Back in 2013, ETCS and CBTC presented, despite their commonalities, two very different radio subsystems – GSM-R and Wi-Fi. Let us explore the evolution experienced by these two technologies over the last five years.

ETCS L2 radio

As described in our 2013 paper, GSM-R is the radio technology mandated by ERTMS standards to provide both interoperable voice services and a data carrier service to ETCS L2.

This has not ceased to be the case in the intervening years since 2013. Most ETCS L2 implementations around the world are still based on circuit switched (CS) data transmission over GSM-R. Several interesting developments, however, have indeed taken place.

ETCS L2 over GPRS

Our 2013 paper already described the trend towards packet switched (PS) ETCS L2 as a way to increase the number of simultaneous ETCS L2 instances that can be supported by the restricted bandwidth available to GSM-R networks around the world, and to prepare towards a future transition out of GSM-R and towards future broadband technologies.

The Annex to Subset-093 described in our original 2013 paper has not yet been formally issued. However, both the UIC and the ERA have provided guidance to support the implementation of ETCS L2 applications over GPRS.

Several ETCS L2 implementation projects include a packet switched EuroRadio interface over GPRS as part of their technical requirements. Banedanmark's S-Bane Signalling Programme has included PS EuroRadio amongst its requirements, and Network Rail (UK) has also planned to deploy ETCS L2 over GPRS for nearly a decade, but no implementations are in service as of today.

In Australia, the Transport for New South Wales Digital Systems project includes the concept of an ETCS L2 system with a PS EuroRadio interface making use of the GSM-R based Digital Train Radio System (DTRS) network, which has been operational since 2014.

Non-GSM-R ETCS L2 implementations

At least two projects in the past years have used TETRA as an alternative to GSM-R for ETCS L2 deployment. The first one was the deployment of ETCS L2 on the Uzen-Bolashak and Zhetygen-Khorgos lines by Kazakhstan Railways. The second one was the Roy Hill Railway in-cab signalling deployment in Western Australia.

Although successful, these two deployments do not represent a realistic alternative to mainstream ETCS L2 over GSM-R/GPRS, due to the interoperability issues introduced by non-standard applications and due to TETRA reaching its end of serviceable life as a 2G technology, just like GSM-R.

CBTC radio

The 2013 paper explained in detail how IEEE 802.11 standard Wi-Fi radio networks had become the radio bearer of choice of most CBTC deployments over the previous decade.

Line	CBTC Supplier	LTE Supplier
Chongqing Metro L5	CRCS	Huawei
Hong Kong Metro DUAT 7 Line	Thales	HKT SmarTone
Wuhan Metro L7 & L11	Thales	Fiberhome
Ningbo Metro L3	Thales	Huawei
Jinan Metro LR1	Thales	Huawei
Shanghai Metro L5	Thales	Huawei

Table 1 – CBTC over LTE projects in service.

This statement holds even more true today. Although a few CBTC systems have been deployed using alternative radio bearers – such as waveguides or induction loops – the majority of the CBTC implementations since 2013 use Wi-Fi-based radio systems to bridge the train-to-wayside gap.

CBTC over LTE

Things have started to change very significantly, however. The limitations that Wi-Fi presents to CBTC systems – limitations in range, quality of service, mobility and (especially) interference – have pushed rail operators and suppliers to look for alternatives.

A series of incidents in CBTC systems in China instigated the China Association of Metros to stipulate in 2014 that all future CBTC deployments in China would use LTE as their radio bearer.

2018 saw the first wave of CBTC over LTE projects entering service, almost all of them in China. Table 1 provides a list of the CBTC systems currently operational over an LTE radio bearer.

The deployment in Hong Kong, however, continues to use Wi-Fi as the primary radio bearer, with a mobile phone carrier (HKT) providing an LTE radio backup.

Future CBTC over LTE projects currently in development include Shanghai Metro Lines 15 (2019) and 14 (2020), as well as the ATC project in Perth, Australia, currently scheduled for 2024.

Immediate challenges

GSM-R obsolescence

Our 2013 paper already mentioned that GSM-R technology was approaching its end of life. EIRENE specifications were first issued in 2000, and the first GSM-R implementations started at about the same time. Some GSM-R networks in Europe are now approaching a second decade in operation.

In telecommunications terms, GSM-R was part of the second generation (2G) of mobile telephony technology. Figure 3 shows the evolution of mobile standards in the last two decades – and this is an evolution that has only accelerated in the last few years.

Figure 3 – Evolution of 3GPP standards.

Standard	GSM	UMTS	LTE	LTE-A	MCPTT	MCData/ MCVideo	5G
3GPP release	R99	R4	R8	R10	R13	R14	R15
Year	1991	2000	2009	2011	2016	2017	2019

As a consequence of this evolution, driven by the increasing demand of mobile telephony data throughput, 2G technologies have become completely obsolete in the mobile telephony environment. Singapore has switched off its last public carrier GSM base station, and Australia followed suit in 2018.

Because GSM is being decommissioned in public mobile carrier networks, suppliers are planning to discontinue those obsolete product lines to focus their efforts and investments into the developing 5G market.

As a result, the GSM-R Industry Group (re-named Railway Operational Communications Industry Group in 2016 to distance itself from GSM-R technology) has guaranteed the provision of GSM-R supplies until 2030, but no guarantees are made beyond that date. In fact, some GSM-R suppliers have already served end-of-life notices for some of their products.

This means that current and new ETCS L2 deployments need to make difficult decisions around the radio subsystem, since they risk having to invest millions in a dedicated radio network with an extremely short product life.

The International Railway Union (UIC) and the ERA have been working since 2012 on a standard to replace GSM-R as the default railway radio technology. The project that is preparing that new standard is called Future Railway Mobile Communication System (FRMCS).

In defining the successor technology to GSM-R, the UIC has decided to follow a philosophy very different from the one that led to the EIRENE and MORANE specifications in the late 1990s. The experience with GSM-R has led rail operators and agencies to the conclusion that demanding significant changes to the core functionality of a mainstream mobile technology leads to limited competition, when many suppliers decide not to pursue a relatively small segment such as the railways mobile radio market. This led to less competition and higher prices at the time to procure GSM-R products.

In order to avoid that effect, the strategy devised by the UIC consists in laying a railway-specific application on top of standard mobile telephony equipment. Partnering with the Technical Committee for Railway Telecommunications (TCRT) at the European Telecommunications Standards Institute (ETSI), the FRMCS project has thus been working with 3GPP to embed GSM-R functionalities into a future LTE/5G standard release. The new FRMCS standard is expected to start replacing GSM-R by 2022. The European Railway Agency (ERA) is already planning the migration from GSM-R and producing studies to that effect.

This migration strategy will be accompanied by a strategy to migrate ETCS L2 to this as-yet-unnamed successor radio bearer technology.

GSM-R bandwidth limitation

Another important issue facing the continuity of GSM-R mobile radio is its limited data throughput capability. Back in 2000, data applications over mobile telephony were still in their infancy. 2G technologies produced data rates that are very low in comparison with modern 4G technology – see Table 2.

Data rates measured in kilobits per second are the main reason why train-to-trackside live streaming CCTV does not use GSM-R networks anywhere – video throughput requirements are far too demanding for 2G technology. In fact, even ATO requires more data than GSM-R is comfortable in exchanging with a single train, and could compromise the capacity of a GSM-R network in cases of heavy congestion.

Peak Rates	GSM-R	GPRS	EDGE	LTE
Uplink	9.6 kb/s	40 kb/s	500 kb/s	75 Mb/s
Downlink	9.6 kb/s	60 kb/s	1.6 Mb/s	300 Mb/s

Table 2 – Peak bit rates comparison.

LTE for railways

LTE as successor technology

So, if LTE is starting to support CBTC, would LTE, as the mainstream 4G mobile telephony systems, be the natural successor technology to ETCS L2 as well?

Our 2013 paper already proposed that potential trend, and whilst this has been evident in the CBTC space, why hasn't it happened yet for ETCS L2?

MCPTT, MCData and MCVideo

The first reason has to do with mission-critical voice services.

CBTC systems have started to migrate to LTE networks as machine-to-machine data applications. Data services were what LTE was originally designed to support, and CBTC was already operating over an IP layer provided by a Wi-Fi network. At an application level, the migration from Wi-Fi to LTE has been quite straightforward – although not completely exempt from issues and modifications to the CBTC application.

Those same mass-transit systems that now operate CBTC over LTE, however, continue for the most part to use narrowband mission-critical voice technologies; TETRA is the technology of choice in nearly all cases.

Mission-critical voice over LTE, however, is right on the horizon. 3GPP issued in 2016, as part of its Release 13, a family of standards to support a service called Mission Critical Push-To-Talk (MCPTT). These standards define a series of functionalities roughly equivalent to those provided by narrowband mission-critical voice technologies such as GSM-R and TETRA. The MCPTT requirements are:

- Guaranteed service availability.
- Call prioritisation.
- Low call set up latency.
- Group communication.
- Broadcasting.
- Voice recording.

The MCPTT concept was extended in Release 14 to other mission-critical services beyond voice, such as machine-to-machine data (MCData) and live streaming video (MCVideo).

So far, being such a new technology, the uptake for MCPTT is still very limited. But there is already one railway reference for the standard. In January 2018, the Korea Rail Network Authority (KRNA) announced the entry into service of the first MCPTT-compliant railway mobile network on the Wonju to Gangneung line. A series of new MCPTT projects are in different stages of development and planned to be in operation within the next few years. Notably, the PTA's Radio Systems Replacement for Perth's metropolitan rail network being of utmost interest to Australia in this regard.

The UIC FRMCS is also planning to tackle this issue, by collaborating with 3GPP to produce a standard equivalent to MCPTT. The way in which both standards will interoperate in the future is still to be seen, but it may be possible to treat the new FRMCS application as a new application to deploy over a standard LTE network that already supports MCPTT.

5G as a successor technology

Another reason against the universal adoption of LTE as the successor technology for GSM-R is the idea that LTE is scheduled to be replaced by 5G in the next few years, so a commitment to LTE would be a commitment to a technology bound to be on the way out before the transition is completed.

While it is true that 3GPP is developing Release 15 and Release 16 standards as we speak, the statement that "railways should wait for 5G" is not entirely based on technical grounds.

The false assumption underpinning that statement is that 5G will be to LTE (4G) what LTE is to GSM-R or TETRA. This equivalence is not accurate. While 5G standards will bring about advanced services and features that are not currently available in conventional Release 11 or Release 12 networks, these changes will not require significant hardware changes.

For instance, the changes to the network infrastructure between Release 10, Release 11 and Release 12 have been relatively minor, and mostly circumscribed to software upgrades.

To provide a more detailed explanation: 5G is, in reality, three different things:

1. 5G NR (New Radio) – a new radio interface that will allow mobile networks to deploy base stations in frequencies higher than any ever used before – above 6 GHz. This will result in many small cells with very small ranges capable of serving thousands of users concentrated in a small area, such as a stadium, an airport or a busy train station.
2. Machine-to-Machine (M2M) services that will support Autonomous Vehicles, drones, and industrial machinery.
3. Internet of Things (IoT) sensors reporting with low-frequency, low-bandwidth requirements the status of thousands of devices.

ETCS L2 falls neatly into the second item in the list, and remote condition monitoring falls in the third, but the area that needs to be covered by the railways – long railway lines – falls mainly under the purview of macro base stations that will barely change through the 5G evolution.

In other words; 5G will not replace the existing LTE sites of a public mobile carrier. Public carriers will upgrade their software and supplement them with new sites where necessary. The same will happen with railway LTE networks, except that currently there are no railway operational requirements for 5G NR, which is the new service that will require most of the new investment. For the railways, 5G will be a relatively minor upgrade, not a complete technology replacement.

Conclusions

Our 2013 white paper made some accurate predictions. We correctly identified the trend to deploy automatic train operation (ATO) over ETCS Level 2, and we predicted the migration of CBTC from Wi-Fi to LTE.

The coming years will show us what is the result of the UIC FRMCS project, and what radio bearer technologies are adopted into the ERTMS standards going forward. We will see if the CBTC transition from Wi-Fi to LTE is sustained and LTE becomes a de facto standard for CBTC systems, as Wi-Fi has been in the last 15 years.

More interestingly, we will see how the evolution of 3GPP standards towards the fifth generation (5G) of mobile technologies both impacts current railway LTE deployments and provides new features to support additional applications such as IoT trackside sensors.

About the author ...

Rodrigo Alvarez worked on ERTMS and GSM-R projects in Spain and UK before moving to Perth (Australia) to lead Titan ICT Consultants' rail division. He has been involved since 2013 with the Public Transport Authority (PTA) of Western Australia, acting as senior project engineer and project manager for PTA's radio systems replacement project and supporting PTA's automatic train control project.

Since 2017, Rodrigo has acted as the practice director of the telecommunications consulting arm of Rail Systems Australia. In that capacity, he has supported the company to expand its operation from Perth and Brisbane into Sydney and Melbourne, working for clients like Sydney Trains, Transport for NSW, VicTrack and Public Transport Victoria, while continuing to be heavily involved in PTA's Radio Systems Replacement project.

Industry news

Medellín Metro signalling upgrade

Colombia: Siemens is to modernise the signalling system of the Medellín Metro, including Line A and the Patio de Bello depot. The contract is worth €42m (£36m $48m.)

The scope includes the supply of Trackguard Westrace MK2 interlockings, modernisation of the LZB automated train control system, replacing the signals with LED technology and upgrading the communications and power installations. The new Patio Bello Westrace MK2 interlocking will control a total of 111 track circuits, 58 point machines and 72 signals, and will be fitted with a specific local control system.

Massachusetts Bay Transportation Authority's subway upgrade

USA: Alstom and partner, Barletta Heavy Division, have signed a contract to upgrade and modernise the signalling systems on the Massachusetts Bay Transportation Authority's (MBTA) Red and Orange subway lines. The contract is worth over $80 million (€71m, £61m).

Alstom will provide Orange and Red line signal upgrades, comprising digital audio frequency technology, and the replacement of the existing relay-based train control with Alstom's iVra(integrated vital processor interlocking). The AFTC5 track circuit product will be used, together with digital signalling designed with the capacity to add additional speed commands in the future to take advantage of improved performance of the MBTA fleet.

The scope also includes the new Model 5F wayside switch machines and LED signal upgrades to the Southwest corridor of the Orange line, as well as a new, fully wired central instrument houses at Ashmont station and Columbia Junction on the Red line.

By upgrading the signalling systems on the Orange and Red lines, which total 72km and encompass 41 stations, MBTA will be able to reduce headway between trains, increase the lines' capacity and maximise fleet performance. The project is expected to be completed in 2022.

Dutch ATO

Netherlands: ProRail, Arriva and Stadler have undertaken a week-long trial of automatic train operation on the Groningen – Zuidhorn line in the north of the country, with a modified GTW DMU successfully undertaking a first run on the evening of 15 March.

Operating in Grade of Automation (GoA) 2, with a driver in attendance, the test train made automated stops at Groningen, Hoogkerk and Zuidhorn. The infrastructure manager reports that the initial tests were very successful, adding that "much has been learned from the data collected".

With ridership on the Dutch network projected to increase by at least 45% by 2030, and freight volumes also rising, ProRail is looking for cost-effective ways to make better use of its existing infrastructure, which it had previously warned was "reaching the limits of maximum capacity".

ProRail anticipates that ATO will allow trains to operate at shorter headways and stop more precisely, supported by traffic management to co-ordinate the movement of trains. The acceleration, speed and braking of each train could thus be optimised to save energy. While the current programme is limited to GoA 2, future tests will look at driverless operation using GoA 3 and GoA 4.

In terms of punctuality, ProRail said 95% of trains currently arrive at Groningen within 140 sec of their booked time, but with ATO the margin could be improved to 55 sec. ProRail is also investigating the use of ATO on freight trains, having undertaken trials with a modified locomotive on the Betuwe Route in December, in conjunction with Rotterdam Rail Feeding and Alstom. This locomotive operated for around 100km using ETCS Level 2.

ETCS in Saudi Arabia

Saudi Arabia: Testing company TÜV Rheinland has handed over the Independent Competent Person certificate for Saudi Railway Co's (SAR) ETCS Level 2 deployment on the North–South Railway, completing formal acceptance by the national Public Transport Authority. According to UIC data, this means that SAR's 2400km network becomes the world's longest single line, ETCS Level 2 signalled, mixed freight and passenger service rail network.

ETCS to Heathrow

UK: Porterbrook has awarded Bombardier an £11m contract to modify 12 Class 387 Electrostar EMUs for use on the Heathrow Express airport services, including the first retrofitting of ETCS Level 2 to existing UK EMUs.

SBB joins openETCS Foundation

Europe: Swiss Federal Railways has become the 18th member of the openETCS Foundation, which provides a platform to exchange experience and jointly initiate train control and automation projects using open source software and open innovation concepts.

Other members include railway operators such as DB, NS and SNCF, plus the UK's Rail Delivery Group, as well as various suppliers and industry experts.

The Foundation's main objective is to encourage the application of open source licensing to safety-critical software and components such as ETCS onboard equipment. It believes this would enable the sharing of development costs between the partners, and avoid vendor lock-in by encouraging suppliers to open up a service market for software updates and upgrades.

The first commercial application of openETCS licensing has already been implemented on the German DB's ETCS-equipped ICE trainsets working the Berlin – München high speed corridor.

According to the Foundation, the openETCS approach would enable cost-efficient and reliable implementation of ETCS using formal specifications and the verification of system requirements to automate code generation and validation, as well as testing. A research and development project in this area has recently been completed thanks to EU funding from the ITEA2 programme (Information Technology for European Advancement).

SBB is already working with other railways and infrastructure managers through the smartrail 4.0 and RCA initiatives to develop a Reference CCS Architecture for the next generation of train control and traffic management systems from the lineside perspective. It envisages that closer co-operation with the openETCS community would help in the development and validation of a matching open onboard CCS reference architecture (openCCS).

Switzerland to implement smartrail 4.0 traffic management system

Swiss railway companies are working together on the development and implementation of the smartrail 4.0 traffic management system. The new solution will integrate interlocking, control technology, trackside installations, data transmission systems and traffic control systems to provide improved traffic management, more efficient use of railway infrastructure and to increase capacity of the network. The smartrail 4.0 programme will replace the current traffic management systems by 2038.

The project started in 2017. Four Swiss rail operators SBB, BLS, Schweizerische Südostbahn (SOB), Rhaetian Railway (RhB) and the Swiss Public Transport Union (Verband öffentlicher Verkehr, VöV) developed the smartrail 4.0 programme. The solution was successfully tested using a simulation with the next target short-term timetable planning with the use of a new traffic management system from late 2022. The final stage of the project is scheduled for 2027-2038, including the industrialised rollout of the smartrail 4.0 programme to replace the existing traffic management systems.

Switzerland started implementation of the ETCS Level 2 system in 2006 when it was installed on the first route – on the Mattstetten–Rothrist line. The country will complete its migration to ETCS Level 2 by 2025. The upgraded ETCS system is a foundation for the smartrail 4.0 – Automatic Train Operation (ATO). In August 2018, SBB tested automated trains on the Lausanne-Villeneuve route using GoA 2. Smartrail 4.0 will provide the implementation of the fourth grade of automation (GoA 4) when the entire journey (including departure, stopping at stations, door closure, disruption management) is performed by ATO.

SBB, the largest Swiss rail operator, is estimated to save 450 million Swiss Francs (£338, €400m, $442m) per year with the new system along with increased capacity of the network and improved train performance.

Virginia Railway Express trains operating under PTC

USA: Positive train control (PTC) is now fully operational on all Virginia Railway Express (VRE) trains, according to the chief executive officer, Doug Allen. PTC is designed to automatically control train speeds and movements should a driver not take suitable action in a given situation. VRE serves Northern Virginia and Washington, DC areas and is the 12th largest commuter rail service in the USA.

The safety milestone was achieved 11 April 2019 when each of VRE's 32 inbound and outbound trains on the Fredericksburg and Manassas lines ran under PTC operation.

Implementation of PTC required close coordination with VRE's host railways. While VRE was responsible for installing the technology on its 20 locomotives and 21 cab control cars, training employees and integrating a back-office system, CSX and Norfolk Southern were required to place compatible equipment throughout their systems as well as on the 90 miles of track upon which VRE operates.

Only four of 41 railways required to implement PTC had done so as of 31 December 2018, the initial deadline imposed by the Positive Train Control Enforcement and Implementation Act of 2015. VRE was one of 33 railroads requesting an extension. The Federal Railroad Administration approved the request after determining that VRE satisfactorily met the statutory requirements necessary to qualify for an alternative schedule.

RAIB report on stranded trains

UK: The Rail Accident Investigation Branch (RAIB) has published its report into an incident on 2 March 2018 when nine trains became stranded near Lewisham in London during bad weather and passengers evacuated themselves onto third-rail electrified tracks.

The report published on 25 March is separate from an action plan which the train operator and Network Rail commissioned from consultancies to address deficiencies in their procedures for dealing with stranded trains.

Using mobile communications equipment in the train cab

GB: The Rail Industry Standard covering all mobile communication equipment in Great Britain has been reviewed and updated.

Most train operating companies will have strict policies about how mobile phones can or cannot be used, as there is potential for the risk of distraction. However, there can be safety benefits in providing an alternative means of communication and there can be performance benefits during situations with perturbed working or failure.

The potential costs both financial and in terms of human life and wellbeing in the workplace were demonstrated at an incident in Chatsworth, California, USA in 2008 where a collision between two trains occurred. The collision was believed to have been caused by the driver of one train failing to respond to a signal while texting on his mobile phone.

However, the driver of the train that derailed at Grayrigg, England in 2007 relied on his mobile phone to make contact with the signaller after regaining consciousness (albeit trains had already been stopped).

Mandatory requirements relating to mobile phones are described in the Rule Book and specific guidance on the appropriate use of mobile phones is contained within individual company policies. In addition, a Rail Industry Standard was published in 2009 on use of mobile telephonic equipment in driving cabs' and provided a recommendation for the minimum level of restriction on mobile phone use that should be specified in company mobile phone policies.

This Rail Industry Standard now covers all mobile communication equipment, recognising the proliferation of devices which can be worn or carried including smart watches, activity tracking watches and fitness bands, wireless headsets, and smart glasses.

An appendix has also been added containing extended guidance to industry on factors for consideration in developing a company policy on the control of mobile communication equipment use in driving cabs.

Another major change is alignment with Office of Rail and Road (ORR) document RIG-2009-06, which emphasises the need for companies to conduct a suitable and sufficient risk assessment around the use of mobile communications equipment in train driving cabs.

Ericsson to acquire Kathrein's antenna and filters business

Germany: Ericsson is to acquire Kathrein's antenna and filters division with around 4,000 skilled professionals to complement Ericsson's in-house capabilities and competences. Kathrein, with headquarters in Rosenheim, Germany and founded in 1919, is a provider of antenna and filter technologies and is an existing Ericsson supplier. The antenna and filters business has a R&D organisation with extensive experience in antenna design and research. The transaction is expected to close in third quarter 2019. Ericsson say the acquisition will increase their investment in 5G antenna technology.

Wi-Fi on DB trains

Germany: Starting in summer 2019, Deutsche Bahn will start upgrading another 1,000 InterCity carriages to equip them with Wi-Fi. By the end of 2021 all DB's InterCity long-distance trains will have free Wi-Fi in 2021.

Deutsche Bahn operates two types of InterCity trains, the InterCity 1 (single-decker model) and the InterCity 2 (double-decker model). The 70 InterCity 2 trains will all have free Wi-Fi at some point during 2020, and all DB's InterCity Express trains (ICE) already have free Wi-Fi.

Like other train operators, Deutsche Bahn uses multi-provider technology which is in use on its ICE trains. This accesses whatever mobile data network is the fastest at any given time, e.g. UMTS or LTE. The technology aggregates the network operator capacities from the three major mobile network providers, Deutsche Telekom, Telefónica Germany and Vodafone which makes higher bandwidths available on board. Just like the ICE trains, Deutsche Bahn will also equip its IC trains with an information and entertainment portal, giving passengers access to news, audiobooks, newspapers, travel information, games and much more.

FirstGroup Wi-Fi using 5G mmWave frequencies

UK: FirstGroup and Blu Wireless have announced a project to improve the quality of connectivity on trains. The technology is claimed to enable reliable streaming, rapid browsing and connectivity to cloud-based applications.

The system is based on Blu Wireless's 'mmWave' communication technology, which will also form part of the next generation 5G networks, and it is claimed that the combination of gigabit grade data rate with cost-effective and low power operation will enable FirstGroup's to provide customers with best in class on train Wi-Fi services.

Electronic beamforming on the transmit and receive antennas will create a moving point-to-point connection of greater than 1Gbps per antenna, and having up to three on-train antennas 'in-beam' at any one moment gives a combined multi-gigabit capability.

The trackside radio unit is designed to be exceptionally small, in order to deploy in a variety of locations, including short trackside poles, gantries, stanchions or platform lighting poles, subject to EMC approvals.

The millimetre-wave radio operates at exceptionally low power (approximately 1% of the power of a typical 4G base station) but will require many more base stations due to the higher frequencies used. First Group plans to deploy the new technology for the first time on South Western Railway.

218 Russian Railway Stations with free Wi-Fi

Russia: An additional 82 Russian railway stations will offer free Wi-Fi by the end of 2019. This means that the total number of stations with free Wi-Fi will increase from 136 to 218.

By the end of 2019 stations in other parts of Russia will also benefit from free Wi-Fi.

Users connected to the Wi-Fi network at Russian railway stations more than 6.6 million times in 2018, an increase of almost 20 percent compared to 2017.

Rural mobile coverage improvement consultation

UK: A 150-page consultation document has been issued by the UK government aimed at improving rural mobile coverage, which may force mobile network operators to open up their networks to rivals in rural areas, to tackle the problem of poor coverage across the British countryside.

Poor national mobile coverage has long been an issue for rural communities, businesses and railways; both for maintenance and coverage for passengers, with more than a fifth of the UK without access to an adequate signal for basic voice services from all mobile operators. Previously plans to introduce national roaming regulations, which would force networks to open up access to their telecoms masts, were put on hold after telecom industry opposition.

Jeremy Wright, the culture secretary, has now instructed the national telecoms regulator Ofcom to examine the cost and benefit of forcing operators to roam on to each other's networks. The government wants mobile phone coverage to reach 95% of the UK's land mass by 2022, which would also help railway companies to provide mobile data Wi-Fi to customers. Ofcom, the telecoms regulator, said in December 2018 that only 78% of the country received an outdoor voice signal from all four networks.

The telecoms industry has argued in the past that national roaming is technically difficult and would lead to a poor customer experience.

North American IAM Annual Conference

Canada: The Institute of Asset Management (IAM), in partnership with IAM Canada, has launched its first Annual North American Conference. This inaugural event runs from October 1-3 2019 in Chicago, Illinois and is focused on Asset Management professionals seeking to gain insight and hear first-hand experiences.

Planned topics will include the asset management journey, the ISO 55000 suite of standards, innovations in asset management, assets in a changing world, building an asset management culture, inter-agency collaboration, management requirements and legislation, the asset management professional and more, each presented and explored through real life case studies, lessons learned, and proven techniques.

For additional information and to register for the event see **irse.info/wb7ev**.

Benefits of GNSS

Austria: In March 2019 the Austrian infrastructure minister Nobert Hofer welcomed a group of European and international experts to Vienna to discuss the important role of Galileo and European Geostationary Navigation Overlay Service (EGNOS) satellite-based positioning technology for the future of the European railway sector. Satellite technology opens up new possibilities for providing a scalable solution for railway positioning and increasing the safety of rail transport, he said. It also supports cost efficiency for rail infrastructure, and promises to become a global success for the exportation of European technologies such as the European Train Control System (ETCS).

Working together, the European Global Navigation Satellite Systems Agency (GSA), the European Union Agency for Railways (ERA), and the Shift2Rail Joint Undertaking (S2R JU) have joined forces to explore the role of satellite technology in future railway systems. Both GSA and S2R JU say they have a key role in leading innovation, and engaging with all stakeholders involved, while ERA is orchestrating the process from a regulatory point of view within the ERTMS framework.

News from the IRSE

Blane Judd, Chief Executive

The IRSE has been busy organising the Institution's Annual General Meeting (AGM) and annual dinner, in addition to preparing for the Council meeting that is held on the same day.

For the first time in the Institution's history, the AGM was streamed live to enable international members and all other interested parties to watch the proceedings. The Vimeo footage is available via the web link **irse.info/8a142**. The video also includes a preview of the Institution's new website which will be launching soon.

The AGM follows a formal set agenda which includes approving the minutes from last year's meeting and formally adopting the annual report and accounts. Following the earlier Council elections, the chair announced the composition of the Council for the year 2019-2020. Full details were published in the May issue of IRSE News.

Then a packed lecture theatre at the IET saw president Markus Montigel hand over the chain of office to the new IRSE president for 2019/20, George Clark, head of engineering at TfL.

Our outgoing and incoming presidents, Markus Montigel and George Clark. *Photos Colin Porter.*

Following on from Markus' presidential theme of "Winds of Change", George has entitled his presidential programme "delivering change". In his address to the AGM he spoke about the challenges facing the global railway signal and communications industry. Across the world there is unprecedented pressure on railways to modernise and deliver ambitious transport strategies cost efficiently. The presidential address can be read in full in last month's IRSE News.

On his last day as president, Markus had the pleasure of presenting the Institution's annual awards to outstanding young signal engineers. The Dell award was given to 34-year-old lead C&I engineer 4LM Janagan Yoganathan, who joined the London Underground group of companies in 2013. This award is made annually under a bequest of the late Robert Dell OBE (past-president) to a member of the Institution employed by London Underground for achievement of a high standard of skill in the science and application of railway signalling.

Dell Award winner Janagan Yoganathan, receiving the plaque from Markus.

Jana was nominated as a result of his work on the 4LM project delivering a new CBTC signalling system for the four sub-surface Underground lines comprising the Metropolitan, District, Hammersmith & City and Circle Lines. He was the principle point of contact for a number of projects all of which have an interface with the TBTC (transmission-based train control) system These have included Jubilee line signalling upgrade (JNSU), Northern Line Extension (NLE) and the works to facilitate the introduction of a more intensive timetable known as Working Timetable 58 (WTT58). Jana was presented with a plaque and a cheque for £300 to be spent as he wished. He told the president that he plans to put the money towards a family holiday to Canada later this year.

Reece Martin receiving the Thorrowgood scholarship.

Next up to the stage was Network Rail senior conformance engineer, Reece Martin, winner of the Thorrowgood Scholarship. This award is also made under a bequest from a past president, the late W J Thorrowgood to a young member

Conducting the business of the AGM, from left to right Andrew Smith (treasurer), Blane Judd (chief executive), Markus and George.

George Clark making his Presidential Address.

The annual dinner took place in the splendour of the Savoy.

Mike Brown MVO, transport commissioner for Transport for London was the guest of honour at the dinner.

attaining at least a pass with credit in four modules of the Institution's examination. It assists the development of a young engineer employed in the signalling and telecommunications field of engineering with £1500 towards an industry-based study tour.

The interview panel said of Reece, that they found him to be well motivated and a keen advocate of the Institution. He has worked in delivery and current Independent assurance as part of the Network Rail Certification Board. He provided a presentation of his thoughts on his development and how they would also benefit the Institution. He plans to spend the prize fund on a visit to study high speed rail in China.

The recipient of the IRSE-Signet Award, Paul Hobden was unable to attend the AGM but details of his nomination were read out to the AGM by Andy Knight, managing director of Signet Solutions. The award is presented each year to the candidate achieving the highest marks in any single module of the Institutions exam. It provides funding for the recipient to attend the Institution's annual convention and was introduced to mark the 20th anniversary of the formation of Signet Solutions Ltd.

Merit Awards are awarded by the Council, and this year's recipients were named as David Nicholson FIRSE for his assistance to Institution members in their preparation for the professional exam and Ian Moore for his long service to the Institution and in particular the York Section.

The annual dinner was held once again at the Savoy and was a complete sell-out. Guest of honour was Mike Brown MVO, transport commissioner for Transport for London and an impressive £3300 was raised on the night for RedR. Their CEO Martin McCann spoke passionately about the work of this international engineering charity which was founded by engineers to train and support aid workers and humanitarian organisations. A full article about RedR and its work can be found in the March 2019 issue of IRSE News.

London & South East Section

Visit to HORIBA MIRA, Nuneaton

Report by Rod Muttram

On 9 April a small group from the IRSE London & South East Section and a representative from the Midland & North Western Section made a technical visit the HORIBA MIRA research and testing site near Nuneaton. Formally known as the Motor Industry Research Association, MIRA was established on the site of a wartime bomber airfield in 1946 just after the second world war and covers some 850 acres (3.5km^2). The site was acquired by Japanese company HORIBA in 2015, a worldwide leader in automotive test systems, as part of a deal to enable HORIBA MIRA to invest in facilities and continue with expansion plans.

Technical presentation

On arrival we were taken into the heart of the site to a modern HQ building close to the site of the old airfield control tower. Nigel Skellern of HORIBA MIRA then gave us a very interesting and in-depth presentation on HORIBA MIRA's work. As well as being a testing ground and having many specialist testing facilities they are a major consultancy in a number of aspects of vehicle engineering, particularly those associated with environmental performance like electromagnetic compatibility (EMC) and reliability in harsh climates. With the significant and ever-increasing reliance on electronics in modern vehicles EMC is now a very important area of HORIBA MIRA's work. Major test facilities capable of holding whole vehicles include environmental chambers and wind tunnels with rolling roads to allow dynamic testing, EMC test chambers and a 'high-g' facility where systems can be tested under high acceleration and deceleration conditions. One of the areas where HORIBA MIRA has done rail work has been to use the high-g facility for the testing of rail vehicle interiors including things like the impact performance of tables. For that kind of work they have a large selection of instrumented mannequins (colloquially known as 'crash test dummies'). These are very expensive pieces of equipment and companies whose equipment damages them on test have to pay to repair or replace them.

HORIBA MIRA is also heavily involved in research and validation for the upcoming generation of autonomous vehicles. The site has test tracks simulating just about every sort of surface and situation and, is building more, particularly to support the testing of smart support systems and autonomy. In that area there is already a simulated 'cityscape' which is being used for the development and validation of autonomous vehicle controls and a new facility is being built with a high speed straight leading to a large 'test pad' where all manner of high-speed scenarios will be able to be set up. In response to questions it is clear there are still some unanswered questions around the safety validation and liabilities for these systems, but the point was made that with the vast amount of investment being made more of these systems will be deployed, and soon.

Many manufacturers have facilities on the site and use it as a base for R&D and testing. The number of new models being tested at the site drives a ban on photography at HORIBA MIRA. We all had to have the camera lenses of our phones covered with tape and the only photo we were allowed was a group shot taken by HORIBA MIRA staff. The manufacturers want to unveil their new models at a time of their choice (often at major motor shows) not to have pictures appearing in motoring magazines as a 'scoop'. The site is now also a major 'Technology Park' with many other businesses present and continues to expand. We were told that about 70% of the work on the site would be classified as R&D and about 30% approval/homologation testing.

The only photo we were allowed to take! Members with Nigel Skellern of HORIBA MIRA on the far right.

Midland & North Western Section

IRSE///
Institution of Railway Signal Engineers
MIDLAND & NORTH WESTERN SECTION

Technical Visit & Annual Luncheon Saturday 29 June 2019

Churnet Valley Railway, Staffordshire

With the kind assistance of Haywood & Jackson Fabrications Ltd and the Churnet Valley Railway (CVR), the committee of the Midland & North Western Section have agreed to return to a location of a previous successful technical visit and luncheon. They have secured places for up to 40 guests this year and seek the support from the whole of the Institution and the S&T Industry to make this yet another successful and enjoyable family event.

The programme is as follows:

10:30 Arrive and assemble at Cheddleton station for a briefing regarding the re-signalling works and a tour of the existing signal box.

11:50 Depart Cheddleton station and alight at Consall station for a tour of the signal box.

12:46 The luncheon train departs Consall station to travel to Ipstones Loop and back, allowing an hour and a half for lunch.

14:15 Arrive at Leek Brook Junction for an explanation of the proposed signalling for the Leek extension project and a tour of the existing Signal Box.

15:50 Arrive Cheddleton station to conclude the visit.

A three-course meal per individual will be provided, the menu is shown opposite.

Special dietary requirements are available upon request. The cost of the technical visit, including train tickets and luncheon (excluding beverages) is £45 per adult and £35 per child (aged 5-15). All children attending must be supervised individually by an adult.

All individuals attending the technical visit must bring with them a railway industry high visibility vest to wear on the technical visit along with stout shoes or boots for walking on ballast and uneven surfaces. The CVR reserves the right to refuse access to the technical visit for individuals not complying with these instructions and any Health and Safety Briefing instructions.

To confirm your attendance, please send an email detailing individual names and individual meal choices of those individuals planning to attend to **acw-57@ntlworld.com** and **ian.james.allison@sky.com**. All payments can be made either via internet banking sort code 09 01 51 Account 09065506 (preferred method of payment), or cheques made out to "IRSE Midland & North Western Section" and sent to the Section Treasurer Clive Williams, at: 4 Mill Rise, Kidsgrove, Stoke on Trent. ST7 4UR. For any further details, please contact Ian James Allison on +44 (0) 7794 879286.

Menu

Starter

Homemade soup of the day served with a fresh crusty roll and butter

Main

Roast topside of beef served with roast potatoes, seasonal vegetables, Yorkshire pudding and gravy

Stuffed chicken wrapped in bacon served with roast potatoes, seasonal vegetables, Yorkshire pudding and gravy

Butternut squash, beetroot and roasted red onion lasagne served with roast potatoes and seasonal vegetables (vegetarian)

Dessert

Warm apple tatin served with custard with tea, coffee and petits fours

Please note that the Institution and administrations whose sites are visited on technical visits cannot accept any responsibility for injury, damage or other difficulty which may arise. Individuals are therefore advised to ensure that their own insurance covers all appropriate eventualities.

This year (2019 - 2020) is the 50th anniversary of the section. To celebrate the occasion a lapel badge is now available at a cost of £5. The badges will be available to purchase at all the sections events and meetings, or email Clive or Ian at **acw-57@ntlworld.com** and **ian.james.allison@sky.com** for postal costs.

Telecomms innovation for tomorrow's railway

Report by Paul Darlington

IRSE
Institution of Railway Signal Engineers
MIDLAND & NORTH WESTERN SECTION

At the March section meeting of the MNW, attended by both signalling and telecoms members and non-members in Birmingham, Tim Lane, principal strategy and innovation manager, Network Rail Telecom (NRT), presented Network Rail's telecoms innovations and how these may be applied to future deployment on the railway.

Tim began by explaining that to support tomorrow's railway, communication networks must be able to provide a trackside internet of things (IoT), with real-time data capture to enable 'predict and prevent', condition-based maintenance and the ability to add points of presence as and when required. This will enable a condition-based maintenance approach to allow interventions to take place before assets fail, and, ultimately, to automate the interventions. NRT's strategy is to be in a position to provide universal rail corridor connectivity, to enable trackside IoT wireless connectivity for an ecosystem of low cost, battery-powered intelligent data sensors and things.

Blue skies technology and red signals

After the serious passenger disruption affecting King's Cross and Paddington station services in London in December 2014, Francis Paonessa, the then managing director of Infrastructure Projects, Network Rail, carried out a review of the incidents and concluded that "Contractors will be required to test any new equipment in an off-the-railway environment before it is used on live railway work." This is especially important with new innovative technology which must prove itself before deployment on the operational railway.

NRT has developed this requirement into three stages of landing new technologies safely and efficiently. The first stage is to carry out the technology definition, evolution and testing in a specialist laboratory environment, such as the 5GUK R&D hub facility run by a number of universities, and known as the R&D stage. Testing then moves to the alpha testing stage with technology proving at the Rail Innovation and Development Centre (RIDC) at Melton Mowbray, Leicestershire in a representative rail environment. Finally, beta testing is carried out via controlled pilot testing and early deployment schemes.

The RIDC site (formerly known as the Old Dalby Test Track) is a dedicated testing and trialling facility for use by Network Rail and the rail industry. It has a 13-mile high-speed electrified test track known as the Down Reversible Line (DRL), and a four-mile low-speed electrified test track known as the Up Reversible Line (URL), where new and modified railway infrastructure, rolling stock, plant and technology is tested prior to operational deployment. The test tracks can be configured as DRL 13-mile, 11-mile or two 5-mile sections which can operate independently. URL can be configured as 2.5 miles (with four-rail DC electric supply) or 4 miles.

It is possible to change the method of operating the test track between multiple operational configurations to offer the best flexibility and accessibility for a range of innovations to benefit multiple industries as well as the rail sector. A two-mile section is non-electrified and well-suited to other testing, such as unmanned aerial vehicles (drones).

GSM-R masts at RIDC Melton.

The RIDC site has a strong history of cutting-edge innovation, which commenced in the late 1960s. Historical events include; the testing of the world's first tilting train (the APT), early tests of radiating cable propagation in railway tunnels and British Rail's spectacular collision of a fast-moving train with a nuclear flask. More recently, the site has hosted intensive testing of the S Stock London Underground trains, Intercity Express Programme (IEP), Crossrail and London Overground rolling stock.

Approximately 20km of optical fibre and 3km of copper cable with 11 nodes, along with five trackside and one hill-top radio mast, are now available for telecoms testing. This includes trackside equipment staging and a high capacity internet feed.

Self-managing and self-healing railway

To deliver revolutionary initiatives in rail requires intelligent operations with increasing use of collecting and exploiting live operational data. This will necessitate developing better ways to harvest, transport and process the data. There have already been benefits from the deployment of intelligent infrastructure, with increasing environmental and asset sensing to achieve better availability of actionable intelligence, but more is needed.

The deployment of ETCS and traffic management will deliver increased capability and flexibility, with trains potentially providing service patterns dynamically linked to demand. What rail requires, and customers insist on, is also better predictability and reliability. There needs to be increased automation and autonomy, resulting in a largely self-managing and self-healing railway. All this will require better ways of collecting and processing data, which will need new ways of communicating.

LoRaWAN Rail temperature monitoring sensor.

C21SPT – Practical IoT realisation and a signal Wi-Fi access point.

IRSE past president Markus Montigel suggested that the term "Internet of Railway Things" (IoRT) should be used in the context of connected systems contributing to controlling the railway and consisting of networks of devices containing electronics, software, actuators, which allows them to connect, interact and exchange data. Markus said he believed that the new world of connected sensors and actuators, which interact and exchange data – the IoRT – can and must control a lot more in the future than has been possible in the past. Devices must appear en masse and be low-cost in order to fulfil their role.

To achieve this, a telecoms network with new ways of delivering connectivity is required. The Network Rail telecoms network consists of 18 000km of fibre optic cable, 22 000km of copper twisted-pair cable and 2500 GSM-R radio sites, with a further 3500 data nodes. All this provides a great basis for connectivity, but innovation is required to exploit this asset even further. Much of the telecoms innovation is already taking place at the RIDC, which provides a location for NRT and partners from industry to develop and test concepts, without affecting the operational railway.

Fibre-optic sensing

Fibre-optic sensing has been covered in IRSE News (issue 248, October 2018). The technology can be used to measure various external parameters along a fibre-optic cable laid alongside a rail route. Light is reflected or backscattered as it propagates through an optical fibre in response to a change in temperature, a bending or pulling force, or mechanical waves in the fibre's proximity, which is sensitive enough to detect noise. The backscattered light is detected at the source, and the location and cause of the backscatter event can be determined.

The systems now deployed in trial are effectively delivering a trackside 'microphone' fibre-sensing capability approximately every 10 metres, so a 50km fibre is the equivalent of 5 000 distributed sensors. Each acoustic event has its own signature and so far over 60 (and counting) potential use case have been identified. These include, wheel flat detection, earthwork failures, train integrity/derailment detection, rail integrity, trespass, and weather detection.

Over 1Tb of data per day per 20km is collected and techniques are being developed to create reliable, actionable intelligence using a variety of intelligent data and event characteristic detection sources, together with machine-learning technology.

The system has recently been used to track different types of trains running along the RIDC test track while, at the same time, the system provided by OptaSense detected earthquakes at Swansea (17 February 2018) at a magnitude of 4.4 at a depth of 7.4km, 240km away, and at Grimsby (9 June 2018) at a magnitude of 3.9, depth 18km, 100km away. It was found that the earthquake signal is best detected in areas where fibre-cable makes good contact (coupling) with the ground.

In the immediate aftermath of the derailment of the Down Virgin Trains Pendolino at Grayrigg on 23 February 2007, the damage to the adjacent Up line 'dropped' a track circuit and caused a southbound Virgin Cross Country Voyager train to stop at a protecting red signal. Had the Up line been monitored using axle counters, the southbound Voyager could have probably run into the derailed Pendolino at high speed, causing a much worse incident. Many of the worst rail accidents have involved a second train running into a derailed train.

Track circuits would not always detect a derailed train and, with many routes now equipped with axle counters for train detection (which are unable to detect a derailed train), fibre optic sensing may be a way of providing a mitigation to similar incidents.

LoRaWAN

Long Range Wide Area Network (LoRaWAN) is a standard for wireless communication that allows IoT devices to securely communicate over large distance with minimal battery usage. It has a similar range to a mobile phone with the flexibility of Bluetooth or Wi-Fi and a battery life measured in years. LoRaWAN is designed for small sensors/devices/things that are battery operated and communicate limited information intermittently. It is therefore ideal for key IoRT requirements such as bi-directional communications, end-to-end security, mobility and low power.

There are two different keys in LoRaWAN to provide security. The network session key (NwkSKey) is used to encrypt the whole frame, including headers and payload. When data is sent, this key is used to sign the message and allows the network server to verify the identity of the sender. An application session key (AppSKey) is then used to further encrypt the payload within the frame.

The unlicensed industrial, scientific and medical (ISM) radio spectrum band is used and, with the system capable of relatively long-range coverage providing connectivity solutions in areas impacted by poor mobile network coverage, it may be ideal for non-frequent low-speed railway communication applications. NRT has already deployed LoRaWAN at RIDC for trial applications of trackside sensing for water level and rail temperature monitoring, and has gained a good understanding of the range and quality of service delivery capabilities.

Use cases could include metering – for example sending several messages a day about current usage; smart lighting; environment monitoring for sound, temperature, pollution, water level, fuel level, vibration and movement; asset management to check the status and location of various assets, access control and level crossing gate status.

Project VECTOR

For lineside applications that require more data bandwidth than LoRaWAN can deliver, and for better trackside coverage, Project VECTOR has been established, which stands for Value Engineered Communications Technology On Rail. This is intended to exploit the 22,000km of lineside twisted-pair copper cables, traditionally used for lineside telephony, such as the signal post telephones (SPT).

In domestic locations, and for some businesses, high speed data internet access is provided via similar copper cables to those used in rail, and very-high-bit-rate digital subscriber line (VDSL) technology. Traditionally, all telephones were powered from the telephone exchange via a central battery, but for high speed data a local power supply is required for the data router. This is why in the event of a power outage home fixed telephones will still work, but internet connections and cordless phones will not, unless a separate battery power supply is available.

Project VECTOR will provide a power supply to a local data modem router via the same twisted pair copper cable, VDSL or symmetrical high-speed digital subscriber line (SHDSL) technology providing equal transmit and receive (i.e. symmetric) data rates. With GSM-R sites located every few kilometres trackside to provide a power supply, it may be possible to provide a high-speed data connection at most locations along the railway. Trials at RIDC have suggested that a symmetrical bandwidth of 12Mbits/s with a latency less than 3ms over a 3km link may be possible.

So, in the 21st Century, can the traditional signal post telephone (SPT), which is still provided as a back up to GSM-R, be replaced with a signal Wi-Fi point allowing drivers to call a signaller via a Wi-Fi voice-calling app on a smart phone? The Wi-Fi point could also provide a high-speed data connection to manage and monitor other trackside equipment, which may include firmware updates to equipment. Could C21SPT or SPDT (signal post data transmitter/receiver) replace "SPT" in railway terminology?

Other use cases could include a fixed telephone via a micro filter for SPTs at key locations and level crossings in addition to a Wi-Fi point, a data connection to a layer 2 data switch or fibre driver, or as a low-powered supply to another operational asset. Could a data Wi-Fi point or a layer 2 data port on a signal be used as part of the Combined Positioning Alternative Signalling System (COMPASS) as back-up degraded mode recovery to conventional signalling?

5G rail testbed

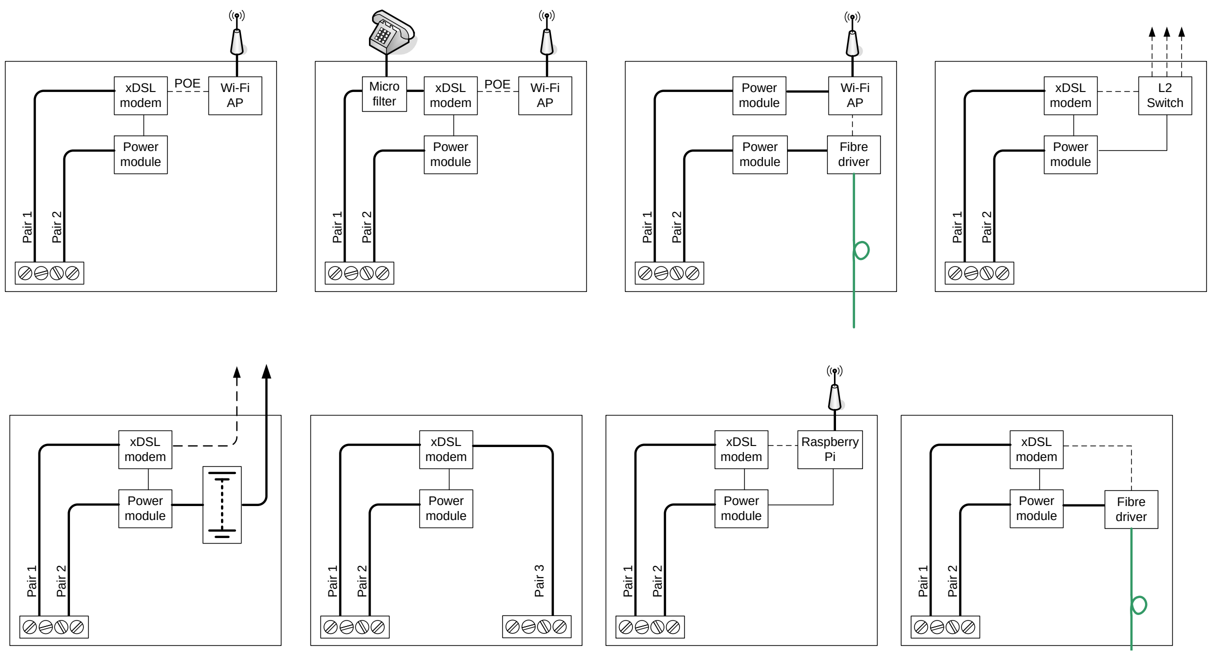
To support the next generation of digital infrastructure, including 5G and full fibre broadband, the Department for Digital, Culture, Media and Sport's (DCMS) 5G testbeds and trials programme is part of the UK government's £740 million National Productivity Investment Fund (NPIF) initiative.

Innovator access to a main line rail environment, with high speed trains running and infrastructure challenges (including tunnels and cuttings), is near impossible to offer on the operational infrastructure. So, as part of the programme, DCMS has funded the creation of a 5G rail testbed at the RIDC that, to be as accessible as possible, is open for both rail and non-rail 5G testing.

The trackside infrastructure includes antenna support structures, optical fibre, equipment accommodation and power supplies at over thirty locations along the test track, which have been located to support the full complement of 5G spectrum bands and reflect the challenges of trackside rail deployment. The site also includes an operational train workshop, which can support test train installation with supervision, support, guidance and safety certification services.

The section was most grateful for Network Rail for providing the accommodation and the presenter. A more comprehensive article on NRT innovation appeared in the May issue of Rail Engineer magazine and a technical visit to the Melton RIDC is being considered for next year by the section.

Project VECTOR C21SPT. Options for various applications using power via a telecoms copper cable pair of wires.



R&D to .tech – Ian Mitchell's 44 years as a Derby railway boffin

Report by Ian Bridges

IRSE
Institution of Railway Signal Engineers
MIDLAND & NORTH WESTERN SECTION

On 9 April the UK M&NW Section held their final meeting of the 2018/19 session, along with the 49th Annual General Meeting, at Signet Solutions in Derby. Prior to the talk, outgoing chair, Ian Allison, presented the Chair's Trophy to Lee Clinton in recognition of Lee's work in encouraging young professionals in the industry.

The main event followed on from the AGM, which was a talk by Ian Mitchell entitled "R&D to .tech – 44 years as a Derby railway boffin". The journey through Ian's career started by him explaining how his career had started all those years ago in that very same building, at that time the hub of British Rail's Research and Development department. As a youngster Ian had been interested in railways, with a pedigree in both sides of his family history, but much of his early career was not in railway signalling, instead he joined BR Research Light Vehicles Section from Cambridge University in 1975.

Some projects Ian was involved in during those early days sparked many memories amongst the audience:

- Speedlink, a proposed computerised wagonload system.
- Precision vehicle positioning – using microprocessors with a "massive" 1KB of memory.
- Transporting waste energy from power stations.

Ian's first encounter with signalling was investigating how to achieve reliable track circuit operation with light railbus vehicles, which eventually led to the development of the Track Circuit Assister (TCA).

A further move occurred in 1983 to the Microelectronics Unit where the Solid State Interlocking (SSI) was being developed in a tri-partite arrangement with GEC (later to become Alstom) and Westinghouse (later to become Siemens). SSI of course, went on to be a worldwide success which still contains the assembler code Ian wrote to control the aspect sequence logic today. Work started around 1990 to understand what the next generation of developments were needed – SSI MK2, but the impending privatisation of the industry brought it to a sudden halt. It would not be for many years that the second generation interlockings were developed independently, becoming Westlock and Smartlock.

Ian's early career included a trip to the USA in 1980 with a lightweight rail vehicle that was developed by BR Research in collaboration with the bus manufacturer British Leyland. This photograph shows the commissioning team from the UK (Ian on the left) with the vehicle after its inaugural run. The location is the Billerica, Massachusetts works of the Boston and Maine Railroad. Shortly after the photograph was taken, the vehicle derailed on the distinctly dodgy track.

Ian was responsible for development of the SSI Design Workstation, which has provided a very long lasting data preparation, testing and simulation environment for signalling schemes around the world. In 1988 he had to dress up in a dinner jacket when this was first demonstrated at a prestigious exhibition of new technology at the Royal Society in London.

It was organisation change that became the focus of the late 20th century for Ian, with the creation of BR Central Services and the eventual sale of BR Research to AEA Technology in 1996. At this point a number of senior engineers left the industry, causing Ian to realise he was now the man that needed to answer the technical questions, there was nobody else left! AEA eventually ended up in financial trouble and had to sell part of the business, which became DeltaRail. The final change came in 2016 when DeltaRail became Resonate Group Limited. Throughout all this change, Ian maintained continuous service and worked on more and more exciting projects.

His talk was accompanied by many photographs from his life and far too much to discuss in one short article. It is fair to say though, a number of industry products past and present, are unlikely to have had the same success had it not been for Ian's input and energy. In IRSE terms Ian has sat on Council, has been a member of the M&NW Section committee for many years, and is currently one of the IRSE News contributing editors. The section would like to record their thanks to Ian for an extremely entertaining talk, reminding us of people and projects from the past that we may have forgotten, and to Signet Solutions for their kind support in allowing to use their premises.

If you would like to find out more about what Ian and his colleagues got up to prior to 1996, you can search the RSSB SPARK 'rail knowledge hub' which contains scanned copies of thousands of British Rail Research reports at **irse.info/463z8**.

Feedback

Re "It's only data": The only 100% safe railway

Steven Dapré's most imaginative contribution to the April 2019 edition of IRSE News on the subject of 'OFF' indicators reminds me of an excellent, and oft-employed, example of the earnest application of Signalling Sorcerery.

It is the 'SPAD'. Otherwise known as the Scheme Plan Acceptance Discussion, this phenomenon involves an even larger and more diverse cast of expert Sorcerers, all of whom come prepared with an immense toolbag full of their personal spanners of all shapes and sizes with which to contribute.

Such SPADs are regrettably all too common and are usually due to failures of the 'AWS' (also known as application of wisdom & sense).

Fortunately there is a simple solution to all of these otherwise intractable problems. It will ensure a truly 100% safe railway. And it is the wholesale application of the principle known as 'ATP' (all trains parked).

Tony Glazebrook, UK

Presidential Programme 2019-20

We are pleased to announce the Presidential Programme for next year, with events in the UK, Denmark, the Netherlands and Australia.

18 September 2019, London	Seminar Future communications systems
1 October, London	Presidential Paper Delivering change through Intelligent Traffic Management
5 November, Denmark	Presidential Paper Delivering change through the National ERTMS programme
5 December, London	Presidential Paper Delivering CBTC in Hong Kong
7 January 2020, Netherlands	Presidential Paper Delivering change – the race against obsolescence
12 February, Sydney	Presidential Paper Delivering metro travel in Sydney
26 February, London	Seminar Developments in train location systems
5 March, London	Presidential Paper Future reference CCS architecture for ERTMS
23/24 April, London	AGM, awards and dinner

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at irsenews@irse.org.

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Membership changes

Elections

We have great pleasure in welcoming the following members newly elected to the Institution:

Fellow

Francesco Corman, Swiss Federal Inst of Technology, Switzerland
Michael McNamara, Gannett Fleming, USA

Member

John-Paul Chesworth, Siemens, UK
Velmurugan Kandasamy, Thales, UK
Ravi Pesaramilli, Metro Trains Melbourne, Australia
Francois Piednoir, Sintra, France
Mohan Sankarasubbu, Ansaldo, Australia
Timothy Shaw, Alstom, UK
Michael Stephens, Auercon, Australia

Associate Member

Mohammed Arifuddin, WSP, India
Rakesh Guda, OSL Global, India
Adam Mather, Siemens, UK
Christopher Mather, Alstom, UK
Gary Payne, GSP Design Engineering, UK
Nicholas Rook, Coleman Rail, Australia
Graeme Turner, Siemens, UK

Accredited Technician

Daniel Hewitt, Volker, UK
Jonathan Sadler, Motion Rail, UK
Lionel Tagoe, Rail Technology Infrastructure Solutions, UK

Promotions

Member to Fellow

Somasundaram Nellaiyappa Pillai, Ansaldo, Australia
Judith Ward, IRSE, UK
Russell Withington, Siemens, UK

Associate Member to Member

Arup Bandyopadhyay, Metro Railway, Australia
Peter Bell, WSP, Australia
Colin Hamilton-Williams, SNC Lavalin Atkins, UK
Richard Holmes, TICS, UK
Claire Hulstone, Network Rail, UK
Reece Martin, Network Rail, UK

Affiliate to Member

Robin Lee, Park Signalling, UK
Adam Meredith, ORR, UK

Accredited Technician to Associate Member

Darren Lewis, KeolisAmey Docklands, UK

Professional registrations

Congratulations to the members listed below who have achieved final stage registration at the following levels:

CEng

Ian Hayes, Omada Rail Systems, Australia
Diego Murillas, Rail Systems Australia

IEng

Andrew Clapham, Network Rail, UK

EngTech

Daniel Hewitt, Volker, UK
Christopher Moran, Network Rail, UK
Jonathan Sadler, Motion Rail, UK
Lionel Tagoe, Rail Technology Infrastructure Solutions, UK

New Affiliate Members

Mousam Ali, Ansaldo, Australia
Sukhvinder Bains, Transport for London, UK
Philip Bell, Rail Control Systems, Australia
Stephen Bias, Network Rail, UK
Jordan Combridge, Melbourne Metro Tunnel Project, Australia
Aneal Dhear, Siemens, UK
Jeremy Harmer, UK
Dave Heffernan, Rail Control Systems, Australia
Hans Ho, YTL Construction, Malaysia
Karthik Kannan, John Holland Group, Australia
Daniel Kesseli, AWK Group, Switzerland
Matthew Knifton, Network Rail, UK
Gowtham Manavalan, Southern Railway, India
Luke Owen, Bombardier, UK
Stuart Park, Network Rail, UK
Prasenjit Rakshit, Serco Dubai Metro, UAE
Patrick Reilly, National Transport Authority, Ireland
William Richardson, Amey, UK
Mohammed Sayeed, Alstom, Saudi Arabia
Abhijeet Singh, RZD International, India
Ashok Srivastava, Railtel Corporation, India
Stephen Thomas, John Holland Group, Australia
Adam Ussher, Rail Control Systems, Australia
Michiel Vijverberg, ProRail, Netherlands
Boning Zhang, Rail Project Victoria, Australia

Due to non-payment of first subscriptions the names of the members below will be removed from the membership database: Abdul Hasnat, Jamie Barwell, Kai Smith, Lesedi Gaolemoge, Mark Townend, Paul Thomas, Venantas Krasauskas and Zhiguo Liang.

Resignations: Alain Fetz.

Past lives

It is with great regret that we have to report that the following members have passed away: Rakesh Chandra Agrawal and Hennie van de Venter.

Current Membership: 5131

IRSE News

Institution of Railway Signal Engineers

July/August 2019

Human factors for automation

Safety and security for automation

Digital twins for predictive maintenance

Embracing automation

There is a lot said about 'Digital Rail' and If we are to make our railways truly digital then we must deliver change like never before. Change is rarely simple but as engineers our key skill is in solving problems. Pace is also important and railways rarely seem to gain public awareness of what has changed. That point struck me when I addressed a recent seminar on Automatic Train Operation (ATO), sponsored by the IRSE and IMechE.

IRSE members have led the push for automation, as seen in the presidential lecture last year on ATO. We even have a Standard (IEC 62267) which defines 'Grades of Automation' (GoA) and although its title refers to Urban transport, automation affects all of us in rail. The crossover from mass transit to suburban services is very real, and whether we implement connected driver advisory systems (C-DAS), ATO at GoA 2 or more frequently now in metro at the driverless level GoA 4, we are on one hand providing a level of interoperation, irrespective of the underlying system being ERTMS or CBTC.

Automated railways bring change to: People – are they more or less vigilant when not driving? Processes – how does this affect track safety, and driver competence if manual operation is required? Technology – accurate stopping requires accurate sensors and algorithms. Environmental considerations – the need for consistent braking and predictable adhesion.

As we strive for a more consistent railway operation and one where dependability is delivered to the customer, we will take a journey through the grades of operation. This is a not a journey to fear with unknowns, as railways have operated ATO since the Victoria Line in London over 50 years ago and there is considerable experience and understanding of the challenges. However, these challenges demand collaboration across disciplines including signalling, telecoms, rolling stock and track. It takes a collaborative effort whilst supporting the operators to create the right concepts of operation.

There are all too few experienced ATO engineers in our profession, something that we need to promote to make delivering the change of an automated railway successful. Success is what the railways need more than ever so embrace automation and be an ATO change champion!

George Clark. President, IRSE

Cover story

A team from Alstom works on equipment at a crossover on the driverless South Island line of the Hong Kong Mass Transit Railway (MTR).

Whilst Automatic Train Operation has been used on mass transit railways since the 1960s, such automation forms only one part of the infrastructure necessary to maintain service.

Switches and crossings form an essential element of any railway, but are particularly mission critical in certain parts of some of the world's most densely used railways. At turnbacks multiple point machines need to operate at very short intervals if they are to allow headway to be optimised. Design of reliable, safe and easily maintained equipment underpins this, but increasingly approaches such as condition management are also deployed for such golden assets.

The size of the tunnels on this railway, the platform edge doors and the complex traction power system are also clear in this photo.

Photo Alstom/Arnaud Février

In this issue

From the IRSE and its Sections

Human factors and ethical considerations associated with automation

Prepared on behalf of the International Technical Committee by Rod Muttram

Automation and autonomous systems are currently getting a great deal of publicity. In road transport there is a lot of 'work in progress' on autonomous vehicles, and driverless technology 'start ups' have been snapped up by the new technology majors such as Google.

In air, the recent tragic losses of two nearly new Boeing 737 MAX airliners with significant loss of life has generated a lot of attention. The update of a decades-old design relied on a degree of new control automation.

In rail, metros are increasingly automated with fully driverless systems now common and main line rail is moving to implement systems such as Automatic Train Operation (ATO) to improve capacity and reliability.

Whilst these changes are driven by undoubted benefits there are also risks that need to be carefully analysed and managed.

ITC Member Clive Kessell about to press the yellow button to put a Thameslink train into ATO Mode during a visit to London in 2018.

Modal differences

Air operates in three dimensions (known as six degrees of freedom as they can move along or rotate about any of the three axes). 'Fail safe' in aviation cannot usually result in a 'stop' state or the plane will crash.

At the other extreme, rail is a one-degree of freedom system. Trains can move along one axis only, everything else is controlled by the infrastructure. For many years 'fail safe' has been used to secure safety, stopping the train and then allowing movement again only once the fault is fixed or under other (often procedural) controls.

Road is in between, operating essentially in two dimensions. The key difference from rail is the ability to avoid collision by 'steering away'. Stopping the vehicle is an option for dealing with some failures.

Current developments/issues

Road

Whether or not you believe the 'hyperbole' there seems little doubt that, with the level of effort being expended, increasing numbers of smart systems will soon come into more widespread use. Exactly what their scope might be remains open to question. Driver assistance systems such as 'lane hold', side collision avoidance and emergency braking on front end proximity are already quite common (interestingly insurance industry data from the Netherlands indicates a higher accident frequency for these vehicles than those unfitted, so perhaps a degree of 'risk compensation' is happening, as when seat belts became compulsory).

Many trials of fully autonomous road vehicles are taking place under controlled conditions; but these have not been without incident and a number of issues remain open. Most of these systems are using 'deep neural networks' which are 'taught' how to drive rather in the way a human is. Safety validation is largely based on accumulated hours of real time running supported by simulation. Test running has been supported/justified by having a human driver present and supposedly able to take over the controls in an emergency.

The engine nacelles of the second generation of 737s, now referred to as 737 Classic, from the 1980s onwards had a flatter bottom to allow sufficient ground clearance under the wing. Having to move the larger engines of the 737 MAX forward and higher led to design decisions that had tragic consequences. *Photo Shutterstock/Caron Badkin.*

It has emerged that when the highly publicised Uber accident in Arizona occurred, in which someone wheeling their cycle across a road was hit and killed by an 'on trial' autonomous taxi, the human 'oversight' driver was watching streamed TV on their phone. Boredom/distraction of the 'oversight driver' may be seen as a transitional issue for autonomous vehicles but is relevant in other sectors and will be discussed further later in this article.

One of the other significant issues is transparency in terms of how these systems work and how they take decisions. Because they are 'learning' systems there are no visible and discrete algorithms that can be validated. If one of these systems makes a wrong decision which leads to an accident it may be very difficult to establish why that decision was made. The author is currently a member of an IEEE working group drafting a standard (P7001) which is attempting to set out acceptable practice for the transparency of such systems. Getting such a standard adopted and used is likely to be a challenge.

It is often argued that these systems can be empirically demonstrated to be safer than a human driver. That is not a high benchmark when well over a million people are killed on the roads worldwide each year. Even in a fairly 'disciplined' environment like the UK the death toll was still over 1700 in 2018. We also accept such a learning process for human drivers, so why should it not also be acceptable for a neural network?

The 'jury is still out' on the degree to which such arguments will be accepted by the public or the media. Even the most complex current neural networks are nowhere near as complex as the human brain. That makes these systems less able to deal with scenarios they have not seen before; the human brain will make decisions using a wide range of embedded knowledge and a hard-to-define 'sense of morality'.

It seems unlikely that lower public transport safety levels will be accepted. For individually owned autonomous vehicles there are still many open questions about who will be liable if such vehicles cause accidents, even if relatively infrequently: The manufacturer? The software/control system developer? Whoever decided on the learning environment? Whoever approved (certified) it for use? The owner? The user/passenger? Will the passenger get routing choices? Fastest, most economical, scenic or will the vehicle always pick the 'safest' even if it is more costly? Contention awaits!

Considering interaction with human drivers; for 'mixed running' many issues arise: If the vehicle's control system is not 'transparent' to analysis to determine cause, how will 'fault' be apportioned in an accident? It seems unlikely that any human driver or their insurer will simply accept that the autonomous vehicle was 'fault free' without evidence (and who will provide that?). If human drivers know that autonomous vehicles exhibit caution, why would they not force their way out in front of one, holding it up? If that happens and the occupant of the autonomous vehicle takes over in frustration where does that leave liability? It is not just on cost grounds that manufacturers want to delete the manual controls!

So, the day when you can hop into your car in Melbourne and say "take me to the Sydney Opera House" then fall asleep on the back seat may be some years away yet. That said, no-one should underestimate the lobbying power and influence of the tech majors, and the ITC has no wish to be seen as Luddites, but for sure it is hard to see how the machine itself can be liable, and things will go wrong.

Air

The Lion Air and Ethiopian Airlines crashes of "4th Generation" Boeing 737 MAX jets with the loss of a total of 346 lives have raised very significant questions regarding the design, certification and introduction to service of this updated aircraft and the human factors associated with pilot training. For two nearly new aircraft to have crashed so quickly in succession and under such similar circumstances is extraordinary and it is hard to see Boeing's initial reaction as anything other than lacklustre.

The 737 is the most successful commercial jet of all time. Its first fight was in 1967 and the 10 000th was rolled out on 13 March 2018. The 737 was originally designed with slim turbojet engines which suited a low wing design. Earlier updates had changed engines to larger diameter turbofans but still in the original position, they just had 'flat bottoms' to the cowlings to maintain ground clearance.

With the advent of newer more fuel-efficient planes, such as the Airbus A320 Neo and Bombardier's C Series (now the Airbus A220), Boeing needed to respond to the reduced fuel burn these aircraft offered and decided to go for the CFM LEAP high bypass engine. The new engine was of a size and diameter that would no longer fit wholly under the wing; it was mounted further forward and higher. This resulted in changes to the aircraft's handling. The centre of thrust is different, such that the aircraft tends to pitch up under high thrust. Worse, the engine nacelles are so large that at high angles of attack they produce lift which

LKAB, transporting iron ore from Kiruna, Sweden to both the Baltic and Atlantic coasts, is just one of the heavy-haul freight railways investing in increased levels of automation. *Photo Bombardier Transportation.*

is forward of the wing centre, increasing the tendency to pitch the nose up. That produced an increased risk of stalling (i.e. of the aircraft's nose getting too high with a consequent reduction in airspeed until lift is lost) and would make the aircraft 'feel different' to earlier models. Boeing's response was not to change the plane's structure (which would have been costly both in terms of engineering and re-certification) but instead they fitted the Manoeuvring Characteristics Augmentation System (MCAS).

MCAS automatically applies a nose down trim in steep turns or low speed flaps retracted flight. When the angle of attack exceeds a limit that depends on airspeed and altitude, the system activates automatically. The pilot will know only because the 'feedback' system pushes the control column forward (with such force that pilots cannot overcome it). The system could be disabled only temporarily.

The MCAS system was configured to depend on input from just one of the Angle of Attack (AOA) sensors which are mounted on the outside of the aircraft and thus vulnerable to ground damage, bird strikes and environmental factors. Whilst there are two fitted on opposite sides of the aircraft, it appears that Boeing and the FAA deemed that the AOA 'disagree alert' was not critical to safe flight and made it an optional feature. When the sensor failed, as it appears happened in both accidents, the system kept forcing the nose down even though a stall was not imminent, and the pilots were unable to successfully deal with the failure. During the author's career he has seen many instances of system failure caused by single sensor inputs, single data sources or single outputs being used in conjunction with multi-lane safe computing platforms and this appears to be another instance of just such a problem. This is a fundamental error, but the alternative is not always simple.

One of the selling features of this new 737 variant was that it was "just another 737" and that minimum pilot conversion training was required (hence the desire for it to feel the same). Training seems to have comprised about an hour on an iPad. Managing MCAS failure is an obvious candidate for simulator training, particularly when previous practice on earlier models might need to be revised to overcome 'habitual learned behaviour'. Such simulator systems are used extensively in aviation for pilot training and regular assessments but presumably would have needed (costly) modification to include these new features. For a more comprehensive description of how simulation is used in aviation see Michael T McNamara's excellent Presidential Programme paper "Human factors in aircraft cockpits, lessons learned" in the April 2019 IRSE News. Part of the changes Boeing is currently preparing is said to be a comprehensive package of simulator training.

For a more complete description of the Boeing 737 MAX issues written by a software engineer who is also a pilot see irse.info/a7zpq.

The only thing the author would disagree with in this article is the view that this was largely down to software, and an attitude that software can always be corrected later so is not given enough attention. The author has seen no evidence that the software did anything it was not designed to do; the problem lies in the system and operational concept definitions and their validation. It looks very much like automation was used instead of costly alternatives without 'whole' system level due diligence. The picture that is emerging of the Lion Air pilots fighting with the aircraft whilst frantically searching through the manuals for an answer to why the aircraft was behaving as it was, and what to do about it, is just awful.

There are some interesting parallels with the way that the UK Automatic Warning System (AWS) was managed as a non-safety critical 'drivers' aid' prior to the Southall Accident in 1997.

Rail

Metros and people movers

So, what about automation in rail? Fully autonomous systems are now relatively common on metro railways and people movers. GoA 4 (Grade of Automation level 4) metros, known also as UTO (Unattended Train Operation) or FAO (Fully Automatic Operation) are in operation in many parts of the world the driver for change will be reducing costs not increasing functionality.

All the current systems known to the ITC are based on a conventional system structure. They have identifiable groups of functions including interlocking, Automatic Train Protection, ATO and door control etc. and are based on programmed software and algorithms that can, and generally have been, validated to high levels of safety integrity (usually EN50128/EN50129 SIL 4 for the interlocking and ATP functions and SIL 0 to SIL 2 for the ATO and door functions depending on system partitioning). None known are yet based on self-learning technology.

Will some of the new technology developed for road 'wash over' into rail? Undoubtedly yes. For People

Movers such developments are already happening. The LIDAR, radar and imaging sensors developed for road vehicles will at least be useful forms of secondary protection. What starts on these simpler layout systems often migrates 'up the food chain' to heavier metros. Certainly, the ITC believes the current cost of additional hardware and software for high availability (e.g. requirements in China which mandate a full 'fall back' ATP solution to allow protected manual driving in the event of CTBC failure – even on UTO lines) are unsustainable in the longer term and simpler fall backs are feasible as autonomous road vehicle technology matures.

The recent accident involving two trains colliding on test in Hong Kong (irse.info/573n4) appears to show the difficulties involved in managing current complex multiple systems.

Main line rail

The further one moves towards heavy rail systems utilising steel wheel on steel rail the more one must deal with extended braking distances and thus the need for the control system to have knowledge of what is happening 'beyond visual range'. Whilst it is clearly possible to 'network' imaging systems to give them some of this capability (platooning of trains in a similar way to the platooning of lorries that has been trialled on some motorways is one suggestion), the safety of current autonomous road systems is largely based on what the individual vehicle's sensors can 'see' within the safe braking distance although some work outside the visible spectrum.

Networking such systems together to share larger scale system knowledge is certainly possible with currently available technology; but doing it to an integrity equivalent to that of today's signalling systems would be much more challenging. Taking the platooning case, the impact energy involved even in a low speed collision between two trains weighing hundreds or even thousands of tonnes and perhaps carrying hazardous materials makes the risk significantly higher than the road case.

SNCF has recently declared an intention to have driverless trains on its high-speed network by 2023, but early tests will all have a person in the cab to deal with 'unforeseen situations'.

Metros are almost universally 'closed' systems with no public access to the track and measures such as platform screen doors to enforce that. The TGV network is at least fenced and has no level crossings. Other main line railways are much more open; fencing is not universal and level crossings common. Braking and detection distances make level-crossing collisions and contact with trespassers something that it is impossible for a driver to always avoid but it remains to be seen what the public acceptance would be of a GoA 4 system in such circumstances and whether Artificial Intelligence (AI) would provide an acceptable response after a collision or glancing blow occurred. Public/media reaction to a driverless train not stopping after an incident would likely be adverse. Imagine a trespasser or a pedestrian misusing a crossing being found trackside hours or days after a shallow glancing impact: but setting up a sensor/AI system to detect such events without a high false alarm rate is non-trivial. For a mining railway in a sparsely populated part of Australia (irse.info/13bzw) the risk might be acceptable but in densely populated parts of Europe, Asia or America?

Nevertheless, the benefits of automation in terms of timetable adherence, available capacity and system level perturbation recovery are now well proven. The ITC thus believes the roll out of main line ATO (GoA 2 with a driver in the cab able to take over and manage unforeseen situations), will continue to grow and that this is the most likely main line automation solution for the foreseeable future. In the UK, Network Rail's Digital Railway programme appears to share that view with the 2017 standard STE/ATO/REQ/001 covering systems up to GoA 2 only. Such an approach is also much more likely to be implementable in terms of industrial relations.

Such ATO solutions do pose a number of human factors issues:

- How will driver competence be maintained? GoA 2 systems on metros have found it hard to maintain a percentage of manual driving to upkeep driver competence because of the adverse impact on capacity. This may not be such an issue whilst we have mixed ATO and non-ATO running but once ATO is extended to all or most of a route then maintaining driving competence becomes a significant issue. The ITC understands that ATO is in service in Czech Republic. We hear that drivers switch off ATO once a week to maintain their competence and report that they are losing "the feel of the train".
- What is the driver's role during automatic operation? Job design to avoid both overload and underload is important. How will low workload with attendant boredom and therefore loss of attention be avoided? It seems unlikely that

Automation of road vehicles is gaining pace, and whilst some of the challenges to those engineering these solutions are common to rail, many are very different.
Photo Shutterstock/Chombosan.

conventional driver vigilance devices will be adequate.

- What information will be presented to the driver during ATO operation? E.g. will the driver be alerted to central control initiated changes for service recovery to avoid interpreting these as a fault, for instance if the train is running late but at below line-speed, because this is being enforced from central control for regulation/conflict avoidance reasons?
- What specific risks are associated with entering and leaving ATO areas and how will these be controlled?
- Will public behaviour at crossings or the behaviour of trespassers or those attempting suicide change as a result of increased automation?

This list is not necessarily exhaustive.

It seems to the ITC that the issue of driver/train captain behaviour in ATO mode will be very important and train operators will need to consider job design and competence maintenance very carefully indeed. The RSSB Human Factors team told us that they had done no work in this area, which we find very surprising. Simulators are used extensively for driver training and the maintenance of competence on the Shinkansen network in Japan, the high-speed lines in China and have been adopted by some UK Operators. We believe that regular training in simulators is likely to form a significant part of such competence management and should include practising for all manner of failures to the benefit of both safety and availability. Regular simulator training of Shinkansen drivers in failure management is one of the reasons that high levels of punctuality and reliability are achieved on Japan's high-speed lines.

When an incident does occur in ATO mode there must be a risk that the operator could be accused of not managing their risks ALARP if a human driver would or even might have performed better. If the driver 'supervising' ATO operation is not paying full attention (and it will not be easy to do so consistently) they may face personal criticism or even criminal proceedings.

Tasks that focus the driver on looking ahead need to be considered including perhaps:

- Noting and recording people on or near the line.
- Condition monitoring tasks.
- Manually validating train location on a regular basis.

Enhanced driver vigilance devices also need to be considered.

One method used in many industries to control boredom and loss of attention in low workload tasks, is job rotation. Multi-skilling could allow the driver and the guard to exchange roles say once and hour. Given the long and acrimonious 'debate' around the role of the guard in the UK that may or may not be attractive to operators or staff. The role profiles are different and certainly in the UK they are presently largely in different trade unions.

That ATO operation requires combination with full ATP to be safe is undisputed. But Driver Advisory Systems (DAS) and Connected Driver Advisory Systems (C-DAS) have been implemented with lesser protection. DAS provides information based on pre-programmed data to help drivers keep to schedule. C-DAS systems take that a step further with data being communicated from central control which allows advised train speed to be adjusted to 'smooth' the service, optimise capacity and recover from perturbation. It has been said that given the different routes feeding into both London's Thameslink and Crossrail it will not be possible to reliably deliver the full service planned without C-DAS to control train arrival times.

At the highest level of capability C-DAS could be considered as a kind of ATO which retains the human driver for safe operation and interface to the train controls. This raises issues regarding system level safety, both in terms of a driver's reaction to conflicting instructions and in terms of the technical integrity of the system. These would be substantially mitigated by a continuous supervision ATP system, but over lineside signals or a truly intermittent system like Train Protection Warning System (TPWS), analysis is needed. The current excellent safety performance of the UK railway has been achieved through a combination of TPWS, driver training and monitoring, improved signal sighting, improved overlap design, and a lot of other measures, and this could be disturbed. One of the C-DAS suppliers (TTG of Australia) told us that their system is assessed to SIL 1 (which may well be sufficient). They also supplied us with a number of background reports and two parts of a specific report produced by RSSB in 2009/10 on the system level impacts of DAS and C-DAS. These seem to suggest that the safety benefit derived from a reduction in red signals encountered is more significant than any risks arising from information conflicts. It seems to the ITC that these conclusions need to be re-assessed and re-validated by operators as systems are rolled out. Careful monitoring and recording of any incidents or precursors should be conducted for the specific circumstances and combinations of systems on their routes and for each change. Once a bigger data set is available confidence will increase and any additional controls that might be needed can be identified and implemented.

Conclusion

The benefits of automation are clear and attractive. But there are risks.

Systems need to be transparent (capable of analysis and correction if things go wrong) and their place in the 'whole system' including interaction with human operators, users and 'bystanders' needs to be assessed and validated as safe as well as effective.

In main line rail the benefits of using both ATO and C-DAS are clear in terms of improved timekeeping and therefore release of additional capacity. But there are questions to be answered about their interaction with drivers, other staff and the public if those benefits are to be delivered without the excellent safety level of many railways being compromised or generating a public outcry, both of which are highly undesirable. There are also issues around how such systems will be funded as costs and benefits do not always fall equitably between the parties involved.

All ITC reports are available on the IRSE website at **irse.info/itcreports**.

What do you think?

Do you agree with ITC's findings and that the benefits of automation are clear and attractive? Does your railway or company have a track record in automation that bears out or contradicts this article? In particular what is your experience around interaction of automated railways with the humans that operate them or travel on them?

We'd love to hear from you, email **editor@irsenews.co.uk**.

Safety and security principles for railway automation

Jens Braband
Siemens Mobility, Germany

This article originally appeared in Signal and Draht issue 5/2018 and is republished with permission.

The discussion on the relationship between security and safety is currently very active, resulting in many different and contradictory recommendations. This paper aims at the derivation and justification of basic principles which can serve as a starting point for further detailed discussions.

Introduction

In recent years there has been substantial discussion about the relationships between safety and security for critical systems. Almost any organisation, such as the International Electrotechnical Commission (IEC), the European Committee for Electrotechnical Standardisation (CENELEC), the German Committee for Electrotechnical Standardisation (DKE) or the Association of German Engineers (VDI), has created a working group on this topic and is aiming at a position paper. Almost every conference has a session on this topic and every journal has had several articles. The positions in the discussions cover a wide range, from complete integration and co-engineering of both disciplines to complete separation of both topics.

This paper aims to establish some fundamental principles and tries to give some general answers to popular questions about railway automation.

Concerning terminology, 'security' is used synonymously for IT security or cybersecurity unless physical security or other issues are meant. In the same way, 'safety' is used for functional safety. It is assumed that the reader is familiar with the basic safety and security concepts as stated, for example, in standards such as EN 50126/50128/5019 or IEC 62443.

What's the difference?

Safety and security have complementary goals: safety mainly seeks to protect the lives and limbs of people or the environment from malfunctions of automated systems, while security aims to protect the systems from attacks from the environment.

But in other aspects they are different. There are different regulatory authorities, e.g. the Federal Railway Authority (EBA) and Federal Office for Information Security (BSI) in Germany, the European Union Agency for Railways (ERA) and the European Union Agency for Network and Information Security (ENISA) in Europe. Different terminology is used, e.g. what is a hazard in safety is a threat in security.

There are different communities and standards, e.g. journals, conferences and standardisation committees are mostly separate with the EN 50126 series for safety, and the IS0 27000 or IEC 62443 series for security.

Methods and solutions are also different, as are requirements, which are often conflicting. Let us take as a simple example the cockpit door of a civil airplane: before 09/11 cockpit doors were mainly open (safety) and afterwards they were shut (security). Then came Helios Flight 522, where both pilots lost consciousness, the crew could not open the cockpit doors (safety) and the plane crashed into a mountain. Afterwards the design was changed so that the pilots had to acknowledge requests to open the door (security), but after a certain waiting time, e.g. three or five minutes, the door opened if the pilots did not answer (safety). Then came the Germanwings flight where a pilot who was left alone in the cockpit ignored requests to open the door (safety) and crashed the plane in order to commit suicide (security). Then the procedure was changed to one in which, if a pilot left the cockpit, another crew member had to substitute for him (security). But this created other security problems, e.g. the crew member might take over the plane (security), and the optimal resolution to this conflict has not been found yet.

So, we have to conclude that safety and security are different and that they cannot easily be merged. Furthermore, security cannot simply be regarded as an add-on to safety or vice versa.

Principle 1: Safety and security are different and should be treated as such.

How can security be treated from a safety perspective?

Safety relies on several environmental conditions or influences that need to be controlled in order to guarantee safety. These are listed in Section B 4.6 of EN 50129 and form a mandatory chapter, "Operation under external influences", in the technical safety report. One of the aspects to be covered is access protection and this is where security has its interface with safety.

The view from a security perspective, e.g. IEC 62443, is similar. Here safety is viewed as an essential function that needs to be protected. Other essentials are operational functions or availability. This means that safety functions can only

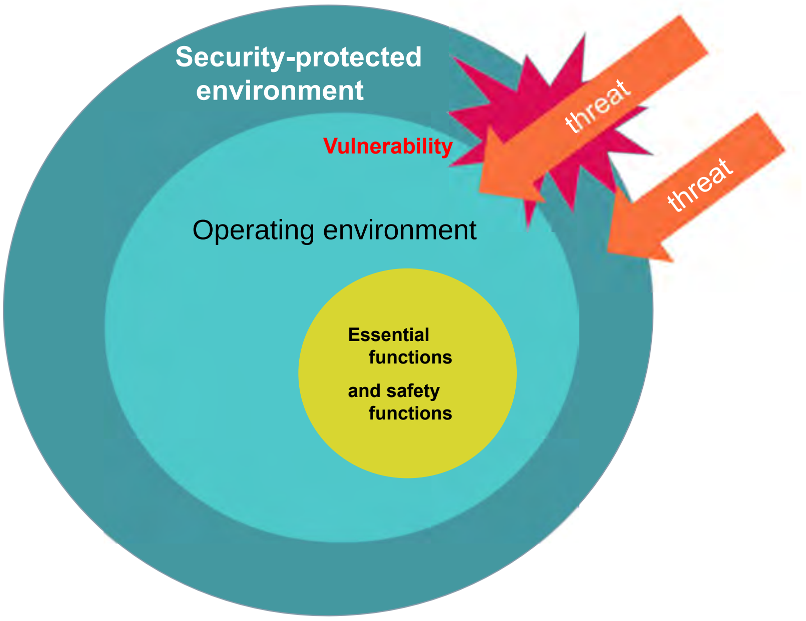


Figure 1 – Security as an environmental condition for safety.

fulfil their intended use in an appropriate security environment. This also explains why the UK Department of Transport is promoting "If it is not secure, it is probably not safe." This leads to

Principle 2: The security environment shall protect essential functions, including safety.

How can we co-engineer security and safety?

Because of the many differences it is not reasonable to integrate safety and security. However, the processes and lifecycles need to be coordinated and appropriate interfaces need to be established.

In particular, in safety risk analysis, hazards resulting from security problems need to be identified, and they are then treated as threats in the risk assessment. Here the safety engineer needs to provide support in order to assess the safety implications but the derivation of appropriate security counter measures is the responsibility of security engineer in accordance with security standards. This gives

Principle 3: Threat and risk analysis is the main interface with safety analysis.

Finally, conflicts between the identified safety and security measures have to be resolved. In the safety risk assessment; the safety assessor needs to assess the safety implications but not the design solutions. Here it can be helpful if the security management supplies evidence in a manner compatible with safety management, e.g. trusted certificates with clearly stated assumptions and application rules. This generally results in

Principle 4: Separate security and safety as far as possible but coordinate them effectively.

This also holds for architecture principles or maintenance processes such as software updates. If safety and security were tightly integrated then any change in security functions might invalidate the safety case. Here an effective strategy could be to rely from a safety case point of view only on those parts of the security functionality that create a secure environment and on the application rules. So, if both the security functionality and the application rules remain unchanged, the safety case may remain valid even if the security software is updated.

This is also recommended by the revised prEN 50129, which recommends referencing security analyses in the safety case only. In order to ease the integration, as well as compatibility, it is recommended to base security considerations on established international standards such as ISO 27000 or IEC 62443. Several analyses, e.g. by CENELEC SGA16 or Shift2Rail, have recommended IEC 62443 as the future baseline security standard for railway automation too.

Principle 5: Security shall be evaluated on the basis of international standards, e.g. IEC 62443.

Can we quantify security?

Security problems occur because of threats to the integrity of the system. These threats arise from attackers who exploit vulnerabilities in the security environment. Attackers act intentionally, using all the information about the system that they can obtain, according to the current state of the art in attacking or hacking. The degree might be different, depending on the attacker. So, differently from safety, no probability or rate of an attack exists. The similarity to safety is that the causes of security threats are similar to systematic faults in safety. Vulnerabilities often originate from errors in the security functionality, mainly software, which is similar to software faults in safety. So, the key finding is

Principle 6: It is impossible to evaluate the security risk probabilistically.

The major difference is that in security an attacker is needed to exploit the vulnerability, while in safety certain conditions in the operational environment trigger the software fault, resulting in a system failure. So, security requirements need to be established in a similar way to safety integrity requirements, i.e. a scheme of target levels similar to safety integrity levels (SIL).

What do security levels and safety integrity levels have in common?

Security levels (SL) according to IEC 62443 are defined with respect to the type of attacker. SL 1 represents unintentional errors or foreseeable misuse only, while SL 2, SL 3 and SL 4 relate to intentional attacks in which the attacker possesses increasing levels of knowledge, motivation and resource. As safety treats security as an environmental condition it is immediately evident that measures according to any particular SIL do

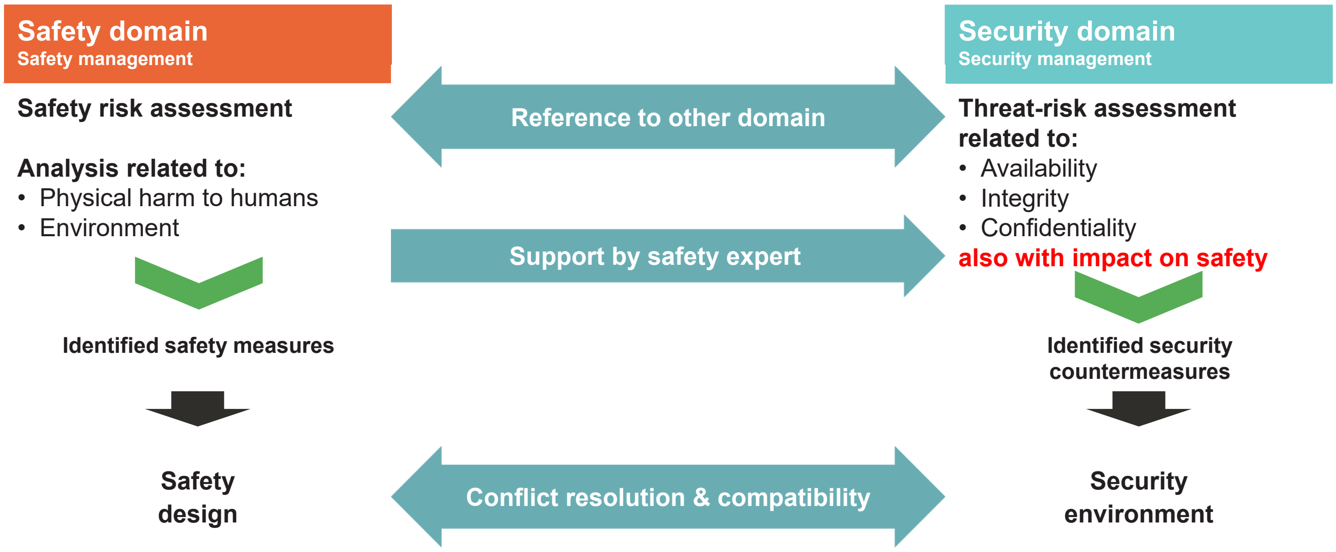


Figure 2 – Safety and security coordination.

not cover measures against intentional attacks. However, errors and foreseeable misuse also need to be addressed by safety systems, so any safety system should also cover SL 1. But for other SLs there is no automatic correspondence between SL and SIL as the SL will always depend on the security environment. It should also be noted that security requirements cannot be fulfilled only by IT measures; physical security measures are also necessary. In summary we have established

Principle 7: Safety and security target measures shall not be coupled.

However, there is a general relation between safety and security approaches. In safety there is the general rule that the first fault shall not be hazardous. Only a second similar fault may cause a failure. So many safety designs rely on detection and negation of the first fault.

In security a similar concept exists: defence in depth. This means that no single security measure shall be regarded as perfect and sufficient. There must always be a second line of defence which protects against an attack. This does not mean that both security measures need to have the same strength, but even for the strongest security measure there must be a fallback. This implies that security measures must also be monitored for their effectiveness.

Who is responsible for security?

As in safety, there is no single individual or body responsible for security. It is a joint effort of the operators (often called asset owners in security), the system integrators (who supply complete systems) and the suppliers (who sell components). But unlike safety, the evaluation processes operate at a higher speed in security. Even without any incident it is good practice to update threat and risk assessments at least once per year and to feed the results forward and backward to the stakeholders at the interfaces. So, last but not least, we have

Principle 8: Security is a collaborative continuous effort.

Finally similarly to safety, effective security protection relies heavily on the company culture. Many successful attacks show a similar pattern:

- first, the attacker gains access to the system (network),
- then the attacker explores the system, often trying to gain higher privileges, until
- finally, the attacker carries out the attack.

Access or higher privileges can be obtained by exploiting vulnerabilities (e.g. weak passwords) or by social means such as phishing. Often, the attacker cannot achieve his goals without operators or employees who breach security rules or are complacent. So, it is very important that security awareness is promoted and trained as part of the company culture.

What do you think?

Jens asks a number of questions. What's the difference between safety and security? How can security be treated from a safety perspective? How can we co-engineer security and safety? Can we quantify security? What do security and safety integrity levels have in common? Who is responsible for security?.

These are all questions many members have to address when delivering control, command and signalling projects. So how do you address these issues? We and fellow members would welcome your views and the sharing of your experiences in the this key area, email us at editor@irsenews.co.uk and let us know.

The SSI Technician's Terminal – then and now

Ian Mitchell

An essential component of any electronic signalling system is the facility for a maintainer to monitor operations, diagnose faults within the system and in the connected equipment, and apply restrictive controls such as barring of routes or maintaining signals in their most restrictive aspects.

This was recognised back in the 1980s when the British Rail Solid State Interlocking (SSI) was under development and so a Technician's Terminal (TT) was a feature of the system from the start. SSI became a hugely successful product in quantity production for more than twenty years. While SSI has been superseded by modern equivalents for new installations, several hundred interlockings remain in service around the world. However, obsolescence of the commercial off the shelf (COTS) components used to build the SSI TT has become a threat to continued operation of these systems, and this has prompted Park Signalling Limited (a Unipart Rail company) to develop a modern equivalent replacement.

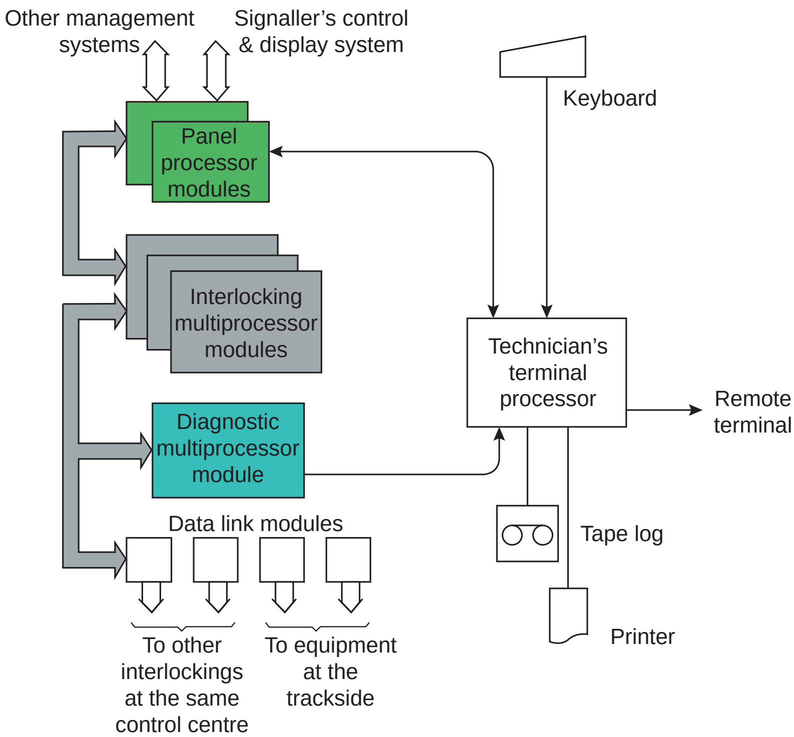


Figure 1 – SSI interlocking architecture.

In the beginning

The SSI system architecture is described in detail in the IRSE 'Red' textbook 'Railway Control Systems', from which figure 1 is reproduced. Each interlocking cubicle contains triplicated interlocking processors that undertake the core safety critical functions, duplicated panel processors which provide the interface to a signaller or traffic management system, and a diagnostic processor which monitors all the communications to and from the system for logging and fault reporting purposes. The panel processors and diagnostic processor are connected to the TT – this approach minimises the direct external connections to the safety critical interlocking modules. Up to six interlocking cubicles can be connected to a single TT.

The diagnostic processor eavesdrops on the trackside datalinks to record the state of messages to and from the trackside functional modules (TFMs) that provide the field interface from the SSI to trackside signalling equipment, and recognises combinations of states that indicate a fault. It contains all the geographic data needed to translate the bit states within the trackside telegrams into meaningful fault reports containing the identity of the failed equipment and the type of failure that has occurred. This means that the TT did not need to be configured with geographic data, as it simply translates the messages from the diagnostic processor into readable text.

The original version of the technician's terminal comprised a half height cubicle with a processor, tape recorder, modem and keyboard/printer. The facilities provided were:

Figure 2 – An early production unit of the SSI TT.
Photo Westinghouse archive.

- Printing of fault reports generated by the diagnostic processor and their time of occurrence.
- Logging of fault reports and interlocking activity onto magnetic tape for subsequent analysis when required for failure or incident investigation.
- Selectively reporting on request the current input and output states of TFMs, requests from the signaller or traffic management system, and internal states of the interlocking.
- Application and removal of restrictive controls on the interlocking, e.g. barring routes, holding signals at most restrictive aspects, disabling point movement and forcing track circuits to the occupied state.

An important component of the system was the tape recorder, which was a Penny and Giles device with two separate tape drives. In normal operation one drive was in use for logging and the other on standby, with a changeover every 24 hours. This ensured the log of events for the previous day was always available to be removed from the TT without interrupting the current day's logging.

A modem was provided for connection to an analogue telephone line to allow dial-in access by a technician from a remote site. To maintain security the facilities available via this interface were restricted to 'read only' functions; the remote user was not allowed to do anything that could alter the behaviour of the signalling system.

The processor used in the TT was the Motorola 6809, a slightly more powerful version of the 6802 microprocessor used in the bespoke SSI hardware. With only one TT required at all but the largest control centres, there was an incentive to avoid developing special hardware, so a commercial off the shelf (COTS) solution was devised. To accommodate the large number of RS422 links required to service six interlockings from one TT, a 'STE' rack system was used with processor and multiple serial interface cards plugged into a backplane via Eurocard connectors

Early enhancements

Following the success of the SSI pilot installation on British Rail and the first few schemes that followed, a number of enhancements were made, and this included improvements to the TT. The original user interface using a keyboard/printer was already outdated and wasted paper, especially when the TT was being used to monitor testing prior to commissioning a new system. The upgrade provided a monochrome visual display unit (VDU) and keyboard, with a separate printer to generate hard copy output on paper only when necessary. The VDU also allowed the original command line user interface to be replaced with a more user-friendly menu driven approach. In addition, a radio clock receiver was provided to synchronise the time stamps on recorded data with a national timing reference.

The other major enhancement was to enable the TT to be used as a simulator for testing interlockings and the connected control centre equipment when disconnected from the datalinks to the trackside equipment. This replicated on-site the facilities of the SSI Design Workstation simulation system that had been developed by British Rail Research to allow off-site testing of SSI geographic data in a design office environment. A rather ingenious solution was devised to avoid the need for additional dedicated simulator hardware. As the triplicated interlocking was designed to continue working with one of the three interlocking modules out of service, a simulation could be set up by re-configuring one of the interlocking modules as a simulator. In this mode the third module listened to the datalink command telegrams generated by the other two, and replied with messages simulating the TFMs and trackside equipment. The re-configuration involved swapping a memory module for one containing simulator software and data in its erasable programmable read only memory, and connecting up an adaptor cable which allowed the simulator module to communicate directly to the TT. The TT was enhanced with an additional colour VDU that provided a visual representation of the states of simulated TFM inputs and outputs on a schematic track diagram, and a trackerball to allow a tester to manipulate the simulated trackside equipment inputs. Facilities were also provided to simulate failures of data links and power supplies that would affect multiple TFMs, and even to run simulated trains through the area. To avoid the having to configure the TT with area specific geographic data, the information required to drive the trackside equipment display was loaded into the system via the magnetic tape drive.

Onset of obsolescence

The use of COTS components in the SSI TT meant that sooner or later obsolescence would become a problem, and this first emerged as an issue with the most complex component, the magnetic tape recorder. This became unobtainable as other applications such as aircraft flight data recorders moved onto more robust and higher capacity storage media, and recorders in service were wearing out through continuous use. By the year 2000 a suitable replacement was urgently required as the event log was now regarded as crucial evidence for incident investigation – tapes were routinely seized and stored securely by the police for analysis by accident investigation bodies.

A solution was devised to replace the tape recorder with an alternative recording method whilst retaining the same interface with the TT processor. This was achieved using an industrial PC (personal computer) programmed to mimic the RS232 interface of the tape recorder. This was developed for Railtrack by AEA Technology Rail and was known as the Technician's Terminal Logger Recorder (TTLR). To support the incident investigation process, it was important that data recording was on a very reliable and removable recording medium, and the chosen technology was a magneto-optical disc drive – in retrospect not perhaps the best solution as this too became obsolescent in due course.

Eventually the circuit boards required to assemble the TT processor also became unobtainable, and the ability to commission a new SSI installation or repair an existing TT came to depend on stockpiled spare parts or refurbishing equipment displaced as result of original SSIs being upgraded to second generation systems. With several hundred SSI interlockings still in service around the world there was a need for a modern replacement for the TT.

Introducing the MT04

Park Signalling Limited was established in 2000 by a small group of engineers who had previously worked in the Manchester offices of GEC Alsthom. The new company established itself as a supplier of advice and equipment to solve problems with electronic signalling equipment that was no longer regarded as mainstream business by the major multi-national suppliers. Several of the company's engineers had participated in the original development of SSI and its applications around the world. Through this involvement it became apparent that the obsolescence of the TT was becoming a significant threat to continued operation of SSI installations, and a decision was taken to develop a long-term replacement based on a modern hardware and software platform.

The problem of handling large number of serial interfaces that constrained the original TT hardware design is now simply solved by means of a 32-way port server, linked by Ethernet to a PC, and the removable logging medium is a USB memory stick. The software has been completely re-written to provide a modern graphical user interface, which can simultaneously display information from several interlockings.

The new TT, known as MT04, was launched in April 2019 at a very appropriate location, the birthplace of SSI in Kelvin House on the rtc Business Park in Derby, UK, formerly the home of British Rail Research. The demonstration even made use of ex-BR research equipment now used by Signet Solutions for training purposes. Speakers at the event included John Slinn, one of the founders of Park Signalling, and Roger Ford of Modern Railways magazine, who re-iterated his view of SSI as one the most significant British railway engineering achievements of the 20th century. A product approved MT04 was installed by Network Rail signalling technical support staff at Lincoln Signalling Control Centre on 12 May 2019.

Figure 3 – MT04 user interface.

It is often said that the lifecycle of modern electronic signalling equipment is much shorter than for older equipment. While an SSI installation is unlikely to achieve the century of service of some mechanical interlockings, it is now 34 years since the commissioning of the first SSI at Leamington Spa in 1985, and the number in service and the reliability of the key components is such that we may eventually see a 50 year old example to rival the life span of other electrical technologies, such as miniature lever frames and route relay interlockings. The availability of modern replacements for support tools such as the TT will be a key factor, and the engineers involved are to be congratulated in taking the initiative to develop the MT04. Now what is needed is a similar job on the SSI Design Workstation so the data preparation environment is also supported into the future.

About the author ...

Ian Mitchell was a member of the original SSI development team in British Rail Research, and has worked continuously for successor companies since privatisation. He is now semi-retired and one of the contributing editors for IRSE News.

Figure 4 – The SSI training system at Signet Solutions incorporates an entrance-exit panel representing the Leamington Spa SSI pilot scheme area.

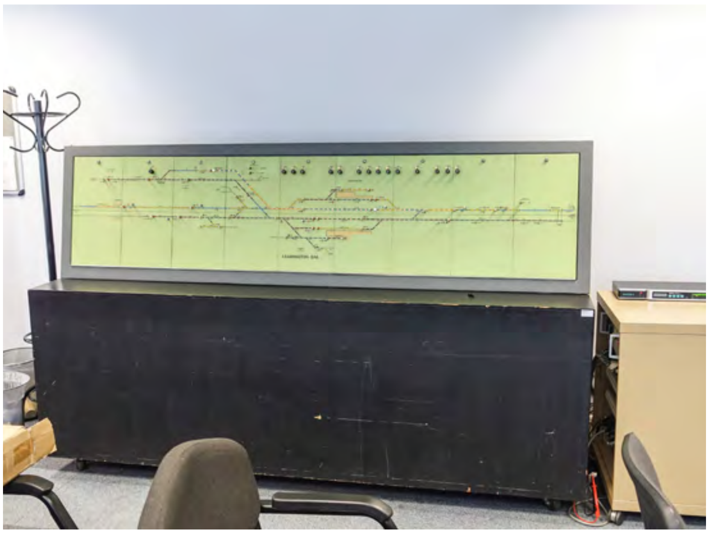


Figure 5 – The new MT04 user interface alongside the SSI interlocking cubicle that was used for the launch event.

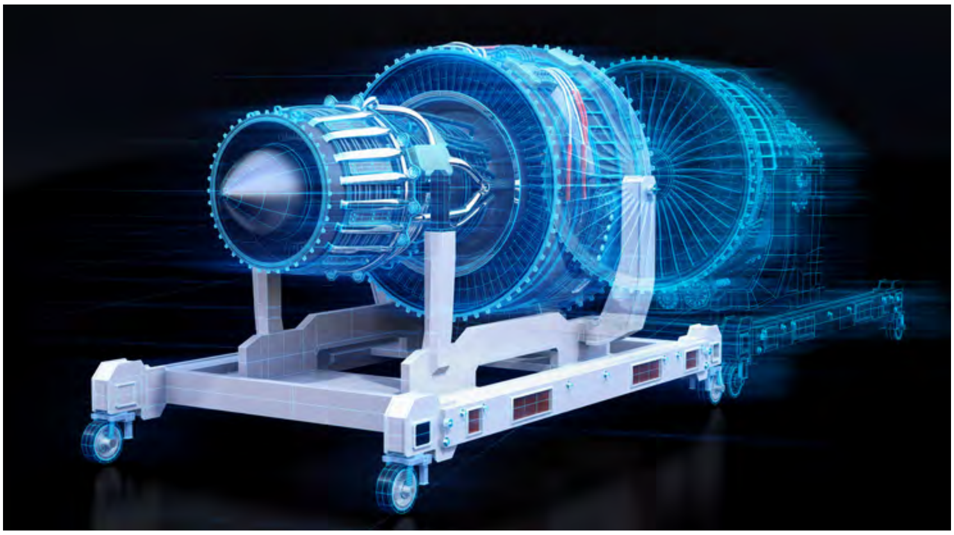
Institution of Railway Signal Engineers

How can digital twins aid predictive maintenance?

Gordon Wai and Amar Vasdev
Rail Safety & Standards Board (RSSB)

A digital twin is a digital replica of physical asset, process, people, place, system or device that can be used for various purposes. Digital Twins are closely related to Building Information Modelling (BIM) systems but are slightly different.



The aerospace engine makes use of digital twin representations of complex systems such as jet engines. Having a computer-based alternative allows detailed analysis and simulation to be carried out virtually on a desktop computer rather than in expensive 'real-life' test rigs. *Photo Shutterstock/Chesky.*

What are digital twins?

Digital twins are virtual, real-time representations. In comparison to other conventional simulations, which only represent purely virtual scenarios, digital twins are intrinsically linked to a physical asset and aim to represent the asset in real-time.

Machine learning techniques, statistical and physics-based models, are used to analyse the physical asset's operational data, and operational and maintenance history. The digital twin then acts as a real-time simulation, allowing the asset to be monitored remotely, enabling predictive maintenance to optimise asset performance.

Recent developments in the technology incorporate cloud technology and augmented or virtual reality to allow users to interact with the digital twin intuitively.

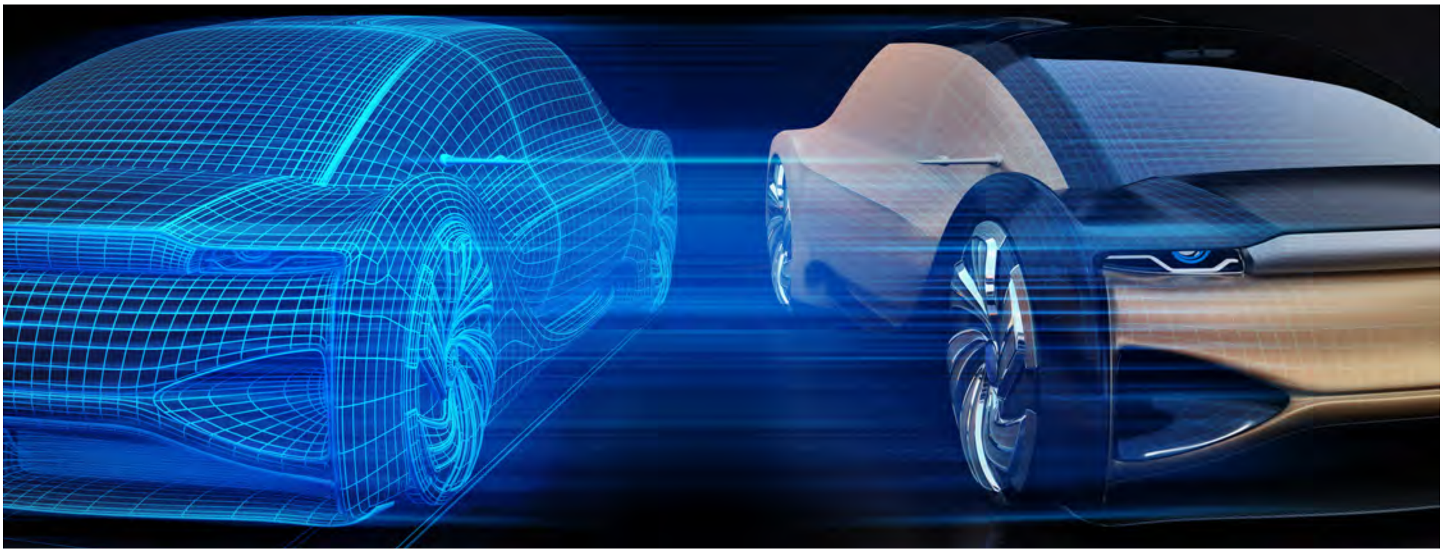
Once a digital twin is constructed, it could be used as the basis of conventional simulations. As digital twins closely resemble their physical counterpart, testing can be simulated at a lower cost than physical testing. This has been described by some as a predictive twin.

Which industries use digital twins?

In the aviation industry, GE Aviation has created digital twins of all prototype engines involved in the development of the GE9X engine, allowing the designers and engineers to analyse the variation in performance between test cycles, and highlighting the effects of ageing components on engine performance. By using the digital twins from existing prototypes, the specific effects of each design variation can be assessed, thereby allowing the best elements of each design to be used to improve the reliability and durability of the final GE9X engine.

In the energy industry, digital twin tools have been developed to provide wind farm owners and operators with an insight into turbine conditions and performance. These tools utilise real-time data from the turbines and meteorological measurement equipment to estimate turbine life-span and enhance asset management capabilities. Predictive analysis of the turbine drivetrain together with structural integrity monitoring can be used to adjust wind turbine variables to increase energy production.

In the heavy industries sector, Aluminium of Greece have worked with GE Power to enhance their aluminium smelting process and increase operational



The automotive industry, and in particular Formula 1 racing, has also seen benefits realised from the use of digital twins.
Photo Shutterstock/Chesky.

efficiency and productivity through the use of digital twins. The technology has enabled Aluminium of Greece to reduce their energy consumption and use of raw materials, and improve the overall plant analysis.

Technology and Rail Industry Readiness Level

Technology Readiness Level (TRL) is estimated to be 9: Actual systems proven successful. Digital twins have been applied in industrial and operational contexts.

Rail Industry Readiness Level (RIRL) is estimated to be 6: Manufacture can repeat quality to meet market needs. Software tools to facilitate development have been released and some digital twins of rail elements have been made or are in development.

How will they impact the rail industry?

By analysing sensor data, digital twins can model the lifetime performance of various assets such as rolling stock, therefore better predicting when faults and failures could occur. This has the potential to reduce maintenance and operational costs by reducing unplanned downtime. Furthermore, applying digital twins can streamline processes such as manufacturing. For example, tracking how rolling stock is designed, configured, built, operated and serviced can identify issues during assembly resulting in targeted actions to optimise the amount of material used and thus improve fuel efficiency.

A geographic information system (GIS) can be used to provide information on the location of assets and create a digital twin of the rail network. Creating synergies between the two technologies can highlight infrastructure faults. In addition, GIS can efficiently determine the location of rolling stock faults, thus supporting faster repair times and minimising network disruption. Moreover, knowing the real-time location of every train may support more flexible train coordination through adaptive routing. Digital twins of infrastructure systems could prevent delays and improve maintenance and operations.

What is the current state of R&D?

Many rail and software companies have invested in cloud-based software systems in order to harness big data for predictive maintenance. Chinese rolling stock company CRRC has developed a prognostics and health management system for critical components of high-speed trains. Siemens has developed Railigent – a suite of applications, based on the MindSphere IoT platform. Railigent allows operators to manage rail data and optimise maintenance and operations. These systems lack the full 3D model characteristic of most digital twins but provide the necessary cloud architecture and integration to enable digital twin development.

For example, the MindSphere platform can be used to gather performance data for Building Information Modelling (BIM). BIM is a process for integrating and managing data on a construction project across the product lifecycle, through CAD representation and standardisation.

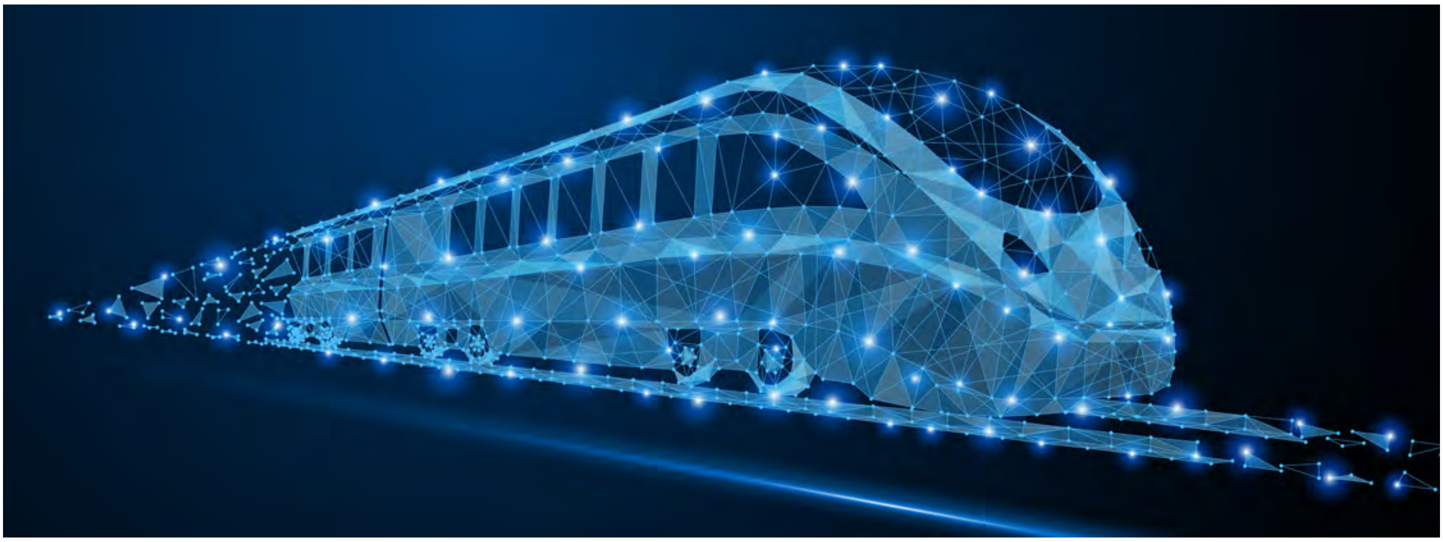
Originally, BIM was intended for project lifecycle management by allowing architecture, engineering and construction teams to work in parallel. However, as it has developed, it has been recognised that the integrated information systems can still be used to support maintenance operations. As a result, BIM systems have been suggested to assist in digital twin development of infrastructure.

Data integrated with BIM systems could be used to create digital twins. Siemens Mobility is collaborating with Bentley Systems to mature BIM systems, using the gathered data to create digital twins for design and construction of rail infrastructure projects. Other digital twin platforms for rail projects have been released by other companies.

Rete Ferroviaria Italiana is currently mapping parts of the Italian railway network to a 3D digital model. Alstom has created a simple, system-based, digital twin of the West Coast Main Line network which tracks train location, maintenance status and depot utilisation thus supporting the train maintenance environment. This digital twin is focused on operational management, specifically maintenance scheduling, rather than technical simulation. The collected data feeds into a digital twin with an optimisation and simulation tool, allowing for real-time arrangements to be made. As a result, Alstom can identify maintenance bottlenecks and smooth maintenance peaks, hence improving availability for the customers.

What uncertainties remain?

Creating digital twins can be challenging. For example, each twin must be tailored to each individual asset or system which can be time-consuming to develop. Due to the complexity of modelling the physical asset and systems, digital twins require expertise, which can be costly. If the asset is not sufficiently modelled, e.g. missing sensor data, a variation between



Rail is starting to adopt the use of digital twin approaches. It is easy to imagine ways in which a digital twin could bring real benefits to most railway engineering disciplines.
Photo Shutterstock/Leyn.

the behaviour of the physical asset and the digital twin will result in inaccurate assessments. Furthermore, cyber-attacks could become a growing threat if digital twins in the Cloud are vulnerable to hackers. Importantly, digital twins will give detailed insight into safety critical equipment. Hackers could use digital twins to find the vulnerabilities of such equipment and use this to target attacks to cause an accident.

What should the rail industry do?

Infrastructure managers could invest in IoT platforms and BIM systems to begin building a platform for data integration. Stakeholders could also ensure legacy and new data systems are interoperable with these platforms – this would require investment in semantic translator systems to convert data in old formats into one suitable for newer systems. Predictive maintenance analytics is a growing field in the railway which lays the digital groundwork for creating digital twins. Stakeholders could collaborate to standardise these data frameworks to ensure they use compatible models, which would enable information sharing and avoid duplicating development work. Rail companies could collaborate with other transport and infrastructure organisations to ensure cross-modal interoperability. This could facilitate the utilisation of innovative new developments from other industries by rail. Stakeholders could also engage with research institutes with expertise in artificial intelligence, to build complex digital twin models of rolling stock, stations and railway networks.

About the authors ...

Gordon Wai is a student research analyst at the RSSB and a mechanical engineering undergraduate at Imperial College London. As part of RSSB's Horizon Scanning team he researches emerging technologies and evaluates their application to the railway. His undergraduate work spans many robotics and control projects.

Amar Vasdev is a former student research analyst at the RSSB with a strong interest in AI and sustainability. Studying Mechanical Engineering at Loughborough University, his final year project focused on the modelling of thermal energy storage for domestic applications.

Design help needed!

The North Yorkshire Moors Railway has recently been awarded lottery and other grants totalling £6.6 million. While most of this money will go on a much-needed carriage shed and essential bridge renewals there will be a substantial amount of S&T enabling works which will severely challenge the existing very limited design resources.

I would therefore be very pleased to hear from any experienced signal designer who might be prepared to volunteer their services to help with this work. Please contact me at **fpsjwiltshire@btinternet.com**.

Philip Wiltshire
IRSE past president and professional head of signalling
North Yorkshire Moors Railway

Photo Shutterstock/Richard Semik.

IRSE

Institution of Railway Signal Engineers

Network Rail railway signalling equipment power system earthing

Paul Darlington

One of the most important requirements for modern railway signalling is a safe and reliable power system for signals, points, interlockings and communications. The power system must be tolerant against failure and provide a constant stable supply in order for the control and communications equipment to operate correctly.

Often taken for granted, or overlooked, power systems can be difficult to provide, given that the railway infrastructure is long and narrow and not always close to an external power source. The earthing arrangements for railway signalling power systems differ from normal industrial and commercial electrical systems, which has caused compliance issues with safety requirements in the UK.

The signalling power supply equipment must be safe, both for maintenance staff and for members of the public when the equipment is located on platforms or at level crossings and faults may occur that result in exposed metal becoming live. However, the supply must always be available and in availability terms it's the same as continuity of supply for other safety critical applications – for example airport ground lighting or hospital operating theatres. So, it's not acceptable to turn everything off when a fault arises, which has been a traditional electrical engineering solution for such hazards.

Railways have invested a lot of time, effort and money in providing reliable power supplies with multiple sources of energy, but in some cases neglected the power distribution network that moves the power to the current-using equipment. This situation has now thankfully changed after much effort by the various engineering disciplines involved.

Class I and Class II protection

Protection arrangements in power distribution networks are generally Class I or Class II. In Class I (as shown in Figure 1) exposed metal parts must be connected together and connected to electrical earth by a separate earth conductor. The basic requirement is that no single fault can result in a dangerous voltage becoming accessible which might cause an electric shock, and that if a fault occurs the supply will be automatically disconnected.

A fault in the installation which causes a live conductor to contact a casing will cause a current to flow in the earth conductor. If large enough, this current will trip an over-current device and disconnect the supply. The disconnection time has to be fast enough and the accessible fault voltage low enough not to harm to a person in contact with any accessible metal. These factors determine the time and the current rating to set the maximum earth resistance permissible.

Traditionally railway signalling power supply distribution systems have been based on Class I individual earth designs, requiring an effective earth arrangement.

A Class II or double insulated electrical equipment installation (see Figure 2) is designed in such a way that it does not require an electrical safety connection to earth. The basic requirement is that no single fault can result in dangerous voltage becoming accessible so that it might cause an electric shock, and without relying on an earthed metal casing. This is usually achieved by having at least two layers of insulating material between live parts and the user, or by using reinforced insulation. Not only is there a safety benefit with Class II, but the reliability is far greater as the supply cannot be tripped due to an earth fault.

The designation "Class II" should not be confused with the designation "Class 2". Class 2 refers to the output voltage and power capabilities of AC–DC supplies, while the IEC (International Electrotechnical Commission) designation of insulation protection, Class II, refers to electrical equipment internal construction and electrical insulation.

Class II power supplies will have a two-wire power cord as opposed to a three-wire power cord with a safety earth connection. Products designed with Class II insulation are often labelled as "Class II" or "double insulated" or will have a concentric square safety label symbol.

Earthing

British Standard BS 7671 (the IET Wiring Regulations – informally called the "regs" by some) covers the primary types of power system earthing arrangement: TN, TT and IT. The first letter in each of these terms defines the connection between the earth and the power supply equipment, T is direct connection to earth, I is no connection to earth. The second letter indicates the connection between the earth and device being supplied, T is a local direct connection to earth, N is a neutral connection supplied by the electrical supply network. The majority of electricians and electrical

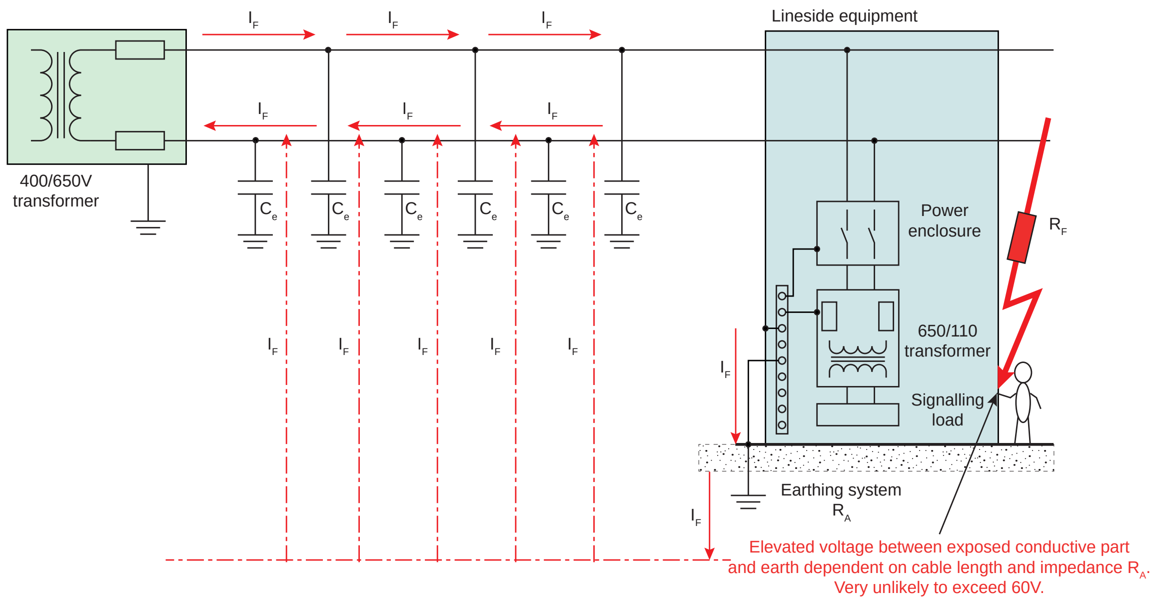


Figure 1 – Class I individual earth system.

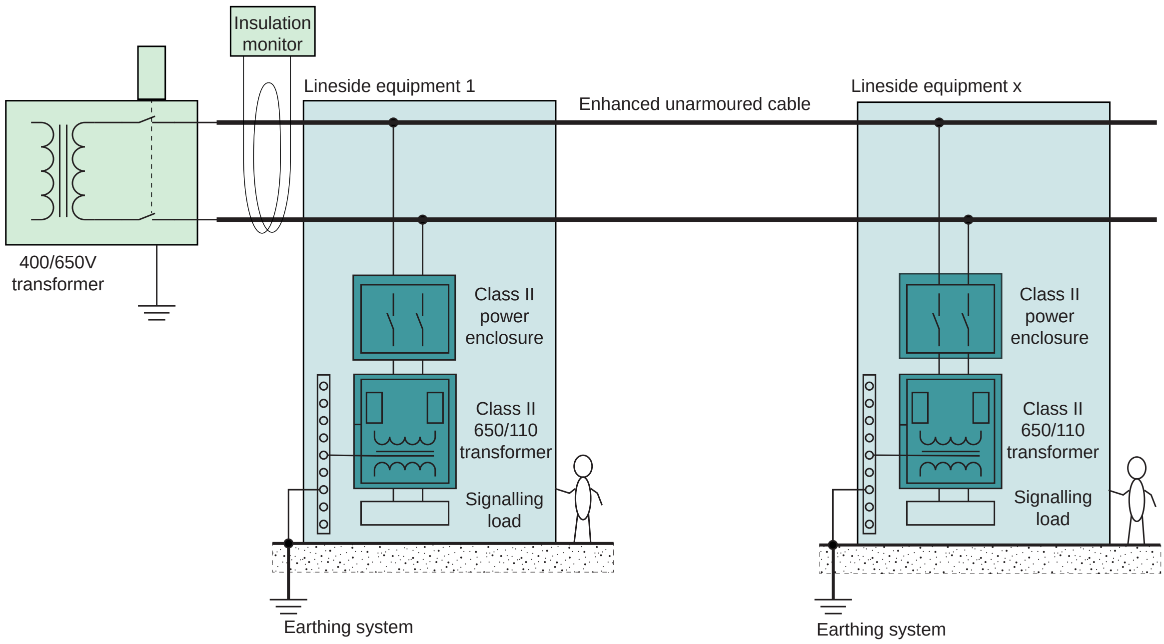


Figure 2 – Class II unarmoured cable system.

engineers will be familiar with the TN type, as the TN variations are the most common type of supply provided by distribution network operators (DNOs). The TN arrangement is deemed suitable for most installations as the provision of a protective earthing conductor ensures that under earth fault conditions sufficient fault current flows to enable the protective devices to disconnect faults within the times required by BS7671. More importantly, the earthing conductor is designed so that the total impedance of the earth fault path is low enough to prevent accessible conductive parts (e.g. the metal enclosure) of the connected equipment rising to a harmful voltage.

In the UK the TT arrangement is often found in rural or remote areas where the use of overhead cables leaves the Protective Earth and Neutral (PEN) conductor more vulnerable to damage. Instead, an earth electrode is provided at the supply transformer with another electrode provided at the installation that is being supplied. The downside of a TT installation is the high external loop impedance value, due to the reliance on variable ground resistance to complete the earth fault loop. This can result in a relatively low fault current and therefore requires a Residual Current Device (RCD) in order to provide assured disconnection of earth faults. The local earth electrode also needs regular testing and maintenance.

The third type of earthing arrangement is the IT type, in which the output of the source transformer is isolated from earth, whilst all exposed conductive parts of the installation are connected to earth electrodes. The traditional way of distributing the power trackside along the railway for signalling in Great Britain has used the IT earthing system.

In the IT system the source transformer output is isolated from earth, although the system will be still be earthed by the stray capacitances of the cables. Should there be a fault with the insulation of cable or functional supply point (FSP) equipment, creating a direct short circuit to earth, there is no return path for the earth fault current, with the equipment remaining operational. BS 7671 gives no requirement to disconnect the supply under first earth fault conditions, so long as any accessible voltage is not harmful and an insulation, residual current or insulation fault monitoring system is present.

The trackside power cables are usually, but not always, two-core, and each FSP is individually earthed using an electrode formed of one or more buried earth rods. An appreciable earth fault current may flow, but the length and resistance of the feeder circuit conductor to the fault locations, as well as the resistance of the location case connection to earth, can result in a fault current that is insufficient to cause automatic operation of the protective device in an acceptably short time. The general mass of earth can be variable which makes the magnitude of earth fault current difficult to predict, but it is not a major constraint on earth fault current in this scenario.

This arrangement is not compliant with The UK's Electricity at Work Regulations, nor BS 7671 (Wiring Regulations). The highest permitted accessible voltage is 50V (BS7671) or 60V (EN 50122-1). This is may be exceeded on some legacy 650V installations and on some large legacy power distribution networks. It is not unknown for connected feeder cables to have a calculated total leakage current of 2.2A, so a first fault of negligible resistance may result in accessible voltage higher than 60V, unless the faulted FSP is provided with an earth electrode of less than 27Ω resistance.

The real problem on a system with an IT Earthing arrangement is with a second earth fault, as an accessible harmful voltage is very likely to be present for an unacceptable duration (see Figure 3). The ratio of the two earth fault resistances will determine how much of the 650V system voltage appears on each faulty equipment case.

It is believed that the non-compliance with BS 7671 arose because there is an exemption for 'railway signalling equipment' which railways relied upon for many years. However, the Office of Rail and Road (ORR) more recently took the view that the exemption from the regulations is only for the 'signalling equipment' itself and not the electrical distribution networks feeding signalling equipment. The Electricity at Work Regulations (1989) are applicable in any case, so non-compliance is not an option.

Improvement Notice

The legacy design, and in particular the hazard from exposed conductive parts of signalling equipment in public areas, resulted in the ORR issuing Network Rail with an Improvement Notice on 19 November 2013. In the notice the ORR said: "650V power distribution networks used to supply power to track side signalling equipment at various locations on Network Rail managed infrastructure are not constructed to prevent, so far as is reasonably practicable, danger. Signal location cases, to which members of the public have access, are not adequately earthed and bonded to prevent danger should exposed conductive parts become charged at dangerous voltages".

The scope of the notice applied to all of the 650V power distribution networks across Network Rail managed infrastructure, and the ORR considered that the situation contravened the statutory provisions contained in Section 3(1) Health and Safety at Work Act 1974 Regulations 4(1), 4(2) and 8 Electricity at Work Regulations 1989.

Network Rail were required to undertake a review of 650V power distribution networks to which members of the public have access, to identify assets where:

1) Exposed conductive parts are not adequately earthed and bonded to prevent danger should they become charged at dangerous voltages.
2) Subject to the findings of 1) above undertake suitable remedial works, prioritised on the basis of risk, to ensure that 650V signal location cases which may reasonably foreseeably become charged as a result of an electrical fault are earthed and bonded.
3) Devise and implement inspection and maintenance arrangements for ensuring that 650V signal location cases to which members of the public have access are maintained to prevent, so far as is reasonably practicable, danger.

or

4) Implement any other equally effective means of achieving compliance with the notice.

Compliance strategy

A number of solutions were identified by Network Rail to comply with the Improvement Notice. These are linked and need to be combined in addressing the risks to the signalling power distribution problem. A suite of Class II-based power system equipment and designs were developed and approved. Signal power network insulation monitoring and fault location equipment have been introduced based on risk. The design and installation of signal power network earthing arrangements has been revised, together with a much-improved signalling power system inspection and maintenance regime. Competences and training have been reviewed and enhanced, both for signalling power system inspection, testing and maintenance, together with improved safe working practices for work on or near signalling power equipment.

In the new inspection and maintenance regime, responsibilities and accountabilities are more clearly defined and include a requirement to inspect and take action based on risk. A consistent national means of classifying defects by codes and the response required, and by whom, has been implemented.

Additional resources required for inspection and implementation of the control measures have been budgeted for. This includes the required competencies. Where a hazard is identified a feasibility design based on risk and the ground resistance may require a Class II retrospective installation, should an improved earth electrode not be sufficient.

Traditionally feeder insulation monitoring equipment can identify that a fault has occurred, but not where the fault is located. The fault could be anywhere on the power network (which can total more than 30km) in a large signal box area, requiring time consuming inspection and testing to locate the fault. Network Rail are currently trialling 'smarter' insulation monitoring equipment which is able to narrow down better the location of any fault. The equipment is based on designs used in the offshore oil and gas industries, and the results are encouraging. Full approval is expected soon.

The Class I collective earthing system (which complies with the regulations) was not specifically identified as part of the improvement notice response, but such systems had been used selectively around the network for a number of years e.g. Mickle Trafford resignalling in 2006 and Crewe-Winsford remodelling in 2008. With the Class I collective earthed system, a three-core armoured cable is used rather than a two-core 650V supply cable. The third core and armour are used together in parallel as a Circuit Protective Conductor (CPC) to equipotentially bond all the equipment together. The bond ensures that in a second fault situation there is a low impedance path present.

The problem with this arrangement is both financial and environmental, as it requires 50% more conductor than the Class 1 individually earthed arrangement. This also increases the risk of theft.

Class II power supply design

Class II was selected not just as a means of eliminating safety risk arising from second earth faults, but also as a

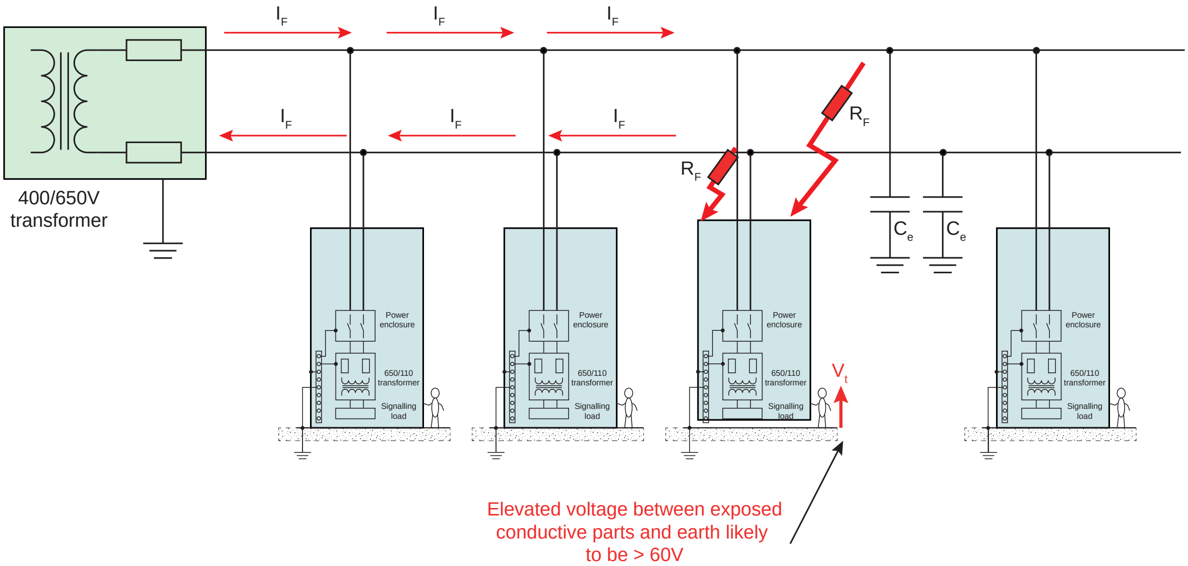


Figure 3 – Class I individual earth system with second earth fault situation.

means of eliminating harmful voltage on accessible conductive parts with first earth faults. An effective local electrical safety earth electrode is no longer required at an FSP on a Class II power distribution network.

Using Class II for railway signalling power distribution satisfies the requirements of BS 7671 regulation 410.3.3 by utilising double or reinforced insulation instead of the traditional automatic disconnection of the supply as protection against electrical shock. This also has the benefit of lower capital cost. However, effective continuous monitoring of the distribution system insulation remains an essential safety feature of any Class II power distribution network – maintenance managers please take special note.

A Class II based design solution has been identified for new build signalling power distribution systems and the renewal of legacy signalling power distribution systems, using two-core unarmoured cables. A number of resignalling schemes have already installed Class II and over the next two years a significant amount of signalling power system renewals will replace Class I with Class II. This includes the West Coast power signal boxes north of Crewe.

Location case and equipment buildings will be provided with Class II switchgear housings and Class II signalling transformers with approved conduit and fittings will be used to provide supplementary insulation and protection to wiring between the items of Class II equipment. Distribution equipment can be connected by either two-core enhanced unarmoured cable or two-core armoured solid bonded cable,

Figure 4 – A wide range of Class II products are now available in the UK from various suppliers. *Photo Unipart Rail.*

provided that the armour is not allowed to traverse the Class II fitted functional supply points. However extensive testing identified that an enhanced unarmoured cable option presents the highest overall level of safety.

The overall Class II strategy will result in improvements to personnel safety, compliance with standards, greater tolerability to DC corrosion, simplified earthing and bonding in AC electrified areas, together with reduced capital costs, better reliability, less maintenance and the ability to integrate into legacy systems.

To support the strategy Network Rail has issued the following standards: NR/L2/SIGELP/27416 Alternations to Signalling Power Supplies, NR/L2/SIGELP/27418 Design, Installation and Testing of Earthing in Signalling Power Systems, NR/L2/ELP/27408 Product Specification for Signalling Power Distribution Cables, NR/L2/ELP/27409 Product Specification for Functional Supply Points (FSP), NR/L2/SIG/30007 [Issue: 2], Product Specification for Power Transformers for Signalling Systems, and NR/L2/ELP/27410 Specification for Class II Based Signalling Power Distribution Systems. The key standards are issued as both signalling and electrification/plant e.g. SIGELP standards and are designed to be user friendly and to inform the right person what they need to do to control the risk.

The strategy was accepted by the ORR and the Improvement Notice was closed down on 22 August 2017, although understandably and quite rightly the ORR is monitoring the situation.

Many thanks to Graeme Christmas, Martin O'Connor and especially Graeme Beale, of Network Rail for their help with this article.

IMechE seminar on ATO

Report by Ian Mitchell

The Institution of Mechanical Engineers (IMechE) has an active Railway Division which organises a wide ranging programme of technical meetings and seminars in various centres across the UK. One recent event was a seminar on 9 May 2019 in London covering the topic of Automatic Train Operation (ATO), which was co-sponsored by the IRSE.

The seminar began with a keynote address from George Clark of TfL, speaking as one of his first duties as this year's IRSE President. He started with the statement "ATO has for too long been a niche area of expertise for signalling and rolling stock engineers and the time has come to bring it into the mainstream". He reminded the audience that when ATO began with the London Underground Victoria line in the 1960s, this was the result of what we now call systems engineering, with an unprecedented level of collaboration between rolling stock, signalling and civil engineers. Fifty years on, ATO is the universal solution for metros, and the challenge is how to bring its benefits of consistent precise train operation to the main line railway.

The second speaker was Imtithal Aziz of Network Rail, who described the ongoing work to define an interoperable ATO solution to work with ETCS on main line railways. Network Rail's Thameslink project was a pioneer in this area, and this experience has fed into the definition of European standards. The Shift2Rail research project is now facilitating laboratory and track testing of prototype equipment from several suppliers to validate the specifications before they become mandated in the Technical Specification for Interoperability for control command and signalling in 2021-2022.

A supplier perspective on ATO came from Thomas Godfrey of Bombardier, who pointed out that ATO is now found on self-contained industrial railways, particularly in the mining industry, as well as on metros. For new metros, unattended train operation (GoA 4) is becoming the norm, and this required the train supplier to provide additional systems on the train to deal with scenarios other than driving the train and stopping at stations. The ability to manage a failed train from the control centre was important, also splitting, joining and awakening in depots. He predicted that once the ATO over ETCS

Railways such as Singapore's Mass Rapid Transit network have used ATO for decades bringing increased throughput, efficiency, predictability and the accuracy necessary to stop aligned with platform screen doors.
Photo Shutterstock/Sorbis.

The use of ATO allows driverless operation of heavy-haul freight, such as Rio Tinto Zinc's autonomous operation in Pilbara, Australia. *Photo ©2018 Rio Tinto Zinc.*

specifications become established, there will be a demand from main line railway undertakings to realise the benefits of ATO, and this will hopefully accelerate the roll-out of ETCS.

Prudeep Vasudev of WSP spoke next on the topic "Integration – making the ATO system work", particularly relevant as his current role is on the Crossrail project. He emphasised that technical integration is only part of the problem, programme integration and operational change are key, and have to be considered from the start. An agreed concept of operation is that crucial and disruption scenarios can be a major influence on system design. The aim should be to deliver as much as possible early in the programme, with each milestone clearly defined in terms of the operational capability to be delivered and the configuration states that will achieve this.

The morning ended with a presentation on a specific project, the supply of new trains and signalling for the Glasgow Subway, from Stefan Rosendahl of Stadler. The unique constraints of this railway, with narrow-gauge track and small diameter tunnels have been a particular challenge for Stadler as train supplier, and their partners Hitachi STS who are providing a CBTC solution. The project is aiming for GoA 4 unattended operation, but there will be a migration phase during which the new trains will run alongside the existing trains in GoA 2, and so they will be delivered with a temporary driver's position. The onboard systems to support unattended operation include a facility to couple a train to another that has failed under remote control, derailment detectors at each end of the train, and a passenger information system that is linked to the control centre via two diverse communication channels.

After lunch Ben Rule and Carine Marin of HS2 described the challenges that will be faced in operating the new high speed line in the UK when it opens in 2026, and how ATO is needed to deliver the required capacity and connectivity. Although it will operate at 320km/h, HS2 is in some respects similar to a metro, with 18 trains an hour on the core London-Birmingham section, and platform dwell and re-occupation times crucial for reliable operation. A particular challenge will be how to deal with variability of arrival times of trains from the conventional network running onto HS2 – it has been estimated that 50% of these will be outside the allocated three-minute slot. The solution will be a traffic management system that can flex the timings for other trains to create a new slot for the approaching train, and ATO to ensure the timings are precisely followed.

The topic of adhesion management was mentioned several times during the seminar, and Phil Dubery of CPC Systems covered this in some depth. Low adhesion is a dual threat to reliable ATO – it prevents the train from braking at the rate assumed in the ATO design, and it degrades the accuracy of train's location measurement system. Experience on London Underground shows this is a significant risk on surface sections of the railway, and a lot of research has gone into how to eliminate causes of low adhesion and detect it when it occurs. Existing ATO systems typically provide a facility to select a lower braking rate to reduce the risk, but applying this across the route has a significant impact on capacity and energy consumption. There is a need for more intelligent systems that can pinpoint where the low adhesion exists and vary the braking rate to take this into account.

The final speaker was TC Chew of Arup, who spoke about the evolution of ATO railways in Hong Kong and Singapore. He described how the first MTR line in Hong Kong in the 1970s was inspired by the London Victoria line, and Singapore followed a few years later. Both systems have seen signalling and ATO on the original routes renewed and new lines constructed. Today there is a mix of GoA 2 and GoA 4 on different lines, but the trend is definitely towards the higher grades of automation.

There were Q&A sessions throughout the day and a concluding panel discussion. A theme that emerged was that ATO is a tool to achieve a level of precision in train operations that cannot be achieved by manual driving, and that management of the timetable in a traffic management or train regulation system is also needed to deliver capacity benefits. Above all, people and processes need to be part of solution as well as the technology. The IMechE is to be congratulated on organising this opportunity to share experience and ideas between rolling stock and signalling professionals on such an important topic.

What do you think?

Is ATO for main line just a gimmick? Does it offer a means of unlocking capacity and improving efficiency? Do we work closely enough with other disciplines, for example colleagues in rolling stock engineering?

We'd love to hear what you think, email us at **editor@irsenews.co.uk**.

IRSE///
Institution of Railway Signal Engineers

Future Railway Mobile Communications System (FRMCS) conference, Paris

Report by Paul Callaghan

On 14-15 May 2019, over 250 participants, 40 speakers, sponsors and exhibitors, from 25 countries representing the telecoms and signalling domains, regulation authorities and standardisation bodies, railway infrastructure managers and railway undertakings, as well as industry leaders and manufacturers attended an important event at the UIC Headquarters in Paris.

The Future Railway Mobile Communications System (FRMCS) conference is the first major international event to focus on the mobile telecommunications system that will, eventually, replace GSM-R and aimed to facilitate an open, relevant and comprehensive exchange of information. The event consisted of six sessions, covering a diverse but relevant range of topics, sandwiched between keynote speeches at the start and end of the event.

Of the opening keynote speakers, the three "dos" and three "don'ts" directed towards the FRMCS Programme by Matthias Ruete (European ERTMS co-ordinator, European Commission) were particularly relevant. These were:

Don't undermine the current ETCS deployment strategy. Don't endanger backwards and forward compatibility, but use Baseline 3 as a building block and don't create "sunk" investment in the period until FRMCS can be deployed i.e. protect any investment in the meantime.

Do ensure sufficient radio spectrum is made available, especially during the migration period from GSM-R. Do ensure a smooth migration strategy from GSM-R to FRMCS and define a country by country timeline for migration to allow the transition to be properly planned, including the decommissioning of the existing systems, and do ensure that the new system is standardised and has solid industry support, to ensure unit costs are kept low.

GSM-R in ERTMS: State of the art and evolution

The first session introduced the existing GSM-R system and the ongoing management within the UIC who committed to maintain the associated EIRENE specifications for at least the next ten years through its various working groups including:

- Operators and Functional Group (OFG) which maintains the EIRENE Functional and System Requirements Specifications.
- European Radio Implementation Group (ERIG) which exchanges information about ongoing GSM-R implementations and discusses gaps in the specifications or implementation reports related to national or international functions.
- Network Management Group (NMG) which coordinates the relations between GSM-R Networks and facilitates agreements between Infrastructure Managers to promote European GSM-R roaming.

GSM-R is likely to be a hard act to follow, having successfully been implemented across some 130 000km throughout Europe and around another 210 000km worldwide.

The session concluded with a presentation on the status of and plans for GSM-R in both Slovenia and France.

In Slovenia, GSM-R is being rolled out across 1207km of railway and 217 vehicles at an average cost of 110 000 Euros per km, with migration from the legacy system due to complete by November 2021. However, in France the focus is more on improving the capacity and performance of the already deployed GSM-R system to support ETCS Level 2 through the introduction of General Packet Radio Service (GPRS), as well as introducing the eREC (Enhanced Railway Emergency Call). eREC is an improvement over REC, resulting in less train disruption in the event of an emergency call.

Enabling digitalisation: FRMCS drivers and rationale

Session two involved presentations from various key players including Jason Taylor of Network Rail Telecom (NRT), identifying the various drivers for FRMCS, specifically the need to have an adaptable communications system capable of supporting applications including asset condition monitoring, train data offload, signalling systems and passenger internet connectivity.

Interestingly, Marine Mizrahi (Director IoTs, SNCF) was keen to emphasise that whilst she had one eye on what was happening with FRMCS, she would continue to rely upon public mobile networks to provide the connectivity she required to support the monitoring and remote control of the 5 000

The FRMCS conference highlighted the rapid progression of technologies. GSM technology (left) has now been superseded by LTE (centre) and train-carried antennas have also evolved (right).

non-critical devices currently in use on SNCF's Internet of Things 'network', at least for the next 18 months or so. She did conclude by stating that currently she was interested in the cheapest and quickest solution to be implemented to satisfy her requirements, and this is definitely something that FRMCS has to be aware of if it is to be considered as a bearer for IoT in the future.

FRMCS Railway initiative: key players and activities

The third session introduced the key players, activities and programme for developing the FRMCS. The session kicked off with a presentation from Dan Mandoc (Network Rail professional head of telecoms and the FRMCS project leader) which introduced FRMCS and the three working groups (Functionality, Architecture/Technology and Frequency) working to deliver the vision.

This was followed by presentations from: Michael Mikulandra (UNITEL chairperson) who emphasised the commitment of industry to support the FRMCS programme as well as re-stating UNITEL's commitment to support GSM-R until at least 2030; Thomas Chatelet (ERTMS officer, ERA) who re-stated the view that FRMCS is a main "game changer"; Ulrich Geier (Shift2Rail's IP2) who explained the relationship between the UIC's FRMCS programme and S2Rs Adaptable Communications System being developed as part of Innovation Programme 2 (IP2), Advanced Traffic Management and Control Systems. This specifically involved aligning the user requirements being developed separately by FRMCS and S2R, as well as explaining how S2R would deliver the demonstrator of the FRMCS, although it will not be able to fully validate all use cases.

FRMCS specification and standardisation process

The most hotly anticipated session four of the conference, in my opinion, did not fail to deliver and over-ran due to the level of interest and questions arising. It started with Eric van Bommel (chair of UIC FRMCS Functional Group) summarising the work to deliver the User Requirements Specification (URS), Functional Use Cases, Functional Requirement Specification (FRS) and Validation via the V-model. Version 4.0.0 of the URS is currently available, capturing some 72 Communication and Support applications categorised as critical, performance or business. The Functional Use Cases developed from the URS have also been completed – both the URS and Use Cases are available on the UIC website for review. The next step is the creation of the Functional Requirements Specification (FRS) which will aim to specify the functional needs in a technology neutral way with the first full version (V1.0) expected in Q2-Q3/2021, ready for inclusion in the FRMCS demonstrator and the next version of the CCS TSI expected in 2022/23.

Ingo Wendler of the Architecture and Technology Workgroup (ATWG) presented how the ATWG was focused on delivering:

- FRMCS system principle requirements reflecting railways' expectations.
- FRMCS system architecture.
- Technology assessment to evaluate compliance and gaps.
- Computation of rail communication traffic models as input for spectrum.
- System Requirements Specification.
- Collaboration with industry at European Telecommunications Standards Institute (ETSI), Technical Committee Rail Telecommunications (TCRA) to elaborate a technical report on FRMCS architecture.

The ATWG developed a traffic model to identify the bandwidth requirements for trains during the migration phase and in the future, identifying critical video as a requirement. The results are summarised in the table and have been used to inform the spectrum needs for FRMCS.

	Traffic per train	
Scenario	Traffic uplink	Traffic downlink
Future evolution	7.42Mbit/s	4.38Mbit/s
Migration phase	3.49Mbit/s	3.5Mbit/s

Guillaume Gach of ETSI summarised how the FRMCS User Requirements make their way from the UIC via ETSI to 3GPP for inclusion within the appropriate 3GPP specifications (see March 2019 IRSE News for a description of 3GPP). Interestingly, the timescales presented suggested that 3GPP Release 16 would be available from early 2020 and would deliver, in a 5G solution, GSM-R comparable services for voice and data, as well as some video services. However, Release 17 which could be available in 2021 would address interworking with GSM-R, interworking with public networks, enhancing data and video, quality of service and 5G System capabilities for mission critical communications to name a few.

The availability of spectrum is likely to be key to a successful FRMCS development and much was said about the need to re-use the GSM-R channels in the 900MHz band. Dirk Schattschneider, chair of the UIC Group on Frequency Aspects (UGFA) explained the work that his group was leading on with respect to spectrum. This involves consideration of the core GSM bands and complementary spectrum i.e. 1900 – 1920MHz and 2290 – 2400MHz. Dirk's group is undertaking numerous studies in order to drive spectrum harmonisation within the European Commission and CEPT (European Committee of Postal and Telecommunications Adminsitrations), with the final decision expected to be made in Q1/Q2 2021.

The engagement of industry

Session five provided an opportunity for Kapsch CarrierCom (KCC), Funkwerk and Nokia to share their plans and visions for supporting the delivery of FRMCS and migration from GSM-R. All three suppliers demonstrated they have been considering and continue to consider the evolution of their existing products towards the FRMCS vision.

FRMCS migration

The sixth and final session of the conference ended on the hotly anticipated subject of FRMCS Migration. Dan Mandoc took the stage to explain that whilst the FRMCS project has, to date, only focused on specifications and standardisation, with migration expected to start in 2024/25, the UIC has established the FRMCS Migration Scenarios (FMS) Project. This project considers 4 work streams; On-board Architecture being led by the newly created Telecoms On-Board Architecture (TOBA) Working Group, Migration Spectrum Needs, Signalling Operation Continuity and GSM-R/ FRMCS Co-existence. Dan presented a plan which resulted in all FMS activities completing by the end of 2022.

Christian Nanni (TOBA WG chair) expanded upon the work of the newly formed TOBA WG and made a very interesting point that whilst there is a general consensus among the players about the key design model that the FRMCS On-Board Architecture shall follow, the opinions on how to best migrate current installations are more divergent. It is a trade-off between protecting investment i.e. avoiding changes to existing equipment, compliance to new architecture to leverage the benefits of the FRMCS on-board system and the time to market which is dependent upon standardisation and development.

The session ended with presentations from Infrabel and Deutsche Bahn on their respective plans for introducing FRMCS and the key challenges they need to overcome. In the case of Infrabel, its ERTMS masterplan to deliver ETCS Level 1 (Full and Limited Supervison) and Level 2 across the entire network for the period between 2020 and 2030 can be delivered by upgrading the existing GSM-R Network to achieve the necessary coverage, capacity and availability requirements. However, FRMCS will be necessary beyond 2030 to support the extension of ETCS Levels 2 and 3 across the entire network and the deployment of Automatic Train Operation (ATO). It was acknowledged that the transition from GSM-R to FRMCS will be tricky in view of the types of transitions to be achieved (ETCS Level 2 circuit switching, ETCS Level 2 packet switching, FRMCS) and the need for systems to co-exist, as well as the criticality of the services but this should be addressed as part of the FRMCS Migration Scenarios (FMS) project.

In the case of Deutsche Bahn, the need for FRMCS is driven by the requirements of its management systems, perceptions systems, localised systems, protection and control systems, and operations systems, all of which drive an anticipated growth in bandwidth. Deutsche Bahn's tentative plan involves deploying ATO and critical video over 5G in the 900MHz or 1.9/2.3GHz bands whilst retaining GSM-R to support voice and ETCS during the migration phase, ultimately culminating in the withdrawal of GSM-R upon successful migration by approximately 2034. Deutsche Bahn is also considering the onboard migration and is keen to minimise the number of onboard upgrades when migrating from the current installations to the target architecture.

A key message repeated throughout the conference was that not only is FRMCS one of the so called 'game changers', it is considered by many as the 'game changer' because of its role in supporting other changers such as ATO, ETCS Level 3, vehicle to vehicle comms, etc.

Special mention was made of those who had developed the original GSM-R solution, including Mike Watkins.

The conference ended with a speech from Keir Fitch (vice-president Transport, European Commission) in which he summarised his seven key expectations of FRMCS:

1. It must cut costs and be based upon commercial off-the-shelf equipment allowing lower unit costs and ensuring it is brought to market faster,
2. It must not delay ERTMS deployment. Need to manage concerns that ERTMS roll out may be delayed to avoid wasted investment in GSM-R whilst waiting for FRMCS to be developed. Any deployment now must have migration to FRMCS built in.
3. Prove cyber-security as part of the design and development process in order to demonstrate robustness and address concerns.
4. The programme needs to be more ambitious. Mr Fitch said it was often difficult to justify why GSM-R is still being rolled out.
5. A more rapid migration path to FRMCS needs to be defined.
6. Resolve the spectrum issues and improve engagement with public mobile network operators.
7. Continue collaboration with all stakeholders, especially the S2R programme.

Whether the FRMCS programme is able to deliver the "dos" and "don'ts" issued by Matthias Ruete at the start of the conference and the seven expectations of Keir Fitch at the end remains to be seen, but I left the conference feeling confident that a well-structured and organised programme and plan were in place to take on these challenges.

Finally, and in a wonderful act of respect to acknowledge 20 years since the establishment of the UIC's European Railway Radio Implementation Group (ERIG) in 1999, the efforts of the three founding fathers were acknowledged by Jean-Michel Evanghelou (head of telecoms and signalling, UIC) when he likened Mike Watkins (the original GSM-R project manager), Robert Sarfati and Klaus Konrad to another great innovator, Steve Jobs, and presented all three with personalised iPads engraved with the message "UIC Global FRMCS Conference 2019 – 20 Years of ERIG". Mike took the opportunity to make an impromptu speech thanking everybody for their support, but also urging the FRMCS programme to learn from the experiences of the GSM-R team when they first developed the system. There is an excellent introductory video available from the UIC on FRMCS at **irse.info/atj54**.

For more news on developments in mobile communications for railways, see our article on the IRSE French Section's technical conference on the subject, p31 of this issue of IRSE News.

Industry news

Nova Scotia's $5 million in rail infrastructure

Canada: As reported in the cover story in April IRSE News, CN Railway (CN) has plans to invest more than CAD5 million (£2.9m, €3.3m, $3.7m) in 2019 to strengthen the rail network across Nova Scotia; improving safety and supporting efficient service. The maintenance programme includes track work, work on bridges, culverts, signal systems and other track infrastructure. Over two years, CN will have made a CAD25 million (£14m, €16,5m, $19m) investment in Nova Scotia.

CN is currently also deploying important safety enhancing technologies across its network, such as the Autonomous Track Inspection Program, Distributed Air Cars and Automated Inspection Portals. These innovations, combined with CN's investments in locomotives, capacity, infrastructure and train crews, will support the safe and efficient movement of customers' goods to their end markets.

The Nova Scotia rail network connects the Port of Halifax container terminals with markets in Central Canada and the US Midwest and accesses CN's Autoport facility that handles vehicles for distribution across North America and to Newfoundland.

Accelerated deployment of ERTMS in Europe

Europe: Projects to accelerate the deployment of ERTMS and the roll out of infrastructure for the use of 'alternative' fuels are eligible to apply for funding under the Connecting Europe Facility (CEF) Transport Blending Facility launched by the European Commission and the European Investment Bank.

The facility is designed to provide financing for projects which contribute to the sustainability and efficiency of the transport sector. It has an initial €200m (£172m, $225m) allocation from the EU budget, which is intended to help leverage funding from national promotional banks and the private sector which might otherwise lack an incentive to invest in infrastructure.

The facility was welcomed by UNIFE, The Association of the European Rail Industry, which said blending public and private funding 'can be a valuable source of financing, in addition to ongoing support from EU funds that remains vital for rapid ERTMS deployment'.

Risk Management Maturity Model (RM3) revision

GB: IRSE News 238 (November 2017) explained the Office of Rail and Road (ORR) Risk Management Maturity Model (RM3) which provides criteria for measuring management capability against five maturity levels across 26 criteria identified as being essential areas of a health and safety management system.

The ORR has now published a new edition of RM3 that it is more easily accessible to those just starting out with RM3, as well as pushing the boundaries of excellence for experienced users.

Since publishing the first edition of RM3 in 2011, the ORR have gained experience in using the model to assess the businesses they regulate and have held structured and meaningful discussions to identify strengths and improvements in company's health and safety management systems. In producing this new edition, they have worked closely with duty holders to ensure that RM3 has matured and adapted to embrace the developments in risk control over the last eight years since it was launched.

The ORR has strengthened the tool by recalibrating the evidence from earlier editions and expanding the range of evidence in each of the criteria, filling in missing gaps and ensuring evidence builds through maturity levels.

The ORR Governance Board expect that, in updating the model, users will see that some assessments of maturity determined from previous versions of RM3 will change. RM3 is not an audit tool, but a model to structure discussions about evidence and where to go next, either internally in organisations or between inspectors and the organisations regulated.

Driverless trains for Glasgow

UK: The first of 17 driverless metro trainsets that Stadler is supplying for the Glasgow Subway has arrived in the city ahead of the start of on-site testing. In March 2016 Strathclyde Partnership for Transport approved the award of a £200m (€227m, $254m) contract for a consortium of Stadler and Ansaldo STS to supply a fleet of trains and signalling.

This is part of a £288m (€328m, $366m) modernisation programme for the 10.5km circular underground metro line. The modernisation also covers tunnels, track and stations, which will be fitted with half-height platform edge doors.

Expected to enter service from 2020, the 1220 mm gauge four-car trainsets with walk-through gangways will replace the existing fleet of three-car sets. According to Strathclyde Partnership for Transport, they will operate without drivers once the signalling and control systems have been fully tested.

New signalling for Turkey

Turkey: Infrastructure manager TCDD has begun testing signalling equipment developed by Yapı Merkezı Idis, YMI the industrial controls and communications subsidiary of construction group Yapı Merkezı.

The company has installed an interlocking, fixed block signals and level crossing control units compatible with future deployment of ERTMS. The equipment was commissioned on a 20km section of the Izmir – Aydin – Denizli line around Çamlık. Development of the interlocking has been undertaken using a commercially available programmable logic controller from Hima, but otherwise YMI says it has not worked with any other established signalling specialist.

Test operations will continue for one year, with YMI's contract including a further two years of maintenance. If this trial period proves successful, the company hopes to get the equipment certified to SIL 4. Certification work will be undertaken by Italcertifer. YMI would then be able to compete in tenders for main line signalling contracts both on Turkish main lines and internationally.

Speaking at the commissioning ceremony, TCDD Chief Executive Ali Ihsan Uygun said the development of a 'national signalling system' was an important element in the country's efforts to modernise its rail network. 'Currently we are in the process of installing new signalling on around 700km of main line and suburban routes', he added.

Sweden's first high speed rail main line

Sweden: SNC Lavalin Atkins has been appointed by the Swedish Transport Administration, Trafikverket, to develop plans for the country's first high speed rail main line.

Working in partnership with Ramboll, SNC Lavalin Atkins will provide a range of services over the next five years to plan and design the Linköping city section of the 160km East Link project – a 250km/h high speed line running from Järna (just outside Stockholm) to Linköping in southern Sweden.

The SEK54 bn (£4.35bn, €5bn) scheme is expected to become fully operational in 2035. The line is planned to be the first of three proposed rail main lines which will connect to form a 440km high speed railway linking Stockholm, Gothenburg and Malmö.

Train 'fortunate' to avoid collision after breaking through level crossing barriers

UK: The Rail Accident Investigation Branch (RAIB) has published a number of safety recommendations measures after a train ran onto a level crossing and broke through the barriers. An engineering train was approaching a level crossing at Penrhyn on the Ffestiniog Railway, a narrow gauge heritage railway in Wales on 6 January 2019 and did not stop, striking the closed upper gate, pushing through it and coming to a stand in front of both carriageways of the road.

There were no injuries and only minor damage caused to the gates, but the RAIB has published its independent safety digest as a collision with a road vehicle could have been fatal and its was "fortunate" that there were no vehicles on the crossing at the time of the incident.

The RAIB said many rules developing following past incidents may have been forgotten as time passes and the reason why they exist might not be obvious, but the "importance of complying with it does not diminish." The report said the accident serves as a reminder of why it's important to follow railway rules and operating instructions, and warned that in this case the consequences of a collision could have been fatal as drivers of road vehicles would have received very little warning due to the curvature of the railway line.

A number of similar incidents have occurred at the level crossing over the past 30 years with the most recent coming in 2007 when a train ran into the gates due to its wheels locking, with contamination again cited as the cause.

Network Rail £2bn investment for Wales and Borders railway

UK/Wales: Plans for a £2bn (€2.3bn, $2.6bn) investment over the next five years across the Wales and Borders have been published by Network Rail. This includes investing £135m (€157m, $177m) to improve signalling in west Wales.

Included in the projects is a renewal of the "iconic" Grade II Barmouth viaduct, and the delivery of Phase 2 of the Port Talbot re-signalling scheme to improve reliability. Other projects include substantial investment in preparing the railway for extreme weather, and installing new pumps at Sudbrook pumping station in south Wales. The funding will support Transport for Wales' investment of £5bn (€5.8bn, $6.5bn) over the next 15 years which will see new trains introduced, improvements to stations, and increased capacity.

Borders Railway extension feasibility study

UK/Scotland: The UK Government has announced its backing for a feasibility study into an extension of the Borders Railway. The plans could see the 48km route extended a further 29km to Hawick, or further across the English border to Carlisle. A full feasibility study will look in detail at the costs and benefits. The Scottish Government already supports the Borders Railway extension, and recently published the Borders Transport Corridor Study.

5G rail testbed

UK:Network Rail Telecom, The Department for Digital, Culture, Media & Sport (DCMS) and the DFT recently hosted the UK's leading telecom influencers at their 5G Rail Testbed at Rail Innovation & Development Centres (RIDC) Melton.

The electrified site makes it possible for innovators to access the latest 432 fibre trackside internet connectivity, high speed trains, masts, structures, innovation hub and multi-disciplined rail professionals.

Collaborators included EE, Nokia, the BBC, Icomera, Telent, Arriva Trains, First Group, Babcock, Telefonica, Jupiter Telecoms plus many more are all united in delivering purpose led outcomes that realise the needs of rail users in the 21st century.

Network Rail has also reported reaching the 100km installation milestone for the new high-count 432 fibre along the Trans Pennine route between Manchester and York.

First UK train station with 5G mobile technology

UK: Birmingham New Street has become the first UK train station to live test 5G mobile technology. Mayor of the West Midlands, Andy Street, recently tested the region's new technology on the New Street concourse. Passengers at the station were also invited to test 5G speeds using a 5G router.

Live testing is now also taking place at a number of sites across the city. The sites are all connected to Vodafone's single converged network, which is already providing 4G mobile, Internet of Things (IoT) technology and business services.

When compatible 5G handsets and devices arrive later in 2019, commuters in busy locations will be able to load a web page or a video instantly. Vodafone is rolling out 5G to a number of key commuter locations across the UK, and will switch on the new network in 19 towns and cities, including Wolverhampton, by the end of 2019.

Low Energy (BLE) transmitter.

USA: Engineers at the University of Michigan have built the first millimetre-scale stand-alone device using the lowest energy version of Bluetooth, called Bluetooth Low Energy (BLE). Consuming 0.6 milliwatts during transmission, the device would be able to broadcast for 11 years using a typical 5.8mm 'coin' battery.

An ordinary radio transmitter circuit requires a tuneable oscillator to generate the frequency, a power amplifier to boost its amplitude, and an antenna to radiate the signal. The university team combined the oscillator and the antenna in a way that made the amplifier unnecessary. They call it a power oscillator.

In the new circuit, the antenna itself acts as the inductor in the resonant circuit, and so it radiates using a changing magnetic field instead of an electric field; this means it can be more compact. Another advantage is that the antenna has a Q factor about five times that of an on-chip inductor.

The research is part of the University of Michigan's M3 project, which is to develop modular, millimetre-scale sensors. The next step is integrating the BLE radio into one of these sensors. Such sensors are needed to deliver the next generation of the Internet of Things (IoT) which will deliver many benefits to industry, including rail control and communications.

Siemens Mobility to upgrade over 11,000 GSM-R cab radios

Great Britain: Siemens Mobility Limited has been awarded a contract by Network Rail to upgrade Britain's entire rolling stock fleet. The upgrade of over 11,000 radios will take place over the next three years, which will see each train equipped with the latest generation of Siemens Mobility's Nexus V4 cab radio. This will provide train operators with improved communication quality and performance, together with the potential to benefit from additional applications on a separate processor card within the radio. The system will be able to support applications such as remote condition monitoring (RCM) and a connected-driver advisory system (C-DAS).

The upgrade will deliver benefits to passengers and the railway. It will resolve the rail safety risk and performance impact attributed to interference on the railway from public mobile network operators and enable them to improve their coverage for passengers at locations where they have had to turn down their coverage or power. The programme also provides the opportunity to explore additional railway applications such as GPS location data for train positioning location and the trial of a track remote condition monitoring application.

A trial of the voice radio covered more than 100 trains, and was undertaken over a two-month period. It concluded in January 2019 and achieved a mean time between failure (MTBF) in excess of 50,000 hours. An evaluation was also carried out on the use of Nexus RCM, an application that wirelessly creates a digital representation of the condition of the track asset. This will provide a targeted and preventive maintenance, rough ride/ defect detection indicator to improve passenger experience.

The hardware upgrade includes a new separate processing card which runs applications such as RCM and C-DAS independently to the voice radio application. The C-DAS application enables any train operating company to implement real time updates of timetables, speed restrictions and other operational requirements, dramatically improving timetable management. Promoting a consistent and economical driving style, the improved train performance will produce energy savings and improve passenger experience.

The upgrade has been designed to support current 4G technology and provides the building blocks to the Future Railway Mobile Communications System (FRMCS).

Belgian GSM-R upgrade

Belgium: Infrastructure manager Infrabel has awarded Kapsch CarrierCom a 15-year framework agreement covering the migration of its GSM-R communications network from R99/TDM to R4/VoIP and the provision of 12 years of maintenance.

This is intended to provide the functionality and resilience needed for the use of ETCS Level 2 over GPRS. The deployment of redundant voice core platforms for the live and testbed networks is expected to increase the availability of the network, with breakdowns lasting a few seconds rather than several hours. The impact of software upgrades on operations would also be reduced.

Radio licence changes to facilitate Active Antenna Systems

UK: The UK telecoms regulator has provisionally proposed to accept a request by mobile networks operators: Three UK, EE, O2 and Vodafone to vary a number of spectrum access licenses for the 3.4GHz, 3.5GHz and 3.6GHz bands in order to facilitate new Active Antenna Systems (AAS). This could help the future roll-out of ultrafast 5G mobile broadband networks.

The proposed change would remove an obligation on the licensees that has been effectively redundant since changes were made to Three UK's (Hutchison/ UK Broadband) 3.6GHz licence at the end of 2018 (i.e. giving them access to a 100MHz block of contiguous spectrum) and is also consistent with the European Union's (EU) Harmonisation Decision.

AAS has already been used with some 3G and 4G networks, although it will be best suited to the design of 5G networks, where its flexible radiation pattern control can help adapt to the changing situations in a mobile network.

According to Ofcom, the practical effect of AAS for consumers could be a higher quality of service in busy areas once a significant number of users have devices which support the 3.4-3.8GHz band(s). This is because AAS helps to enable Massive Multiple-Input Multiple-Output (MIMO), which can "increase the capacity of the radio access network in busy areas.

GHz frequencies can provide very high data transmission rates, although more radio sites will be required for these range of frequencies than the lower frequencies currently used in mobile networks, such as GSM-R networks.

Freight traffic management

Switzerland: Intermodal freight operator Hupac is to automate its route planning and traffic management processes using sensor data and analytics provided by ETH Zürich spin-off company Nexiot.

Hupac has previously equipped wagons with Nexiot sensors which provide information on their location, impact events, border crossings and mileage every five minutes. Nexiot's software will now be integrated into Hupac's in-house management systems, enabling this data to be used to predict delays, plan routes and manage traffic flow.

Drones for ATO

France: Thales is developing a concept of special drones for Automatic Train Operation (ATO). The air vehicles will be equipped with advanced optronics, infra-red sensors and other leading technologies. The drones will fly ahead of the autonomous trains monitoring the tracks and points.

The concept of drones for ATO is known as Railbots. "We are currently working on the concept of Railbots, the rail drones of the future. They will be moving on the track ahead of the train, and programmed to run autonomously," said Pierre-Antoine Benatar, Marketing Manager for Thales' Transportation Activities. They will gather and transfer the information about the track conditions.

The unmanned aerial vehicles will work as a co-pilot of the autonomous trains and will help them to react faster on any problem or obstacle. "Be it aerial or track-bound, drones could truly become a critical part of rail safety when operators move towards autonomy in the future ".

ERTMS-capable locomotive simulators for UK

UK: GB Railfreight is investing £850k (€967k, $1.1m) in two Corys full-cab ERTMS-capable locomotive simulators for its new training school at Peterborough. The simulators are being built using the recycled remains of EMD locomotive 66 734, which was involved in a landslip and derailment at Loch Treig in Scotland in 2012.

The simulators will initially cover the route from London King's Cross to Peterborough, with a route-building tool which will enable the addition of all other GBRf routes. When finished, the simulators will provide cutting-edge training to GBRf staff and the wider rail industry.

News from the IRSE

Blane Judd, Chief Executive

Michael's donation

Last month saw the annual Member's lunch, held at the Union Jack Club in London. The event was well attended with representatives from all levels of membership.

It's a good time to catch up with colleagues past and present and for one long standing member the thought of the occasion brought back such happy memories that he enclosed a generous donation to the Institution in his letter of regret to the invitation.

Now 82, retired Inter-City performance engineer Michael Thwaite was unable to make the journey to London from his home in Trowbridge as he is the main carer for his wife who sadly has advanced Parkinson's disease. A long-standing member of the Institution, he sat on the recruitment and publicity committee for 15 years and was secretary for five. He was the brainchild behind the introduction of IRSE News suggesting to Bob Blythe back in 1982 that the IRSE should have its own magazine.

In his letter to our administration manager Hilary Cohen he wrote: "Unfortunately I must offer my apologies and decline the invitation....it has been a pleasure to have been associated with the Institution over the past sixty years. In memory of those wonderful years I enclose a cheque for Institution funds."

Thank you, Michael. You were missed at the luncheon and your former colleagues send their warm regards.

IRSE and INCOSE interactive workshop

Following on from the success of last year's collaboration between the IRSE and INCOSE, we held another workshop entitled 'Digital Signalling Upgrade; Beating the Challenge.' It was hosted by outgoing president Markus Montigel and organised and facilitated once again by Karl King and Mike Morua from Frazer-Nash Consultancy who also kindly sponsored the lively and thought-provoking hands-on event.

Over 35 railway signal engineers attended the content-packed day held at Broadway House in London where they worked through the challenging scenario of developing requirements for the upgrade of a TPWS/AWS signalling system to ETCS Level 2 with no signals, including an upgrade of the control system with a traffic management system and a continuous drivers advisory system for all rolling stock.

Here's what one delegate had to say about the experience: "The workshop was very beneficial to me because I was able to learn the importance of various aspects of requirements capture and most importantly paying particular attention to the users. It was exciting to interact with various people from different companies and different roles and exchange ideas on how to proceed with the signalling upgrade and various practices within the industry. Some people had strong opinions on upgrading the control system before the interlocking and others had strong views on upgrading the interlocking before the control system. Regardless of the order of the upgrade we were able to identify some crucial requirements. We imagined what a day in the life of a driver and an operator would be and identified needs from their perspective."

Thank you to all who submitted feedback which will be taken into consideration for future events.

www.irse.org

Our new website is going live soon, possibly by the time you are reading this issue. It will provide far more functionality and convey a more dynamic and modern image. For the first time it carries video content with our first production featuring current members talking about what membership of the IRSE means to them.

In the run up to the launch a temporary microsite was created with details of upcoming events, membership application forms, licensing scheme details and exam information, including payment for the October 2019 exam.

Presidential Programme update

In a change to the programme the meeting on 12 February 2020 will now be held in London UK and on the topic of "Future reference CCS architecture for ERTMS". The March paper (date to be confirmed) will be held in Adelaide Australia and will be about "Delivering metro travel in Sydney". Full details will be in the September issue of IRSE News.

Do we have the right email address for you?

Members who have not updated us with their correct email address may be missing out on all of the e-communications you should be receiving. We now send out a monthly e-news bulletin to all members with links to the highlights of the current IRSE News and more details on events for the coming month. Please email **hq@irse.org** to update your records.

Subscriptions now due

Invoices for subscriptions are being processed and we are receiving payments. If you have received yours, please pay promptly via either the new website, direct debit, sending payment details to the London office or ringing up the office – contact details on p37 of this issue.

CPD spot checks

CPD monitoring has started for 2019 for those who are professionally registered with the Engineering Council via IRSE. If you don't engage with the monitoring by submitting records of your professional development activities, then you may have your professional registration removed. All IRSE members are expected to maintain and develop their competence as well as assist in the development of others.

IRSE News reader survey

We welcome your views on IRSE News. It is your publication and your feedback is important so we can make IRSE News even better! Please complete the survey online at **irse.info/irsenewssurvey**. Those without internet access can telephone the London office to request a paper copy.

Australasian Section

AGM and technical meeting March 2019

A new generation – people and technology

Report and photos by Allan Neilson

The IRSE Australasian Section held its AGM and technical meeting in Brisbane 15 to 17 March with a theme focused on "A new generation – people and technology". The Friday technical meeting was held in the Brisbane Convention and Exhibition Centre and incorporated the AGM formalities, as well as the conference gala dinner in the evening. Trade displays were also set up in the foyer for attendees to visit. A parallel partners daytime programme focusing on sites of local city interest was organised for both Friday and Saturday.

The organising committee set out to encourage attendance by younger members in the industry and on the Thursday evening before the technical meeting a younger members event advertised as "Speed Networking" with the Younger Members' Society and hosted by Queensland members Yvette Griggs and Robert Bragg. This event focused on what the IRSE had to offer with a social twist.

The Friday technical meeting attracted a good attendance of 171 members and guests. After opening remarks by the section chair Kaniyur Sundareswaran ("Sundar"), the keynote address was given by Arthur Stamatoudis (director Network Integration and Operations for the Cross-River Rail Delivery Authority). His presentation very clearly illustrated the accessibility focus of the new rail build on the existing central business district area and connectivity with the existing Queensland Rail (QR) network.

Following this was a presentation by Markus Montigel of his 2019 presidential address "SIL 4 is not always SIL 4". He used a simple example of trap points at a converging junction which were designed to arrest an approaching train but had the net effect of providing an obstruction to another signalled flank movement through the junction. The message is to consider the operational context in its totality.

The IRSE Australasian Section secretary Les Brearley acting in his capacity as accreditation manager briefed the audience on current developments with the Graduate Diploma in Railway Signalling. Subbajit Dey (EIC Activities) then explained how a holistic system engineering assurance methodology aims to predict, prevent and mitigate potential hazardous events, and if utilised at the beginning of a project, it will also help facilitate better financial planning for project definition, implementation, integration, acceptance and operations while reducing the cost of design changes.

After morning tea Diego Herrere (Rail Systems Australia) talked about the "digital train radio case for GSM-R radio in NSW, explaining the options possible and the technology pathway chosen. Jacek Mocki (from Motzky) then delved into digital document revision identification methodologies and illustrated a solution for field inspection.

Steve Boshier from the Melbourne level crossing removal project explained how he was achieving the "completion process". He referred to it as being the unloved part of the project and often considered an end of project activity, but he stressed it is a whole process that must commence at the start of the project and finishes when all the defects have been closed out.

Markus Montigel, Michael McNamara and younger member meeting convener Robert Bragg.

Attendees with New Zealand connections: Left to right Allan Neilson, John Skilton, Steve Boshier, Mark Fynmore and Bill Blackmore.

Some of the Australasian Section committee members gathered before the committee meeting.

Dinner speech by committee member Georgina Hartwell representing the dinner Sponsor WSP.

Group photo outside the Wulkuraka Maintenance Centre.

Gary Forster (Rail Safety Systems) and Katherine Eastaughffe (ACMENA) then talked about an Australian development of an innovative low-cost solution for the provision of active signage at rural and regional level crossings. The development known as the Rail Active Crossing System (RAXS) fundamentally sought to achieve low cost without impacting safety. The extensive independent safety assessment methodologies to achieve CENLEC SIL 3 standards were explained by Katherine.

After lunch, the formal 2019 AGM session was held, chaired by Sundar. Six new committee members were voted in including Paul Szacsvay who has taken over the role of treasurer from Geoff Willmott. Geoff has been our long serving treasurer and in earlier days also held the position of secretary, so now takes a well-earned retirement from Australasian Section administration affairs. Geoff spent the last 27 years on the committee including 12 years as secretary/treasurer then 6 years as treasurer.

George Nikandros from QR then presented his session titled "To be sure". He explained how Assurance is about providing a level of confidence that the objectives will be achieved (including safety and fit-for -purpose attributes), and hopefully increasing that level of confidence as the project progresses through its development lifecycle to completion.

"ETCS evolution and intelligent management" was the theme of the next session delivered by Yagyu Daisuke (Hitachi) and Federico Nardi (Ansalso STS). This paper describes the innovative solutions for the digitalisation of railway infrastructure and the achievement of high capacity, reliable, and cost-efficient rail transport. This included the evolution of ETCS, for improving network capacity, and minimizing infrastructure upgrading.

The final session paper consisted of the final 2018/19 presidential paper "Human factors in cockpits: Lessons learnt in the light of ATO" presented by Michael McNamara (Gannet Fleming) in person. A most informative session comparing aviation control to rail control philosophies. This paper was live streamed and was available throughout the world. This paper has since been published in IRSE News.

The chair (Sundar) then gave the closing remarks with thanks to the authors and sponsors plus the local organising committee led by Mark Fynmore. The Australasian Section committee held a meeting before the commencement of the gala dinner event attended by almost 90 delegates, guests and partners.

The Saturday technical site visit programme started with a visit to the Wulkuraka Maintenance Centre, which is a new dedicated maintenance centre run by Bombardier to roll out, maintain, service and repair the 75 'new generation' six-car electric multiple unit commuter trains fleet supplied for the Queensland Rail city network. This facility was well laid out incorporating state of the art maintenance equipment as well as a comprehensive 'depot protection system' for train movements and traction overhead isolations.

The second site visit was made to a QR field installation at Chelmer Station consisting of a Trackguard Westrace Mk2 field equipment with fibre-optic transmission links with the CBI based at the QR Central Control Centre.

The third visit of the day was to the QR Rail Management Centre where delegates were able to view operations in the new rail management facility from the viewing gallery where the network wall mimic displays clearly showed overall train movement activity on the city rail network. After that the long serving equipment room was visited which housed a number of new CBI office units as well as some older miniature relay interlocking racks. The transition from older (legacy) equipment to newer CBI equipment was clearly apparent.

An informal Saturday evening dinner for delegates and partners was held at the Plough Inn restaurant on the popular but noisy South Bank precinct.

On the following day a number of enthusiastic members and partners joined the social day trip to St Helena Island to visit the historic settlement. St Helena is located in Moreton Bay 5km from the mouth of the Brisbane River. The Island has a fascinating history and in its past functioned as a high-security colonial prison from 1867.

The group boarded the MV Lady Brisbane for a tour of the Brisbane River on the way to the Island. Captain Jim gave a great commentary on the yachts, ship yards and varied industries along the river. On arrival, the group split into two for the tour of the Island visiting the ruins of the penal settlement, the chief warden's residence and the cemetery. They even inspected a tramway line complete with platform and throw-over points that was used to transport people and goods from the causeway jetty to the settlement. The establishment was classed as the 'latest' in prisons at the time with large areas under cultivation and its own bakery. The area is now populated with a large number of wallabies.

Remnants of the island's old tramway.
Photo Les Brearley.

Wallaby making its home on the island.
Photo Les Brearley.

Irish Section

IRSE Institution of Railway Signal Engineers IRISH SECTION

Successful collection for Mindwise

During the Irish Section IRSE dinner held in Belfast on 1 December 2018 a collection was held to support the charity Mindwise, a leading mental health charity in Northern Ireland. They deliver over 30 key services, and is run by more than 100 staff and 80 volunteers who with the backing of more than 300 members raise awareness, campaign for change and support more than 9000 each day affected by mental health issues in their journey to recovery.

MindWise provides expert advice and information to people with mental health problems and those who care for them, as well as giving help to health professionals, employers and staff. The team also provides evidence to the media, government and local Health Trusts to improve mental health policy.

The staff possess a wealth of in-depth knowledge and experience and are highly trained to provide specific solution-based guidance and offer information and advice. They can provide advice and information on a wide range of mental health issues including: 24-hour care, treatment, medication and therapy, living with severe mental illness, children and mental illness, maximising benefits, helping people look for work, the law, individual rights and government, and carers information.

Huw Bates (Irish Section treasurer, right) and Colin Mcvea (committee member, left) handing over a cheque for €1050.

French Section

Technical conference on future communications for rail

Report by Jacques Poré and Hugh Rochford

On 7 February 2019, the IRSE French Section (IRSE-FS) held its technical conference on "Future Communications for Rail" at SNCF headquarters in Saint-Denis (North of Paris).

Around 40 people attended, including Christian Sevestre, formerly SNCF signalling director, IRSE past president 2014-2015 and IRSE-FS chairperson. Jacques Poré, senior technical expert at Alstom Transport and former IRSE president 2005-2006 and IRSE-FS vice-chairman, and Hugh Rochford, project manager at SNCF Réseau and secretary of the IRSE-FS.

Opening the conference, Christian thanked Michael Mikulandra from Kapsch, UNITEL (the association of European suppliers of telecommunications for rail in UNIFE), Shift2Rail (S2R) projects led by the European Commission (EU) for attending from Germany, along with Bertrand Taquin, director of the System Division – Telecommunications at SNCF Réseau (Network).

Hugh gave some general information about the IRSE, the IRSE French Section (FS), together with IRSE News, underlining the high technical level of the IRSE FS conferences and events that allow partners from all domains in the rail business in France (and Belgium) to meet and exchange ideas in a friendly and constructive atmosphere. He also took the opportunity to present practical details of how to apply to the IRSE and the French Section, Hugh himself being the point of contact.

Michael Mikulandra from Kapsch then presented his paper "The Future of Railway Communications – From GSM-R to FRMCS, Shift2Rail Adaptable Communication System".

Michael began by saying that today rail in Europe and the World, for main lines and urban use a mixture of radio systems providing services to a vast range of users, including voice and data services for signalling. GSM-R is widely used, but also TETRA networks and many analogue legacy systems. This mix is difficult to manage, especially between two users. GSM-R is now very stable, available and reliable, and when a problem occurs users know how to fix it. There are however challenges and communications technology is quickly evolving.

The radio domain sees a range of organisations and stakeholders involved. The UIC-led FRMCS (Future Rail Mobile Communication System) project is collecting the requirements for the future. This includes what the system should support and not forgetting a smooth migration. Other organisations include Shift2Rail (S2R), the international institution ETSI and its 3GPP Working Group (WG) for mission-critical applications such as for the police and the fire departments.

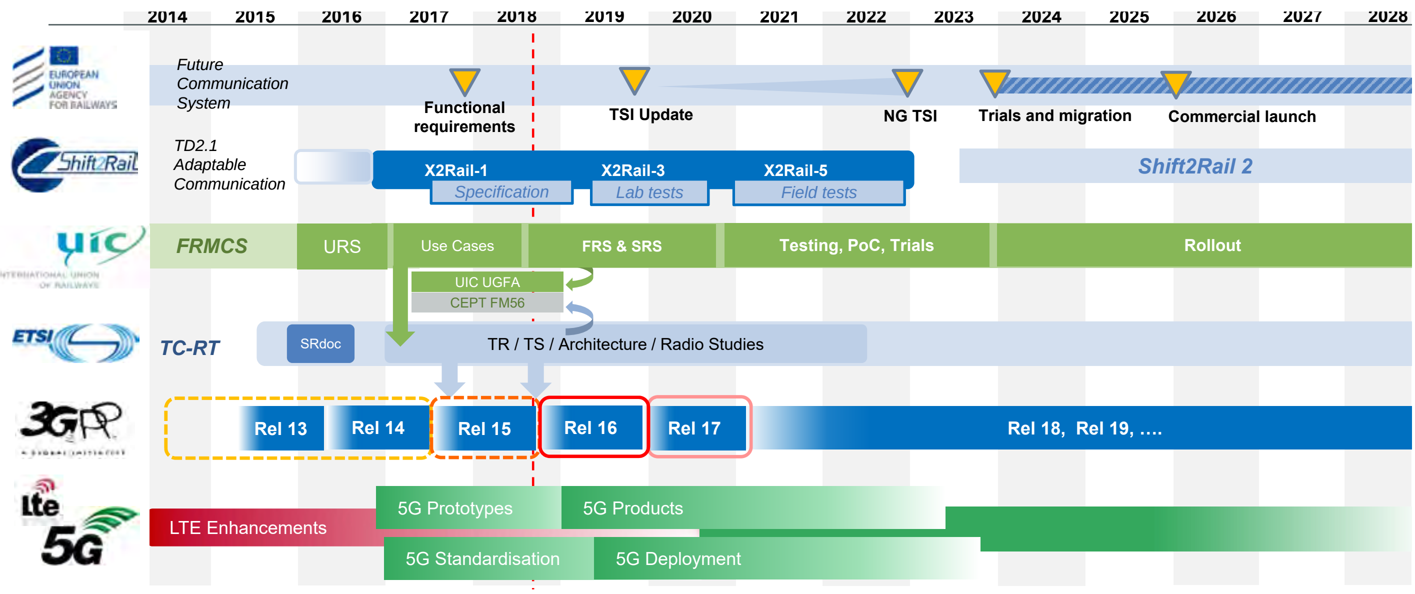
Key requirements for the future rail radio system have to include the needs of the existing systems and for new needs such as

The IRSE-FS technical conference was well attended.

Michael Miulandra from Kapsch presenting his paper.

ATO (Automatic Train Operation). ATO has been in operation with metros for some time, but is completely new for some main lines. Future radio also needs to support new multi-system applications. The signalling profession also wants to decouple the application from the communication.

Michael Mikulandra asked the question: Why are we doing this evolution? There is a strong convergence in the communication world towards a flexible architecture that will support other systems, for instance supporting Wi-Fi, or 5G Satcom. The way



Michael's slides showed the timeline and milestones for current and future developments in mobile communications (FRS is Functional Requirement Specification, URS is User Requirement Specification, SRS is System Requirements Specification).

forward is consequently towards technology standardisation. The WG (3GPP) has recently finalised its Release 15, with new functionalities, including quite a few railway-specific functions. This work is being continued in Release 16.

What could be the best solution? The key concept is to become independent from the communication system, with an architecture built in different layers, integrating the need to select, combine, aggregate and to face capacity issues. This could involve integrating LTE or 5G with Wi-Fi. The transition from the existing GSM-R system (that is not as sophisticated) needs to be taken into account. For future systems, spectrum availability is a key question. Today, railways mostly use the frequency band of GSM-R, but additional spectrum would be very helpful. We must also take care that using higher spectrum frequencies will need more infrastructure equipment for reliable coverage, and this will add cost to the fixed infrastructure.

Which technologies should be used asked Michael Mikulandra? Europe, especially the EC, has started to push 5G technology for public uses and different market requirements, including railways; rather a political approach. Benefits from 5G include life cycle aspects that are better than LTE, considering a lower capital cost for 10+ years. To support this statement, recent press releases include: "New 5G networks will offer a great opportunity for railways" says CER. "The 5G philosophy is very attractive for railways" says ERA. "We can ensure our major transport networks and urban centres are 5G ready" say UK rail organisations. It is stated by some that 5G is more powerful than alternatives, supports other services e.g. Internet of Things (IoT), ATO over ETCS. It is more flexible and allows decoupling services internally. Latency could also be an important argument in favour of 5G, with the possibility to offer different qualities of service.

Michael presented the topic TD2.1 "Advanced Communications" inside the S2R programme for signalling, namely Innovation Programme IP2 and its five "Projects" named X2Rail-1 to X2Rail-5. The key requirements are convergence and bearer independence. The specification phase has been nearly finished in the X2Rail-1 Project. The next Project involving TD2.1 is X2Rail-3 will start to focus implementing prototypes in a lab environment (the documentation will be publicly available). The final Project X2Rail-5 will add field tests of the prototypes in a real rail environment.

The future communication system will subsequently encapsulate all interfaces for FRMCS in both train and track-side environments. The recently created UNITEL association of telecommunication expert suppliers in UNIFE briefly presented its nine members and how it is continuing the former ROC-IG working group. The timeline for 2025-2028+ is available.

Michael closed his presentation with one slide highlighting the Kapsch role. Michael is himself TD2.1 leader in S2R as well as an active member of UNITEL as he had been in ROC-IG

Bertrand Taquin, director of the System Division – Telecommunications at SNCF Réseau (Network) then presented "The Evolution of Radiotelecommunication Systems at SNCF".

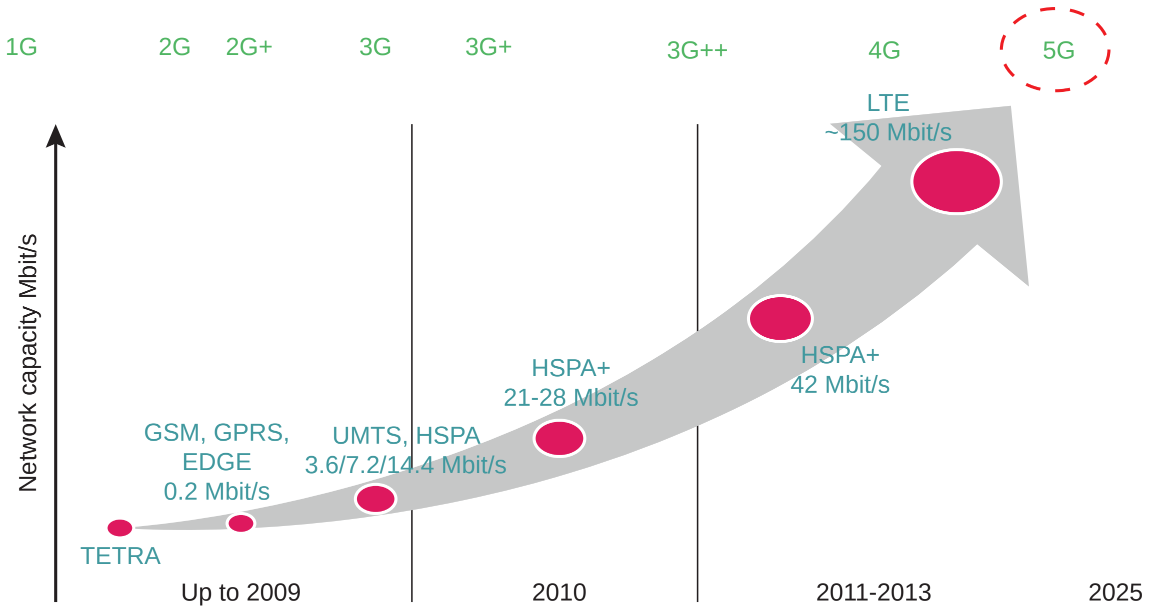
He began by saying that SNCF fully supports what Michael had presented. Bertrand explained the SNCF classification of the radio applications with a drawing on two axes. Horizontally with the technology axis and vertically with the application axis .

Today, SNCF Réseau uses a mix of solutions. TETRA is used in stations e.g. for activities prior to train departures, for track works, to cover large infrastructure working areas, for shunting purposes, and for temporary speed restrictions. These applications use very short messages.

Regarding GSM-R, it has been said that there is no interoperability (at least that is easy) but in fact it works well and today SNCF Réseau has a 15 000km long network in operation, with 2 600 radio sites, and 9 000 items of rolling stock equipped. GSM-R has increased the rail system performance and the necessary high level of reliability are generally met. GSM-R has allowed trains to be operated with only one rail personal on-board.

The evolution of radio technologies was explained, with one of the main common sayings, as confirmed by the previous speaker, being: "5G will do everything". However, Bertrand said rail does not have the same life cycle as in other industries and rail needs proven only. A main line railway network is large and installing a new solution always takes time, and we have only just finished installing GSM-R! GSM-R will be supported until 2030 but the next solution needs to be started now.

A slide comparing the throughput allowed by different radio technologies and solutions was explained. The aim at



	TETRA	GPRS	4G	5G
Data rate	7.2kbit/s per time slot (4 max)	70kbit/s	150Mbit/s	> 10Gbit/s
Latency	~1s	~1s	10ms	< 1ms
Train speed	< 100km/h	350km/h	350km/h	500km/h
Frequency band	400MHz (SNCF)	900MHz (SNCF)	<6 GHz	Up to 100GHz

Bertrand's presentation included a view of the throughput delivered by the adoption of various radio systems.

SNCF Réseau will be a generic network, services-orientated, for all possible functions (track, data, video and bearer-independent. Allowing a management of priorities, for each service with an increased level of cyber security.

The performances that are being offered with 5G technology include throughput, density and latency. With 5G, everything will be virtualised and software created with deported functions from the core towards the user, through deported 'boxes' spread among the network. SNCF Réseau says that 5G will mean quicker actions everywhere, for all needs (including for all types of lines, UIC1 to UIC9), and it will be much less expensive as far as hardware, and maintenance, is concerned. 5G also promises higher flexibility, allowing the use of new services.

Bertrand then explained how SNCF Réseau sees migration for the short term (replacement of TETRA, acquiring knowledge, pre-industrialisation of a use case, preparing a demonstrator -namely experimenting with ATO as well as for the long term (including current European working groups). With SNCF Réseau having a large network, any migration must consider the extensive investment that has already been made in GSM-R.

Among the recent findings, it has been identified that there could be a risk of a gap of solution required between the years 2019 and 2025.

The first step for SNCF Réseau should be the upgrade of Paris-Lyon High Speed Line to ERTMS/ETCS, resulting in an increase from 13 to 16 train operable/commercial slots per hour.

Christian Sevestre thanked the two speakers, adding that "we have today understood complex matters", before opening the questions & answer session. The questions were confidently answered and the questions included, SIL 4 aspects especially when going to private operators, the case of the border/limit between two operators and/or two protocols, cyber security, and migration including rolling stock equipment crossing a border between countries.

After the paper presentations, Q&A and the usual vote of thanks to the entertaining expert speakers, all attendees met for discussion, questioning and networking around drinks and nice 'petits fours' kindly provided by SNCF.

For further information regarding the IRSE French Section, please contact Hugh Rochford at **irsefrenchsection@gmail.com**.

The IRSE near you …

The IRSE's thriving French Section is just one of our local organisations around the world, organising a range of technical events such as the mobile communications conference.

Attending, and recording your attendance, at these events is a useful way of maintaining your continuous professional development (CPD).
For information about IRSE activities in your region, visit **irse.info/nearyou**.

Minor Railways Section

S&T Technician of the Year Award 2019

This award is designed to encourage a greater interest in railway signalling and telecommunications within the Minor Railways sector whilst increasing the awareness of the IRSE and its Minor Railways Section.

The award is administered by the IRSE Minor Railways Section and is targeted at S&T staff and volunteers aged 16 years and over from the Minor Railway Section. Such persons must be actively working in maintenance, installation, testing or design of S&T equipment and systems. Nominations should be made on a nomination form, which may be obtained from the www.irse.org or by email from mrsvisits@irse.org.

Anyone can make a nomination, except for nominating themselves. Nominations must close on 15 September and judging will take place through October with the award being made at the section's Autumn Technical Seminar.

The winner will receive: Nominal ownership of the Charles Hudson Trophy for the period of one year, a cheque for £500, a commemorative certificate and miniature trophy, one year's free membership of the IRSE at an appropriate grade, an IRSE logbook to enable the winner to record their technical development, and attendance at an industry leading training school for one of the Minor Railways Sections technical training workshops with a cheque for £100 towards subsistence.

Should the award winner be a group of individuals then following will also apply: The commemorative certificate will be awarded to the group as a whole along with one miniature trophy. One year's free membership at the appropriate grade will be awarded to one individual in the group, as nominated by the winning group. Attendance at one of the sections technical workshops will be awarded to one member of the group – but further places may be awarded at the discretion of the Minor Railways Section. One cheque will be awarded to the group.

Feedback

Re Critical doors

Clive Kessell's article on Critical Doors in the May issue was a great article, well described and with the right amount of detail. You should ask Mr Kessell for more contributions he is an excellent writer.

As an aside it did make me think about how we reduced dwell time in the past. I expect some readers may be too young to remember the slam door trains we had on Southern Region, each carriage was divided into sets of two three seat by two seat rows (or six x six) with their own doors either side of the carriage (a bit like a strip of corridors). The entire contents of the set could be emptied on a platform within less than 30 seconds (often 18 souls).

Because the doors were manual, passengers could anticipate the train coming into the station and open them in readiness to leap off and empty the carriage even quicker. Some brave souls even stood on the running board! Even when a train was pulling out of the station fit passengers could open a door and leap on.

It's a wonder TfL haven't considered them (updated of course as their crash worthiness wasn't very good), it would certainly reduce dwell time.

Martyn Hart, UK

Re Cover story, June IRSE News

The Cover Story in June issue of IRSE News shows the mis-spelling of Eaglescliffe Level Crossing!!

Anthony H Walker, UK

Apologies that we inadvertently swapped a "g" for an "a" in our spelling of Eaglescliffe, many thanks to Anthony for pointing this out. Ed.

Re Critical doors and Repoint

Further to the articles in the May issue on "Repoint – the future of track switching?" and "Critical doors". I do like the Repoint system, it has a real 19th century flavour. I wonder what similar things are to be found in the Patent Office. I note that the acknowledged drawbacks don't include the lack of trail ability. The testing needs to include making a 'wrong route' trailing movement and assessing the damage.

To be pedantic, as I often am, some train doors do re-open when obstructed, lift fashion – just not external ones.

JR Batts, UK

Past lives: Hennie van de Venter

On 11 April 2019, our esteemed IRSE colleague, Hendrik (better known as Hennie) van de Venter, passed away after a long illness.

Hennie was born on 1 September 1939 in the district of Kimberley, South Africa and was the seventh of eight children. He grew up in Warrenton, a town to the north of Kimberley and not far from the point on the South African map where the Northern Cape, Free State and North West Provinces meet. His father was in the transport industry, a bus driver with the South African Railways and Harbours. After primary and secondary school education in Warrenton, Hennie completed his formal education at the other extreme of the Western Cape Province, i.e. at Stellenbosch University where he graduated as an Electrical Engineer in 1962.

Hennie was a keen sportsman while at school and beyond. He played rugby for the Warrenton High School 1st team up to the time that he matriculated in 1957. He also participated in cricket and athletics.

From university he followed in his father's footsteps and joined the South African Railways and Harbours as a pupil engineer. The company had intentions of turning Hennie into a telecommunications engineer, but soon after joining he was able to make a successful escape into the signalling world. On completion of his six-year in-house signalling engineer training, which was centred in Port Elizabeth, a coastal city in the Eastern Cape, he moved to the Esselen Park Training College on the eastern side of Johannesburg where the developing and production of training manuals was Hennie's principal task.

In 1964 he married Philippina Schutte (better known to most as Pina), whom he had met in Stellenbosch. They have three children and five grandchildren. During their married life, both Hennie and Pina continued with their interest in sport and became keen tennis players.

The Signalling Head Office was his next career move where, as senior district engineer, he met some of his lifelong and dedicated IRSE Southern African Section colleagues such as Harry Ostrofsky, Vic Bowles and Ben van der Merwe. In September 1969, he was registered as a Professional Engineer by the Engineering Council of South Africa (ECSA). Later, in 1989, he successfully completed a post graduate Senior Management Programme at the University of Pretoria.

Hennie was accepted as a founding member of the IRSE Southern African Section in 1982 and he served a number of terms as the IRSE local section chair. Hennie was awarded Honorary Fellow membership status of the Institution in 2005. Pina willingly supported Hennie's career and his IRSE interests. Foreign IRSE members, in particular presidents, who have visited South Africa have expressed appreciation for Hennie's and Pina's readily given hospitality and assistance.

During this period, the railways of South Africa were undergoing radical change with heavy investment in electrification and resignalling along with the provision of automated marshalling yards. Hennie's skills were much in demand. He became a technical specialist for the resignalling schemes, especially in the AC immunisation and marshalling yard equipment field. Many of the advances made in signal engineering technology are due to his pursuit of new ideas and applications. One of the less known achievements was him being the author of the first South African published signalling handbook titled "Signalling Principles of the South African Transport Services which was also translated into Afrikaans (a unique achievement). Following a period as inspecting engineer, he was appointed chief signals engineer in Transnet in 1994 and also later in the then South African Rail Commuter Corporation, now the Passenger Rail Agency of South Africa. In these roles he will be remembered as a manager of note, a mentor with wisdom and a loyal colleague and friend for many who worked with him.

Hennie van de Venter, 1939-2019.

Hennie's highlight term as IRSE local section chairperson was in 1998 when the IRSE Convention took place in South Africa under his role as chair. The professionalism with which the IRSE Southern African Section conducted its affairs owes much to individuals who, with apparent ease, made time in the hurly burly of life at senior level to organise events for the benefit of their members. Hennie was such a person. While occupying the demanding position of assistant general manager, Infrastructure Engineering in Spoornet, he had been in charge of the IRSE committee that organised the outstandingly successful 1998 Convention in South Africa. In "electric speak", these responsibilities in series would have been challenge enough but Hennie dealt with them, in his characteristically unflappable manner, in parallel. Cy Porter, the president that year, remarked that he was and probably still is the luckiest president with regard to IRSE Conventions. His major contributions were simply to agree a course of action already planned or to choose from a number of well-thought-out alternatives.

Hennie was a dedicated family man, a man of supreme integrity and a perfectionist. This is evidenced by the telescope he built by hand to pursue his interest in astronomy, a project that took him years to complete after his retirement in 1999.

Although being quiet spoken, Hennie had a wicked sense of humour which we will miss. Our hearts go out to Pina and family at this, the end of a very painful period.

Ryan Gould

Past lives: Adriaan Heijnen

In the early morning of Christmas Day 2018, we suddenly lost an engaged member of the IRSE Netherlands Section, Adriaan Heijnen.

Adriaan was a real engineer. What his eyes saw his hands could make. After an eventful start of his education, with highs and lows and an interlude in the Dutch army as a tank commander, he completed his BSc with a cum laude (Latin for "with praise" or "with honour"). His degree work was his first contact with railways as he joined the Spanish company his brother worked for, developing a proof of concept for a Traffic Control System, CTC-type, based on a Digital PDP-11 computer.

After earning his degree, Adriaan then moved to the Leiden University where he joined the FOM-institute. The Stichting voor Fundamenteel Onderzoek der Materie was established in 1946 to foment basic physical research. He developed operating systems for experimental control systems, based on Motorola microprocessors.

After a couple of years, he wanted something else and was lured by Stork Bepak to become head of software development for the food industry's processing lines they produced. PLC programming was to become a thread in his life, which led him to think: "you know what, I can do this better if I work for myself". So together with two partners he set up a company.

Chance had it that after several years his brother again called on him; to enforce the capabilities of Holland Railconsult (now Movares) in a role as project manager for signalling, a role he fulfilled till his retirement in 2017. Several major re-signalling projects as well as tunnel installations for Amsterdam Metro (North-South Line) made him a known and outspoken member of both IRSE NL, as well as the Dutch signalling community.

Adriaan Heijen, 1951-2018.

After Adriaan's retirement he continued his PLC-programming activities, this time on board fishing ships located in Katwijk, the village he lived in for 30 years. The Faroe Islands, Iceland, the Canary Islands and Cape Verde were some of the destinations where he either boarded or left the ships, re-programming fish processing equipment while at sea.

Adriaan could always be heard wherever he was. There was a single occasion where he was silent for two days. This was in a bus in India during a convention tour when he was suffering from 'Delhi belly'!

Adriaan left behind his three daughters, Josine, Francine and Pauline, his sister Katja and his brother Frans.

Frans Heijnen

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at irsenews@irse.org.

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Membership changes

Elections

We have great pleasure in welcoming the following members newly elected to the Institution:

Fellow

Steve Denniss, WSP, UK
Joeri Minne, Infrabel, Belgium
Kenny Van Heuverswijn, Infrabel, Belgium
Helen Whitton, Network Rail, UK

Member

Roger Aebi, Thales, Switzerland
Amir Alif Amir Hamzah, Systra, Qatar
Hilary Castle-Hartnick, ACTOM, South Africa
Enrico De Cassan, Verkehrsbetriebe Zurich, Switzerland
Avesh Maharaj, R&H Rail, South Africa
James Moon, J & A Consultancy, Canada
Michael Summers, Integrated Rail Engineering Services, Australia

Associate Member

Mark Earl, Siemens, UK
Iqbal Ghazali, Mass Rapid Transport Corporation, Malaysia
Pratyusha Juvva, WSP, India
Jake Knight, Arup, UK
Devendra Kumar, Dedicated Freight Corridor Corp, India
Kevin Liemburg, Alstom, Netherlands
Ashir Qureshi, Siemens, UK
Matias Rocha, ADIFSE, Argentina
Kok Lin Tay, JYW Consulting, Australia
Matthew Ward, Siemens, UK
Shripal Yadav, Dedicated Freight Corridor Corp, India

Accredited Technician

Michael Willis, MECX, UK

Promotions

Member to Fellow

John Boss, John Boss Consulting, Netherlands
Aryldo Gentill Russo Junior, Certifer, France
Anthony Kerry, Network Rail, UK

Affiliate to Fellow

Eric Aliot, Network Rail, UK

Affiliate to Member

Dixon Fung, MTR Corporation, Hong Kong
Geoffrey Kaing, Rail Control Systems, Australia
Andrew Plumb, Siemens, UK
Mashia Tebele, Bombardier, UK

Affiliate to Associate Member

Adam Williams, Network Rail, UK

Affiliate to Accredited Technician

Sofia Maria Angelara, SNC Lavalin Atkins, UK
Jonathan Roseveare, SNC Lavalin Atkins, UK

Professional registrations

Congratulations to the members listed below who have achieved final stage registration at the following levels:

EngTech

Sofia Maria Angelara, SNC Lavalin Atkins, UK
Michael Willis, MECX, UK

New Affiliate Members

Matt Brown, Australia
Mandeep Dhillon, Metro Trains Melbourne, Australia
Eleni Douvi, Deutsche Bahn, Germany
Jack Gascard, Mott MacDonald, Australia
Fredy Gonzalez, EMC Technologies, Australia
Eoin Grace, Irish Rail, Ireland
Toufik Hadjer, UK
David Hardman, Network Rail, UK
James Higgins, Railsure, UK
Caroline Horton, Linbrooke, UK
Nitin Jois, Thales, India
Rhiannon Jones, Network Rail, UK
Maaz Ahmed Khan, Concord Electrical, India
Bhaskar Korukonda, Quest Global Engineering, India
Gerald Lambert, Rail Control Systems, Canada
Abinaya M, BHEL Trichy, India
Marianne Maslikosa, Sydney Trains, Australia
Catherine Meakin, Linbrooke, UK
David Mullen, Irish Rail, Ireland
Oisin Murphy, Irish Rail, Ireland
Debi Nayak, Rail Vikas Nigam, India
Brett Nelson, BrettNelson, UK
Hasnorsyahizan Norizan, Mass Rapid Transit Corporation, Malaysia
Russell Oliver, Rail Project Victoria, Australia
Kantha Pandaram, Alstom, Australia
Rushan Pun, Transport for London, UK
Hazem Radi, Network Rail, UK
Bashar Shamimul, Australian Rail Track Corporation, Australia
Petru Simiuc, McLaren Resourcing, UK
Frank Stengewis, Electrical & Tunnel Safety Control, Netherlands
Suresh Subramani, GGTronics, India
Muhsin Surmeli, Thales, Turkey
Kate Wallace, Transport for London, UK
Helen Willeboordse, Spoorgloren, Netherlands
Yidan Zhai, John Holland Group, Australia

Due to non-payment of first subscriptions the names of the members below will be removed from the membership database: Tawsif Ahmed, Amir Hassan Alamir, Akshay Kumar Arya, Onkutlule Bautlwetse, Sayed Ghayoor Hussain, Elango Palanisamy, Dhirendra Singh, Sik Lam Siu, Xiamoeng Wan and Charlie West.

Resignations: Hidaka Daisuke, Leo Koenderman, Maarten van Pernis and Terence Weston.

Reinstatements: Marc Antoni and Hugh Williams.

Past lives

It is with great regret that we have to report that the following member has passed away: Roderick Townsend.

Current Membership: 5176

IRSE News

Institution of Railway Signal Engineers

September 2019

Southend pier
heritage challenges

Traffic management
empowering people

Passive provision
the return of Ruth

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Our fixation with detail

Not wanting to stereotype, but my experience of working in the railway thus far has led me to realise that engineers, particularly design engineers, can be prone to obsessions with detail. From the eight behavioural styles identified by Belbin, "Completer Finisher" would be the type that rings most true. Whilst their attention to detail and need for perfection can bring significant benefit, I have concerns that as we move into a more austere period in UK main line rail, where life extensions and piecemeal renewals will form the norm, the inability to acknowledge when enough detail is enough has the potential to cause serious problems.

My concern stems from the phrase 'reasonable opportunity'. When a scope for a project is identified, a legal requirement is to look wider than the initial limits to ensure that the opportunity is not overlooked to include additional necessary elements. This can be interpreted as considering updating everything to every modern standard. The resultant reasonable opportunity reports become lengthy, detailing every specific wire, relay and control called to task when they are found wanting. Almost universally, the output of such report is that to fix these issues is simply not reasonable. This begs the question, if it was never going to be reasonable to fix it, why spend the time, effort and money detailing it?

The test for reasonable opportunity is about identifying residual risk and informing the asset owner of the risk they need to manage. It is well known that risks occur at the system boundaries, and it is at these boundaries where we should focus attention. Can the new system be integrated in with the old? Will it be a seamless transition for the driver and the signaller? Are we creating any operational deficiencies or complications? Is our failure to recover legacy systems impacting on overall system reliability? Will avoiding an additional cost now lead to an increased cost in the future?

When considering what is reasonable, question whether the end user, be it the passenger, driver, signaller, asset manager or maintainer, will gain any benefit from the improvement. If the answer is no, perhaps it was never reasonable to consider it in the first place.

Lynsey Hunter
signalling risk and review engineer
Network Rail
and IRSE Council member

Cover story

The Vale of Rheidol Railway is a narrow-gauge heritage railway that runs between Aberystwyth and Devil's Bridge in the county of Ceredigion, Wales. The line was the last British Rail (BR) route to be operated by steam and the first to be privatised.

It has three sections with ground frames at each end of the loops, locked by an Annetts key fitted to each section token and controlling a lower quadrant, GWR style semaphore home signal, along with facing point lock levers and point levers. On arrival, the train crew protect their train by reversing the points behind them. They then advise the duty officer who, once satisfied, gives authority for the next section token to be removed from the mechanical interlock. This locks the preceding token into the interlock, and releases the token for the next section. Visit **irse.info/i6y0m** for more information provided by John Tilly.

Photo Paul Darlington

In this issue

From the IRSE and its Sections

Southend Pier Railway signalling

Kevin Weston

The current Southend Pier (in the south east of England) was preceded by a wooden pier built in 1830 which, after 1851, had a narrow-gauge horse tramway to convey goods and visitors to the pier head. The north end of the pier is land side with the south end sitting in the Thames Estuary.

Construction of the current pier started in 1887 and the plans included provision for an electric railway, the building of which started the following year. The railway was completed in 1891 and ran the full length of the pier, 1¼ miles (2km). It was single track with a of gauge of 3 feet 6 inches (1067mm) and was electrified by a third rail at 500V DC positioned between the running rails. The electrification was led by Colonel Crompton. The rolling stock was a single 'toast rack style' coach. The system expanded and by 1930, the line was double track with four trains, each of seven coaches.

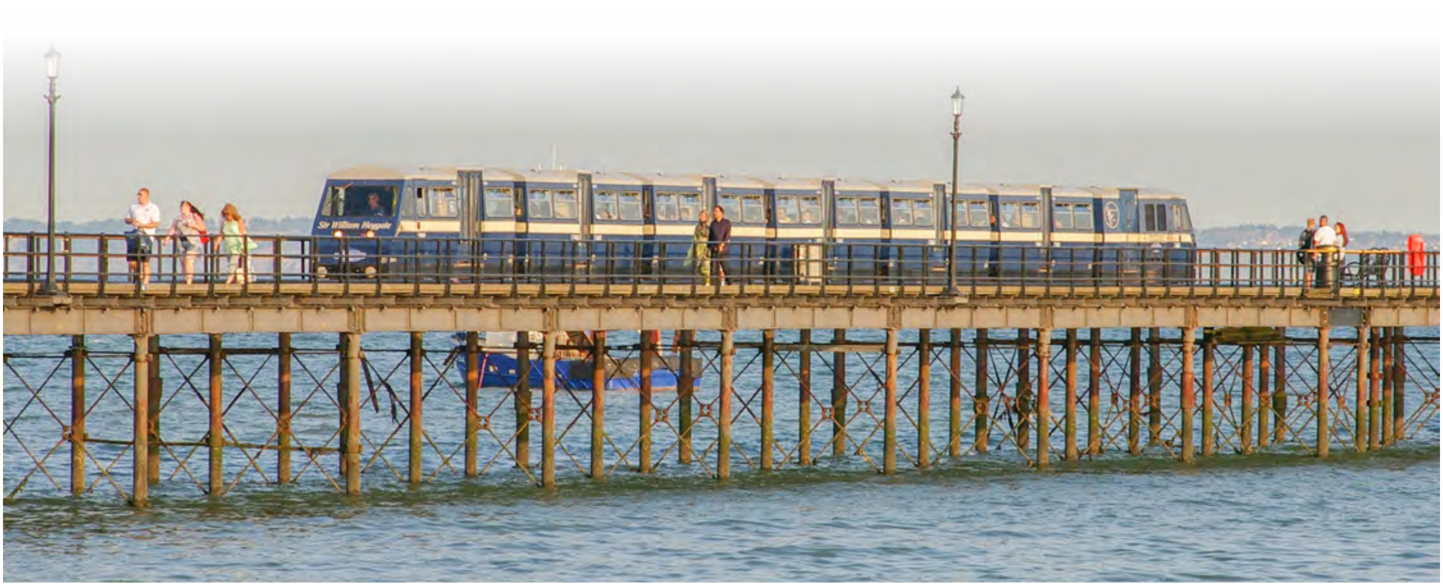
In 1949, the rolling stock was replaced with new trains built by AC Cars of Thames Ditton in Surrey. The new stock comprised four trains of seven, 4-wheeled coaches, liveried in green and cream. Each train could carry up to 260 passengers. At a top speed of 18mph, the journey took 4 minutes each way, and during peak periods a train ran every five minutes until 11pm. The record for passengers carried in one day stands at 55 000.

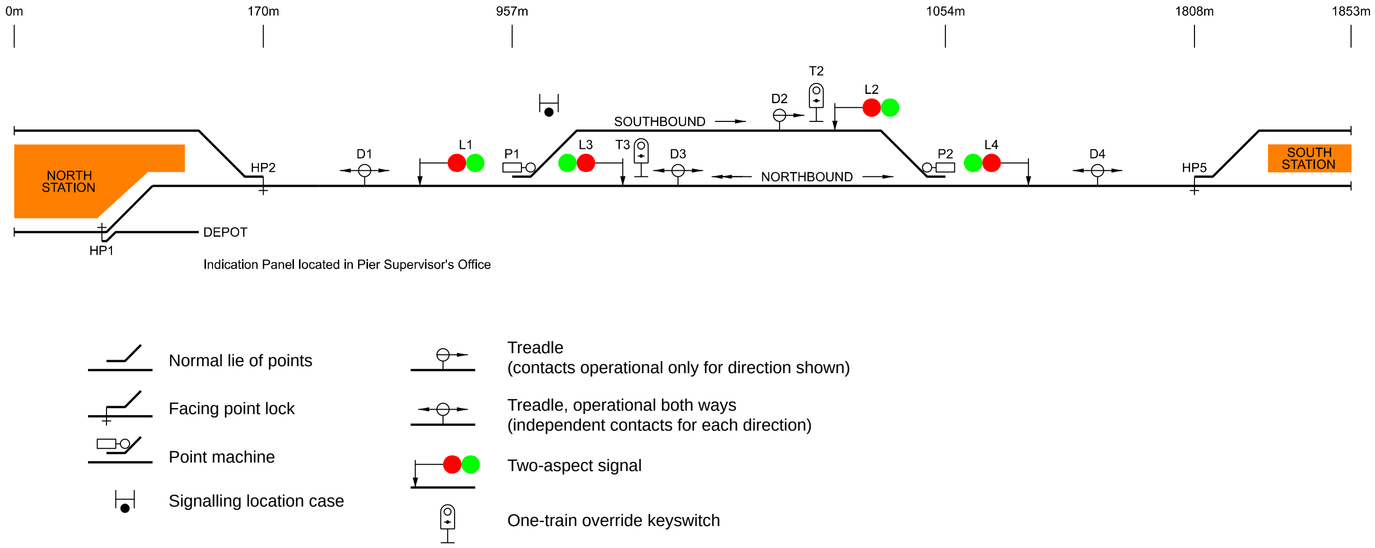
In 1978, the railway closed due to deterioration of the equipment and the cost of repairs. The 1949-built electric cars were withdrawn, although preserved examples can be found at various places including the Southend Pier Museum.

The railway was completely rebuilt, and was reopened on 2 May 1986 by Princess Anne. The new line is 3-foot gauge (914mm), comprising a single track with a midway passing loop and twin-track terminal stations at each end. Two new trains were built by Severn Lamb consisting of a diesel locomotive and six coaches. These trains are not diesel multiple units, they operate with the diesel locomotive at the pier head end and a driving trailer coach.

Original Signalling

The original signalling consisted of a signal box at each end, situated about 200m (220 yards) from the station. The track layout at each signal box included a facing and trailing crossover in the form of a 'scissors crossover'. The points were protected by two-aspect (red/green) signals and although very few records exist, photographs show the junction signals from the double track section to the platforms consisted of two separate signal heads.





Southend-on-Sea Pier Railway track plan.

Various contemporary photographs of the period show that the points were operated mechanically with 'economic' facing point locks and a mechanical fouling bar. It is assumed that track circuits were not used.

Each signal box was positioned on the east side of the pier, over-hanging the Thames, which must have been an interesting place to be in rough weather. A lever frame was provided in each signal box, the exact type is unknown but appears to be a Saxby & Farmer "A" pattern or Westinghouse "A2". It is not known what form of block working (if any) existed between the signal boxes.

Photographs taken in the last year of running show that the south end crossovers were partly recovered, and it is likely the railway was being operated as two single lines from the northern, shore, terminus. The Pier museum has various signalling artefacts on display.

1986 signalling

When the railway reopened in 1986, new signalling was provided by GEC-General Signal Limited of Borehamwood, Hertfordshire. The redesigned layout is single track approximately 1.85km long between the buffer stops at the North (Shore) and South (Pier Head) stations. A loop is provided about halfway, with the north end points at 957m and south end points at 1054m from the 0m datum, the North station buffer stop. The loop is long enough to accommodate a train 56m in length.

The loop consists of a short section of double track with home signals for moves into the loop and starting signals for moves out. The signalling into and out of the loop during two train operation is controlled automatically by the passage of trains operating treadles.

An indication panel is provided in the pier supervisor's office.

The system is normally 'switched-out' when one-train working is used, and all trains run on the Northbound line through the loop. Override key switches are provided at each starting signal. These are used for one train working when the signalling is 'switched-in'.

There is no signalling at the North and South stations. All points are operated by 1-lever ground frames; these are fitted with facing point locks and secured in position with padlocks.

Equipment

All the original 1986 equipment was installed by GEC to the then-current British Railways (BR) standards. The design uses standard BR specification relays, power supplies and other equipment. The relays are housed in a BR type large location case (as per standard drawing BRS-SM 431) located at the north end of the loop. All the external equipment is directly fed from this location and no disconnection boxes are used.

The relays are to BR930 specification of various types working at 50V DC. BR930/004 single and BR960/211 twin relays are generally used, with BR961/017 twins for point detection, BR943/172 for the point WRs and BR949/6047 for the point timer relays. The only non-BR specification relays are used for the 15 second treadle timers. These are GEC type ZT7701 solid state timers, with which I am not familiar, and I would welcome any further information.

Power is derived from a dedicated AC mains supply and transformed to 110V AC via a BR924A 240/110 500VA transformer. Power for the points is via separate BR967 240/110 5A transformer/rectifier. No battery back-up is provided for the points. A standard BR865 110/50 1A transformer/rectifier is provided for the relay circuits.

The points are operated by HW1121 machines, a variant of the standard type HW machine and which, I believe, are used frequently in Australia, although not so much in the UK. The original signals were GEC type LU2000 short range two-aspect (red/green) but these have recently been replaced with Dorman LED signals as part of the upgrade work. All train detection is by Silec Forfex two-arm treadles. A treadle is located about 120m on the approach to the loop in each direction, this activates the route calling for an approaching train and resets the routes for a departing train. Another treadle is positioned just before each loop exit signal, positioned such that it proves a complete train in the loop. An override key-switch is provided at each loop exit signal for one train working.

An indication panel is provided in the pier supervisor's office, which shows the point positions and the signal aspects. The panel indications relays are Keyswitch-Varley type P34 fed at 50V DC from the pier location supply. A 24V AC supply is provided at the panel for the indications.

Operation

The following information is taken from the railway's Operation & Maintenance Manual.

5.2 System Operation

5.2.1 Normal (Two Train) Operation

(a) Southbound Train.

A southbound train leaving from the North station operates treadle D1, causing the interlocking to call for points P1 to move to reverse. When the points have moved and are detected and locked in the reverse position, the red (stop) aspect of signal L1 clears to a green aspect. The train then proceeds into the loop up to signal L2 (at red) and in so doing, operates treadle D2, thus proving its presence in the loop and clear of points P1. The operation of treadle D2 also causes signal L1 to be replaced to red.

NOTE; if the previous southbound train did not cross a train at the loop, then points P1 will be retained in the reverse position.

(b) Northbound Train

A northbound train leaving from the South station operates treadle D4, causing the interlocking to call for points P2 to move to normal. When the points have moved and are detected and locked in the normal position, the red (stop) aspect of signal L4 clears to a green aspect. The train then proceeds into the loop up to signal L3 (at red) and in so doing, operates treadle D3, thus proving its presence in the loop and clear of points P2. The operation of treadle D3 also causes signal L4 to be replaced to red.

(c) With both trains detected in the loop section, 15 seconds after both treadles D2 and D3 have been operated, the interlocking calls for:

(i) Points P2 to move to reverse and when detected and locked in position, for signal L2 to clear to a green aspect, allowing the southbound train to depart from the loop towards the south station.

(ii) Points P1 to move to normal and when detected and locked in position, for signal L3 to clear to a green aspect, allowing the northbound train to depart from the loop towards the north station. NOTE; for the last northbound train, points P1 will be retained in the normal position after the previous train.

(d) Departure of the northbound train operates treadle D1, which replaces signal L2 to red. Departure of the southbound train operates treadle D4, which replaces signals L3. The operation of either treadle does not move either of the points in preparation of the next train.

5.2.2 Single Train Operation

Single train operation is normally used with the signalling switch off, however if the signalling is switched on, the following procedures must be used;

(a) Southbound Train

A train leaving from the North station enters the loop section up to signal L2 as detailed in section 5.2.1, paragraph (a). The train driver then operates override switch T2, which simulates the arrival of a northbound train in the loop, causing the system to operate as detailed in section 5.2.l, paragraph (c) (i) and (d). Note; the 15 second delay for setting the forward route still applies after operating treadle D2 and the override switch.

This procedure should be used for the first southbound train on a two-train service.

(b) Northbound Train

A train leaving from the South station enters the loop section up to signal L3 as detailed in section 5.2.1, paragraph (b). The train driver then operates override switch T3, which simulates the arrival of a southbound train in the loop, causing the system to operate as detailed in section 5.2.l, paragraph (c) (ii) and (d). Note; the 15 second delay for setting the forward route still applies after operating treadle D3 and the override switch.

This procedure will be used for the last northbound train on a two-train service.

Sand, sea, salt...

The pier loop is positioned about 1km from the shore. In good weather, and with flat, calm water, it is a pleasant place to be. In bad weather, and during a high tide, the Thames Estuary can, and does, wash over the pier and the railway. The railway, location case and the signalling equipment is subject to the type of rough weather that on the main line would be experienced only at places such as the south Devon sea wall between Dawlish and Teignmouth.

It is therefore no surprise that by early 2000, some of the equipment needed replacing due mostly to salt corrosion. In 2002, a new location case was provided and the original relay bases with GEC connectors were replaced with Westinghouse bases. The existing relays were either serviced or replaced and all new wiring was provided. The replacement location case was fitted with tighter seals and the base, which is bolted direct to the wooden pier decking, completely sealed against the salt atmosphere.

The point machines had new covers made by a local manufacturer of thicker gauge (and heavier) steel and new seals were provided for the covers and cable entries. The track is laid direct onto the pier, so the treadles must be mounted in a gap cut into the wooden decking. This means the bottom of the housing for the treadle is exposed to salt water during rough weather. The 2002 work replaced all the treadles.

Fire and ships

In 2005 a fire severely damaged much of the pier head including the South station. The station was temporarily re-sited until a new structure was opened on the original site in September 2009. Although the passenger trains were not damaged (they are stored at the North station when not in use), two maintenance wagons were destroyed in the fire.

In September 2011 the pier, and the railway, had to close for three weeks when it was hit by a barge that had slipped its moorings in high winds. In February 2012 the pier was again hit, this time by a fishing boat, closing the pier and the railway for a weekend while repairs were carried. Since the pier has been open there have been a total of 17 recorded collisions by shipping.

Assessment

In 2016, Alan Keef Ltd, a well-known engineering company for narrow gauge railways, was asked to assess the track and signalling as part of the Railway's ongoing maintenance programme. Alan Keef Ltd has limited knowledge of signalling and so they approached DEG Signal Ltd (now part of Ramboll) to assist. Alan Keef Ltd and DEG Signal Ltd had previously worked together on a major track relaying and resignalling project for Longleat Railway.

Location case and HW1121 point machine before refurbishment. The high tide on the day when this photograph was taken gives an impression of how exposed to the elements the equipment is.

In April 2017 I was asked to carry out an assessment of the railway's signalling infrastructure. It had been 15 years since the last major overhaul and while on many railways that length of time does not normally cause any major issues, the pier railway has exceptional problems with the saltwater atmosphere. A visual assessment was carried out of both the pier location and the indication panel in order to prioritise any remedial work.

The main problems found were; treadle D2 had been damaged in a minor derailment the previous year, although it still functioned correctly. The seals on the signal heads were no longer effective, these had not been replaced as part of the 2002 work. The location earthing was not up to current standards and the indication panel had several damaged lamp holders so that some indications were not effective. A full correlation of the signalling needed to be undertaken to provide a new set of drawings and a full maintenance test would be required on the power supplies, signals, treadles and points.

Ongoing maintenance

As the railway is running every day from the start of April until the end of the year, it was decided to wait until early 2018 when the pier and the railway is not open on Monday and Tuesday. In March 2018 I returned for a three-day visit along with one of our assistant designers, Tom Denning. We travelled on the Sunday, the start of the second "Beast from the East" storm. I left home in 6 inches of snow and while there was no snow at Southend, the temperature on the pier was -5°C on Monday.

With limited available time on site, our planned work for this visit would be to: Carry out power supply testing and assess if any of the transformers or rectifiers needed to be replaced, cable insulation testing on the tail cables and the 19-core cable between the location and the indication panel, carry out facing point lock and detection tests, along with a full function test of the system, assess treadle D2 to see if it could be repaired or needed to be replaced, assess the override key-switches to see if they needed to be replaced, and carry out a wiring correlation to produce new drawings.

Below: Russell Gell (left) and Tom Denning testing point machine P2 at the south end of the loop in the cold weather of March 2018.

Right: Tom Denning removing the corroded key-switch housing at the south end of the loop in much warmer weather.

Installing the refurbished treadle (D2).

The badly corroded base for the post of key-switch T3, with the replacement post next to it.

Refurbished point machine cover for points P1 at the north end of the loop.

South end exit of the loop showing refurbished treadle D2, new key-switch post T2 and new Dorman LED signal head (L2) on the refurbished post.

We found the power supplies and cable insulation tests were all within accepted limits. The key-switches, while still working correctly, had suffered serious corrosion on both the posts and the key-switch housing. It was decided that Alan Keef should construct two new posts and that DEG would provide two new key-switch boxes.

The facing point lock tests were carried out in the traditional manner, of winding the points by hand while someone held the gauge in the correct position. Also, as is the tradition, the person in charge (i.e. me) holds the gauge while the assistant (i.e. Tom) gets to wind the point machine. The railway uses 35lb flat-bottom rail with relatively short point blades, so there is not much weight for the machine to move. This was Tom's first experience of winding a point machine and even with lightweight rail, after winding each machine a few times, he told me it was hard work. To complete our testing, we got to "play trains". Tom, and our manager Russell Gell, who was on-site to help us, would operate the treadles and key switches as required to simulate train movements while I observed the correct operation of the relays.

The damaged treadle did pose a problem. When the train ran over it, the cover and mounting bracket were bent, and the mounting lugs on the treadle were broken off. However, the main body was not damaged but the internal contacts, although still working, had been corroded by salt water which had entered through the damaged cover. The railway had in their stores two used treadles which could be stripped for spare parts. Removing the treadle for repair would effectively put the loop out of use, meaning that only one train could run. The alternative was to purchase a new treadle (costly) and replace it at a future date. The pier supervisor agreed that they could operate one train only up to July but would need the loop for the school summer holidays.

Alan Keef staff removed the treadle to their workshop where they were able to re-weld the lugs back on to the body and straighten out the mounting bracket. It was then delivered to me where, with the assistance of the Longleat Railway workshop, I was able to replace the cover and contacts, as well as build another working treadle from the remaining parts.

Upgrade work

We returned to the railway for a two day visit early in July 2018, complete with two rebuilt treadles, two new key-switch boxes, a complete set of new drawings and in much better weather. Trains were running every day so we were limited in the work we could do.

The first job was to replace treadle D2. It is not as easy as with ballasted track as the treadle fits into a hole cut in the pier decking. The usual mounting plates for a treadle on flat-bottom rail are used but they are coach screwed into the decking.

Few railways are quite as close to passing shipping as the Southend Pier Railway.

The next job was to remove the old key-switch boxes ready for Alan Keef staff to replace the posts. The boxes were only held in place by 10mm bolts, but the corrosion meant they had to be cut off. Tom, as my assistant, would now find out how good he was with a hacksaw. Alan Keef provided new galvanised and painted posts, which should resist the salt for at least as long as the old posts.

The signal heads were still a problem. The door seals had perished in places and the screw catches holding the doors closed were no longer effective. The salt atmosphere had corroded the threads. It would have been possible to strip the signal heads, replace the seals and provide new screw catches. However, it would not be possible to remove the signals until after the summer season and they would need to be replaced, at least by the following Easter. This would mean two site visits to recover and replace the signals. It was decided that although repairing the treadles was a viable option, repairing the signals was not and that providing new signal heads would be a better long-term option. Alan Keef staff, however, would strip the old signal posts and repaint them on site.

Therefore, it was agreed that new signals would be Dorman LED miniature tunnel signals. I have used these signals for nearly ten years at Longleat and they have proved very suitable for a low speed narrow gauge railway where a main line type signal would be too large and expensive. The existing signals are two-aspect red/green, and the Railway wished to retain those aspects for the new signals. We therefore opted for the three-aspect red/yellow/green signals but not using the yellow aspect.

In March 2019, during more cold weather and high winds Russell Gell and I arrived in Southend for another three-day visit. This visit had three main jobs: Replace the signals with new LED heads, provide compliant earthing in the pier location and rewire the indication panel and replace the old indication lamps with LEDs.

Our first priority was to disconnect the signal head cables so that Alan Keef staff could strip the posts and repaint them. While that was happening, we would start the panel rewiring, about a day and a half's work. This time the pier was closed all week as there was some structural work being undertaken. This meant we were not constrained by trains, other than the occasional works train.

The mounting for the new signals is different to the original GEC signals, so Alan Keef staff had designed and built adapter plates with new rubber seals for the top of the old posts. Each head has slotted mounts which allow it to be aligned correctly. As there were no passenger services running, we were able to arrange for one of the trains to make a few trips so that we could align the signals correctly by viewing from the cab.

The rewiring of the indication panel was much more civilised in the warmth of the pier supervisor's office. The indication supply is fed from a 24V AC transformer and the existing indications used type T-1 Bi-Pin lamps mounted in an 8mm diameter lamp-holder with a common NX24 return. We did not wish to change the power supply or drill out the panel apertures, so we looked for suitable 24V AC, 8mm diameter LEDs. The lamp-holders were also direct wired to Weidmuller type MK3/12 terminals lower down in the panel, which were beyond the length of wire provided on most commercial LEDs.

We settled on using Oxley 8mm diameter, high intensity 24V AC LEDs with 300mm long flying leads but they would be wired to a new set of Weidmuller type MK3/12 terminals mounted on the back of the panel fascia. The new terminals also provided the common NX24 return so there was no need to provide any additional wiring from the relays to the new terminals.

Conclusion

The refurbishment work over the last year involved a total of eight days on site, one day in the workshop refurbishing treadles as well as many other days of preparation in the office, planning the site visits, searching for replacement parts and assessing what would be the best equipment to use in this unique environment. Maintenance on many railways will involve removing insect infestation and dealing with vandalism. The Southend Pier Railway has to deal with different problems, including salt water corrosion and occasionally being hit by a passing ship. This project also provided a perfect opportunity for one of our younger signal engineers to gain valuable practical on-site experience with signalling equipment.

The upgrade work has meant that the signalling on the Railway should have another 15 years' service before any more major upgrade work is required.

Railway Traffic Management: technology to empower people

David Palmer
Head of Main Line Rail, Thales

Network Rail is investing in new technology to support a continuing growth in passenger numbers, but the success of the solution is all about people, not the technology.

The UK rail industry is facing a daunting challenge. Passenger numbers have doubled to 1.7 billion per year since the mid-1990s and are expected to double again over the next 25 years. Clearly, it is impracticable to expand the infrastructure to meet this rapid growth. So, what else can we do?

If you had a clean sheet and were designing and building a national railway from scratch, you would probably think along the lines of driverless trains and automated everything. But there is no clean sheet.

The truth is, if we want to be able to cope with the relentless growth in rail traffic, we need get even better at managing it. And that's where technology comes in. Not by replacing people with computers, but by supporting them to make better decisions. Successfully realising the benefits of a digital railway is not about deploying fancy technology, but ensuring the user is at the heart of the whole design and implementation of the solution.

The journey starts here

Today, the industry employs teams of expert operators who not only understand the job in front of them, but who have a lifetime of experience in the fine nuances and complexities of our rail network – something that would be difficult to replicate with computers.

But as the railway becomes busier and more complex, the role of an operator can at times resemble that of a firefighter, and technology becomes a valuable tool in supporting decision making. Traffic Management is one such technology – enabling operators to make more proactive decisions and resolve potential delays before they occur. Following the successful implementation of Traffic Management in other countries, one of the earliest Digital Railway initiatives was to bring the technology to the UK.

As part of a comprehensive evaluation of different Traffic Management Systems (TMS), Network Rail decided to prototype three solutions, funding the creation of a test bed or 'model office' for each.

Teams of technical and operating experts used the systems daily over three months, as though in a real control room, to review how the systems performed and understand what lessons could be learned. After the exercise, Network Rail selected Thales' ARAMIS (Advanced Railway Automation, Management and Information System) for its Rail Operating Centres at Cardiff and Romford.

The original intention was for the system to be integrated with signalling systems, but a decision to adopt a more incremental approach was taken during the project. Both systems are now operating in 'decision support mode', and in the case of Wales, over a much larger area than initially planned.

Decision support mode allows operators to become familiar with the baseline technology and provide continuous feedback, while also delivering operational benefits at an earlier stage. The TMS can then be interfaced with other industry systems, including signalling, driver advisory, and stock & crew, alongside a robust business change programme.

The operator is presented with a preview of the planned schedule for the current day, in graphical and tabular forms, which is constantly updated by various data sources in real time. Train running information and timetables can be viewed and modified in several ways, and the operator is presented with a number of views including:

- Train Graph – which highlights any planning and route conflicts.
- Platform Docker – for decision support at stations, e.g. when platforms become unavailable.
- Train Line Schematic – which shows where trains are at any given moment and their planned routes.

Importantly, the system can predict a wide range of conflicts before they occur, flagging them to the operator who then chooses one of three modes to resolve them: 'Manual' (for immediate and direct intervention), 'Assisted' (where options are presented and can be reviewed before implementation), and 'Automatic' (which resolves problems according to pre-defined rules).

Changes to the plan are immediately visible to the signallers through a read-only view, which helps to reduce the number of calls and emails between signallers and TOC control operators. When interfaced, the changes would flow directly into whichever signalling system is in place.

International traffic management

ARAMIS is now in operation across sixteen countries including Germany, Austria and Portugal, controlling more than 50 000 trains every day. This wide customer base, modular and configurable design (with over ten configurable modules), and ability to operate in decision support mode or fully integrated with the local signalling control system, makes it a strong candidate to support railway operations across the World.

Where do we go from here?

The need for better rail Traffic Management is not confined to the UK. Rail traffic in Europe now stands at over 465 billion passenger-kilometres per year, a number which has grown steadily for five consecutive years, and the upward trend is mirrored globally. As the world's railways become bigger and busier, it seems that for technologies like ARAMIS, the time has come.

Does it take us further towards automation? Yes, but not in the helter-skelter, must-be-first way that's being adopted by other transport industries. No one knows what the rail network will look like in 25 years, but one thing is for sure: by giving people the information they need, when they need it, we are helping them to manage the challenges that are thrown at them. We are preparing the industry for the future.

None of this will solve the primary causes of delay and cancellations that make the headlines on slow news days. But it will help the highly skilled experts that run our railways to make timely, effective decisions that put passengers and freight users at the forefront.

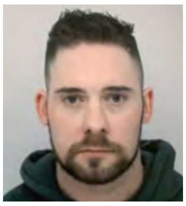
Right now, and for years to come, traffic management is all about the people, not the technology.

What do you think?

What is your experience of applying traffic management solutions? Does your railway or company have experience of applying similar technologies to those described in this article in other countries? Is your experience that the UK could benefit from learning from successes, or indeed things that have gone less well, in other countries?

Let us know by emailing **editor@irsenews.co.uk**.

The development of tokens and tokenless block with a modern twist



Kevin Chivers
Signalling Principles Verifier

The token system is a robust way of implementing block working on a single line. Today's main line railway in the UK still employs many token machines, and they are in widespread use on heritage lines.

Network Rail's Wales & Western region takes the record for the most sections being protected by token machines with 64 machines in use on their network. North West & Central region uses 16 machines, Eastern region 23 machines, Southern region eight machines and Scotland's Railway has six machines. That's a total of 117 Token machines still in use on the GB network today.

The token system works perfectly well when trains move through the section alternately in each direction as the allocation of tokens works in an even fashion. But when trains predominantly move through the section in one direction the tokens 'build-up' at one end of the section forcing the signaller or authorised person to make a trip to collect and redistribute them.

An advancement over this was the staff and ticket system whereby for multiple trains going in the same direction each driver would be issued a ticket to take with them (their movement authority) along with being shown the staff or token to give reassurance that the entrance signal box had permission for trains to pass. The last train in the group travelling in this direction would also be issued a ticket along with the staff or token which they would pass on to the signaller at the end of the line – a 'positive' indication that they were the last train.

Collecting tokens was slow and interrupted the railway timekeeping because when collecting a token from the signaller the train had an enforced speed of 10mph (16km/h) as set by the Ministry of Transport but just as importantly to enable the signaller and driver to actually exchange the token.

There are two types of token machine currently in use on Network Rail. The first is the Great Western Railway type followed by the Tyers machine. The Tyers company purchased the patent for the western machine so they could sell it to other railways of the UK network. Each of these developed into a number of different variants.

The Tokenless Block System

The tokenless system was a development of the token system. The system did away with the requirements for any train driver to signaller interaction, hence reducing human error. Both systems are deemed to achieve Safety Integrity Level (SIL) 3, but the token system would lower than that of tokenless which would be deemed a strong SIL 3 due to the reasons described here.

Note that the Radio Electronic Token Block (RETB) system in use in Scotland is outside the scope of this article.

The tokenless system utilised reed Frequency Division Multiplex (FDM) for transmission between signal boxes whereas the token system uses polarised circuitry over standard lineside cabling.

The tokenless system has an advantage over the token system when switching out an intermediate signal box during quiet times. With the token system this is not easy to achieve and generally involves placing a token into a special instrument for every section being switched out. Whereas the tokenless system utilises switching slides. When these switching slides are operated, they release the interlocking (just like a king lever) for opposing signals to be cleared at the same time.

When the layout is simple, the token system does not require lineside signals as authority is provided by the issuing of the token to the train driver.

Engineering problems

Generally, single lines operate over what can be significant distance between signal boxes hence the requirement for considerable lengths of lineside cabling. Apart from the inherent maintenance nightmare this brings, it creates a large cost for the cabling itself with the possible problem of cable theft and finally voltage loss down the line.

We as engineers can get around this problem of voltage by using relays with high resistance to 'rob' all of the voltage in the circuit.

Until recently shelf-type relays were our only choice. Shelf-type relays being used in 2018 for new or existing schemes is

The new Unipart Rail IP-based token machine.
Photos Ian Allison.

not desirable but with the recent advent of the BR930 QS2, a neutral relay and the BR930 QBB2, twin polarised relay recently type-approved and going into production with Siemens Mobility it has become practicable to solve this problem with BR930 relays.

The QS2 and QBB2 relays have a substantial 16kΩ coil resistance and are able to overcome large values of line resistance which can be present. However, as these relays are specialised and in short supply the lead time can be long.

What now?

As a modern twist, Park Signalling Ltd, (a Unipart Rail Company) has developed a future-proof token machine known as DiBLoC. Each machine will be assigned a unique IP address and will connect to a router with CAT6 cabling. The connection from the router to the outside world can be by optical fibre, 4G cellular network, satellite or to a railway company's own telecom network. Consequently, issues relating to long line resistance or sourcing specialist relays with long lead times are eliminated.

The token machines can be produced inexpensively and hence a single line can be resignalled for relatively low cost. Not only will this be of benefit to Network Rail when budgeting for resignalling schemes but could be of interest to the heritage railway market.

As there is now a new, modern way of replacing token machines it is perceived there may well be a drive to replace many of the existing variants on the rail network. Consequently, there has been a recent project to redraw and modernise the existing E10,000 suite of drawings relating to token Instruments. The new set of drawings will be renumbered to sit within the new E10,000 numbering sequence.

The drawings have been presented to Network Rail's Signalling Circuits Standards Working Group (SCSWG) to be critiqued by industry experts. The latest set of drawings will be issued by Network Rail in the near future. It is now believed that the recent updates to these sheets will help to cover every eventuality and scenario that signalling designers may encounter including the new Unipart Rail internet-connected instruments where cable connectivity is a particular challenge, the simpler western-style terminal instrument, the more involved Tyers terminal instrument with the direction indicator, two-galvanometer intermediate instruments and Universal machine with basic functions only (for NSTR, No-Signaller Token Remote, and where more elaborate arrangements are implemented by externally connected devices).

Recently Network Rail embarked on re-engineering the token system and developing a long-term strategy to return existing units to as-new condition (in collaboration with Unipart Rail). This requirement has been driven by fears of general obsolescence, the cost of replacing in modern-equivalent-form and concern over the consequences of a catastrophic incident such as a fire destroying some apparatus, an event that did actually occur recently.

Beside the limited number of standby units Network Rail had there is also the challenge of the equipment being highly reliable and consequently a limited number of people with relevant fault-finding experience. The success of the system throughout its lifetime has been good, as it silently performs its duties 'behind the scenes' causing little reason for concern.

Therefore, in order to increase availability of the system, the plan is to refurbish a quantity of units (around ten) per year, standardising on just four types: simple terminal, terminal, intermediate and universal, each able to be used with the four key patterns.

With special thanks to Graeme Christmas.

Neutral host networks

Paul Darlington

Neutral hosting is a means of improving mobile radio coverage in locations where the provision of reliable connectivity can be difficult and to avoid duplicate investments. It is also one of the fastest changing and developing areas of mobile telecommunications throughout the world. Telecom companies, enterprises, and railways cannot always justify the capital cost involved in providing dedicated and often replicated mobile radio facilities, and neutral hosting may provide a solution.

With neutral hosting, Neutral Host Networks (NHNs) consisting of antennas, masts, leaky feeders, and active electronics, are provided by 'landlords' or service providers and shared to provide coverage in difficult areas as shown in Figure 1. Such networks could be 'self-provision' networks, provided by a landlord, a pure third-party carrier or by a Mobile Network Operator (MNO) acting as a site-specific carrier. NHNs could provide a way forward for improving radio facilities for railways, for customer and business purposes or even operational communications.

NHNs are predominantly aimed at locations where the provision of reliable connectivity can be a big challenge, particularly in busy locations such as conference centres, entertainment venues, airports, stations and large shopping centres, especially at peak times. NHN models are also relevant where coverage siting or economics pose challenges, such as rural areas, roads and railways.

Examples of neutral hosting

In the UK, examples of shared Distributed Antenna Systems (DAS) can be found inside the Trafford Centre (shopping centre) in Manchester and at Anfield Stadium, the home of Liverpool Football Club. In Aberdeen city centre a partnership with O2 has provided the UK's first fibre-connected Small Cells Network (SCN) for faster and higher capacity mobile services.

Transport for London is looking at a NHN to bring 4G for passengers to the Underground, through the deployment of neutral host infrastructure, and Network Rail Telecom (NRT) is involved in assisting mobile network operators to tackle public radio 'not spots', where there is poor coverage near to the railway. NRT recognise that this will help to remove poor coverage areas for rail customers, lineside neighbours, and rail maintenance teams, together with improving Wi-Fi access on trains where this is provided via public cellular radio systems.

An NHN has been already been provided in the Severn Tunnel to provide coverage for the Emergency Services Network (ESN) critical communications system. ESN will provide radio facilities for police, fire and rescue, ambulance services, local authorities and first responders such as inshore rescue. While the Severn Tunnel NHN currently only serves the ESN, other MNOs could be accommodated.

Neutral host infrastructure

Neutral host infrastructure comprises a single, shared network provided on an open access basis to one or a number of MNOs. Neutral host operators can reduce their own network costs, whilst offering a network for sharing and the model could challenge traditional larger, vertically integrated MNOs, with more cost-efficient use of infrastructure through greater levels of sharing / utilisation and to improve the quality of service for customers.

Network sharing

Neutral Hosting solutions can be at the antenna level or can be an entire Radio Access Network (RAN) solution with aggregation, backhaul and routing for multiple sites. With the introduction of 5G technology, network sharing will be enhanced by new techniques such as 'Slicing', enabling defined usage of spectrum and network assets to ensure network owners and/ or users can be clearly segmented to meet security, Quality of Service (QoS), billing and service levels. Initially, network slicing will primarily be used at the core and transport layers of a network, but as 5G evolves it will migrate to the RAN and potentially users to create fully end-to-end slices.

Control and User Plane Separation (CUPS) provides the architecture enhancements for the separation of the control and user plane functionality. CUPS was introduced in 3GPP Release 14 and is set to be a key core network feature for current 4G and future 5G systems. Mobile Edge Computing (MEC) will bring application hosting from centralised systems to the network edge, closer to users and the data generated by applications.

Broadcast modes are extremely efficient when multiple users are consuming the same content, such as live radio or video. As new capabilities bring more intelligence across the whole of the

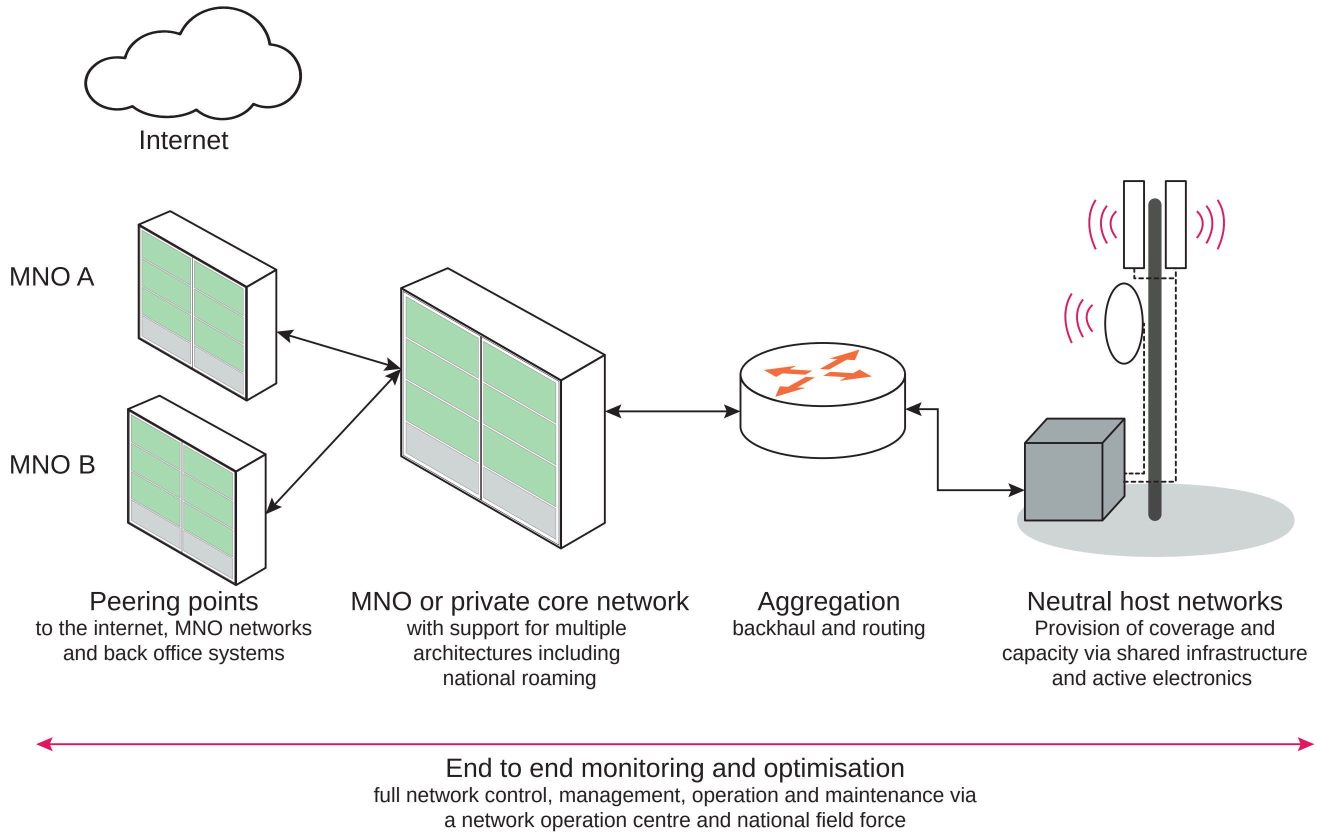


Figure 1 – Neutral Host Networks (NHNs) consisting of antennas, masts, leaky feeders, and active electronics, are shared to provide coverage in difficult areas

network, broadcast modes may be used to push content to the network edge and into the MEC nodes for local consumption.

As frequencies increase, as proposed by 5G, coverage distances decrease. However, the size of antennas decreases, which means more antennas can be used in smaller forms. Increasing the number of antennas enables the ability to transmit further, focus power into smaller areas and re-use spectrum more efficiently, as the beam gets directed more precisely. Multiple-input and multiple-output (MIMO) allows increased capacity over a radio link using multiple transmit and receive antennas to exploit multipath propagation.

Railway operational radio requirements

Could neutral hosting and network sharing provide a solution for future railway operational radio requirements; with the rail infrastructure manager providing masts, aerials and data connections and an MNO providing a 'slice' of their network for mission critical railway priority traffic? The technology exists to provide this model and to share infrastructure to the benefit of all involved.

There would however be a variety of technical and commercial challenges and compromises that must be carefully considered and addressed. Who pays for what and the timeline for renewal would need to be clear, and who takes responsibility when things go wrong? Would an MNO be prepared to take the commercial and reputational risk if an issue on their part of the network resulted in an incident?

The traffic and revenue income to the MNO is likely to be relatively small compared to the rest of their business, so would there be a business case for providing the functionality and QoS the operational railway would require? The rail infrastructure manager is likely to require full visibility of the MNO network to assure safety validation for rail operational services. Would an MNO be able and prepared to grant such visibility? Who has the final say in any design change or equipment outage? These are some of the issues that would have to be addressed in any such proposal.

Before GSM-R was provided, Railtrack (the predecessor of Network Rail) considered using an MNO to provide all train radio requirements, but the proposal failed for some of these reasons. When the GSM-R network was provided Network Rail considered roaming on to public GSM networks in rural areas to save costs. The problem was that in such situations the public GSM network could not provide all the GSM-R functionality and once GSM-R coverage was available along a route there was no guarantee of a train roaming back on to the railway GSM-R network. Technology however has moved on and LTE technology and neutral hosting may address some of these issues.

Using a shared radio access network can create restrictions for MNOs who wish to maintain a competitive differentiation capability and not give too many secrets away to their competitors. The risk of sharing active equipment can also cause network congestion and restrictions to data in areas with high traffic demand.

Beyond rail public policy may wish to encourage network sharing to reduce the costs of mobile service provision in rural areas. But forced network sharing of the MNOs, such as domestic roaming, will remove all investment incentives. So, who would take the first step and invest in the required infrastructure?

Replacing GSM-R with a neutral host model may be a step too far, but NHNs are likely to be installed at busy stations at the very least. It will be interesting to see how neutral hosting develops as overcoming the issues identified could be a way of reducing costs and increasing connectivity for both railways and society.

"It's only passive provision ..."

Stephen Dapré

We already met Ruth in the December 2018 and April 2019 issues of IRSE News, and for any newcomers the plot so far is that Ruth and other characters are entirely fictitious, and live in a fictional but somehow familiar world. Ruth followed her Grandpa Harold and Uncle Bob into the railway industry and their fictional national railway has been divided into Communities. Ruth is currently in charge of signalling alterations for a station upgrade and in the previous issues she has encountered interlocking obsolescence and signal sighting.

"Morning Ruth, I suppose you've already heard that the weekend didn't go so well?"

This was not the Monday morning that Ruth had wanted. Her contractors were meant to be installing a large new signal gantry structure during a rare Sunday closure of the line.

"Yep, so what happened?"

"Well, it is more a case of what didn't happen. There was a problem with the paperwork so the contractor was unable to start work."

"What sort of problem, I reviewed it all twice and it seemed fine?"

"One digit of a phone number was incorrect so the contractors couldn't contact anyone to sign in to the worksite."

Ruth groaned. Although she had very carefully reviewed the substantial paperwork that accompanied any attempt to work on the track, even she hadn't dialled every phone number listed to check each one was genuine.

"Didn't they try phoning someone else to find the correct number?"

"Well, sort of – they rang our national Community of Communities Centralised Call Centre (CCCCC), but after waiting on hold for ages the CCCCC told them our project wasn't on their system so they refused to believe it actually existed. The contractors did eventually ring the signaller on a handy signal post telephone (SPT) on the platform without actually going on the track. The signaller told them whom to contact, but by then it was too late to start."

"I thought we had plenty of contingency in the programme?"

"Yes, but the contingency is only there for contingency situations."

"But surely this was…oh never mind!"

Ruth had no more time to discuss it; she was due to dial in to the Monday morning conference call. As usual 57 minutes of it would be listening to other people discussing unrelated weekend works many miles away in her Community, and now her allocated 3 minutes would consist of listening to others grumbling about the waste of a good Sunday block, without changing the outcome.

Harold on the hill

Ruth had already arranged to drop in to see Grandpa Harold on her way home that day. She enjoyed his company because he was a kind old man, however she also felt some trepidation because he couldn't help cross-examining her about how modern practices compared with his own working days. Harold had recently moved into a care home on a gentle hill with pleasant views overlooking their home town in the distance, and when she arrived, he was in the communal lounge talking to a care worker who was reaching down the back of the TV.

"Hi Grandpa, what are you doing?"

"Ah, hello Ruthie. The staff here didn't know how to play back videos on the TV so I was explaining the connections for them, I thought it was obvious that the video signal comes out of here and needs to be plugged in there but they don't seem to know about anything."

Ruth felt inwardly proud of her 100-year-old grandfather explaining the wiring to care home staff who had been brought up on clouds and Wi-Fi. Once he'd finished and a film had started playing loudly, they retreated to sit down in another room. Conversation quickly moved on to railways, with Ruth explaining the latest work on her project.

"Now Ruthie, tell me again: why are you building new signal gantries?"

"Because we need to extend the station platforms for longer trains."

"Fair enough, so just pick the signals up and put them on new bases, and run a new tail cable."

"Grandpa, you know it isn't that easy. The signal structures have to be built to modern standards."

Ruth patiently explained how modern signal structures had to be built to withstand freak weather events, turbulence from passing freight trains with the aerodynamic qualities of bricks, and minor earthquakes because folklore said there had been one

Derby was resignalled last year, and it can be seen that the new gantries are designed to allow for electrification. Not far away, the Leicester area was resignalled in the 1980s with similar passive provision, however electrification of the Midland Main Line from London has yet to reach Leicester over 30 years later. When will the wires get to Derby?

several centuries ago. On gantries the walkways were specified for a loading of four maintenance technicians in case the usual team of three had a trainee with them, even though there was barely space for four people and typically most team members preferred to stay on the ground and watch one person do the work.

Harold wasn't ready to accept that.

"When I was building our first colour light signals, we would get a used oil drum, dig a hole the right size for it, put the drum in the hole, fill it with concrete and plant the signal post or some bolts in it. Job done in a few hours; lasts forever. Uncle Bob was doing much the same on his job's years later, why can't you just continue with that? It does seem a dreadful waste of taxpayers' money!"

Ruth wanted to argue back about health and safety legislation, the fact that a few of the oldest signals planted in oil drums were now leaning at curious angles so they were covered in warning notices to say climbing them was prohibited, and that she paid far more tax than Harold nowadays. However, it had been a long day and it was better to just let Harold have his say; in any case he had a twinkle in his eye and Ruth knew he was only trying to tease her.

"Perhaps I ought to bring you into the office to tell them how to do it properly, Grandpa!"

Second attempt

A few Mondays later, Ruth again arrived at work to be greeted with news about the weekend's work. This time, the gantry had been successfully installed. Admittedly it had taken considerable persuasion to get another suitable Sunday block, with the local train companies all complaining even though the whole purpose of the project was to allow them to run longer trains. One company objected because although they didn't run any Sunday services through the station, they sometimes used it to stable trains. Nonetheless it was a small triumph of engineering to get the gantry erected, which was duly noted with muted praise during her three minutes of glory on the morning conference call.

Less than a minute after leaving the conference call, Ruth's phone rang. The incoming call was from a local number that seemed familiar.

"Ah Ruthie, there you are!"

"Grandpa..?" Ruth whispered into the phone. "Is everything OK?"

"No, what on earth have you done?"

Ruth was wondering whether she had been (incorrectly) named and shamed in some intriguing family scandal, but Harold wanted to talk railways. He continued:

"That...that...STRUCTURE. What is it for?"

"Oh – that! I did explain we had to build it to modern standards. Why, can you see it?"

"Can I see it? I could even read the signal aspects from my window when I got up this morning!"

"Well, modern signal heads are very bright to ensure they are visible in all conditions."

"That doesn't explain why the structure is so tall?"

"Ah, it's only passive provision. We were told to allow for clearance for future electrification with overhead lines."

"Is that really likely? They would need to completely rebuild that low road bridge over the station, and all the other bridges along the line. Try asking uncle Bob, several of his generation worked on resignalling projects where they were told to assume future electrification yet it never happened. Somewhere along the Community of the Centreline I think."

"To be fair, some other schemes in the last few years did not allow for overhead lines, only to find that electrification was announced soon afterwards, so now they are busy replacing gantries that are almost new."

"Maybe, maybe. Anyway, that still doesn't explain why you've put the gantry so far from the platform ends, I thought you were just doing some modest extensions for those longer trains."

In summer 2017 platforms 1-6 at Waterloo were remodelled for longer trains, and this new gantry appears to allow for overhead electrification. However, at present all lines use third rail electrification from Waterloo throughout South West London to most destinations! Conversion to overhead electrification seems highly unlikely in the near future, whilst longer-term the lineside signalling is due to be superseded by ERTMS.

"Ah, that's only passive provision as well – the train companies insisted on it because they might be getting even longer trains sometime."

"Well, even you'll be retired by the time they get around to doing that, they would have to completely rebuild the terminal station in the capital city to accommodate them! Now then, I'm sure there are more signals as well – there weren't that many signals there when I worked at the station."

"Well spotted, yes there are, but they are fixed reds at present. We were told another project may introduce some turnback and bi-directional moves."

"What you mean is they are only passive provision as well..?!"

Ruth hesitated before answering quietly:

"I suppose so, yes."

Ruth decided that whilst there were logical reasons for including passive provision in her scope, it would not be quick to convince Harold; instead it was best to conclude and say a friendly goodbye. When she came off the phone, a colleague in the office said:

"Who was that? They were giving you a right grilling!" "Oh, just a local stakeholder with interesting views."

Another email

Despite Harold's concerns about the scope, Ruth was pleased that the work had now been delivered. Just as she started to relax and think about making a tea, she received an email. Despite carefully resetting her spam filters recently, the mysterious Binary Railway group (who were leading the in-cab signalling project) had somehow used their advanced technical powers to find another way into her Inbox.

Dear Person in Charge of Traditional Signalling

It has been brought to our attention that you are making alterations to lineside signalling. You will of course be aware that we recently published our new standard "Passive Provision for Binary Railway Systems". We recommend that you urgently review your scope to ensure your project is compliant, otherwise re-education may be required.

Ruth knew that (as with all good science fiction) resistance was futile. Just as she was wondering what to do about it, the door burst open. In bounced the new graduate who had just joined their project team for a placement. Ruth had an idea.

"Hi, good timing! On your induction week, what did they tell you about Binary Railway?"

"Well it was really impressive, they said that one day everywhere would use UTCS (Universal Train Control System), and we wouldn't need lineside signals. In fact, the session about mechanical signalling was deleted from our programme because we were told it was no longer relevant, we could always visit a museum to learn about it."

Ruth winced, relieved that her grandpa's excellent overview of her site did not include hidden microphones.

"Well, if you're really keen to learn about UTCS, how about you help me with a task: you could review a Binary Railway standard to see how it may apply to our project."

"Certainly, sounds fun!"

Fun was not quite the word Ruth would have used, however she didn't want to dampen the innocent enthusiasm and finding answers would help both of them. She forwarded the email she had received to the graduate who then disappeared happily down the corridor to start work.

Before she could continue with her day, one of the installation team walked up to her desk.

"Ruth, there was just one problem from the weekend that could not be resolved on the night. We need another two new SPTs, we ran out of stock."

"Oh wonderful – OK, I will ring the national stores to get some."

Ruth rang the CCCCC helpline, and after navigating through numerous menus of options she was told she was position 19 in the queue. Fortunately, that now gave her enough time to get her first drink, including the daily challenge of finding which of the three office fridges actually contained the milk carton. (She even considered leaving her phone waiting on her desk whilst she went to the bathroom, however that would be a bit too risky: she would need indefinite time to battle the stubbornly ingenious toilet roll holders that always guaranteed every cubicle met the facilities performance specification to have two full rolls available, yet would never release a single sheet of paper undamaged without a fight.)

Eventually her call was answered.

"Hi, do you have any SPTs in stock?"

"Let me just check…yes we have 14."

"Excellent, can we have two please?"

"No, they only come in packs of seven; we are not allowed to split the packs."

Ruth paused while she imagined what geometric shape of packaging caused the standard bulk pack of SPTs to be in sevens rather than an even number.

"Oh well, can I order one pack of seven then please? We can always use the spares elsewhere."

"Ah, I'm afraid that won't be possible – our customer service quality procedure says we must always retain at least two packs in stock otherwise we might be unable to meet sudden demand."

At this point Ruth instinctively took the phone away from her ear and looked down the earpiece, until she remembered that she was a highly qualified S&T engineer who should really understand that even with digital multiplexing phones don't work like that – and it might look a bit daft. She ended the conversation briskly and turned to the installer.

"We might have to wait for the extra SPTs, do you know which signals need them?"

"The ones at the far side, we just started from here and kept going until we ran out."

"Don't you realise that some signals are fixed at red for now because they are only for passive provision?!" Ruth was now getting irritated.

"Passive provision, what's that then?"

Ruth weighed up whether this was intended to be a deep philosophical question – but it wasn't.

"It's like future-proofing for things that might or might not happen."

"Dunno about that, we were just told every signal needed them installed so I can't close the log."

"Fine, in that case what we can do is borrow two SPTs from two of the signals fixed at red? We can always sign them out of use for now."

"But how can we sign them out of use if they aren't yet in use?"

Ruth was now lost for words. The silence was only broken by the team organiser who had picked up an incoming call for Ruth:

"Ruth, I have the Community's hindsight engineering department on the phone, they want to come and do their post-commissioning audit to point out all the things we could have done differently to be more efficient. When would be a good time for us?"

"In about 30 years once we know if the passive provision was ever useful", Ruth thought to herself before replying: "Not just yet."

Some answers

A few days later the graduate reappeared. Ruth could immediately spot the impact of genuine front-line experience: the door opened more slowly, and the graduate seemed to have aged several years.

"Hiya, how did you get on?"

"Erm…it may sound strange, but I'm not really sure. It took me ages to read, but I was struggling to find out what we actually need to do about it."

Ruth put on her best attempt at a surprised face.

"Oh, well thank you for researching it anyway, it was important to check how we could comply."

"Actually, I did find two definite requirements when new interlockings are being provided."

Ruth was about to explain that her project was (thankfully) continuing to use the existing interlocking so she didn't really need to know, however she was conscious that the graduate had worked hard to find some answers for her so it might seem ungrateful. She ought to at least be aware of the new requirements – and it might be good CPD.

"OK, so if we were going to provide a new interlocking here, what would be the additional requirements?"

In the 1980s British Rail started to introduce Driver Only Operation (DOO) on some suburban networks. However, ongoing resistance from unions meant that DOO was never introduced on Waterloo services. The photo shows some overgrown CCTV monitors at St Margarets near Twickenham that were installed in the 1980s and then maintained in working order for many years, yet were never used. Was this accidental passive provision?

It's not just signalling. When the customer information system (CIS) was designed for Stockport station 30 years ago, it included passive provision for two abandoned bay platforms with no track. This was for a proposed Bolton to Stockport shuttle service that was never implemented. The photo shows the two now filled-in platforms, and no sign of the CIS displays. In the background can be seen the still-operational Stockport No 1 signal box.

"Well: firstly, all new interlockings must allow 25% spare capacity for future UTCS."

"I see – so how is that capacity measured?"

"I wondered that, it didn't really say – I'm guessing data..?" said the graduate tentatively.

"Or timers. Or latches. Or I/O channels, it could be any or all of those. So, what is the other requirement?"

"All new interlockings need two extra datalink sockets, labelled UTCS" said the graduate proudly.

By now Ruth was running out of acceptable facial expressions to convey her true feelings so she quickly thought of a follow-up question:

"Ooh, I suppose that seems sensible. Why are there two identical UTCS sockets?"

"Ah, that's obvious: you need two datalinks on modern computer systems for diversity and redundancy."

"Well yes I guessed that, what I meant was how do you know which socket is for which data link, surely they should be labelled differently?"

"The standard prohibits that because different UTCS suppliers might use data links called A and B, Left and Right or Master and Standby. It is important to be neutral on such matters."

Ruth wasn't sure whether to congratulate or console the graduate, however her thoughts were cut short by her phone ringing yet again. After politely thanking the graduate for their genuine efforts she answered the call. This time it was a pleasant surprise: it was an invitation to a special event.

A day out

Ruth was getting cold. Train depots were not the warmest of places, especially the outdoor bits, and the event had seen plenty of interest from across the industry so there was a queue at the access steps to board the train. It was the launch of the new H87 train, and Ruth had been invited by the Tiger Stripes train company because they appreciated how hard she and her team had worked to deliver the station project for their new trains. They had even provided a warm buffet beforehand, which seemed only fair.

Eventually Ruth got her turn and was able to visit the driving cab. Like most new train cabs there was an impressive array of buttons, lights and screens, and the air had that lovely aroma of newly manufactured electrical equipment and furnishings. The only thing that slightly detracted from the shiny modern ambience was a clumsy plastic cover fixed over what were presumably some extra buttons.

"What's under that cover?" Ruth asked one of the hosts.

"Ah, we were hoping people wouldn't ask that" said a sheepish-looking Tiger Stripes person. "If you really want to know: the door controls. The trains were specified for passive provision for drivers to operate the doors themselves sometime in the future, but the unions argued that it isn't passive if it already works. We had to cover up the controls before any driver would agree to move this train into place for the launch day."

She then moved along into the interior of the carriage. There was a cluster of important-looking visitors being shown around by a Tiger Stripes manager.

Presently he pointed to an equipment cupboard behind some seats and said:

"I bet none of you can guess what is inside this cupboard?"

The visitors started reciting a string of acronyms and terms covering everything from complex electronics and types of air valve, to spare cups for the buffet trolley, with no success. Having waited patiently Ruth decided to have her turn.

"Actually, I think I know what's in there."

The host raised an eyebrow and invited her to continue.

"Absolutely nothing" said Ruth.

The host looked simultaneously impressed and disappointed that Ruth may have stolen his finale.

"Really, what makes you say that?"

"Isn't it obvious? It's where the UTCS trainborne equipment should go, but at present nobody knows what to install so it's just an empty cubicle – it's only passive provision."

What do you think?

The term passive provision can be open to interpretation. It should mean to provide for the future where there is no extra cost. In reality this can be difficult to achieve without increasing the day one cost of a scheme. What do you think? Do we make adequate or too much passive provision? We would love to hear your views and experiences of providing passive provision, so why not let us know by emailing **editor@irsenews.co.uk**.

Industry news

ERA becomes cross-border rail traffic authority in Europe

Europe: The EU Agency for Railways (ERA) has assumed the responsibility for vehicle authorisation and safety certification. This is part of the EU's aim to create a Single European Railway Area, as well as to simplify railway-related authorisation and certification processes. Rolling stock manufacturers operating across the EU can now follow one single, integrated process to procure vehicle authorisations and single safety certificates.

Companies can also request European Railway Traffic Management System (ERTMS) trackside approval. All applications can be submitted through ERA's One-Stop Shop IT tool (OSS). After receiving the application, ERA will assign a project manager who will serve as the personal contact and adviser for the applicant throughout the process. Each of the applications will also be assessed by a dedicated multilingual expert team.

European nations Bulgaria, Finland, France, Greece, Italy, The Netherlands, Romania and Slovenia have already adopted the new system, while Switzerland will use the regime on a case-by-case basis starting this month. Other EU countries are expected to adopt the legislation by June next year.

Long-term digital development framework

UK: Network Rail has published a framework that sets out the long-term delivery of digital signalling, to bring significant benefits to passengers and help suppliers to plan resources.

The long-term deployment plan (LTDP) has been published in response to a request from the Department for Transport for a plan that shows future signalling renewals to be 'digital' (ETCS) or 'digital ready' beyond Control Period 6. The LTDP takes account of the scale and complexity of fitting out in excess of 4,000 trains and the upgrading of more than 19,000 miles of network, and shows how modern signalling and train control technology can be delivered in a way that makes the best use of renewals funding.

It proposes a partnership approach between Network Rail, the train operating companies (both passenger and freight), the rail industry supply chain and government. It recognises that the delivery of digital signalling requires multiple stakeholders to work together, coordinating budgets and asset renewal plans.

The plan was published alongside a two-day digital railway conference, hosted by Network Rail, that focused on closer working across the industry and how a new partnership approach to deliver the railway as a whole system will result in a better service for passengers.

Shift2Rail – ETSI and Future Railway Mobile Communication System (FRMCS)

Europe: Shift2Rail and ETSI signed a Memorandum of Understanding (MoU) in Paris at UIC's conference on the Future Railway Mobile Communication System (FRMCS).

Shift2Rail research and innovation results will be feeding ETSI working groups facilitating, under the leadership of the European Commission, the creation of the next future-proof standards for telecommunications applicable to the railway. Shift2Rail expects that this cooperative work among the sector will help the practical market implementation of solutions like wirelessly connected trains (next generation of train control management system or TCMS) and, together with the European Railway Agency, adaptable communication systems applied to train to ground communication for ETCS, but open to all rail mode needs.

Shift2Rail is also collaborating in the research area on railways signalling communication with the UIC project FRMCS. The consolidated approach would enable bearer independence, scalability and modularity enabling future-proof features of the successor of GSM-R that the European Agency for Railways will have to consider in the context of the new Control Command and Signalling Technical Specifications for Interoperability (CCS TSI).

SNCF – 4km test run of remotely controlled locomotive

France: SNCF has completed the first test run of locomotive hauling a flatbed wagon and a carriage travelling 4km between Villeneuve-Saint-Georges and Juvisy, Paris, by remote control. The test train was driven remotely from a control centre established at Vigneux-sur-Seine, and follows 18 months of research and development.

The run tested satellite transmission and the use of a private cellular LTE network equivalent to 4G. Cameras fitted on the locomotive provided real-time images for the driver in the control centre, who accelerated and braked the train. SNCF announced in September 2018 that it is partnering with French state-owned research institute Railenium alongside Alstom, Altran, Ansaldo STS and Apsys on the freight element of the autonomous trains project, which involves equipping an Alstom locomotive for Grade of Automation (GoA) 4 operation.

The test was a key step in the project and will allow further tests to be undertaken focusing on developing the techniques and equipment in preparation for commercial applications and to combine the deployment of satellite communications and 4G technologies. The project has also succeeded in automating the recognition of signals, and will move forward with the automation of obstacle detection in the coming months.

SNCF has agreements with two consortia to develop and integrate autonomous passenger and freight train prototypes for main line infrastructure at GoA 4 by 2022.

New UK interlocking

UK: The first implementation of SNC-Lavalin Atkins' new digital interlocking technology on a UK passenger-carrying line was commissioned on 22-23 June.

The control system covers a short section of line between Fulwell and Strawberry Hill in southwest London. It is controlled by a VDU-based signalling workstation within Feltham signal box, but control will eventually be transferred to the Basingstoke Rail Operating Centre.

The commissioning forms the first stage of Network Rail's Feltham area resignalling project which is being undertaken over several years. It follows a successful roll-out of the system on non-passenger lines within the Crossrail depot at Old Oak Common.

The signalling system, with the ElectroLogIXS interlocking at its core, uses Newgate barrier machines; an auto re-configurable power supply; a Resonate Scalable control system; a telecoms multi service network to support ElectroLogIXS; Frauscher axle counters; Camlin, remote condition monitoring and CCTV transmission; centralised Frauscher axle counter system for train detection; and a 650Vac lineside signalling power distribution with Camlin auto-reconfiguration.

New processes for the design and verification of their control systems have been developed, along with producing a library of approaches which will streamline the design of future systems. The hardware is modular and IP network connected, enabling equipment to be placed in easily accessible locations to reduce the amount of time that staff need to spend trackside.

Atkins estimates that the resignalling of all the Feltham signalling project area with conventional SSI would have required in the order of 3000 relays and 450 lineside equipment locations. Using their new system this will reduce to approximately 130 relays and 220 lineside equipment locations, resulting in a step change in reliability. It will also create a 20% capital saving compared to older systems, with a 65% life-cycle cost saving over 30 years.

The next deployment of the system is expected to be between Norwich, Great Yarmouth and Lowestoft in early 2020.

Three-year ETCS project

Sweden: Trafikverket has started work on a three-year project to resignal the Malmbanan heavy haul line between Boden and Riksgränsen with digital interlockings and ETCS at an estimated cost of SEK3bn (£255m, €280m, $310m). The contract has been awarded to Umeå-based Eitech Engineering AB.

Most of the existing interlockings on the iron ore corridor are more than 50 years old, and around 40% of the equipment will be life-expired by 2022-23. Interlocking replacement has thus become an urgent priority, ahead of the roll-out of ETCS, and will account for around 90% of the total cost. However, the work will be co-ordinated with other planned capacity enhancement measures including the lengthening of selected passing loops. The number of interlockings will be reduced from 50 to seven.

Trafikverket had decided to start the resignalling project on the 'least sensitive' section of the Malmbanan between Gällivare and Råtsi. Installation of a new optic fibre communications link began in May, and work on the resignalling started near Gällivare on 4 July . Commissioning of the new interlockings is to be completed by 2022.

CRRC unveils SigThemis ETCS solution

Sweden: At the UITP Global Public Transport Summit in Stockholm on June 10, CRRC Corporation Limited of China presented its SigThemis ETCS solution. Developed by CRRC Zhouzhou Locomotive Institute, SigThemis is based on the specification for SRS 3.6.0, which was published by the EU Agency for Railways in June 2016.

Presenting details of the technology, Geng HongLing, vice chief engineer for CRRC Times Signal & Communication, said the Radio Block Centre (RBC), Computer-Based Interlocking (CBI), European Vital Computer (EVC) and Centralised Traffic Control (CTC) are SIL4-certified and compliant with relevant TSIs.

The CTC has a triple-redundancy architecture to optimise reliability and the EVC can support standardised interfaces with legacy national signalling systems. SigThemis can simultaneously support baseline 2 and 3 functions.

CRRC says SigThemis is also fully interoperable with its Chinese Train Communication (CTCS) Level 0 technology. CRRC's CCS research unit is now developing vehicle-to-vehicle communication through SigThemis as part of its work on Automatic Train Operation (ATO).

Atlas Spanish ERTMS Level 2 high-speed in commercial service

Spain: Alstom's Atlas train control system has entered commercial service on the Valladolid-León high-speed line in the north of Spain. The contract from Adif, was awarded to an Alstom-led consortium in 2014, to upgrade the Valladolid-León section with ERTMS Level 2.

The project will see the Valladolid-León line running with increased safety and availability, with maximum speeds increasing from 200 to 300km/h.

The contract includes the design, procurement, installation, commissioning and 20 years of maintenance of the signalling, fixed telecommunication and Automatic Train Protection systems, the centralised traffic control, security equipment, the mobile GSM-R communications equipment and infrastructure for trains and mobile phone operators.

Kazakh digital signalling

Kazakhstan: Kazakhstan Railways (KTZ) has signed a memorandum of understanding (MoU) with Alstom for the development of digital technologies for railway signalling.

The agreement covers the development of digital signalling and interlocking technology, which will be implemented during the modernisation of interlockings at Kazakhstan's largest stations.

The MoU follows an agreement signed on 29 July between Azerbaijan Railways (ADY) and Alstom to provide technical support for ADY's locomotive fleet.

Australia's first driverless metro

Australia: Sydney Metro, Australia's biggest public transport project, has opened the North West Metro and the start of revenue service, delivering Australia's first fully automated, driverless metro service.

The Metro North West Line is stage 1 of Sydney Metro and includes 36km of track, 13 stations and a depot. The new network will provide a level of service with a train every four minutes in the peak in each direction.

Alstom has been responsible for the project management, design, supply, manufacturing, testing and commissioning of 22 six-car Metropolis trains and their Urbalis 400 CBTC signalling systems. The contract includes a 15-year maintenance contract for the trains, signalling, depot operations and equipment.

The trains include three double-doors per car for improved access and passenger flows, large windows and ambient LED lighting. They will also have the highest levels of customer safety including real time CCTV monitoring, emergency intercoms and the way-finding aids for customer information and real time travel information.

The CBTC system operates in unattended train operation (UTO, GoA4) and delivers moving block with safe braking distance between trains, interfaces with rolling stock, platform screen doors and communications and Automatic Train Supervision. Driving profile and dwell times are regulated automatically to achieve run times, optimise performance and manage delays.

Communication is via 5.8GHz Wi-Fi, which also delivers in-train real-time CCTC coverage with eight video streams per train. Platform screen doors (PSDs) at three new underground stations provide segregation of passengers at platforms from track and moving trains. Platform

Edge Barriers (PEBs) are provided at all other stations, synchronised with train doors for authorisation, timing sequence and interdependent isolations via interfaces with the signalling system, together with obstacle detection on both train and platform doors.

The Metro line is currently being extended from Chatswood to Bankstown via the City and by 2024 Sydney will have 31 metro stations and a 66-kilometre standalone metro railway in addition to its extensive suburban rail network.

New Bahrain Metro

Bahrain: Al Zayani Engineering, KPMG and PriceWaterCoopers (PwC) have been shortlisted for a contract encompassing technical, financial and legal consultancy services, to assist in the tender process for the design, construction and operation of phase one of a new metro project.

Costing up to $2bn (£1.6bn, €1.8bn) the Bahrain Metro project will include a 184km-long network comprising six lines and will be implemented in four phases. In the first phase, two lines encompassing a 30km-long network covering 20 stations will be built.

Driverless metro for South America

Chile: Metro de Santiago has selected Systra to provide consultancy services for construction of driverless metro Line 7, including the design of railway systems, workshops and rolling stock.

Line 7 is one of three new routes and four extensions announced by President Sebastián Piñera in June 2017. These would add 57 route-km and 44 stations to the city's metro network. Construction of the 25km east-west line with 19 stations is expected to begin in 2020 for completion by 2026 at an estimated cost of $2·5bn (£2bn, €2.2bn).

Passenger service begins on Doha metro Red Line

Qatar: A soft launch for the driverless Doha metro took place on May 8 with the start of passenger services on the Red Line operating on the section between Al Qassar in the north and Al Wakra in the south, with 13 stations.

The four-station section between Al Qassar and Lusail, and a branch to Hamad International Airport, are due to open by the end of the year, along with the east-west Gold and Green lines. The Gold Line will run from Al Aziziyah in the west to Ras Bu Abboud in the east, with the Green Line running from Al Riffa in the west to Al Mansoura in the city centre. Interchange between the three lines will be provided at Msheireb.

Kinki Sharyo is supplying the three lines with 110 three-car trainsets from its factory in Osaka in co-operation with Mitsubishi Corp as part of the railway systems consortium, led by Mitsubishi Heavy Industries. MHI is also responsible for the track, power supply, platform screen doors and tunnel ventilation. Thales is supplying CBTC, telecoms, a security system, an operations control centre and an automatic fare collection system. Hitachi is undertaking facilities maintenance.

Automatic passenger counting

France: Thales has selected Eurotech to supply embedded hardware and internet of things software for the automatic passenger counting systems to be installed on trains for the future Grand Paris Express metro lines 15, 16 and 17. The project will require at least 1400 passenger counters, and potentially up to 4 250.

These will collect data on the number of people in each vehicle at every station, to help manage services and improve passenger information. Eurotech is to supply its DynaPCN passenger counters along with its Everyware Software Framework data collection and remote configuration technology.

Smart railway programme

Saudi Arabia: Saudi Railway Company (SAR) has entered a memorandum of understanding with Huawei to initiate smart railway programme. Under the partnership, SAR and Huawei will collaborate on a range of smart railway initiatives, including the application of a next-generation railway wireless network, Internet of Things (IoT), artificial intelligence (AI) and cloud services. The partnership will also explore the idea of deploying 5G technology across the SAR rail network.

Established in 2006, SAR is one of two state-owned companies to operate Saudi Arabia's railway network. With the two-year contract, SAR aims to procure real-time information of railway tracks as the Saudi Arabian railway faces extreme weather conditions, with temperatures reaching up to 55°C.

Long Term Evolution Automatic Train Protection System

India: Indian Railways has signed a memorandum of understanding (MoU) with RailTel Enterprises (REL), a wholly-owned subsidiary company of RailTel Corporation of India, to upgrade its signalling systems.

The scope of modernisation includes Automatic Train Protection System with Long Term Evolution (LTE) based Mobile Train Radio Communication System (MTRC), with the deployment of electronic interlocking. The signalling system will be implemented in four different sections, which are among the busiest routes in the country.

It includes the 165km-long Renigunta-Yerraguntla section of the South Central Railway, the 155km-long Jhansi-Bina section of the North Central Railway, the 145km-long Vizianagaram-Palasa section of the East Coast Railway and the 175km-long Nagpur-Badnera section of the Central Railway.

The MRTC will be deployed utilising a LTE backbone to enable connectivity between all rail staff, including drivers, guards and control office. Initially, the system will be provided on 500 locomotives and overall, the project is expected to cost Rs16.09bn (£190m, €210m, $231m) and is expected to complete in 2021.

Tram collision and overspeed safety system to be tested

Europe: Bombardier Transportation launched its Collision & Overspeed Monitoring & Prevention Assistance System for trams and light rail vehicles at the UITP Global Public Transport Summit 2019. Testing of the technology will take place on trams in Wien and Blackpool.

Developed in co-operation with the Austrian Institute of Technology & Mission Embedded, COMPAS builds on Bombardier's Obstacle Detection Assistance System that has been in service since 2017 and is now used by five light rail operators.

COMPAS incorporates vision-based overspeed prevention and automated obstacle detection assistance. Bombardier expects COMPAS to be granted commercial service authorisation by mid-2020.

Collision warning system for trams

Netherlands: Amsterdam city transport operator GVB has invited tenders for the supply of a collision warning system for its fleet of 155 Siemens Combino trams, saying this would assist tram drivers, help improve road safety in the increasingly busy city and reduce damage to its vehicles.

GVB envisages that cameras or radar systems on the front of a vehicle would provide an audio and visual warning if there were a risk of a collision with another road user or an object on the line.

This follows tests using seven trams on Route 17. The intention is that the roll-out across the Combino fleet will be completed by mid-2020.The 63 new 15G trams that GVB has ordered from CAF are to be supplied with a warning system fitted as standard.

RSSB "Over the Horizon"

GB: The Rail Safety and Standards Board (RSSB) has introduced a "Over the Horizon" series of articles which focuses on the New Mobility Services landscape and its implications for rail transport in the coming 5-10 years. RSSB say it is a topic of strategic importance for the industry, and RSSB has partnered with the new Connected Places Catapult to deliver the initiative.

Driven by technological innovation in wireless connectivity, sensor networks, location data, digitisation and social media platforms, new passenger transport options have developed in dense urban areas, to rethink mobility.

Whether car sharing, bike sharing, ride hailing, ride sharing, microtransit solutions (e.g. small buses on demand), Mobility-as-a-Service (integrated transport bundles), or shared autonomous vehicles, New Mobility Services (NMS) have the potential to blur the line between public and private transport, between owned and shared vehicles.

NMS operate a shift from traditional scheduled transport towards user-centric and on-demand mobility solutions which embody the idea that transport should be responsive to the needs and preferences of travellers and of society.

Plan to make UK private level crossings safer

UK: Improved signage to protect motorists and pedestrians using private level crossings could be introduced under plans announced by the UK Department for Transport. Private level crossings are intersections where a railway crosses a road or footpath on private land. The gates often need to be operated manually with some crossings requiring users to telephone a signaller to check that it is safe to cross.

There are around 2 500 private crossings in the UK, representing more than a third of all level crossings on the network. To improve safety at these crossings, the Department for Transport has worked closely with Office of Rail and Road (ORR) and Network Rail to revise and make improvements to the signage used.

New designs have been tested at Cannock Chase in Staffordshire since August 2018. The government now intends to introduce legislation to the Private Crossings (Signs and Barriers) Regulations 1996 which would see these new designs brought onto the network next year.

Successful six-month point machine test

Kazakhstan: The national railway KTZ, in cooperation with KazElektroPrivod the equally owned joint venture of Alstom and SOP Trade, has completed a six-month test of their P80 point machine on a turnout designed by Prommashkomplekt and installed at Shiderty station.

The locally manufactured P80 has a design life of 20 years and is suitable for main lines, freight and metro use at speeds up to 180km/h. The KTZ Ekibastuz signalling and communication department found no technical issues during the tests, which included 1 200 operations in winter temperatures as low as -40°C.

Wi-Fi for Californian intercity trains

USA: In America the Capitol Corridor Joint Powers Authority (CCJPA) has selected Nomad Digital to install, test, operate and maintain a Wi-Fi network on-board Capitol Corridor trains operated by the CCJPA and their service partners.

Built on Nomad's router technology platform, R5001, and Connect software, the Wi-Fi solution includes a service-based delivery model for all hardware, software, facilities, utilities and labour.

The network will ensure CCJPA's wireless infrastructure and supporting systems deliver good capacity, performance and operational reliability over the initial five-year contract. The network will evolve over the term of the contract, allowing upgrades to be sequenced onto the train fleets replacing obsolete systems.

Middle East railway communications

Israel: Motorola Solutions has won a contract to supply Israel Railways with up to 3000 push-to-talk over cellular mobile devices equipped with its WAVE group communication service, and to operate and maintain the network for three years.

The system is intended to support operational communications across the rail network, including offices, yards and depots. Motorola said WAVE would eliminate the barriers between devices, networks and locations, allowing users with radios, smartphones, tablets and laptops to communicate seamlessly and share voice, text, photos and video with individuals or groups.

European Commission's Delegated Act on C-ITS for Vehicle-to-Vehicle radio systems.

Europe: The GSM Association (GSMA) is urging European lawmakers to reject the European Commission's Delegated Act on C-ITS (Cooperative Intelligent Transport Systems) because it favours Wi-Fi technology over cellular alternatives C-V2X and eventually 5G, according to a Reuters report. The proposed legislation sets out guidelines and rules for C-ITS that are intended to improve road safety and traffic efficiency across the EU.

The C-V2X direct communication mode is designed to offer vehicles low latency communications for Vehicle-to-Vehicle (V2V), Vehicle-to-Roadside Infrastructure (V2I) and Vehicle-to-Pedestrian (V2P).

The GSMA's position is that the Wi-Fi technology favoured in the Delegated Act, ITS-G5 based on the 802.11p standard, is outdated and inferior to cellular-based C-V2X in terms of security, reliability, range and latency. Also, the standalone Wi-Fi technology doesn't integrate easily with other smart city communications systems. But C-V2X does because it uses existing 3G and 4G networks and will be compatible with 5G.

New trains for Docklands Light Railway (DLR)

UK: CAF has been awarded the contract to design, manufacture and supply a fleet of 43 trains for the DLR by Transport for London (TfL). The DLR is an automated light metro system serving the Docklands area of East London, England. It reaches north to Stratford, south to Lewisham across the River Thames, west to Tower Gateway and Bank in the City of London financial district, and east to Beckton, London City Airport, and to Woolwich Arsenal south of the river Thames.

Originally the DLR used signalling based on a fixed-block technology developed by GEC-General Signal and General Railway Signal. This was replaced in 1994 with a moving-block TBTC (Transmission Based Train Control) system developed by Alcatel, called SelTrac.

The new five-car trains will be based on CAF's metro vehicle design, with the first entering passenger service from 2023. Thirty-three trains will replace DLR's oldest rolling stock which is nearly thirty years old and will increase frequency and capacity across the network.

News from the IRSE

Blane Judd, Chief Executive

Changes to the IRSE Professional Exam

This year's exam date is Saturday 5 October 2019 for all exam centres, and the opportunity to book exam modules for this year is now closed (closing date was 30 June).

The IRSE Education and Professional Development committee has carried out a major review of the IRSE Professional Exam to ensure it continues to meet the needs of both the industry and Institution members. For those planning to sit the exam in October 2019 and/or October 2020, they will see no change to the current status of the compulsory module 1 (safety of railway signalling and communications) plus three other optional modules from the seven available.

In October 2020, an additional new paper will be available to sit, testing a breadth of knowledge and understanding across all aspects of signalling, control and communications engineering. This new paper will be called "Module A – Fundamentals of Railway Control Engineering" and will be a qualification in its own right and also a pre-qualification for sitting the more advanced modules. From October 2021 onwards, only the new "Module A" plus three new compulsory advanced modules will be available. These new modules will cover the current full exam syllabus with a wide range of questions to enable candidates to answer questions relevant to their own specialisation.

Passing all four new modules will lead to the qualification of the "IRSE Professional Examination" just like today. Those who have/will have passes in the current exam will not lose out, they will not have to start the exam again, and there is no time restriction for them to continue their studies. The IRSE Professional Exam remains a high standard of professional knowledge and is acceptable as a 'top up' to suitable qualifications for registration as Incorporated Engineer and Chartered Engineer status.

Blane's world

The past few months have been hectic, productive and frustrating – not necessarily in that order! First of all, can I thank all members for their patience and understanding whilst we undertook the long and, at times frustrating task of launching the new IRSE website. I am pleased to say that it is now live, albeit with a few minor teething problems that we should hopefully have ironed out by the time this edition of IRSE News is published. The new website has far more functionality than any of its predecessors and will ably meet the needs of our Institution for many years to come.

I have been working on the new strategic vision for the IRSE to take us beyond 2020. I shared this with Council and more details will be published in a future edition of IRSE News.

Part of my role involves meeting with other Institutions and engineering organisations to represent our industry and make sure our voice is heard. In May I met with the Engineering Council. I have been asked to chair the Engineering Technician development group on behalf of IRSE to bring together interested professional engineering institutions (PEI)s to promote EngTech registration. This is particularly important as the IRSE will be engaging in End Point Assessment of apprentices and our licence is linked to EngTech readiness. Later that same week I represented the IRSE at a meeting of all Professional Engineering Institutes PEI leaders where we discuss important matters such as the mutual global recognition of professional engineers. This was followed by feedback on the further research following Professor John Uff's research into the "missing three million" (irse.info/fc9wx).

In July I represented the IRSE at the Digital Railway Steering Group, working in conjunction with WSP and other stakeholders where we discussed plans for a forthcoming workshop. I also met with an End Point Assessment Organisation to agree processes for assessing apprentices for EngTech readiness.

The IRSE takes over the secretariat of the Rail Engineering Forum this year and Andrew Simmons from Network Rail will be chairing the group on behalf of the IRSE. I attended a meeting to discuss the handover and am looking forward to the many opportunities chairing this important industry group will give us.

Members' Lunch boosts charity funds

We are delighted to let members know that another £220 was raised at the June member's lunch (in London) for RedR through sales of the IRSE heritage logo cuff links, tie pins and donations.

The event gives UK members the opportunity to catch up with past and present colleagues and friends over a convivial lunch which this year was held once again at the Union Jack Club in London.

For 2019 it was decided to boost the impressive £3300 total raised for the disaster relief engineering charity at the IRSE annual dinner. Event organiser and executive assistant to the IRSE chief executive Hilary Cohen, had the idea to sell the memorabilia in aid of charity.

Hilary said: "Now that we have our new branding, we were wondering what to do with the small stock of tie pins and cuff links we still had bearing the original Institution logo. It occurred to me that the annual luncheon would be the perfect place for us to combine raising more money for RedR with giving members the opportunity to own a piece of IRSE history. We gave away the memorabilia in exchange for a donation, and I was touched as always by the members' generosity."

Merit Awards

Each year the IRSE Council recognises a member or members who have made an outstanding contribution to the Institution through nominating them for an IRSE Merit Award. For 2019, two awards were made. David Nicholson FIRSE was recognised for his assistance to Institution members in their preparation for the professional exam and Ian Moore FIRSE received his award in recognition of his long service to the Institution and in particular the York Section. I had the honour formally presenting David with his award at Atkins offices in Victoria, London.

Blane, right, presented an IRSE Merit Award to David Nicholson.

First Presidential Paper

On 1 October 1730 at Broadway House, Tothill Street, London SW1H 9NQ our first presidential programme lecture of president George Clark's year will take place. Andy Bourne of Arcadis will present "Delivering change through intelligent traffic management". For more information on this and other IRSE events visit irse.info/events.

Future communications systems: IRSE Presidential Programme seminar

Recognising the rapid rate of change in telecommunications and the impact of this technology on our industry, a host of leading industry voices from Transport for London, Network Rail, communications experts and suppliers will be taking part in a seminar on future communications systems.

This event will run from 0900 to 1700 on Thursday 7 November (a change to the original published date) at the Institution of Civil Engineers, 1 Great George Street, London, SW1P 3AA.

This event will be of interest to anyone with a vested interest in the future of signalling and communications systems within the mainline and metro railway environment, in particular those specifying or delivering future renewals projects, existing and prospective suppliers signalling and train control suppliers and major network operators. For more information and details on how to book visit irse.info/futurecomms2019.

IRSE Scottish Section Annual Dinner

The Scottish Section will be holding their Annual Dinner on Thursday 14 November at the Marriott Hotel on Argyle Street, Glasgow, for 300 guests. Open table tickets are £25 for Members, with differing prices for Younger Members and for non-member guests, and full tables can be ordered for corporate hosts. Please contact Peter Allan for further details at peter.allan@siemens.com.

CBTC conference

The IRSE is pleased to announce that the 4th CBTC and Beyond conference will be held at Fairmont Royal York in the downtown Toronto, Canada on Thursday 28 and Friday 29 November 2019. This year, we are looking into presentations covering all advanced and communications-based train control solutions. On 29 November, there will be the opportunity to visit Metrolinx's largest transit expansion, Eglinton Crosstown LRT, under construction by Crosslinx Transit Solutions (CTS) – a consortium of ACS-Dragados, AECON, EllisDon and SNC-Lavalin.

The opulent surroundings of the Atrium at The Landmark hotel, venue for the 2020 IRSE Annual Dinner.

The keynote speaker at the conference will be Phil Verster, Metrolinx president & CEO. Papers will include topics on; Analysing, assessing and comparing Communications-Based Train Control (CBTC), European Train Control Systems (ETCS), Positive Train Control (PTC) systems and other Enhanced Train Control (ETC) systems; updates for advanced technology train control projects currently being implemented or planned for Light Rail Transit (LRT), metros, intercity, freight and commuter rail systems; providing lessons learned in implementing advanced train control systems in a brownfield environment; actual revenue service operating and maintenance experience; looking to the future, what are the user business needs? and what research & development is currently underway on new/improved technologies to further improve operating performance while reducing life cycle costs. See the IRSE website (irse.info/cbtc) for booking details.

IRSE Annual Dinner 2020 – save the date

The 2020 IRSE Annual Dinner will be held on 24 April at a brand new, larger venue, the Landmark hotel at 222 Marylebone Road, London. This allows us to expand the event from a capacity of 350 guests to 500. Pricing will be the same as 2019 at £159 a head and pre-dinner hosting arrangements remain unchanged. Order forms and more details will be available in December.

Indonesian visit

The London office was recently delighted to welcome members of the Indonesian section, Yanto Yulianto and Ahmed Sugiana, pictured below.

London office

Polly Whyte, our new head of membership and registration

Lindsay Jones

Polly Whyte has joined the IRSE head office team as head of membership and registration, taking over from Christine White who retired earlier this year after 13 years of service to the Institution.

Polly has considerable experience of working in similar roles within other professional bodies. Lindsay Jones met up with her earlier this month to find out more about the woman behind the role.

Tell me about your career so far?

I came into the engineering world via a circuitous route. After completing my degree in politics and economics I started work with Kent County Council where the two most formative roles I had were within the economic development department and directly supporting the Leader of the Council.

Whilst there I was lucky enough to meet many interesting people from industry, politics and the arts who lived and worked in Kent, one of whom introduced me to the world of professional engineering institutions. He encouraged me to apply for the brand-new role of regional development manager with the IEE (IET as it now is). It was a role I loved and which developed from simply supporting local branches to working with companies and encouraging and supporting engineers through professional registration.

From here I joined one of the companies I had been working with to support their succession planning activity. The organisation was concerned that a large percentage of its engineering workforce was approaching or over the magic age of 50 and positive action was needed to attract new blood. Of the many projects I worked on two stand out. In the first I headed up a team that worked with 14-19 year olds within schools and colleges opening their eyes to the job opportunities in engineering and encouraging them to study the subjects that would help them enter this world. In the second I developed training programme from scratch that sat alongside the company's graduate training scheme and the apprenticeship programme to take the best apprentices as well as new, specifically recruited, employees through to IEng registration. This included working with a London university to design a BEng qualification specifically for the company, completed on a day release basis.

I was then appointed to the EngTechNow campaign, a two-year collaborative programme between the Gatsby Foundation, the Engineering Council and the three largest engineering professional bodies in the UK (IET, IMechE and ICE). The aim of the campaign was to change the image and raise the profile of the technician workforce in the UK whilst demonstrating the benefits of professional registration to technicians, industry and the wider public.

What attracted you to the IRSE role?

Working within the engineering community has been a rewarding and inspiring part of my working life. It has provided me with an appreciation of the important role professional bodies play in supporting and encouraging individual engineers to achieve their potential and improve the safety and environment of the wider world.

The opportunity to get back into this sphere of work and to use my knowledge and experience to support the IRSE and its members was the main driver in my applying for the position. My short time here has felt a bit like coming home!

What are your first impressions of the Institution?

My first impression of the IRSE is that of an organisation with fantastic volunteer support and masses of potential. Until I got here, in common I suspect with many other people, I had the impression that there was a large number of people working at head office. In fact it's the opposite. The team here is small and the vast amount of work they have achieved is testament to their commitment and dedication to the Institution.

I have joined the IRSE at an exciting time. We are nearing the end of the current 2015-2020 strategy and entering the next phase of the Institution's future. We have a strong team in place led by chief executive Blane Judd and I look forward to working alongside colleagues at head office as well as members to deliver the new 20/20 strategy.

London & South East Section

Annual General Meeting

Report by Trevor Foulkes

The London & South-East Section held its very first AGM at Arup's offices in London on 21 May 2019. 43 members attended including the IRSE president and chief executive. The meeting started with Simon Eastmond giving a short presentation on the work that Arup UK Rail is currently involved with in the signalling area in the UK.

Trevor Foulkes (chair) then welcomed everyone to the meeting and introduced the president, George Clark. George said how pleased he was that the L&SE Section had quickly been established and was so successful. Trevor thanked Transport for London for making rooms available to for the meetings during the year and for ARUP for hosting the evening. He also thanked the members of the committee for their support throughout the year.

Mike Ward (secretary) presented a summary of the year's events which covered a diverse range of subjects, most of which have been reported in the IRSE News. Trevor presented a draft programme of events and talks for the year ahead. Vincent Louie (treasurer) was unavailable due to family issues, so Trevor gave a summary of the year, which included the section receiving £1500 from the IRSE London office to assist with the section establishment.

The current committee members are chair Trevor Foulkes, vice-chair Jerry Morling, secretary Mick Ward, treasurer – Vincent Louie. Committee members Paul Baker, Konstantinos Banias, Paul Callaghan, Rod Muttram, Anil Rana, Vivich Silapasoonthorn and Benoit Surroca.

As no nominations were received for 2019-2020, it was agreed that the current committee members should continue. The AGM was followed by three short papers.

The first of these was "The origin of standards for ETCS" presented by Richard Stokes

Richard explained the origins of the ETCS Standards, how the CENELEC Standards were initially developed and how they changed since the installation of ETCS in Germany, France and the Cambrian lines in the UK. He said that the driving display icons needed to be standardised across the manufacturers in order to keep displays consistent for the driver. Richard explained that some trains had up to nine different types of train control equipment making it confusing for the driver.

The second paper, presented by Judith Ward and Polly Whyte was on the subject of the value the IRSE can bring to its members.

Judith and Polly described the organisation and roles within head office. Judith then gave an overview of the licensing scheme and how these were being aligned to registration. Polly described the levels of membership and how members can gain Engineering Council registration through the IRSE. Judith followed this with a talk on professional development and how events can contribute to CPD. Finally, Judith gave an overview of how the professional examination is to change in the near future.

The presenter of the last short paper was unavoidably detained, so Blane Judd, chief executive talked about the future direction of the IRSE.

Blane described how he thought an engineer, although he/she might be a member of the IRSE, should be able to get information from any professional engineering institution. Signalling today is not an isolated skill but needs to integrate with many other disciplines to deliver projects. This developed into a general discussion within the meeting.

From left to right. The event was well attended.
Section chair, Trevor Foulkes.
Polly Whyte and Judith Ward.

Midland & North Western Section

IRSE
Institution of Railway Signal Engineers
MIDLAND & NORTH WESTERN SECTION

Churnet Valley Railway – technical visit and steam lunch

Report by Ian Mitchell

The Midland and North Western Section has a long established tradition to combine a family social event and meal with a chance to see the latest signalling developments on one of the heritage railways in our area. On 29 June 2019 we visited the Churnet Valley Railway in Staffordshire for lunch on a steam hauled train and a visit to three signal boxes.

This particular heritage railway has a rather more complicated geography than most. Two routes of the North Staffordshire Railway crossed at Leek Brook Junction just outside the town of Leek – a north-south route from Macclesfield to Uttoxeter and an east-west route from limestone quarries at Cauldon Lowe to Stoke-on-Trent. The present operation is comprised of parts of both routes south and east of the junction, with plans to extend northwards back into Leek. The track linking westward to the main line network at Stoke-on-Trent still exists in a derelict state and might be revived for commercial freight traffic in future.

Our visit began at Cheddleton station where we were greeted by Emma Haywood and Dominic Beglin representing the railway's S&T Department. The signal box here was relocated from Elton Crossing on the Sandbach to Alsager branch and is a typical North Staffordshire Railway design with a McKenzie & Holland lever frame using 'cam and soldier' locking. This currently serves as a shunting frame controlling access from the yard to the running line, but it is being extended and altered to allow reinstatement of a crossing loop with full signalling. The box also houses instruments that allow no-signaller key token working north to Leekbrook Junction and south to Consall.

We then joined the train for the short run to Consall. The railway closely follows the River Churnet and the Caldon Canal along the valley, and the waiting room at this station is cantilevered out over the canal. The signal box here has another McKenzie & Holland frame, but this is fully operational controlling a crossing loop.

Then it was back on to the train for a complete round trip of the line north and east to Ipstones, then back to the southern terminus at Froghall, and finally to Leekbrook Junction where our S&T Department guides had patiently waited while we finished our meal. The signal box here is the original one at the location, externally restored but not yet in operational use. There is an ambitious plan to re-instate the triangular junction here to allow trains from both the existing routes to access the proposed new station in Leek.

An excellent day out was enjoyed by 40 members and guests, thanks to the generosity of our sponsor, Haywood & Jackson Fabrications Ltd, and the hospitality of our guides from the railway.

Top, the McKenzie & Holland lever frame in Consall signal box.
Above, the MNW group visiting Cheddleton signal box.

Minor Railways Section

IRSE
Institution of Railway Signal Engineers
MINOR RAILWAYS SECTION

2019 Annual General Meeting and visits

Report by Ronald H Whalley

As the outgoing chair of the section, I have been volunteered to record the two visits which Mike Tyrrell and I had worked on for the previous nine months to coincide with the sections' AGM and tenth anniversary.

Now nine months to organise two visits seems a long time, but, in the ever-changing world of both the professional and 'heritage' rail industry the frequent changes of staff and even, initially, difficulties in making contact with the correct person soon absorbs whatever contingency there is in the annual timetable. As the date approached the final numbers were agreed, 25 plus two children for the Saturday AGM and visit, and 14 for the Sunday event.

The AGM and Saturday visit was at the East Lancashire Railway (ELR) at Bury, north of Manchester. The meeting took place in the very well-appointed transport museum building which was the first headquarters of the ELR and just a couple of hundred yards away from the ELR main station in Bolton Street.

During the organisation of the meeting, Mike and I had discussed the timetable for the day in order to have the morning meeting, a lunch and then cover as much of the route as possible, with visits to at least two signal boxes. As we congratulated ourselves on the first draft we were suddenly thwarted by a change of timetable due to a wedding train having been booked on the same day. A second draft showed that the AGM must not take longer than 25 minutes and the lunch would have to be pre-packed and eaten on the train. Such is the task of the timetabler!

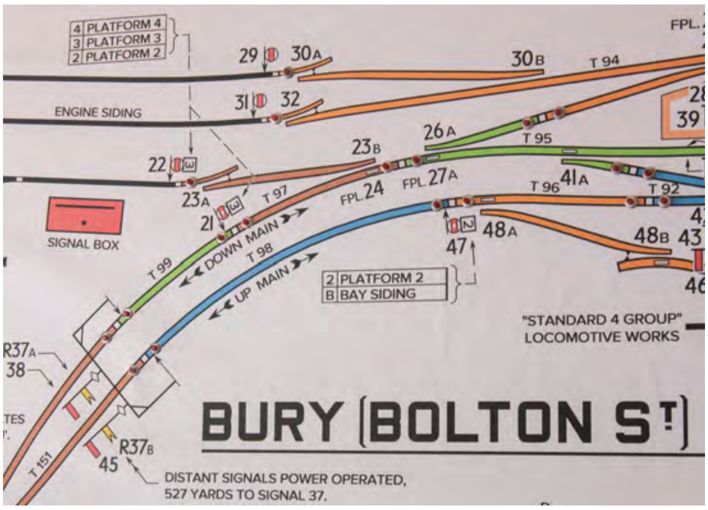
The principal themes of the AGM were succession management, the raising of our profile amongst a wider audience, the launch of the 2019 Volunteer S&T Technician of the Year award and the potential challenge of more stringent competency requirements by ORR in the heritage sector, something which the section has been working on for some time.

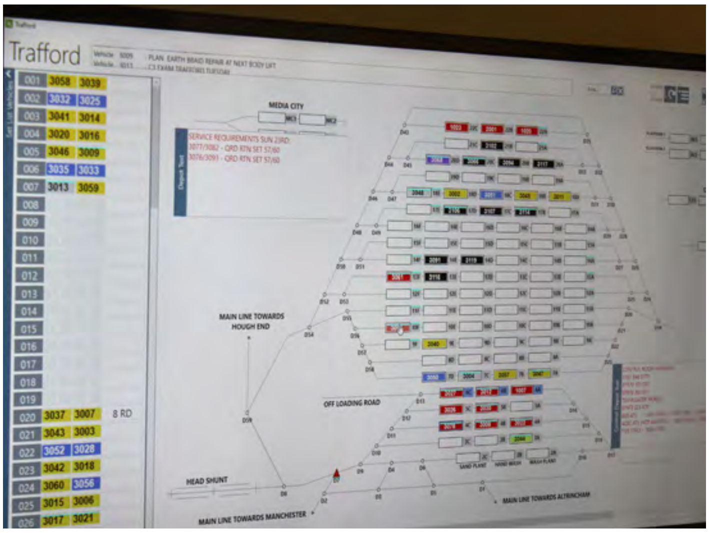
Once the AGM official business had been completed (in a record time of around 20 minutes) we were given an excellent presentation on the history and signalling of the ELR by their director of signalling, Peter Duncan. Peter has been involved with the ELR since its inception and I am sure that many of the delegates who are responsible for signalling on minor railways had great empathy with the travails which Peter illustrated during the development of the system for the ELR.

Following the presentation, we moved to Bolton Street station where we collected lunch and boarded the well filled 11.55 to Ramsbottom. Here we divided into two groups to visit the signal box which controls the loop which has a busy road crossing at one end. Any railway risk assessment here would show that trying to cross the road is far more dangerous than any railway activity!

The signal box here contains a 40 lever LMS style frame. The section from Bury Bolton Street, which was originally worked by token, now uses an acceptance lever with track circuit block whilst the next section to Rawtenstall is worked by Tyers key token. Most of the railway uses traditional mechanical 'rodding and crank' drives, the south end loop points are motor worked.

From the Saturday visit to the ELR. Left, Bury Bolton Street signal box diagram.
Right, waiting to visit Ramsbottom signal box.
All photos P J Woodbridge.





Photos from the Sunday visit to Manchester Metrolink. Left, tram locations within Trafford Depot. Right, a collision-damaged tram.

At 13.20 we boarded the next train to Rawtenstall where, during the run round time, many delegates were seen to be eating ice cream from the strategically placed buffet car in the back platform.

Just outside Rawtenstall is a highly skewed level crossing which was gated and used to lead to a small industrial site. Following a 'road improvement' by the Local Authority (LA) in 1988 the road was widened which then required four gates and a 12inch (300mm) lift in order to provide a station gradient of 1 in 264 as the station was then a terminus. The LA then compounded the felony against the wishes of the railway, by connecting this road to a local bypass which considerably increased the amount of traffic over it. Eventually a financial contribution by the LA helped to upgrade the crossing to MCB.

Time did not permit a visit to this signal box, and the next departure was taken back to Bury where some delegates made a tour of the signal box whilst others first made the trip to Heywood.

The signal box at Bury Bolton Street controls the complex junction between the three platforms, the line to Heywood (and the national network) and the route to Buckley Wells, the workshops, and the connection to Metrolink. The frame here is a 65 lever LMS frame with very few white levers!

Because of trespass issues when trains are not running the Heywood branch is gated. When the gates are locked off the line keys are released which then enable the branch to be used.

Another innovation used at the ELR are some 'electro hydraulic' semaphores, where a traditional semaphore signal is operated by a ram driven by a clamplock type pump unit.

To round off the variety of signalling, the home signals for Bury from Heywood are colour lights, so all tastes are catered for. Peter, who accompanied us during the visits, and his team of S&T technicians are to be congratulated for their work on what was, during our visit, a very busy railway.

The second visit of the weekend took place on the Sunday morning when some 14 people arrived at Manchester, Queens Road Metrolink station. After walking to the original depot, we were greeted by Robert Ball who gave us the visit safety briefing and explained the development of Metrolink from the original conversion of two British Rail lines to a complex system of six routes with two short working routes.

The second cross city line through Exchange Square has improved not only the capacity of the system, but has made it more resilient in the case of failures. Robert explained that all of the original trams had now been replaced with a new and much larger fleet which was shortly to be increased even further. It was interesting to the author that the street running 'chime whistle', which he introduced on the original fleet, is still in use in a digitised form on the new cars!

After this introduction we boarded a tram at Queens Road and made our way across the city to the more recent depot at Old Trafford. Here we were given an explanation of their 'visualisation room' during an excellent buffet lunch by Chris Stinchcombe, Keolis Amey Metrolink's engineering director.

The paper displays on the walls enable staff, in one quick look round the room, to see the situation regarding maintenance, availability and reliability of all aspects of the system. Using this method trends may be spotted much more easily than looking at multiple data on PC screens!

We then moved into the main control and communications centre for the system and Robert Oliver, the duty controller provided an explanation of the various work stations.

The displays show the full track layout and the position of the trams, just as any modern 'ROC' will do for heavy rail. A discussion took place regarding the balance between having absolute central control and a pure 'line of sight' (LoS) system because in the event of a major failure and shutdown, the LoS system could perhaps keep operating. Something for future operators and S&T staff to think about.

The control room also has extensive CCTV coverage of the system so that technical, passenger and security issues can be observed and acted upon. One workstation is also used to keep passengers informed via 'social media', indeed it is sometimes through this that the control room learns about overcrowding or other problems before the SCADA system picks it up.

After the control room we had a tour of the maintenance facility given by Brian Rowbotham who showed us their very advanced wheel turning machine and other facilities which enable a very high utilisation of the trams to be achieved. He also showed us the recent result of a lorry trying to argue with a tram. I suspect that the truck driver will not argue with any more tramcars!

The thanks of the IRSE Minor Railways Section go out to the staff at the East Lancashire Railway and to those at Keolis Amey Metrolink for an excellent two days of information, and don't forget that participants can claim CPD points for these visits.

York Section

IRSE
Institution of Railway Signal Engineers
YORK AND THE NORTH EAST SECTION

North Eastern Railway Engineers' Forum

The North Eastern Railway Engineers' Forum (NEREF) is a multi-disciplinary body drawn from the professional institutions with strong railway interests, namely the IRSE, Institution of Civil Engineers (ICE), Institution of Mechanical Engineers (IMechE), Institution of Engineering and Technology (IET), Permanent Way Institution (PWI) and Railway Civil Engineers' Association (RCEA).

Individually, the institutions – including of course the IRSE with its York Section – have local sections and hold technical meetings for their members. NEREF was established to promote knowledge and understanding across the disciplinary interfaces.

The railway industry in the North East is actually pretty vibrant. The former large British Rail centre of employment in York has spawned a remarkable number of successor companies and others that have been attracted by the pool of talent. Train building has returned with Hitachi at Newton Aycliffe – and Siemens at Goole and an Innovation Centre for Talgo at Chesterfield in prospect. Other firms such as Sabre Rail and Henry Williams have a continuing presence regionally. Major developments such as HS2, Northern Powerhouse Rail (NPR), York Route Operating Centre (ROC) and East Coast Main Line upgrades are also significant.

On Tuesday September 17 2019, NEREF will be holding its 23rd annual event in York at the National Railway Museum in the Mallard Suite from 18.00 to 21.00 with refreshments from 1730. Kindly sponsored by Sabre Rail, it is titled "Rail in the North East – Meeting the Challenges".

In the North East, as elsewhere, railways face many challenges. Traffic growth and the need to accommodate both HS2 and NPR require strategic vision hence Stephen Hind, Network Rail's presentation on "Leeds Integrated Master Plan". New trains raise compatibility issues so Rob Armstrong, from Eurofins, York will talk on "EMC – Upgrading the railways in the north" and, to address the challenges of global warming, Claire Brint of Network Rail will talk on "Managing the risk from railway earthworks", and Mike Muldoon from Alstom on "Hydrogen powered trains" – with Teesside potentially an early application of the latter.

Attendance is free of charge to attend but pre-registration by email to **rhgibbon@gmail.com** is essential to secure a place.

A new Hitachi-built Azuma train for the East Coast mainline at York. *Photo John Armitstead.*

Younger Members Section

IRSE
Institution of Railway Signal Engineers
YOUNGER MEMBERS SECTION

IRSE Examination modules 2, 3 and 5 study weekend, 1 – 2 June

Report by Reuben Dakin

The Signet IRSE Exam study weekend has become a regular feature of the IRSE Younger Members' calendar over a period of more than ten years, hopefully giving many aspiring signal engineers a leg up the professional ladder.

Every year, some presenters' faces change whilst others stay constant. Stepping into a breach where others feared to tread, the constant Peter Woodbridge admirably took charge of event planning to ensure another successful year. Thanks are due to Tom Corker for a successful innovation this year; the use of a booking website, EventBrite, eased the administrative burden by capturing registration details directly into a spreadsheet.

Presenters Peter Woodbridge, Dorothy Pipet, Russell Withington, Andrew Love, Dan Heeley and Reuben Dakin welcomed 24 prospective and potential future exam candidates, over the weekend of 1-2 June at Signet Solutions' Derby Training Centre.

Over drinks and refreshments, introductions were made, learning objectives were assessed and individual choices made for the two days' sessions.

Saturday started with some general sessions on exam technique and general preparation, followed with a range of subject-specific sessions. Subjects included handling the module 2 main line layout, control tables, answering technique, a wide variety of trackside equipment, SPADs & incident investigation, fault tree creation and low-cost signalling.

Dorothy's daughters kindly (but probably unwittingly!) loaned their prized wooden pull-along trains, which graced the 'tracks' of the largest-scale-ever-printed module 2 layout, performing perfect run-rounds, station stops and turnbacks to the amazement of the audience.

Signet Solutions provided generous and comprehensive buffet lunches on both days, fortifying the strength of participants and presenters for the afternoon sessions.

Thanks to specific input from Andrew, we were able to include for the first time some detailed sessions on how to handle the 'rapid transit' alter-ego of the module 2 paper. From thorough analysis of the headway requirements through to a fully populated layout, the audience much appreciated the new content, leading to a comment of "is that all there is to it?" from a surprised participant.

A common theme repeated in various sessions is that exam technique is everything: you may know and understand the subject very well, but if you don't answer the question in a way which convinces the examiner of this, your knowledge and effort count for nothing.

Following Saturday's formal events, the intensive social programme comprised the always well appreciated visit to the CAMRA-awarded Brunswick, followed by a meal at Cosmo Restaurant. The extensive menu choice, "eat until you regret it" format and a pre-paid deposit combined to make this a popular choice with extensive opportunity to network

A group photo of all the participants and presenters.

outside normal circles. Those who chose to take the 'watching the football' alternative were apparently disappointed!

There's always an oceanic rift between the audience knowingly nodding in understanding when a subject is discussed with them, and the uninspired blankness which then pervades the room when faced with the need to actively answer a question on the topic. Therefore, a rigorous programme of self-imposed 'exam conditions' practice is essential for the serious candidate. Sunday provided this opportunity, with many of the participants attempting mock exams across the modules, some for the first time. The organisers have continued to lend their valuable time in giving feedback on this work, but in the real world you may need to make use of peer review from colleagues, line manager or study group companions.

For those who felt they were not yet ready to put pen to paper (even with the option of getting some hints from a tutor), Andrew led a small group who together spent the entire day working through a wide range of written questions from the mock exam papers.

Around a quarter of the event participants had no immediate plans to sit the exam (indeed some had a very good excuse, not even being employed within the industry!); therefore, further general awareness sessions were appropriate. Peter demonstrated interlocking functionality and how this related to Control Table entries, whilst Dan continued with his enthusiastic and comprehensive equipment demonstrations, bringing in his extensive real-world maintenance experience.

In the afternoon many attended the post-mortem of the "signalling the layout" mock paper whilst others opted for similar inquests of other various mock exam questions which were all well appreciated.

Peter Woodbridge demonstrates signalling principles using Leamington Spa panel.

Following the event, positive feedback has been received from the attendees, indicating a strong improvement in their confidence in tackling exam modules in future years.

Following the success of this year's event, it is likely to be repeated in 2020; the organisers are already looking at possible dates, which may well be a month or two earlier in the year.

Those following the exam will be aware that a change in its structure will occur in 2021. Although the syllabus remains unchanged, the way in which the candidate's knowledge and understanding are 'sampled' will be different. The introduction of the initial module A in particular will mean a step change will be needed in the learning and preparation required by the candidate, such that the unprepared will suffer a major setback.

It has already been mentioned how the delivery of these events relies on the year-on-year dedication of a small number of individuals. Whilst such input is to be applauded, we must not forget the need for succession planning. Many previous students have returned multiple times as tutors, but some are now finding that their family responsibilities conflict.

The organisers would welcome volunteers from across the industry to assist with future events. Not only will this help in making the offered content of the study weekend up to date and relevant, it will also provide a valuable Continuing Professional Development (CPD) opportunity for the individuals prepared to give something back to the profession which has nurtured them so far.

We wish to all exam candidates for this year and future years, both perseverance in your pre-exam preparation, and good luck on the day!

Would the IRSE Examination offer you a way of progressing your professional development?

Passing the IRSE Exam demonstrates your knowledge of railway signalling and telecommunications principles and practices and can provide valuable support for your application for professional registration. Professional registration provides a benchmark through which the public, employers and clients can have confidence and trust that registered engineers and technicians have met globally recognised professional standards.

The IRSE exam is one way of 'topping up' the academic qualifications required for registration. While preparing for the exam you will have support from workshops and study groups such as those explained in this issue of IRSE News, and you will be learning material relevant to your career in railway command, control, signalling and communications.

Visit irse.info/irseexam.

IRSE Examination modules 1 and 7 study event, 15 June

Report by Michael Bastow and Dhanya Srivathsan

IRSE
Institution of Railway Signal Engineers
YOUNGER MEMBERS SECTION

At the T-1 meeting for this year's Module 1 & 7 IRSE Exam preparation workshop there was some doubt amongst the organisers that the event could go ahead as scheduled on the 15 June 2019. Only a handful of people had signed up, a possible side-effect of the planned changes to the IRSE Exam format.

However, there was no need for worry. Thanks to a wave of late registrations the venue at Atkins' (member of the SNC-Lavalin group) Axis office in Birmingham, UK was full of engineers (most young but several not so young!) from across the industry; client and contractor, main line and metro, signalling and telecoms, as well as people who could share their systems engineering expertise from railway operations and aerospace.

David Nicholson, chief engineer & professional head of engineering management at Atkins and Peter Woodbridge, research & development senior technical authority at Siemens, led the workshop sessions throughout the day. The first session was an introduction to the IRSE Exam. Particular attention was paid to how the current format maps to the proposed new format, set to take effect from 2020/21. This was followed by introductions to Module 1 – Safety of Railway Signalling & Communications and Module 7 – Systems, Management & Engineering. Then it was time for the participants to get involved. The group separated into different rooms, to avoid disturbing each other, and discussed a past exam question from their chosen module, guided along by either David (Module 1) or Peter (Module 7).

Lunch was provided, and attendees were able to network before the rapid-fire session. To avoid any sleepy minds after lunch, Peter subjected the attendees to a series of quick-fire questions allowing only a few seconds to answer. He also tested the participants' knowledge of key terms, such as reliability, availability, validation and verification, by asking them to match them to their definitions. The results of the definitions test provided a good indication of the overall exam readiness of the group. There was an approximate 50:50 split between the scores of the participants (or the 'units' being subjected to this quality assurance check), some scored highly (one person got 100%!), and others would need to brush up on their definitions fairly sharply if they intend to take the exam this year. This rapid-fire session also helped participants gain valuable insights into how much knowledge they can recall when under pressure.

Another open discussion session followed before the final session of the day. Here participants could choose between tackling a question under exam conditions, or a session led by David on exam technique. The latter was the popular choice, with only three people attempting a question under exam conditions.

Despite the uncertainty prior to the event it turned out to be a success and was once again offered free of charge thanks to the kind sponsorship of Atkins. Thanks must also go to David Nicholson and Peter Woodbridge who each year give their free time to share their engineering wisdom with younger members that are preparing to sit the IRSE Exam.

Below, David introducing Module 1.
Right, Peter introducing Module 7.
Bottom right, heads down for the quick-fire question session.

Your letters

Re HF and automation

Rod Muttram misses an important point when comparing rail safety with the Boeing 737 MAX accidents, July IRSE News issue. In the case of rail, he refers to 'fail safe' stopping the train. However, bringing a busy railway to a halt introduces its own safety risks, which is why when British Rail Research was developing Solid State Interlocking (SSI) they adopted triplication of the vital safety processors with two out of three (2oo3) majority voting to deliver reliability.

In this way, if one processor malfunctions it can be over-ruled by the other two and the railway continues running in fail safe mode.

As Rod points out, fail safe in aviation cannot usually result in a 'stop' state which would result in a crash. On 4 November 1966 a de Havilland 121 Trident airliner made the world's first 'blind' landing in passenger service. The basis of this capability was triplication of the flight control system from the angle of attack sensors to the powered flying controls, with 2oo3 majority voting throughout.

Contrast this with the 737 MAX which is fitted with two angle of attack sensors, but the flight controls took the signal from one, alternating between the two sensors for each new flight. A facility to compare the two-sensors and alert the pilots to any disagreement was an optional extra.

Not for the first time I query the received view that railways have much to learn from other, "more advanced", transport modes.

Roger Ford, UK

Re cover story: red road lights

Was the photo on the cover of the IRSE News June 2019 issue designed to test readers' knowledge of level crossing red road lights operation? Unless the standard has been changed, the reds should show left & left then right & right. The photo shows left & right lit.

Mike Hanscomb, UK

We have been assured that there is no requirement to 'synchronise flashing' of left and right road lights at level crossings in the UK, and that no standard exists to mandate that functionality.

Relay based flasher circuit design intrinsically provided synchronised flashing of 'left' and 'right' lights. Modern electronic systems where each light is driven from a different driver card may start in synchronisation but drift while the lights are operational due to slight differences in the timing between different cards of a similar manufacture.

There is no proven ergonomic benefit or disbenefit in providing synchronisation. Ed.

Re Power Supply earthing

What a brilliant article in the Jul/Aug IRSE News on subject of Power Supply earthing. It has made clear to me in one article a lot of what I think electrical engineers should have been explaining to us (as end users) for many years. When I was in the Western Signalling Divisional Office 40 years ago I had grave doubts about whether we made adequate arrangements for earthing or fusing of 650V.

Whilst some did do basic calculations to ensure that enough volts were left at the end of a 650V spur to ensure things worked (or remained working), the cable sizes were never big enough to ensure that a short at the end of perhaps a 10-mile spur blew the fuse at the source. Rings were even worse. 30 years ago I insisted that we left rings open at specific places to give the fusing a chance – and also to help with diagnosis should we get a blown fuse. I had quite a battle convincing some of our technicians the reasons why – but at least they respected that I had my reasons even if they didn't agree when I pointed out it made their job easier!

Even after railway privatisation in 1994 when E&P took on 650V supplies they were often 'cagey' about explaining what you've so well set out, and used to just quote 'the regs' without explaining the background.

John Jenkins, UK

Re Optimising ETCS

I found the article by Noel Burton (IRSE News March 2019) very interesting. I particularly liked the points he made about the ease of reconfiguring the system once all the infrastructure and stock is fitted. This would mean that once you have ETCS in full use then improvements to track layouts or platforms can be done at less cost compared to conventional signalling. I was also interested in the section about optimising the approach speeds to curves. Given that many administrations run track test trains to measure track geometry would it be possible to use this data to configure the ETCS using an automated process?

Trevor Foulkes
Chair London & South-East Section, UK

"Feedback" becomes "Your letters"

One of the most important functions of IRSE News is to give our members a voice on all matters relevant to our industry and the Institution. We welcome your feedback on our articles and features, but we also welcome your letters on any relevant topic.

Perhaps you have some success you'd like to share, an important lesson you have learnt the hard way or a burning question that you'd like to ask to members around the world.

Recognising that this column is about much more than just 'feedback' we've changed the heading to "Your letters" and look forward to hearing from you.

Email editor@irsenews.co.uk, we look forward to hearing from you!

Past lives: Ning Bin

Professor Ning Bin, until recently the president of China's Beijing Jiaotong University (BJTU), tragically died in a road traffic accident in Beijing on the morning of 14 June 2019. He was on his way to a One Global Rail Conference when the car he was travelling in was struck from behind and lost control. Despite the efforts of the emergency services he died later in hospital.

Prof Ning was a great supporter of the IRSE and was instrumental in the setting up of the IRSE Chinese Section and the organisation of the 2016 International Convention in Beijing. As well as being a Fellow of the IRSE, he was also a Fellow of IEEE, the Institute of Engineering and Technology (IET), and the China Railway Society. He was made a Fellow of the Chinese Academy of Engineering in 2017.

Born in Jishan, Shanxi Province in May 1959, Prof Ning was admitted to Beijing Jiaotong University, formerly the Northern Jiaotong University, in 1977. In 1982, he began to teach at the Telecommunication and Control Department of the university as a lecturer, then as an associate professor, eventually becoming a professor. He advanced through several managerial and committee roles to become the president of BJTU in March 2008. He was also a visiting research fellow at Brunel University, UK from Sept 1991, and a visiting research fellow at the University of California, Berkeley from 2002 to 2003. As a strong supporter of Chinese High-Speed Railway's 'Going Global' strategy he built many international links including strong ties with the UK's York, Birmingham and Lancaster Universities.

Prof Ning was considered a senior expert in the areas of train operation control systems for high speed railways, urban rail transit train control and intelligent transportation systems in China. Under his leadership BJTU supported the development of CTCS3 for the Chinese high-speed network (the Chinese derivative of ETCS Level 2), and at its Key State Laboratory for Rail Traffic Control and Safety conducted the interoperability testing between Bombardier's on-board system and the on-board system from what was then Ansaldo for the first high-speed line from Wuhan to Guangzhou, during 2006-2009.

Ning Bin, 1959-2019.

He was also instrumental in BJTU's work to develop China's 'home grown' CBTC solution for metros, now in use on many lines, (through Traffic Control Technology (TCT), a company that derived from BJTU) and the Safety Assessment Research Centre (SARC).

He stepped down from the presidency of BJTU in May 2019 and was planning to once again become more involved in research. He had recently been appointed director of the Sichuan–Tibet Railway Research Center.

Many of us in the IRSE knew Ning well and considered him a friend as well as a real expert in his field. He spoke excellent English and sharing dinner with him was always a pleasant and convivial experience. The world has lost a fine and inspirational engineer and manager, and a thoroughly good and likable man. The IRSE sends its condolences to his family and colleagues. He will be sadly missed.

Rod Muttram.

How much of your work counts towards your CPD?

Continuing professional development is an essential part of being a professional engineer and a member of the IRSE.

Had you ever thought about how many ways there are to carry out this CPD though? Here are just some examples of how you can do this – just remember to record your activities!

Additional responsibilities: Increasing or refreshing your skill set and demonstrating your personal responsibilities by volunteering to take on additional duties such as supervising others.

Buddying, coaching or mentoring: Sharing your knowledge of your company, discipline or industry by acting as a buddy, coach or mentor.

Shadowing: Increasing your understanding of your company or industry or widening your domain knowledge through work shadowing.

IRSE events and conferences: Increasing your technical knowledge and widening your network.

Management skills: Increasing and practicing leadership skills by organising sharing knowledge sessions such as 'lunch and learn'.

Developing your career: Increasing your profile by transferring to another grade in IRSE.

Technical knowledge: Increasing or refreshing your knowledge by reading up in technical papers, journals (like IRSE News) and specifications on projects, techniques or equipment being used.

Have you had your say about IRSE News?

We're often told that receiving IRSE News is one of the major benefits of membership of the Institution, bringing a wide range of industry and section news, topical articles, feedback and information relevant to our membership.

But what do you think?

Please help us to make IRSE News better by completing our readers' survey, visit

irse.info/irsenewssurvey

Closing date 30 September.

Don't forget that we always value your feedback, suggestions or articles by email to editor@irsenews.co.uk

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at irsenews@irse.org.

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Membership changes

Elections

We have great pleasure in welcoming the following members newly elected to the Institution:

Member

Shanker Katigasu, HSSI, Malaysia
Bernhard Seybold, trafIT Solutions, Switzerland
Xiaofeng (Simon) Zhao, Bombardier NUG, China

Associate Member

Lewis Cogley, Network Rail, UK
Matthew Ely, V/Line Corporation, Australia
Sam Griffiths, Transport for London, UK
Kristian Lee, Amey, UK
Kevin Njuguna, Network Rail, UK
Daniel Palmer, Colas Rail, UK

Accredited Technician

Emma Gilchrist, Motion Rail, UK
Paul McCarthy, Siemens, UK
David Playle, Transport for London, UK

New Affiliate Members

Mamdoh S Arbaeen, INECO, Saudi Arabia
Liam Brady, Network Rail, UK
Lucas Campbell, Ricardo Rail, UK
Kenneth Chan, Key Direction, Hong Kong
Nathan Coffey, Mott MacDonald, Australia
Deborah Du Plessis ERB Technologies, South Africa
Ross Dzewu, Network Rail, UK
Paul Ebbens, Network Rail, UK
Ryan Farrow, Network Rail, UK
Zach Glasspool, Self-employed, UK
Sunil Grover, Aurecon, Australia
Somya Gupta, Nirma University, India
Dewald Hamman, ERB Technologies, South Africa
Matthew Hodgson Barratt, Network Rail, UK
Shubham Jadam, Thales, India
Richard Keimel, WSP, Canada
Romiel Khoshabeth, WSP, Australia
Chun Yeung Lee, MTR Corporation, China
Stanneth Siu Tin Lee, MTR Corporation, China
Zhan Yuan Leong, Hitachi, Malaysia
Daniel Li, John Holland Rail, Australia
Matthew Mitchell, Siemens, UK
Ondela Mnyani, ERB Technologies, South Africa
Alamsyah Mohamad Nur, Mitchubhi Heavy Industry, Indonesia
Saipradeep Penugonda, Siemens, India
Donald Phillips, Babcock, UK
Sukhvir Riyat, Network Rail, UK
Uthiyakumar Sachithanantham, Hitachi, Malaysia
Amrik Singh, Network Rail, UK
Satendra Singh, Delhi Metro, India
Thomas Sudholz, John Holland Rail, Australia
Kara Symes, Public Transport Authority of Western Australia, Australia
Deon Van Den Dool DRB Technologies, South Africa
Robert Verbeek, Projectengineer Signalling, Netherlands

Promotions

Member to Fellow

Aruppukottai Ayya, WSP, Australia
Yogesh Chauhan, Alstom, UK
Ian Roulstone, Siemens, Thailand
Aqeeluddin Saiyad, WSP, India

Associate Member to Member

Barry Baldrey, Hitachi, UK
Matthew Hunter, Siemens, UK
King Lam Ng, PYPUN-KD & Associates, Hong Kong

Affiliate to Member

Priannka Kumar, Aurecon, Australia

Professional registrations

Congratulations to the members listed below who have achieved final stage registration at the following levels:

EngTech

Emma Gilchrist, Motion Rail, UK
David Playle, Transport for London, UK

IEng

Lee Cleverley, Network Rail, UK
Reece Martin, Network Rail, UK
Andrew Reilly, Network Rail,UK

CEng

Claire Hulstone, Network Rail, UK

Resignations: Laura Arenas Salmeron, Simon Ball, Michael Coleman, Peter Dean, Barend Du Plessis, John Foreman, Ana Gallego Pinera, Maria Grayson, Ian Hart, Michael Hynd, Satoshi Itoh, Robin Kerr, Brian Kirk, Bruce Larter, Elena Leiva García del Castillo, Robert Piper, George Plant, Andrew Price, Allan Pyne, David Rhodes, Mike Rogers, Henk Schomaker, Bart Smolders, John Sneider, Paul Tanner, Andrew Uttley, Paulus Van Kempen, Klaas van Smeden, Robert Van Wissen, Johan Verschaeve, David Wells, Gary Young, and Robert Young.

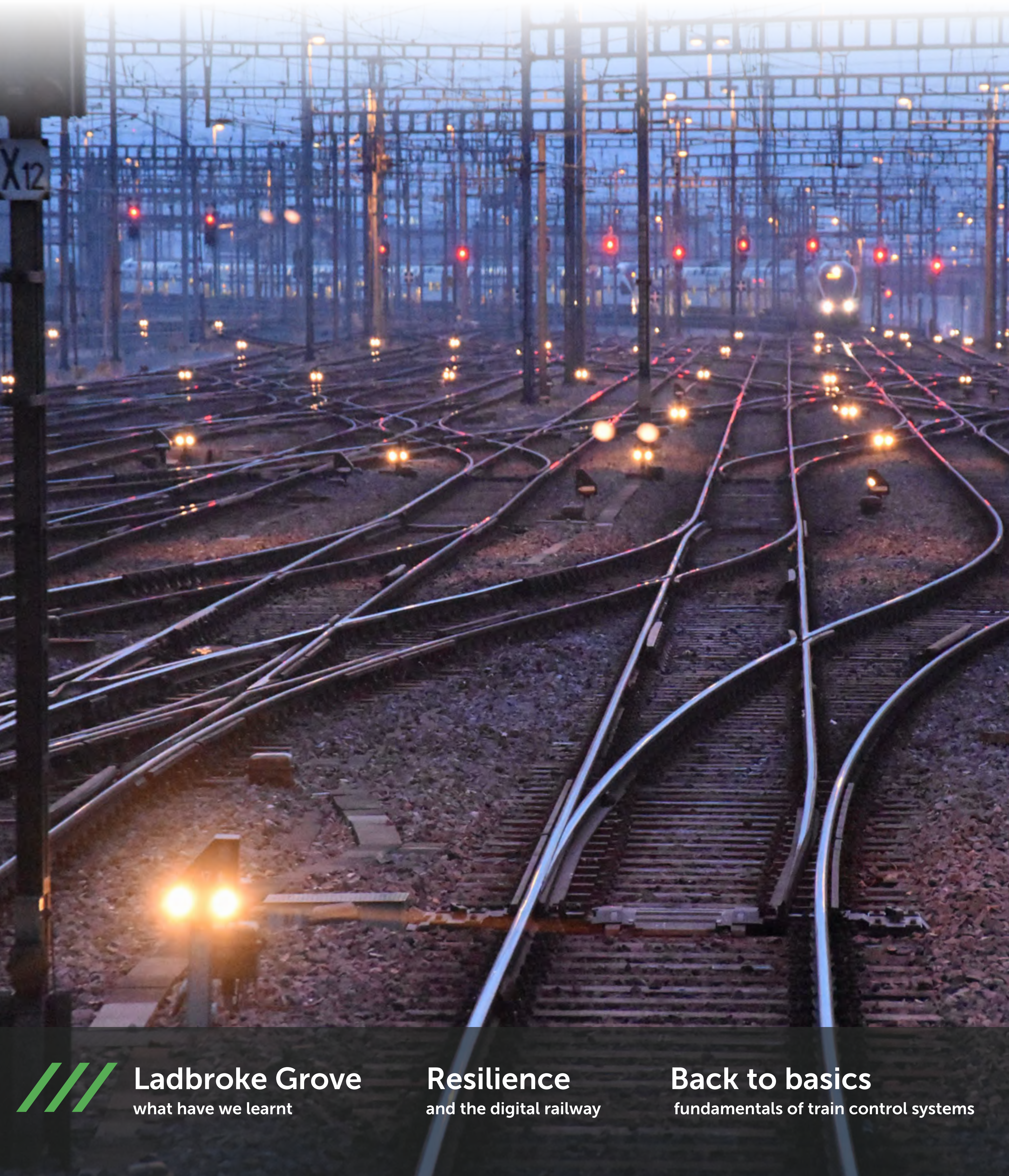
Past lives

It is with great regret that we have to report that the following members have passed away: Charles Beatson, Anthony Cook, Bin Ning and Colin Waters.

IRSE News

Institution of Railway Signal Engineers

October 2019



Ladbroke Grove
what have we learnt

Resilience
and the digital railway

Back to basics
fundamentals of train control systems

Saying goodbye to summer is always hard but why not get back to business and improve your existing knowledge or start afresh as a signalling engineer.
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IRSE

Institution of Railway Signal Engineers

Issue 259
October 2019

In this issue

Feature articles

News and opinion

From the IRSE

People resilience

This month's IRSE News features a number of articles exploring the topic of engineering resilience. Resilience on the railway can mean the ability to keep the railway running during equipment failure, or during environmental events such as bad weather, but it can also mean the ability to cope with changes in the workforce and the skillsets expected of them. Resilience also applies to human health with evidence showing that serious harm to physical and mental well-being can be caused by stress at work.

A recent newspaper article claimed that the incidence of mental issues in the construction industry is greater than average, with suicides occurring in extreme cases. There has been a rise in the number of people suffering from stress, anxiety and depression. Contributing factors include homesickness, job insecurity, financial pressures, isolation and bullying. In many countries industry is structured around tiers of subcontractors competing with tight margins. Principal contractors may commit to protect workers, but this doesn't always ripple down the supply chain.

The main causes of the distress appear to be loneliness, being on site sometimes a significant distance away from family for weeks at time, and working long hours. A union safety advisor on a major construction project was recently quoted as saying that the number of people going absent is similar to 50 years ago, only now it is with stress and mental issues not physical injuries.

This directly affects our industry. We have people working long hours, sometimes away from families and friends and working hard to achieve tight deadlines. Companies have to compete for the next project, which could be at home or overseas. Engineers and technicians may work from home far more than in the past, and travel long distances. They may not always have the security of a depot or office with people to talk to, as they did in the past.

Many companies are aware of the issues and are implementing various mental health programmes, including staff trained as mental health first aiders. Companies need to address the root causes of stress, not just treat its symptoms. We can all help as well, by looking out for our fellow workers and sometimes just picking the phone up and talking to a lone work colleague.

Paul Darlington
managing editor, IRSE News

Cover story

Looking west through the throat of Zurich main station (HB) at dusk on 19 March 2018. HB's buffer stops are some 420 metres behind us. The tracks ahead lead to all compass corners. IRSE Swiss Section member André Rüegg told us about HB's interlocking. A Siemens SpDrS-SBB equipped with a desk-mounted track diagram and pushbuttons, its first workday was 15 May 1966. It monitored and controlled HB's signals, points and 106.7Hz track circuits via a network of underground chambers connected by foot tunnels. With the launch of Zurich's S-Bahn in 1990, a ZN/ZNL90 system began setting routes using trains' numbers in the interlockings at HB and nearby stations remotely. Scheduled movements at HB have grown from 993 daily in 1966 to 3100 today. In 2014, an operations centre at Zurich Airport for the eastern third of Switzerland took control of HB's interlocking. SBB has announced no plans to replace it.

Photo and caption by George Raymond

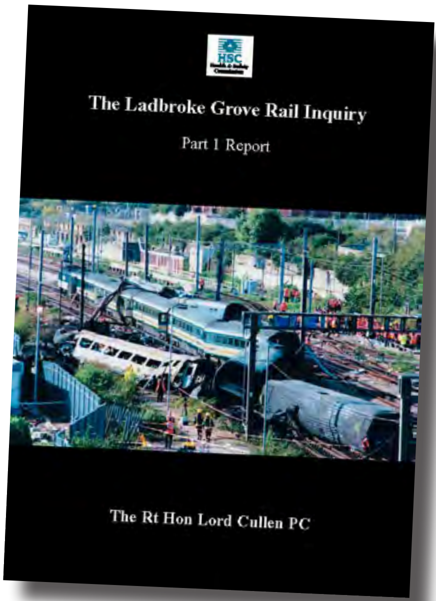
20 years after Ladbroke Grove – where are we now? A personal view

Rod Muttram

The UK rail industry was shaken by a head-on collision that occurred on the Great Western Main Line between London's Paddington station and the west of the country in 1999. The event led to a lot of negative publicity for the railway, challenged perceptions about the safety of the network, and led to increasing calls for the application of automatic train protection. In this article Rod Muttram looks back over the past 20 years and considers what has changed since that tragic day.

At approximately 0809 on a bright sunny morning on the 5 October 1999 a Thames Turbo train leaving Paddington passed signal SN109 at danger and a short time later collided head-on with an inbound High-Speed train (HST). The collision speed was in excess of 130mph. 31 people, including the two drivers, died and hundreds were injured. The damage to the Thames Turbo train was so severe that when the Railtrack (the predecessor to Network Rail) zone director arrived on site he thought it was a two-car train. In fact, it was a three-car unit but the damage to the front carriage was catastrophic – the diesel fuel in its tank had been atomised resulting in a huge fireball which also engulfed coach H of the HST.

I had been director of safety and standards at Railtrack for just two years and I and my team had been working hard to understand and better control these kinds of risks; it was the event we always feared would occur before we got there, the British railway system is large and change takes time.



The tragedy that occurred near London Paddington Station in 1999 led to a changed approach to safety in the UK rail industry. Lord Cullen's report ran to several hundred pages. 20 years on, what has changed?

What has happened since?

Thankfully at the time of writing those fatalities were the last in an Automatic Train Protection (ATP) preventable accident in the UK and Britain's railways are now amongst the safest in the world. Indeed, the single passenger fatality in the Grayrigg derailment (when a high speed passenger train was derailed due to a defective set of points on the West Coast Main Line) was in February 2007, which means that it is now not only 20 years since there was an ATP preventable fatality but also over 12 years since there were any passenger fatalities in the UK resulting from a collision or derailment. That is an amazing improvement over the historic position and everyone in the industry who has played their part, big or small, has a right to feel immensely proud. But I would suggest that there is no room for complacency. The improvement has come not from one 'magic bullet' measure but from a very large number of improvements working in combination and sustaining all of them requires constant vigilance.

In the aftermath of the Ladbroke Grove collision there were three Public Inquiries: Ladbroke Grove Part 1 into the specific circumstances of the accident, Part 2 into the industry safety structure and the Joint Inquiry into Train Protection Systems (jointly with the inquiry into the Southall Collision on the 19th September 1997). Those inquires drove many improvements (as did the main part of the Southall inquiry) but it is important to also recognise that many, including the key Train Protection and Warning System (TPWS) were already being developed before that and were scrutinised by the inquiries.

AWS (the yellow magnet middle right of the photograph) and TPWS (right foreground) still work together across the UK rail network. *Photo Shutterstock/TreasureGalore*.

The Joint Inquiry into Train Protection Systems considered both TPWS and the European Train Control System (ETCS) as part of its deliberations and it was seriously suggested by many that TPWS should be abandoned in favour of accelerating ETCS. Fortunately, the evidence given by people like Sir David Davies and me prevailed and TPWS was recommended as the short-term system with ETCS to follow. Time and time again we see that the gestation and implementation times for these systems is very long. Implementation of the Automatic Warning System (AWS), which still works in combination with TPWS, took over 50 years.

It is a matter for eternal regret that we did not get TPWS in place in time to prevent Ladbroke Grove, but equally had a recommendation to cancel TPWS been accepted by the inquiry we can now be reasonably certain that further lives would have been lost. It is worth remembering that the Joint Inquiry also recommended the implementation of ETCS on the East Coast, West Coast and Great Western Main lines by 2008. That was not achieved and eleven years on from the deadline ETCS is only just coming into UK service on the likes of Thameslink and Crossrail.

TPWS success factors

Many people contributed to the development and deployment of TPWS, too many to mention all of them here, but I would like to pay particular tribute to the late Dr Peter Watson (at that time the Engineering Director of British Rail) who I still view as the real 'father' of the project. In 1994 a report was published on the use of safety cost/benefit analysis (CBA) to rank and prioritise safety investment. This was in response to recommendation 48 of the Inquiry into the Clapham Junction accident that "The Department of Transport and BRB (the British Railways Board) shall make a thorough study of appraisal procedure for safety elements of investment proposals so that the cost-effectiveness of safe operation of the railway occupies its proper place in a business-led operation".

The report had used the two BR-ATP (British Rail – Automatic Train Protection) pilot schemes on the Great Western and Chiltern lines as case studies and showed that they were much too expensive to be justified against other potential safety investments (some to 6 to 7 times more than the benchmark). At that time there were many much less costly safety investments which were not proceeding due to lack of funding, particularly in the road sector. When David Rayner, at that time director, safety and standards for Railtrack, and I presented the report to the then Secretary of State for Transport (Brian Mawhinney, now Lord Mawhinney) he endorsed the decision that BR ATP should not be further deployed as recommendation 46 from the Clapham Inquiry had proposed it should be within five years of system selection from the two piloted options.

I have heard it said that such a decision was immoral; that you cannot "put a value on a life" and that because the technology existed to prevent these kinds of accidents it should have been implemented at any price. I would strongly contest that the opposite is true. Be it for countries, organisations or individuals, resources are never infinite. Given finite resources the 'moral and ethical' thing to do is to have a transparent process which seeks to use those resources to deliver the best overall benefit; in terms of safety investment to deliver the greatest reduction in fatalities or harm. Otherwise money spent on most current or 'best lobbied for' measures would leave nothing to be spent on other things that could have saved more lives.

The UK National Health Service wrestles with similar issues all the time in terms of funding new and expensive treatments from a constrained budget. But it is wholly understandable that someone who has lost a loved one in an accident that could have been prevented, or whose sick child is refused a life-saving treatment, finds such arguments hard, if not impossible, to accept. Nevertheless, good governance requires such transparent processes whilst continuing to strive to reduce the cost of the measure or find another way to address the issues.

Peter Watson recognised that the risks associated with Signals Passed at Danger (SPADs) remained high because, whilst the average risk supported the CBA conclusion not to extend BR-ATP, within the risk population there remained the risk of a large multi-fatality accident similar in consequences to Clapham (how prophetic that turned out to be). Sometime in mid-1994 he invited me to his office in Euston House. He believed, and I supported, that there was no 'do nothing' option. British Rail and Railtrack agreed to jointly fund a package of R & D to look at reducing SPAD risk and the SPADRAM (Signals Passed At Danger Reduction And Mitigation) project was born from which TPWS and a host of other measures emerged. As BR wound down my Electrical Engineering and Control Systems Directorate, Railtrack took over 100% sponsorship under the guidance of the pan-industry Train Protection Steering Group (TPSG) which I chaired.

One of the potential measures evaluated by what at that time was still BR Research on our behalf was enhancing the functionality of the existing AWS system by adding a 'train stop' and a 'speed trap' which could not be overridden by the driver in the way that the AWS warning could be, even for a red signal. Ladbroke Grove data recorder evidence showed that the driver of the Thames Turbo overrode the AWS warning at SN109 which was at Danger and drove on. Exactly why we shall never

know; there were many potentially contributing factors, but the fact that the warning for a stop signal could be overridden is AWS's 'Achilles Heel'.

Such an enhanced AWS system would reduce risk even if not deployed at every signal, it did not need 100% deployment to start to deliver benefits and the modelling showed that by targeting the deployment at high risk signals such as those controlling junctions it was theoretically possible to deliver 80% of the benefit of ATP for around 20% of the cost. The key thing was to get the system level cost as low as possible. That meant ensuring simple and quick installation as well as getting the component costs right.

At some point in this process David Fenner, then the project manager, changed the name from Enhanced AWS (E-AWS would have risked ridicule) to TPWS. A performance specification was written and put to competitive tender with a target cost. The competition was won by Redifon MEL, now part of Thales, and was based on a right-side door enable system they had developed for London Underground. It was a simple system based on electronic timers, with no complex processing. Loops in the track passed signal status to the train. Two loops co-located made a train stop, spaced apart gave a speed trap, with the speed set easily by the distance between the loops. The electrical interface to the lineside signalling was simple and, critically for keeping the system cost low, the on-board unit was a simple bolt in replacement for the AWS relay box needing only a subsidiary antenna under the train, a small additional control unit in the cab, and minimal additional wiring. Trains could be retro fitted within a single overnight shift keeping the 'disruption costs' low.

Critically the 'numbers worked'; the projected cost met the CBA criteria for such a system, and we would have been able to justify implementation by a mandatory Railway Group Standard. I really believe that the industry would have done this on its own. Not without some arguments, and it would have taken longer, but it would have been done. In the end that was never tested. In the aftermath of the Southall accident HM Railway Inspectorate produced the Railway Safety Regulations 1999 which were laid before parliament in August of that year. These mandated fitment of some form of train protection within five years of their coming into force on the 30 January 2000.

The Regulations did not mandate TPWS specifically but were written in a way that it was a permissible solution whilst leaving room for something technically better. Except where the BR-ATP pilots were already fitted nothing else could have met the timescale. Shortly after the Regulations were enacted and one week into the Southall Inquiry, Ladbroke Grove happened. The size of the public outcry, stoked by those hostile to privatisation accusing the industry of 'putting profit before safety' (all of the subsequent inquiries concluded that had no foundation, but it has stuck in the public psyche) meant that Railtrack committed to implementation in four years. Apart from a few problem areas that was essentially achieved.

So, TPWS really had the wind behind it – it was designed to be simple to install, particularly to retrofit rolling stock; it met the (then) cost criteria for being 'reasonably practicable' and anyway it was really the only credible response to a mandatory Regulation. Whilst installation was achieved in around five years much of the 'ground-work' had been done before the Regulation was written, we had started the project another five years before that.

Other factors

Many other things have contributed to the improvement in safety performance that has been achieved. Other technical measures include the Driver Reminder Appliance (DRA), also a SPADRAM development, which reduces platform starter SPAD risk, and the work that has been done to remove or mitigate sub-standard signal overlaps. Better data analysis has led to specific measures to reduce risk at identified multi SPAD signals and control centre alarms expanded and made clearer and easier to distinguish, particularly SPAD Alarms.

The Railway Safety Regulations 1999 also mandated the end of Mk1 'Slam door' rolling stock. The fleets of new trains brought in since the time of Ladbrook Grove have better braking with almost universal Wheel Slide Protection (WSP) and automatic sanders as well as improved crashworthiness if the worst does ever happen. And of course, we should never forget the people. The UK has one of the best trained and most professional bodies of train drivers in the world. The advent of 'Defensive Driving' and the enforcement of speed by TPWS on the approach to high risk signals all go to promote and reinforce safe behaviour. Improvements still continue with Network Rail

In complex areas such as Glasgow Central station, pictured left, TPWS has added a great deal of complexity to design and test in order to offer greater levels of protection than was previously available. *Photo Shutterstock/DRussell78.*

recently implementing the 'overrun management' initiative where a SPAD alarm triggers replacement of signals in the vicinity – with the logic implemented in the SIL 2 control system and not in the interlocking, simplifying design and approval.

It is also worth remembering that at the time we developed TPWS the Department for Transport (DfT) recognised a higher Value of Preventing Fatality (VPF) for risks that might lead to multiple fatalities than for risks that might only lead to one or two. VPF is the 'benchmark figure' against which safety investments are tested. If a measure costs less than the VPF for each fatality or equivalent fatality (an aggregation of injuries) it prevents it is probably worth doing; if it costs more, then it is probably not good value. Other factors should always be considered, and there should be an attempt to understand the uncertainties involved. VPFs are generally based on research into 'public perception of willingness to pay' i.e. on societal preference. Later research concluded that a life lost in a multi fatality accident should not be valued more highly than those lost singly and the 'two-tier' VPF was dropped in favour of a single figure. The most recently published DfT figure is £1 897 129 in 2017 prices. At the time we developed TPWS we were using circa £2 400 000 for multi fatality risk. With the additional buffer-stop protection and extra speed traps mandated by the 1999 Regulations that was probably exceeded. Taking into account inflation the incremental investment for TPWS would not now be deemed 'reasonably practicable' as £1.9M equates to less than £1.2M in 1999 prices.

Despite that, I do not believe anyone would seriously suggest that it was wrong to have implemented it.

So, why do we still need ETCS?

We only ever intended TPWS to be a stop gap until ETCS, mandated by European law to be used for all significant upgrades, became stable and readily available. As stated above the Joint Inquiry into Train Protection systems recommended fitment on the three major main lines by 2008. In the event it has taken much longer for the ETCS specifications to mature than anyone could have predicted in the late-1990s.

ETCS started its life as a common system for high-speed lines: its use for those was mandated by Directive 96/48/EC in 1996. It was not until 2001 that 2001/16EC extended the mandate to conventional lines. The two Directives were later replaced and consolidated into 2008/57/EC. In the mid 1990's we identified that for even moderately dense conventional lines the GSM-R radio communication from track to train had insufficient allocated channels to support operation in the 'circuit switched' mode that had been envisaged for high speed lines. Given the number of communicating trains that would be within a communication area, particularly close to major termini, the system would need to use the General Packet Radio Service (GPRS) (2G/3G data). It was not until 2015/2016 with the production and release of ETCS Baseline 3 maintenance release 2 and GSM-R Baseline 1 that EGPRS (Edge enabled GPRS) formed part of the specification, rendering the compliant system really 'fit for purpose' in a UK network context.

The extension to conventional lines and the need for compatibility with the operating rules of the railways of 27 member states with railways (and Malta theoretically gets a say even though it has no railway to be 'backward compatible' with) has driven a very complex set of requirements and thus a very expensive and complex solution.

Further, early in the standardisation process there was a debate about whether the ETCS project should follow a 'black box', 'grey box' or 'white box' approach. I and some of the other railway representatives at the time favoured 'white box' which would have mandated a standard architecture with interchangeability at the sub-system level enabling active competition between the suppliers throughout the lifecycle. The suppliers favoured 'black box' with standardisation only at the air gap interfaces which they felt would involve the minimum change from their existing products and allow them to preserve some of their unique features and advantages. 'Grey Box' would have been somewhere in between with standardisation of some of the sub-system interfaces. In the end the suppliers won and what we have is at best a 'dark grey box' system.

That leads not so much to an oligopoly as to a connected set of monopolies. Since every manufacturer's system architecture is slightly different and the physical size and shapes of their on-board equipment sub-systems are different, once a train has been designed for one supplier's equipment it is very difficult to change. So, competition can only happen in a somewhat constrained way at the beginning of a fleet procurement.

ETCS and the cab signalling it brings are seen as the long-term solution to improving UK rail safety

Bombardier's Elizabeth Line trains must integrate ETCS, TPWS and Trainguard CBTC. Seen here in CBTC standalone mode.
Photo Bombardier.

Because ETCS is complex, and provides continuous protection, transition strategies that provide benefits incrementally (as was the case for TPWS) are very hard to find so wide scale fitment is needed before benefits are delivered. The success of TPWS means there is very little incremental safety benefit to be had, so ETCS has to be justified by other benefits such as capacity improvement. Whilst there is real pressure for increased capacity on many routes, there are also many that are still under-utilised and so making a system wide business case for ETCS is difficult.

This list is not exclusive, but I hope gives the flavour that unlike TPWS having 'the wind behind it', ETCS has faced some significant headwinds.

Nonetheless I believe it is the only way forward, because of the following issues.

- Within the reduced overall risk there remains the potential for failures with catastrophic consequences; particularly as demand on the network continues to increase. Consider a SPAD in heavy traffic at a non-TPWS fitted plain line signal resulting in a rear end collision. If a derailment results, then a three-train collision similar to Clapham might occur. Whilst with modern more crashworthy rolling stock the consequences would likely be much less severe there is still significant potential for loss of life.
- Is it really sustainable to continue to rely on the wide range of connected measures outlined above to secure acceptably low SPAD risk? There must be a probability that one will eventually fail.
- From a technical perspective the existing UK system still depends on AWS which, certainly from a wayside perspective, relies on 1950's magnetic technology. The investment decision needs to be made on a 'modern equivalent replacement' basis, based on the cost of all of the systems and measures ETCS would replace. When buying a new car you would not judge the reasonableness of its price based only on the new features it offered you over your old one.
- ETCS is now really the 'only game in town'. If the UK does eventually leave the EU and try to have its own standards the volumes are too low to be attractive to multiple manufacturers and by the time the development cost was amortised little or nothing would be saved, it might even be more expensive. The only real alternative is to continue to 'muddle along' managing the obsolescence and other costs associated with a hotchpotch of systems and methods and then try to defend that when the inevitable happens.
- The manufacturers must play their part. I believe a move towards greater interchangeability would not disadvantage them in the way they fear because the size of the market would grow. The trend away from high obsolescence-risk dedicated hardware towards architectures that support commercial-off-the-self (COTS) implementations must continue for both wayside and on-board. There has been a massive investment in the ETCS software and that is what now needs to be stabilised and preserved so that eventually implementation costs will fall as the past cost of software production and homologation are amortised.
- The only really effective way to fight the skills shortages that undoubtedly exist for these 'new' technologies in the rail sector is to start to create a consistent market by having a steady and planned programme of deployments.

Conclusion

20 years after the Ladbroke Grove collision the UK industry's record on safety performance improvement is one to be proud of but the recent tragic loss of two trackworkers near Port Talbot reminds us that we can never be complacent. The record on investment in modern protection systems is less impressive for a wide variety of reasons although much has been done in some areas. I believe it is time to stop agonising over the business case, accept ETCS as the future system on a modern equivalent asset basis and plan a steady deployment process across the network. We owe it to those who died and were injured, and to all the families and friends affected by failures like Ladbroke Grove not to let performance slip. With the capacity pressures on many parts of the railway a modern ATP system is the only sensible way forward and ETCS is the only 'game in town'. Government, suppliers, train operators and Network Rail must all play their parts to make that deliverable without waiting for the painful incentive of another tragedy.

What do you think?

What is your experience of the challenges, and solutions, described above on your railway, in your country or in your company? Is the UK following the only available path? Was TPWS an appropriate stop-gap. Email **editor@irsenews.co.uk**.

Solving the resilience problem in the digital railway

Tim Whitcher

Mikela Chatzimichailidou

Designing safety critical systems like signalling and train control is arguably the most important job on the modern railway. While some physical infrastructure and rolling stock continue to rely on tried-and-tested designs, signalling is undergoing a transformation with the introduction of what is commonly referred to in Great Britain as the Digital Railway (DR).

Our networks are increasingly congested, with more and varied traffic types. As we move toward a dynamically controlled model within this complex ecology, our ability to manage complexity and to assure the systems to the same level of safety integrity must evolve with the technology.

To achieve this, we need to facilitate a new management approach that incorporates a more targeted level of risk modelling. By progressively assessing system design – using data collected across the system lifecycle – we can continually refine a design and test its resilience, making enhancements as well as corrections where standards are deficient or non-existent. In doing so, we put system risk engineering back in the hands of the signalling engineers.

Introduction

Railway systems are comprised of complex mechanical, electrical and electronic systems with many moving parts. Within this highly technological and engineered accumulation of systems, both human and automated agents are responsible for ensuring the integrity and efficiency of the system. Therefore, along with the physical system (the technology; rolling stock; infrastructure etc.), railway systems also incorporate operational issues and services, such as timetabling, pricing and integration with other modes of transport, as well as system properties which emerge from the interactions between elements of the system. Typical examples of emergent properties include: safety, customer experience and reliability of services, financial viability,resilience, sustainability and carbon footprint.

“Both human and automated agents are responsible for ensuring the integrity and efficiency of the system”

As the digital railway system of systems gets more complex, engineering resilience into the solution to keep trains running becomes increasingly business-critical.
Photo Shutterstock/ VMCgroup.

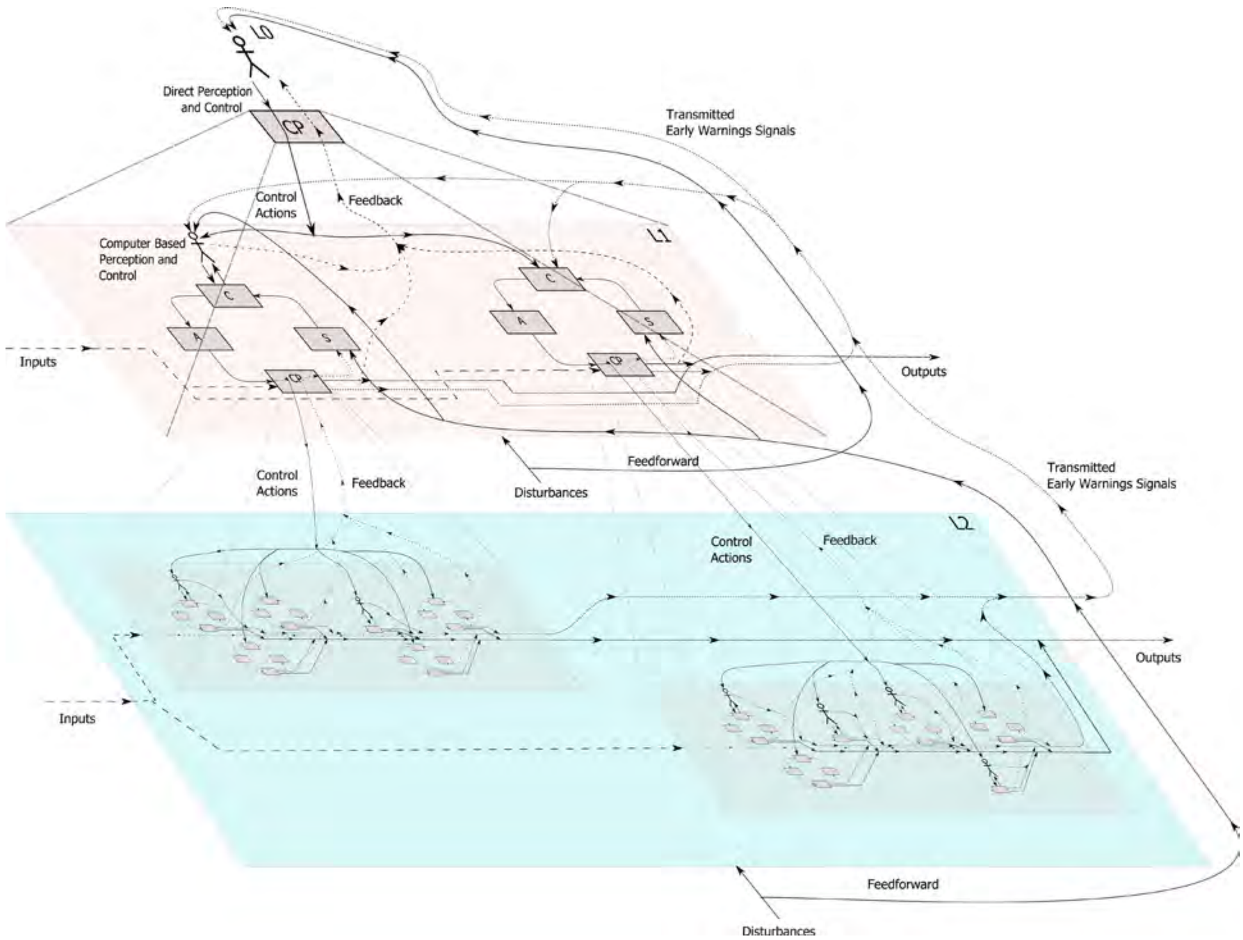


Figure 1 — a complex socio-technical model.

"Resilience is the ability of the railway system to respond to change, disruption or challenge ..."

"Railways can be considered as a system-of-systems"

What do we mean by 'resilience'?

Resilience for our purposes is the ability of the railway system to respond to change, disruption or challenge in such a way so as to continue to provide a suitable level of service as an output.

Railways can be considered as a system-of-systems (SoS) [1], the overall performance of which depends on factors that include network regulation, infrastructure and rolling stock reliability, organisational safety management and human factors. And the railway SoS is changing. Critically, modern railway systems are moving from a distributed system of local control points to being increasingly distributed only at the data collection end, and progressively aggregated toward the central hubs. For train and traffic management, these are the Rail Operating Centres (ROCs), and as these become focal hubs for the routes, the ancillary systems and services are likely to follow, putting the right people in closer proximity to each other, in imitation of the data. This will facilitate increased and more efficient networking, helping to reduce and remove existing system lags.

Figure 1 [2] shows a generic architecture for a SoS. If we look more closely at Figure 1, we can see the hierarchy consists of many control loops. A control loop is the elementary part of the SoS model as defined here. The 'stick figure' icons indicate humans (individuals or teams) that control various system processes. The technical components of that system are the elements marked as 'C', 'A', and 'S', standing for automated controllers, actuators, and sensors, whilst the 'CP' element denotes one of the controlled processes of the system. A control loop, formed by the elements with the letters 'C', 'A', 'S', and 'CP' on them, depicts a fully automated part of the system.

The parts of the system where humans exercise indirect control over the controlled process, with an automated controller in the middle, are denoted by the bidirectional arrows between the stick figures and the elements with the 'C' letter, together with the rest of the control loop, which includes the controlled process.

Finally, the parts of the system where humans have direct control over a process are denoted by the bidirectional arrows between the stick figures and the elements with the 'CP' label. In Figure 1, control entities are designated by the stick figures, as well as by the elements with the label 'C'. The control entities located at a specific hierarchical level enforce safety constraints [4] on their controlled processes, which include other control entities located at the lower hierarchical levels. In Figure 1, for instance, there are three hierarchical levels: L0, L1, and L2.

The system parts are organised in hierarchies and linked to each other with control actions, early warnings, and/or information feedbacks that strive to keep the system in equilibrium. The complex links of responses and feedbacks are important because the system exhibits a dynamic behaviour that stems from the interactions between the system parts. A system exhibits resilient behaviour by adapting to changing conditions in order to maintain control over its properties, such as safety and performance.

Once digital railway infrastructure is in place it is possible to make decisions about how to deliver customer experience based on any available data sets. *Photo Shutterstock/ Connel.*

Definition of the problem

The DR can revolutionise the way we manage our networks. It presents the opportunity to integrate systems and data, which enables the decision-makers (whether human or machine) to control the networks based on real-time data from multiple sources, to perform train and traffic management functions.

But it does not stop there. Once the infrastructure is in place it can be extended to include smart ticketing, passenger loading data, weather monitoring (and the effect it has on ridership, or customer dispersion along a platform, for example) and any other data-driven input. If you can collect, codify, analyse and present the data, you can make network regulation decisions based on it.

"How do we build resilience into this new ecology?"

All the systems in the DR ecology are interlinked and interdependent in a similar way as shown in Figure 1. As the adoption of digital systems and associated working practices increases, so too will the centralisation of data aggregation and usage. Points of failure will also aggregate, becoming fewer but having greater impact.

As the ROCs take over each route, the network will move from a distributed control network of some 800+ signal boxes across the UK today, to a truncated control network of 12 ROCs. Each ROC will therefore cover a greatly increased area.

So how do we build resilience into this new DR ecology, and how do we prepare it for rapid service recovery in the event of failure?

"Decision making is based on a more complex array of information"

Proposed solutions

The change in ecology and the shift to digital requires a little more exploration. Transport systems by their nature are complex – and they integrate into a much broader urban environment, which brings challenges around EMC (Electromagnetic Compatibility), third-party interference and communications overload. These issues will be exacerbated if not properly managed as part of the system evolution. Train control becomes even more complex as we add automation on the main line. For example, many automated Traffic Management (TM) conflict resolutions may still require the operator to make the final call, but do not present the logic behind the decision – for the first time, the operator is out of the loop. When we consider the integration of this with other transport planning systems used by the TOCs and other operators (such as road or maritime), the degree to which the train control system is not just safety critical but mission critical comes sharply into focus.

ROCs consolidate a lot of control and data in one place – making each ROC a single point of failure for each route and presenting the challenge of ensuring that a failure does not become mission critical to an area potentially encompassing 20% or more of the country – for example think of the chaos that would ensue in the UK if London North East Route goes dark!

Decision making is now based on a more complex array of information and, as mentioned, without the operator fully understanding the logic behind it; so, as reliance on that system builds, the operator's ability to instinctively respond to problems will conversely reduce.

Furthermore, all this takes place in an era of intense media coverage, where network performance is increasingly scrutinised by a despondent public. Despite falling reliability rail in the UK remains a key means of moving people and goods en masse; and failure carries more impact than before, with greater economic consequences for lost transit, fines and damages.

The shift from a conventionally signalled and controlled ecology to a digital one changes the approach to system performance assurance in a fundamental way. In the current ecology, systems

RiskSOAP Test Case	Description	Conclusion
Aviation: mid-air collision accident [1]	This application was the first attempt to quantitatively express the positive correlation between risk awareness and system resilience. RiskSOAP showed that the system as-designed (i.e. target system before the accident) was able to retain and process more risk related data compared to the one involved in the accident.	Decisions made during design led to an increased risk during operations, thereby reducing the resilience of the design, which subsequently factored into the cause of the collision.
Robotics: design of robotic platform for domestic use [3]	The values of the RiskSOAP indicator generated for the different system designs reflected the system dynamics. The values fluctuated every time the system design changed. Design changes made in relation to the capability of the system to be risk aware were correlated to equivalent levels of safety performance. The system design was changed as safety requirements were added to ensure that even if the robotic platform fails (i.e. it is unreliable), the whole system (human-machine interfaces) will maintain its resilience and assure human safety.	It was proved that resilience is not a static system property, but (in this test) improved along with the application of system safety recommendations mainly on the human-machine interface. Resilience and safety were positively correlated, whereas resilience and reliability were not.
Highways: maintenance of road tunnel [6]	RiskSOAP defined a tunnel design with risk awareness capability over and above that of designs that comply with the EU and World Road Association (PIARC) directives. RiskSOAP was key in determining the final design as it led to the identification of system safety requirements, which were added to the new designs on top of the EU and PIARC recommendations.	The RiskSOAP indicator was used as a selection criterion and decision-making tool to select and make modifications in the road tunnel under maintenance. The indicator showed that maintenance improved the resilience of the system, as well as its safety.

Table 1 — RiskSOAP tests.

are largely isolated from the outside world, using dedicated fibres to communicate often using parochial railway-only protocols. The servers and equipment sit in isolated equipment and control rooms and can only be accessed by authorised personnel. There are minimal cyber security threats and the system integrity is largely secure.

The new paradigm relies on digital systems with a completely different architecture, increased exposure to cyber threats and inherent resilience challenges leading to increased risk; assuring this is now a key imperative.

In building our new model of network operation we need to consider new approaches to communications:

- Physical security at all sites needs to be assured and guaranteed.
- Servers need to be encrypted.
- Communications links need to be high bandwidth, low latency and continuously available.
- ROCs need to be able to communicate, in real-time without performance interruption.

Defining a resilient system

It is important that we are able to collect the right data, so that we can perceive and comprehend complex system risks. Data can unveil unwanted deviations that indicate the presence of threats and vulnerabilities of the system, and therefore help us predict the systems performance in terms of resilience.

RiskSOAP [3] is a system assurance method paired with a system performance indicator. It is a comparative method that systemically and systematically produces results by measuring the difference between 'work-as-done' (i.e. system as-is) and 'work-as-designed' (e.g. target system). RiskSOAP test cases are illustrated in Table 1.

The RiskSOAP methodology is founded on three approaches, combined in a unique way. These are performed in the following order:

1. System-theoretic process analysis (STPA) [4].
2. Early warning analysis based on the STPA (EWaSAP) approach [5].
3. Binary dissimilarity measure to depict the distance between the different system configurations.

The methodology guides system designers and engineers in collecting meaningful data, turning them into information (e.g. requirements and specifications) to calculate the system performance and resilience. Moreover, by applying the method to different intervals throughout the entire system life cycle, we can maintain situational awareness, predict the future system states and adjust operations to maintain the system performance at an acceptable level and secure its resilience.

RiskSOAP has been tested for use in such areas as the update of road tunnel designs and man-machine interfaces in aviation and robotic platforms. It has caught the attention of Network Rail and Transport for London in the UK, as well as being reviewed by experts from industry and academia around the world.

"RiskSOAP has been tested for road tunnel designs, aviation and robotic platforms"

"Disaster recovery systems are expensive and rarely used in rail"

Disaster recovery sites

Disaster recovery is the process of bringing the system back on-line after a major or catastrophic failure. This capability is a fundamental component of 'resilience'. The objective is for a community and its economic functions to recover quickly and soundly, after a major event.

Highly integrated systems, such as the aggregation of network command and control into a single ROC, present a big locus of impact should one 'fall over'. To protect the network against this threat one or more disaster recovery sites are required to replicate the essential functions of the ROC in a secondary (and third) location, which is secured and robust against the threats that took out the primary ROC. This needs to have compatible technology and data to enable a rapid transfer of control.

Disaster recovery sites are expensive and rarely used in rail – this needs to change if we are to use them as a foundational part of our strategy. In that instance we need to do two things:

1. Use them as training hubs for operators and maintainers to (a) keep their competency at the highest level, (b) keep the disaster recovery ROC in line with the latest technology and data releases (c) but also use this opportunity to close the loop, that is, utilise feedback from operators and maintainers to re-think and maybe design more user-friendly interfaces and data representation.
2. Hold as many open interfaces as possible to facilitate the use of the disaster recovery ROC as a fall-back for multiple field ROCs.

"The advent of DR is ushering in a new paradigm in technical support for the railway"

Dedicated support teams and DevOps (Development/Operations)

In order to support rapid failure recovery, maintenance teams need to be intimately familiar with the systems and always up to date with the latest technology and associated skills and knowledge. Digital systems are not likely to fail often but when they do, the integrated nature of the new ecology means more associated systems are affected across a wider area.

To counter this, maintenance facilities need to be equipped with a full simulator suite for the systems under control. Any spare time between routine maintenance and inspections should be spent on the simulators running through failure scenarios, practicing diagnostic routines and response techniques; making sure that no matter what event occurs the team is capable and agile enough to respond promptly.

The advent of DR is ushering in a new paradigm in technical support for the railway. It will require the upskilling of personnel, and the provision of more tools and theoretical training, as the actions systems perform are now entirely in the software domain, with no direct observation possible.

We will need to keep maintenance teams better informed, even when things are going to plan, in order to build their familiarity with the system. Greater use of situational awareness and workflow tools will help manage response times, and clear action plans will help to prevent misunderstandings through different interpretations of events.

One of the advantages of the DR ecology is that it delivers efficiency gains that enable us to turn our attention to continuous improvement. By virtualising our systems we are able to work on them remotely, design, build and test upgrades, and implement these in a system-wide download in minutes. This brings the railway into the fold of DevOps – combining work streams from developers and operators of the system to rapidly develop, implement and enact enhanced performance.

The DevOps cycle provides both benefits to capture and risks to manage: the benefits are that the system can now be enhanced incrementally and with minimum service disruption; this will facilitate a rapid change in the capability of the service if played correctly.

This flexibility is not without risk, as the procedure for remote updates now means the system has another access point to secure against cyber threats. But it is a known risk, a quantifiable risk, and a risk we can control – indeed, the RiskSOAP model is designed precisely for that purpose and gives us a new model for network assurance and risk modelling.

Conclusion

Transportation systems combine social and technical components that work together to achieve the purpose of the system. These complex socio-technical systems consist of many parts, controlled by human or automated agents in constant interaction and close cooperation, though usually located in different hierarchical levels and at distant regions. Communication and control are critical in order to retain, comprehend and share data and information, maintain awareness of possible threats and vulnerabilities and, ultimately, enhance the resilience and safety of rail transport systems. Ideally, such attributes should be embedded into systems from the concept stage onwards, so they become an integral and intimate part of the infrastructure. Signalling and control engineers will continue to play a vital part in this process, within the new DR ecology.

We are building a more interconnected world which will provide the railway and its passengers with many benefits. As the returns build, so does the complexity and risk and we must be ready to mitigate this with solutions tailored to our shared digital future. Tools like RiskSOAP and the wider implementation of disaster recovery processes and technology will help signalling control and communication engineers increase resilience, by supporting the design, development and maintenance of systems that are self-aware of their vulnerabilities and can pro-actively prevent and instantly react to accidents and losses.

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IRSE News analysis: why do our systems need to be resilient?

The article "Solving the resilience problem in the digital railway" discusses how we may achieve resilience. During the editorial process of preparing this issue two events occurred in the UK that demonstrate why train control and communication systems need to be resilient and perhaps more importantly why the range of resilient systems is expanding.

The first incident related to British Airways. They had a problem with online check-in which resulted in it becoming inoperative for some airports including the prime London airports of Heathrow and Gatwick. The consequential queues and delays at the airports ultimately caused the cancellation of around 100 flights. This is not an issue with direct relevance to a railway, although some high-speed operators may move towards airline style check-in in the future.

The other event started with a National Grid problem with electricity supply. Two power stations, one gas fired and the other a wind generation station ceased supply within one minute of each other at the beginning of a Friday evening rush hour. The cause of the shutdowns appears to be unrelated and the total loss of supply amounted to around 1.4GW. This significant loss of supply resulted in a frequency drop close to or below the threshold limit.

Consequently, load was shed which particularly affected supplies North and East of London and included railway supplies. Without the load shed there was significant risk the entire grid would become unstable and have to be shut down. Within 15 minutes new supply was in place and National Grid worked with the local distributors to return supplies, most of which were fully operational within 30 minutes of the initial event.

The railway, however, and in particular routes over which Thameslink trains operated continued to suffer for several hours. For reasons that are at present unknown, the manner of the loss of supply to the trains caused the on-board Train Management System (TMS) to malfunction. When the power returned the trains could not move until the TMS had been reset in a controlled manner. Around 20 trains failed to reboot and required a technician to attend before they could continue. Getting technicians to stranded trains is logistically challenging and took several hours. The resulting delay meant some of the trains needed to be evacuated, effectively closing the affected routes to all traffic.

Two individually small or temporary issues resulted in major disruption and gave us a greater appreciation of the importance of resilience in our societal systems.

Thinking closer to home are we sure we are building resilience in to the systems we develop today? We are on the edge of a significant change in railway systems and especially signalling.

On metro railways signalling is moving rapidly toward CBTC based systems. On the main line networks the move to equivalent systems, such as ETCS, is likely to be the major change over the next two or three decades. You could ask how much longer will the primary signalling system be "lights on sticks"? Capacity, availability and reliability are key motivators for these moves as is the need for increased safety. But they are not the only factors.

The railway is fundamentally a system for moving people and goods from where they are to where they are required and increasingly this needs to be done with a very high degree of confidence.

Railway signalling has traditionally maintained safety by stopping trains. However, stationary crowded trains with no opening windows and failed air conditioning present an unacceptable situation and could directly result in a hazardous situation for those on-board. In the electricity supply failure incident some of the trains were trapped underground for hours with no lights.

People require confidence their train will arrive close to the planned time, or if there is a delay that this is notified promptly and accurately. To do so requires comprehensive traffic management systems linked to the real time railway and able to adjust and predict the outcome of any change. The aim is to minimise delay.

However, rescheduling a train en-route is only part of the challenge. Rolling stock rosters need amendment and the train staff also need to be factored in to the change. Customers, passenger and freight, get frustrated when they are not informed of what is happening.

They require timely and accurate information to provide reassurance to their journey or so they can make alternative arrangements. We must therefore build resilience into every system and interface including information transmission systems. Do we do enough work during the design stage to ensure resilience is built in? Do we make sure the whole picture is understood and that our solutions will function even when one element has failed?

Do we adequately test to ensure embedded software systems will recover after power supply outages or frequency drift? Do we consider the need for disaster recovery control centres? How would we recover from a fire or flood situation of a rail operating centre controlling a large railway network?

The railway is a complex system of systems attempting to deliver, with an extraordinary degree of reliability, the passenger or freight to their destination at the time previously planned. Resilience is critical to the success of that venture if it is to be achieved day in and day out.

The two incidents discussed illustrate the complexity of our modern world and that a problem may arise in the most unexpected arena. They also emphasise the reason for resilience throughout all of those systems. Thus it is good to see others are considering methods of ensuring resilience can be considered and designed in from the earliest stages of a project onwards.

Resilience will be the main topic of this year's ASPECT conference and IRSE News plans to publish a number of the most interesting papers. If you are attending ASPECT and identify a paper you believe would be of interest to a wider audience please let us know at **editor@irsenews.co.uk**.

What smart railways can do for smart cities

Frank Heibel

As our cities grow, the need for mass transport increases. Individual car traffic, even if smarter and more automated, will reach a saturation point with stifling congestion in peak traffic. Public transport thought leader 'Doc Frank' Heibel is convinced that city railways have significant capacity reserves which can be unlocked with modern technology. This article was first published as a guest post for the Smart Cities 2019 conference in Melbourne, Australia.

There are many intriguing concepts for transport innovation. Autonomous cars, shared mobility, mobility as a service, and demand-responsive transport are just some of the buzzwords which promise a solution for today's and more so tomorrow's transport problems. Yet they cannot resolve the biggest problem of transport in cities – road traffic congestion. Why? Because all those trendy innovations rely on road transport. And as road transport keeps growing, roads will eventually get clogged, and the only innovation effect left is that people are stuck in traffic in cars that are self-driving.

More infrastructure – road or rail?

Building new transport corridors within city centres is enormously expensive. If such investment is deemed unavoidable, at least the transport capacity of that new corridor should be maximised. Studies conducted for Perth, Australia showed that a railway line with rather modest service frequency of twelve trains per hour can carry the same number of commuters as a six-lane freeway.

On that basis it is little surprise that a new inner-city rail corridor would have a better benefit-cost ratio than a similarly expensive new road. Mistrust any reports that claim otherwise.

Using existing infrastructure better

Before spending big money to duplicate infrastructure, one may want to make sure we get the most out of the infrastructure which is already there. Perhaps the best question here is not whether expensive new transport infrastructure should be road or rail. (I believe we need a balance of both, by the way.) A smarter question would be, what if the capacity of existing transport corridors could be increased so much that additional corridors are not even needed for many more years?

Road traffic congestion is the biggest problem of transport in cities. *Photo Shutterstock/ Novikov Aleksey.*

Smart technologies – how good are they?

In road traffic, there is a lot of hype around "Intelligent Transport Systems", mostly a glorified variety of variable speed signs for traffic flow control. How much additional capacity will this provide? I think many would be delighted if a practical increase of around 10% was the outcome. Impressive looks different.

The capacity reserves in our city railway systems are significantly higher, between twenty and one hundred per cent depending on how much the current rail system has been squeezed. And the investment to unlock those reserves is much lower than for building more infrastructure.

Doc Frank believes that urban transport capacity reserves can be unlocked by using modern technology. *Photo Shutterstock/ Serpetko.*

What is needed for better railways?

The primary investment need for increasing the capacity of any railway is trivial but sometimes overlooked – more trains. The second investment area is the upgrade of existing rail infrastructure so that it can accommodate more trains. One example is augmenting traction power supply, since more electric trains on a railway need more energy. The other area where modern technology can overcome a constraint for higher capacity is what I call "High-Performance Signalling". There are two global mainstream technologies that can provide such high-performance signalling – Communications-Based Train Control or in short CBTC, and enhanced varieties of the European Train Control System (ETCS) Level 2, what I refer to as ETCS Level 2+. It should be noted that there is more to high-performance signalling than just more capacity. Other important benefits include higher availability reducing system downtime due to technical failures, improved service reliability which means a higher percentage of train services run on time, and increased levels of automation.

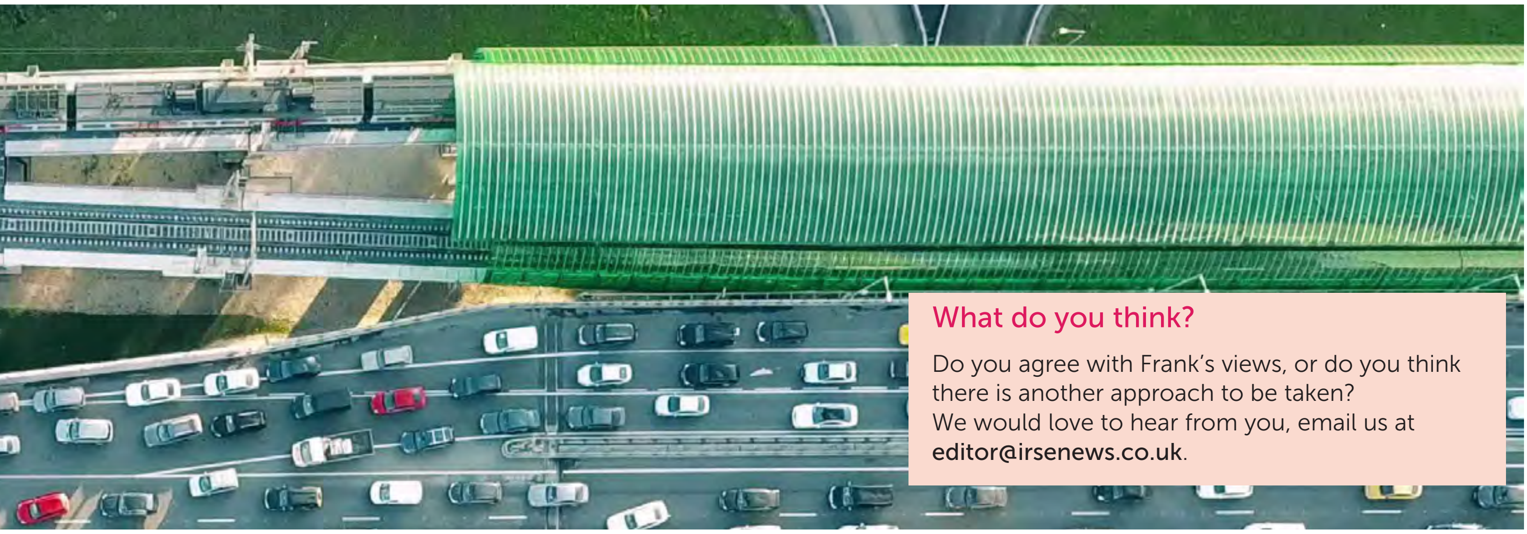
High performance signalling, either CBTC or enhanced ETCS Level 2+ with automatic train operation, is currently being introduced in all four of the biggest Australian cities – Sydney, Melbourne, Brisbane and Perth. Those state-of-the-art signalling technologies will allow the running of many more trains than possible with the existing legacy signalling systems thus alleviating issues related to growing demand for commuter traffic in peak hours.

Invest smarter

Signalling technology may not be as photogenic for our politicians as a new train, tunnel boring machine or railway station. But the introduction of high performance signalling is a smart and more cost-efficient way to increase commuting capacity. And which political decision-maker would not want to be seen as smart and cost-efficient?

About the author ...

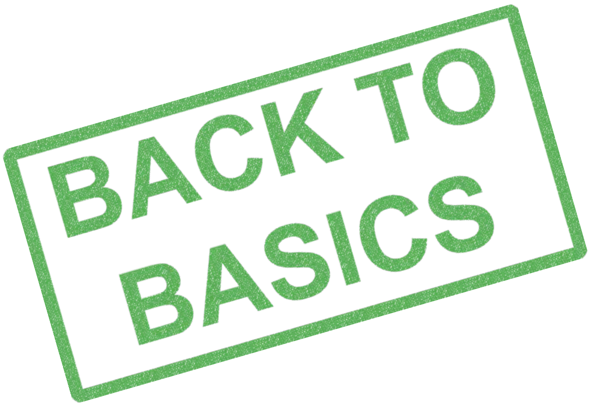
"Doc Frank" is a globally recognised strategy advisor and thought leader for high-performance railway signalling. He has advised government railways in all four biggest Australian cities and several projects outside Australia on planning and implementing their next-generation signalling technology to boost capacity and improve operational performance.



What do you think?

Do you agree with Frank's views, or do you think there is another approach to be taken?
We would love to hear from you, email us at **editor@irsenews.co.uk**.

Fundamental requirements for a train control system



In the first of a planned series of 'back to basics' subjects on train control and communications, this article summarises the fundamental requirements for a train control system. These requirements will be familiar to experienced signalling engineers, but are recommended reading for anyone new to railway control and communications and for IRSE members preparing to take the IRSE Exam.

The requirements were originally set out in the IRSE Signalling Philosophy Review (2001) and have subsequently been reviewed and revised a number of times. They are available in full via the IRSE website at irse.info/ex3ous.

The requirements are not mandated by the IRSE, although the Institution regards them as essential for any train control system.

The word 'signalling' is defined by the IRSE as all the equipment, electrical, mechanical or otherwise, methods, regulations and principles whereby the movement of railway or other traffic is controlled. Throughout the requirements, and in this article, the phrase "train control system" includes the people, procedures and technology used to signal trains; and where the single word "system" is used it means the "train control system". Where the phrase "signalling system" is used, this means the part of the train control system which is implemented by means of technology, which could be both infrastructure-based and train-borne. The requirements are equally applicable whatever form of train control system (as defined above) is used to control train movements. Accordingly, they are written at a high level, with the intention that users interpret and apply the requirements through the specific method of train control that is proposed for a railway.

The requirements are in three sections. The first deals with operational requirements, the second with functional safety requirements, and the third addresses supporting safety requirements.

Operational requirements for train control systems

The system will need to meet the needs of operators in terms of:

- permitted train movements (such as normal running; joining/ splitting; platform sharing, shunting);
- permitted routing of trains;
- capacity provision and utilisation;
- and flexibility of operations.

The system may also contribute to efficient resource management, such as efficiency in traction energy consumption, and minimising wear and tear on the track.

If, in addressing requirements for safety, the proposed design constrains the operability of the railway, the impact of this will need to be assessed and minimised (but without compromising acceptable levels of safety, of course).

In order to deliver the timetabled train service, the specification and attainment of appropriate levels of reliability and availability are essential. Reliability and availability also contribute to overall levels of system safety. Maintainability is essential in order to ensure that the specified levels of reliability and safety continue to be met throughout the service life of the system.

To achieve required levels of overall availability, the provision of degraded modes of operation is desirable. However, human intervention as a means of safely controlling train movements under failure conditions (e.g. signallers authorising trains to pass signals at danger, manual on-site operation of points) entails significantly higher risk and is therefore not the preferred means of meeting this requirement. Transitions to and from degraded modes of operation will need to minimise risk, facilitated by "graceful degradation" as well as timely and safe mechanisms for recovery to normal operation.

Train control has a long history but is evolving rapidly as technological change offers new alternatives to manage the safe movement of trains to deliver the optimum experience for railway passengers and freight users. There is however a series of underpinning requirements for any train control system. *Photo Shutterstock/hxdyl*.

Functional safety requirements for train control systems

Before a train is given authority to move along a section of line, the section of line needs to be proved to be secure (see below) and clear of other traffic, to prevent derailments and collisions, and to avoid conflict with movement authorities given for other trains.

Exceptions to this are circumstances where a train is permitted to enter an occupied section of line, such as for platform sharing, coupling of trains, permissive working, and shunting.

Where the train is stationary at a station, depot or siding, activities such as train preparation, loading, unloading, closing doors must also be completed before the train is moved. However, these activities are not normally regarded as part of the functionality of the train control system.

The term "secure" (see above) refers to a limited set of safety requirements, primarily relating to the position and locking of points, and the routing of other trains. Signalling systems do not usually prove that the line is clear of all obstructions, or that the gauge is correct and the track is physically stable, so other control measures may need to be considered to manage these risks.

When authority to move along a section of the line has been given, the security of the line needs to be maintained for the movement until the complete train has:

- passed clear of the section of line; or
- the authority has been rescinded (withdrawn) and the train has come to a stand; or
- the authority has been rescinded (with information communicated to the train) with the train having sufficient space to come to a stand safely before the start of the section of line over which authority to move had been given.

In some signalling systems sectional route release is used, whereby parts of a section of line are released progressively when the train has passed clear, to facilitate earlier setting of other routes.

The train driver (or the automatic train operation sub-system [ATO]) will require unambiguous, consistent and timely information that enables safe control of the train. This may include:

- proceed/stop information;
- the provision of warning information regarding the approach to the end of the movement authority or a section of lower speed line, to enable the train to brake safely;
- the provision of speed, routing, gradient, braking capability information.

In addition, data entry sub-systems may be required in order to input train parameters that are relevant to the safe operation of the train control system (e.g. weight, length, braking capability).

Sufficient space will be required between following trains to allow each train to brake to a stand safely; this is usually calculated on the assumption that the train ahead is stationary.

Suitable control measures will be required in order to prevent and/or mitigate the consequences of a train:

- passing the end point of its movement authority;
- exceeding the maximum permitted speed;
- moving without authorisation.

Examples of technical solutions for these include overlaps, train protection/warning systems, flank protection, approach control/release of signals, provision of trap points and speed signs. It may also include other measures, e.g. driver competence, provision of information to drivers and operating rules.

Protection will be required for the public and trains at level crossings, although not all level crossings are necessarily protected by the signalling system itself (in simple cases an independent means of protection may be adequate based on risk). The operation of a level crossing will need to minimise the road closure time, otherwise this could lead to crossing misuse by pedestrians and road vehicle drivers.

Trains, worksites and workers will need to be protected during engineering work. This could include:

- facilities for controlling the access of trains to sections of line where work is taking place or where safety has been reduced as a result of engineering work;
- ensuring that the section of line is clear of obstructions (e.g. engineering vehicles) when work is complete and before trains are allowed to run over it;
- restricting the speed of trains to help protect track workers or because of the condition of the track;
- warning trackside workers of the approach of trains.

In order to provide a safe and efficient railway the signaller will require unambiguous, consistent and timely information, and suitable control facilities, to enable the safe authorisation of train movements (the term signaller also include other personnel who may have responsibility for authorising train movements). This includes the provision of information required under failure and degraded mode conditions, as well as for normal operations. Ancillary information systems such as train describers, critical fault alarms and data entry systems may also be required. When designing the signaller interface systems, human factors assessments will contribute to safety and efficiency.

Facilities for communication between signallers and others will be required, for both normal operation and degraded/ emergency working. This includes communication with:

- train drivers;
- signallers in neighbouring control centres;
- train operators and route controllers;
- level crossing users;
- emergency services.

The nature of the communications systems will need to be appropriate for the purposes required, for both normal operations and failure/degraded mode situations.

A means will be required for preventing trains from being routed onto a section of line with which they are not compatible. Situations where this requirement could apply include:

- incompatibilities of gauge between track and train;
- incompatible traction supply systems for the train;
- incompatible train-borne train control sub-systems;
- restrictions on access to tunnels for certain types of trains;
- restrictions on specific train types being permitted on routes, adjacent lines etc, at the same time, such as hazardous freight and passenger trains.

In order to instruct a train to stop in an emergency, appropriate facilities will be required. This could be met by functionality within the signalling system itself to enable a movement authority to be withdrawn, or by the use of an alternative/ independent means such as radio communication with the driver. The speed and reliability with which a message can be given to a train to stop needs to be commensurate with the risks associated with the emergency. The risk of stopping trains in unsuitable locations also needs to be taken into account.

Essential supporting safety requirements for train control systems

The assignment of safety targets for a train control system will need to:

- be commensurate with, or better than, the levels of safety performance of comparable systems already in service;
- meet the reasonable expectations of users;
- comply with legal requirements.

The compatibility of the operating rules with the rest of the train control system (and their completeness) is essential for the safe operation of the railway under normal, degraded and emergency conditions.

Even though the system may be highly automated, there will always be a measure of dependence on human interaction, for instance during degraded mode operation or during maintenance. Appropriate allocation of functions between the signalling system and operators, and designing the overall train control system to make it easy for operators and maintainers to perform their actions safely, is vital. The human factors will need to be addressed to help provide a safe and easy system to operate, both for operators and maintainers.

Modern signalling systems usually revert to a safe state, such as signals automatically restoring to “stop”, although this may not always be necessary or desirable (and indeed mechanical signalling systems do not generally do this). Designing the system so that failures and faults are self-revealing to operators and maintainers will aid prompt and safe rectification, and will help to avoid situations where a fault is latent (hidden) and does not reveal itself until some other event occurs.

Unsafe interactions of the system with other railway systems and equipment need to be avoided. This includes both interactions where there is an intentional interface with other systems and equipment, such as other railway infrastructure and trains; and interaction where there is no interface, such as electromagnetic interference. Unwanted external influences that could adversely affect the safety and availability of the system include:

- environmental/ climatic effects;
- cyber-attacks on software-based subsystems;
- vandalism;
- unwanted electrical/radio interactions with non-railway systems.

Problems can occur when introducing new rolling stock on routes with older signalling systems, which may not be immune to interference generated by new trains. Introducing new rolling stock in a controlled manner will facilitate early identification and rectification of problems not addressed at the design stage.

Systems that are designed so far as possible to prevent the possibility of inadvertent errors during maintenance and repair work, and which incorporate diagnostic systems for monitoring the health of the equipment, will contribute to its continuing safe operation and minimise the risk of introducing undue risk to either the operational railway or the personnel carrying out the work. These considerations may have implications for e.g. the design of equipment and its physical location.

Personnel who design, build, test, commission, operate and maintain the signalling system, or in any other way form part of the train control system, will need to be competent in order to perform their tasks and duties safely and efficiently. This includes the competence of designers, testers, drivers, signallers, maintainers and others whose activities contribute to the overall safe working of the system. The application of suitable procedures for personnel selection, training, assessment and periodic review will contribute to continuing competence.

What do you think?

What other ‘back to basics’ articles would you like to see in IRSE News? Why not share your experiences with other engineers? Email **editor@irsenews.co.uk**.

New interlocking systems introduced in the UK

Paul Darlington

Over the last year two new types of Computer Based Interlocking (CBI) signalling systems have been introduced in the UK, one by Hitachi Rail Signalling & Transportation Systems (STS) and the other by Atkins, a member of the SNC-Lavalin Group.

In December 2018 a consortium of Hitachi Rail STS and Linbrooke Services Limited – with Arup providing the signalling system design deliverables; delivered the resignalling of the line between Ferriby and Gilberdyke, on the north side of the River Humber using the STS (previously Ansaldo STS) SEI (system d'enclenchement informatique) interlocking and MTOR (module toute ou rien) SEI object controllers.

Over the weekend of the 22, 23 June 2019, Atkins commissioned their first ElectroLogIXS electronic interlocking and level crossing controller. This was on the Shepperton branch, part of the Feltham signal box area south west of London. ElectroLogIXS is a programmable logic controller licensed to Atkins, exclusively for UK rail use. The importance of the product is illustrated by the fact it is the first totally new interlocking to be introduced in the UK for some years.

Common requirements for both schemes were to: use only Network Rail approved LED signals, axle counters and clamp lock points; introduce the capability of communicating with a Radio Block Centre (RBC) to enable future easy upgrade to ETCS, once compatible rolling stock is available on the routes; eliminate or reduce the use of relays in the systems, and to locate the lineside equipment in equipment cabinets, not in buildings or equipment rooms. Communications between equipment and the control centres would use the FTNx IP telecoms network, with no requirements for dedicated cables.

Ferriby and Gilberdyke

The SEI interlocking system was originally developed in France and is not the same as the earlier STS 'ACC' signalling installed between Crewe and Stockport. The ACC system originated from Italy and controls STS lineside assets, but the SEI system is able to control Network Rail standard catalogue item lineside assets, although some new interfaces were required.

While the STS SEI interlocking was already in use for HS1 and the Cambrian Lines these did not require lineside signals, whereas Ferriby to Gilberdyke required LED aspect signals.

Oxmardyke MCB-OD crossing between Ferriby and Gilberdyke during construction. The road is closed and the semaphore signal is still standing. *Photo Network Rail*.

Temperature-controlled location case developed specially for the Ferriby to Gilberdyke project. *Photo Arup.*

Cave Crossing gate box has been replaced with Cave obstacle detection crossing. *Photo Network Rail*.

There was a SEI interface which was already used in other countries for such applications, but this had a relay interface. So, a new interface product was developed for the UK called the SEI – CLSS (colour light signalling system). This was based on a similar existing SEI product, but new electronic cards were required for signals (IOM SX) and points (IOM AG), together with a new current proving module.

The SEI interlocking uses 'two out of three' digital technology for reliability and is able to interface up to 100 MTOR object controllers with each MTOR having 20 vital outputs, 26 vital inputs and 8 non-vital inputs allowing each object controller to interface with multiple signalling assets depending on their I/O requirements. It supports open standard data communications interfaces and is able to take advantage of modern IP 'off the shelf' telecoms switches, without requiring dedicated cables between the central safety processor and the object controllers.

The new CBI signalling fringes with Selby route relay interlocking (RRI) to the west and Hessle Road RRI in the east. Between Ferriby and Gilberdyke nine manually controlled level crossings with obstacle detectors (MCB-OD) have replaced the previous manually controlled gate/barrier crossings, together with two miniature stop light (MSL) crossings. Crabley Creek crossing was proposed to be replaced by a bridge, but due to problems with land take it has been retained as a manual gate box. Bombardier EBI Gate 2000 controllers were used to control the MCB-OD crossings. EBI Gate 2000 is solid state and controlled by object controller devices, therefore no conventional relays are required, improving reliability and reducing maintenance requirements.

The SEI equipment was designed to be located in equipment rooms, but to make the scheme cost effective a new lineside temperature-controlled location case (TCL) was designed. The cases are approximately 1.5 times the size of a normal lineside case and are multi discipline, split into three portions.

One section of the case contains the telecoms fibre terminations, switches, patch panels and axle counter equipment. The middle section contains the object controllers plus the LED signals and points interface modules together with battery backup supplies for the switches, and the third section contains the power supplies, TPWS modules, relays, contactors and cable terminations to the lineside equipment. The Frauscher axle counter FAdC system uses a decentralised architecture enabling a track section to be evaluated locally by locating the FAdC system boards along the lineside, and communicating via Ethernet along the route using the latest COM-FSE design. Thus everything is solid state, in line with the 'no relay' requirement.

The system is controlled from the York Railway Operating Centre (ROC), which has Controlguide Westcad operator workstations supplied by Siemens. An Hitachi RCCS (route control centre system) workstation could have been used but Network Rail required all the York ROC workstations to look the same. This required a new standalone protocol conversion railway interface (RIF) to be developed to link the Westcad workstation to the SEI interlocking. This had to take into account the Hitachi automatic route setting ARS system and interfacing to the EBI Gate 2000 level crossings. York ROC was also provided with an SEI technician maintenance terminal.

Shepperton branch

The ElectroLogIXS hardware that has been used on the Shepperton branch is manufactured by Alstom (formerly GE) and is a Vital Logic Controller (VLC) using internet protocol (IP) communications and diagnostics via a scalable remote condition monitoring system, and a common hardware platform for both trackside and control parts of the system. The ElectroLogIXS chassis-to-chassis communication uses RP2009 (SIL4) protocol with no safety reliance on the network. The product acceptance covers both 'interlocking' and 'level crossing controller' applications, and both of these have been used on the Shepperton branch commissioning.

Atkins' strategic programme for future signalling systems aims to change the way signalling projects are delivered in the UK. It uses a wide range of products and components to deliver a full train control, signalling and power system; from interlockings to level crossings, to barrier arms, power supplies and cables. The scheme involved 11 separate product acceptance approvals.

Initially the Shepperton branch will be controlled from a single workstation located at Feltham signal box, before being transferred to Basingstoke rail operating centre (ROC) in a later stage within the overall Feltham resignalling programme.

Standardisation of equipment and lower number of trackside equipment location cases is a major benefit of the system. It has been calculated that resignalling all of the Feltham signalling project area using conventional SSI would have required in the order of 3000 relays and 450 lineside equipment locations.

Introducing new systems to an established railway such as Network Rail requires balancing innovation with compliance to existing standards such as those for control and display (left) and existing trackside hardware (right).
Photos SNC Lavalin-Atkins.

One benefit of ElectroLogIXS is that it requires fewer relays than other systems as shown in the location case above left. The photo on the right shows activities trackside during the commissioning of the Shepperton branch.

Using the new system will reduce this to approximately 130 relays and 220 lineside equipment locations.

The solution developed is based on a design that permits the use of more readily available non discipline specific software engineers, rather than scarce signalling designers. This allows signalling engineers to focus on the core functional signalling requirements. New methods of data production and testing using modelling techniques and empirical processes have been introduced, together with repeatable data modules, designed and tested once and used many times.

The 'Level Crossing in a Box' (LCiaB) as a concept based on delivering a complete crossing in a container ready for installation. In the Shepperton scheme the solution has been provided at Hampton MCB-CCTV (manually controlled barriers with closed circuit television) crossing.

Currently LCiaB is specified for MCB-CCTV but it has been designed so that is can easily be configured for other types of MCB and as a miniature stop light (MSL) crossing. The crossing solution consists of two or four barriers. Up to six sets of traffic signals (wig-wags) and four 'Standing Red Person' signals can be supported. The barrier machine, supplied by Newgate, is also new to the UK signalling market and is 110V AC powered, with each barrier boom driven by a three-phase inverter and motor through a gearbox. Angular detection of the barrier is by factory set rotary blades detected by proximity sensors. There are a pair of industrial safety switches which mechanically detect the drive spindle when it is in the lowered position.

A small safety controller (PLC) provides machine control via a set of 24V DC control and indication lines connected to the Level Crossing Controller (LXC) case. Manual operation is achieved with a small hydraulic pump and cylinder system. It is claimed that a machine has already completed in excess of 3 000 000 fault-free operating cycles in the factory.

What do you think?

Have you been involved in a signalling project that has seen established products used in new markets or applications? If so why not share your experience with an article in IRSE News? Email us at **editor@irsenews.co.uk**.

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Institution of Railway Signal Engineers

The Network Rail digital long-term deployment plan

Claire Beranek

In common with many other railways across the globe, the infrastructure provider for GB rail, Network Rail, is faced with maintaining a large and complex network whilst introducing digitalisation to improve operational performance and customer experience. In this article Claire explains the background to this challenge and the current approach in relation to the immense amount of work involved within an industry constrained by the availability of suitably skilled labour.

The problem: managing asset sustainability

For some years Great Britain has lagged behind several countries in Europe in that it hasn't had a long-term plan in place for roll-out of the ETCS (European Train Control System) across its infrastructure. Several attempts have been made in the past to produce a plan, but they haven't succeeded due to being either undeliverable or too costly. At the same time GB has a signalling asset sustainability problem, with 65% of its external assets expected to be life expired within 15 years, (86% in 20 years) and government funding unlikely to be able to rise to meet the costs of conventional signalling renewals. Figure 1 shows the average remaining asset life of signalling assets on the network until the end of 2029.

The requirement: a long-term digital deployment plan

To address the problem, a request (Figure 2) was received from the Secretary of State for Transport on 19 March 2018 to produce a long-term digital deployment plan to be delivered to the government at the end of February 2019. It was to be an aligned rolling stock and infrastructure fitment plan, developed with the wider rail industry. The plan was to be at the lowest whole life cost to the industry.

The UK government funds the railway in five-year control periods (CP), so the plan was to consider the period from CP7 (April 2024) onwards, and not to change the CP6 (April 2019 – March 2024) already agreed workbank. CP6 renewals were to continue to deliver in line with a standard "digitally ready specification".

Approach supported by the rail industry

The team that put the plan together comprised Network Rail representatives, digital railway experts, RIA (the Rail Industry Association) representing the supply chain and RDG (the Rail Delivery Group) representing the train and freight operating companies. Team meetings had representatives of all those stakeholders present.

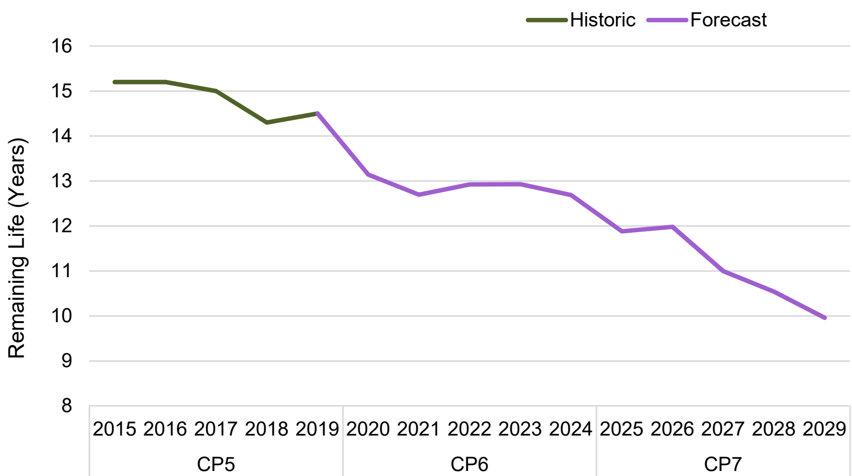

Figure 1 – Average remaining asset life of signalling assets on Network Rail infrastructure.

Department for Transport

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19 March

Digital Signalling Renewals in CP6

Firstly, I would like to thank you for the work you and your staff have undertaken in developing a clear and ambitious strategy for the transformation of Britain's railway into the digital age. I am looking forward to supporting you and your team on the launch of this Digital Railway strategy in the near future.

Britain's railways are crucial to our economic future so, as the Secretary of State for Transport, I have challenged our rail industry to put passengers at the heart of everything the railway does. I see the Digital Railway as an essential part of realising our shared goals of running more trains, faster, more safely and on time.

I am pleased to see that work has already begun to deliver the Digital Railway. While I have been Secretary of State, the Government has allocated an additional £450 million to accelerate the deployment of digital signalling technology and in the November 2017 Budget we announced a number of Digital Railway projects, including between Manchester and York, which are now being developed with this funding. In addition, I am encouraged by the progress being made by the industry in developing a rail sector deal that supports the Digital Railway, and the steps being taken toward a more substantial deployment of digital technologies on the East Coast Main Line, the further development of which will be supported by a £10 million contribution from the National Productivity Investment Fund.

As we discussed at the recent Network Rail Board dinner, in order to deliver the significant benefits to passengers, taxpayers and the rail industry that digital signalling will bring, we must see an end to the deployment of conventional, analogue signal renewals at the earliest opportunity. Consequently, I would like to see a plan of all signalling renewals and upgrades in CP6 and beyond showing them to be digital, or at the very least digital ready so as to enable future upgrade to full digital operation to be delivered with minimal cost, time,

Figure 2 – The Secretary of State for Transport wrote to the CEO of Network Rail asking for a long-term digital deployment plan.

The plan was to be infrastructure renewals-based, aiming to maximise the life of signalling assets, and resignal with a digital solution at the point of external asset life expiry – meaning at the moment the majority of signals, track circuits, location cases required renewal.

It was recognised that a digital signalling solution would be cheaper than a conventional signalling solution, and the cheapest way to resignal the railway is with a 'signals away solution' which required all trains passing through a digitally resignalled area to be fitted with ETCS prior to the resignalling date.

This approach then required close liaison with the RDG to understand which trains were cleared to pass through an interlocking area to ensure exact alignment between train fitment and infrastructure fitment.

Affordability and deliverability constraints

The plan was based on some key affordability and deliverability principles which were endorsed by all the parties developing the plan. The CP6 signalling budget was agreed to be indicative for future control periods, and a 'unit cost to the business' was calculated including core costs and add on costs to compare conventional renewal cost and ETCS costs. This unit cost was developed based on recent tender returns, and received buy-in from internal and external stakeholders, and in line with the recent GB Rail sector deal (the agreement between the government and the rail industry). The ETCS unit rate was estimated at £315K per SEU (Signalling Equivalent Unit) as compared to a rate of £419K per SEU for a conventional resignalling.

The current SEU figure based on returns from each of the Routes is around £459K. This comes from looking at expenditure on conventional resignalling during CP4 and CP5. Further investigation supported by Network Rail infrastructure projects delivery organisation focused on the most recent projects suggests £419K/SEU as a more representative figure for the purposes of the long-term deployment plan.

The SEU volumes for ETCS renewals were identified across all routes and integrated into a national ETCS workbank. A deliverability ceiling per annum was agreed with Network Rail infrastructure projects delivery group and the Rail Industry Association at 3000 SEUs for ETCS and 1800 SEUs for conventional.

The train retro-fitment delivery schedule was built up on the assumption that one unit of one class per operator could be fitted at one time, with the maximum number of trains to be retrofitted in one year limited to 251. Deliverability was supported by RIA, the RDG and the National Joint Rolling Stock Project.

The principles behind the plan were agreed with all stakeholders, including areas such as driver training, franchise renewal dates, expected train life, and signalling renewal cycles.

An iterative process to develop the plan in association with the industry

The initial first pass of the plan (Figure 3) was unconstrained by deliverability and based only on signalling renewals need. The plan was developed using a sensible geographical area for resignalling at a time, with adjacent areas of about 100-300 SEUs receiving an ETCS work type resignalling when required by the signalling external asset condition. The first pass of the plan showed a 'bow wave' required due to asset condition, with work volumes increasing through CP7 to a peak in CP8.

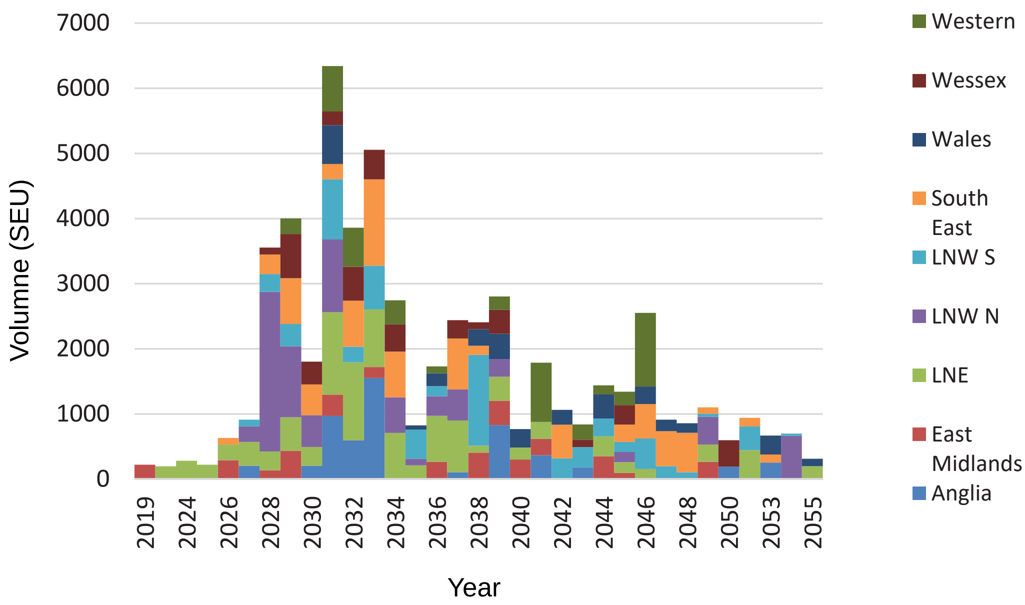


Figure 3 – First pass of the plan for England and Wales unconstrained by deliverability.

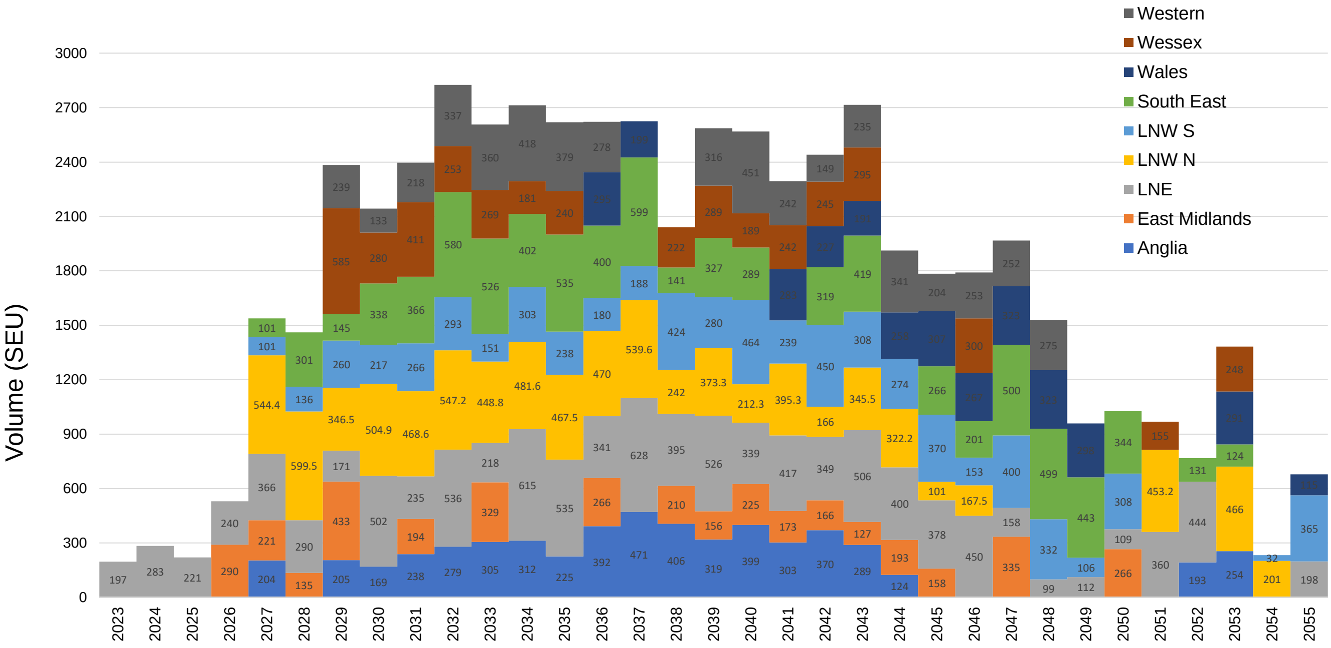


Figure 4 – Constrained delivery plan for England and Wales.

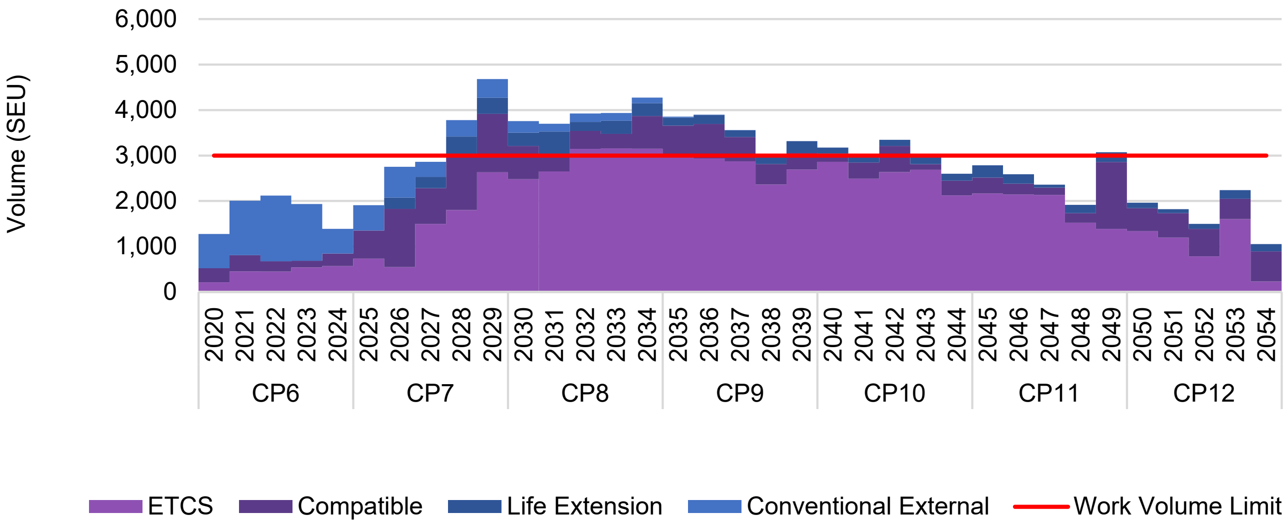


Figure 5 – Digital signalling volume constrained profile for England and Wales.

This variance in workload was unhelpful to the supply chain, and hence a process of renewal deferral was agreed with each route asset manager, assessed on performance criticality, and obsolescence risks. The preference from the supply chain was to smooth delivery geographically as well as by year, aiming to constrain each of the routes in the country to 300 SEUs delivery per annum, as well as 3000 nationally with some flexibility allowing partnering up of delivery areas to give flexibility across adjacent route boundaries.

With the national unconstrained volumes showing a peak at around 6000 SEUs per year for England and Wales, this roll-out required considerable smoothing. The performance criticality rating was applied to each interlocking based on five years of performance data, and on the amount of work requiring deferral in each year, interlockings were proposed for deferral by up to seven years (high criticality interlockings receiving less deferral than low criticality interlockings).

The signalling renewal plan met the deliverability constraint

The delivery plan (Figure 4) successfully met the deliverability constraint, with ETCS interventions ramping up in CP7, following on from the dominance of conventional renewals in CP6 (Figure 5). Life extension work was also required to keep aging interlockings going until the deferred ETCS date, plus some ETCS compatible work such as re-controls or partial digital renewals.

However, at current ETCS unit rates, this plan still exceeds budgetary constraints.

At current ETCS unit rates, budget constraint was not met

Figure 6 shows the cost profile with the horizontal line in red showing expected government funding allocation based on

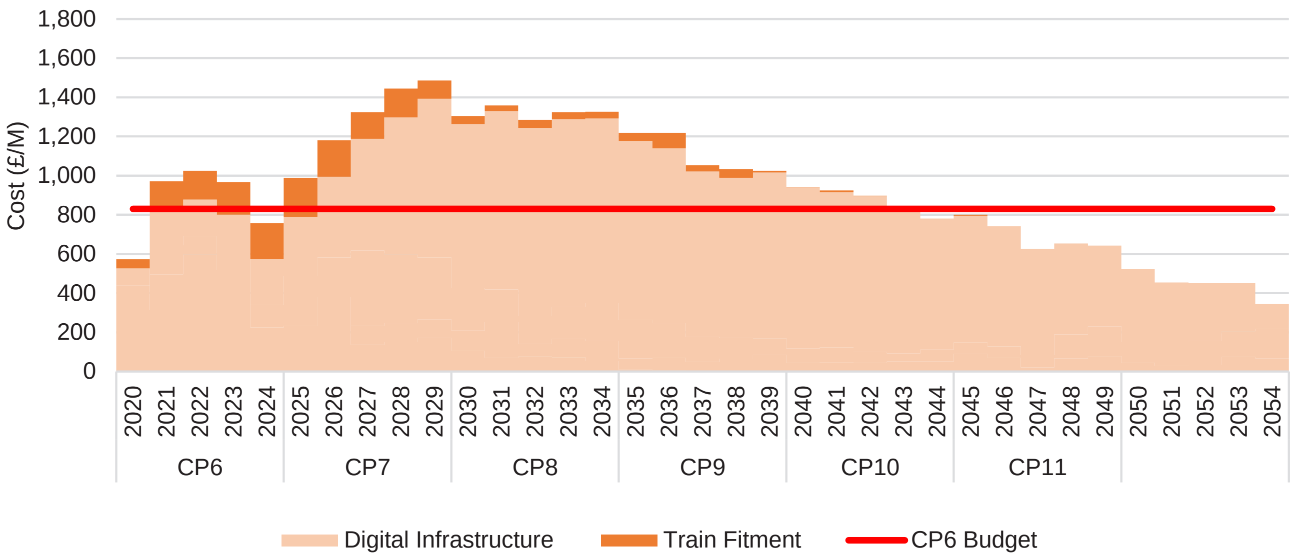


Figure 6 – Digital signalling constrained cost profile (including train fitment).

CP6 levels. It can be seen that during the peak years of ETCS delivery in CP7 and CP8 costs exceed the budget levels, hence the government has provided research and development funding in CP6 to look at innovative solutions to bring down the unit rate cost of an ETCS resignalling. The cost of train fitment compares with the infrastructure fitment, and this assumes that the bulk of train fitment would occur in CP6 to facilitate the infrastructure roll-out from CP7 onwards.

The key findings

In creating the long-term digital deployment plan, it was noted that digital technology was required to sustain the network and could be delivered at a sustainable volume; however, although more affordable than conventional signalling, costs still exceed CP6 budget levels for the first three control periods. Digital signalling will deliver higher performance and better safety, and there is potential to reduce digital signalling costs towards CP6 budget levels through innovation. It also provides a better long-term cost solution, and supports the Rail Sector Deal (a commitment created jointly by the UK government and rail industry, see **irse.info/o6mlf**) as well as innovation strategies. For the duration of the plan, train fitment and infrastructure renewal plans have been aligned successfully, and while this is a baseline integrated digital renewals plan, further consideration will be necessary to understand enhancement opportunities. For the future, a robust change control mechanism will be essential to manage and coordinate the interests of train and infrastructure stakeholders, and this is currently being developed.

Next steps

Although the plan was developed and provided ETCS roll-out for every interlocking in the country from the start of CP7 up to 2055, and aligned with train fitment, it required a significant investment by the government in CP6 to fit large numbers of trains. The government have indicated that their latest thinking is a more measured approach to train fitment, still holding to the philosophy that all trains passing through a site are ETCS fitted prior to the interlocking being renewed with an ETCS solution.

The RDG and Network Rail have therefore commenced looking at the early deployments in the plan, and are considering three sites to suggest to the government for train fitment to enable infrastructure renewals in CP7. Further consideration will need to be made by the government as to policy decisions around new train fitment/rolling stock with ETCS at the point of manufacture, as well as long-term funding of the freight fitment programme, which precedes CP7. The plan now requires embedding in route plans, with a change control process coordinated centrally. Integration of the plan with enhancement opportunities is also required to seek better value solutions and better outcomes for both passengers and freight users, and a technology roadmap has been created to co-ordinate and channel R&D funding to improve ETCS technology and process efficiency. Preparation of the industry and the supply chain will be required for transition to digital signalling.

But what is an SEU?

In the UK the concept of a Signalling Equivalent Unit (SEU) is used to estimate and compare the cost of signalling projects. The number of component parts of a signalling project at sub system level – points, signals and level crossings is calculated to establish the number of 'SEUs'. Dividing the total cost of the project by the number of SEUs determines the SEU rate. In very simple terms the SEU rate is the cost of each single point end, signal, level crossing including funds to cover items such as the required interlocking, supplementary detectors, cables and equipment rooms.

About the author ...

Claire is a route asset manager signalling for Network Rail based in Manchester. She has extensive experience of signalling maintenance, asset management and renewal sponsorship. She has also assisted in IRSE exam study groups for many years as well as being a school governor. Claire is chartered engineer and holds a bachelor's degree in electrical and electronic engineering.

Engineers of the future

Jennifer Gilleece Jones

Engineers in the industry generally appreciate that a career in engineering and the railway is interesting and rewarding, with the opportunity to make a difference and leave a legacy. To many outside the industry though, they see engineers as people who come to fix broken washing machines and railway workers as people who only drive trains, sell tickets or work on big disruptive construction sites while they want to travel.

This means there is a whole section of society missing out on the wonderful opportunities they could have with a career in engineering and/or the railway because they don't know what it is all about. Without some understanding, many young people don't think to investigate it when considering their career options. It is a shame for people to miss out on the opportunities a whole industry could offer them.

According to the May 2019 UK Government Migration Advisory Committee's Shortage Occupation List (irse.info/0o92d), there is a shortage of engineers and it is expected that this will get worse over the next five years. The publication identifies four core reasons for the shortages, most of which influence people at a young age: social mobility, gender, perception of engineering and pay. They also highlight that one fifth of the existing engineering workforce is estimated to retire in the next 10 years, with this figure much higher in many railway engineering functions. The situation is similar in many countries throughout the world.

To help overcome much of the lack of understanding of what engineers and other Science, Technology, Engineering and Mathematics (STEM) professionals actually do – as well as the knock-on effects of this – many individuals and organisations are helping to raise awareness. This includes visits to schools and groups of young people, as well as parents and teachers, to demonstrate the range of opportunities available within engineering and the rail industry.

The publishing of this article coincides with three such major events in the UK – Rail Week (8-14 October 2019), Future Engineers (26 October - 3 November 2019 and 25-31 May 2020) and Tomorrow's Engineers Week (4-8 November 2019).

Dispelling myths about what engineering, particularly on railways, involves is a key part of encouraging future generations to join our industry and create a sustainable future for rail transport.
Photo Railweek.

Rail Week

RAILWEEK 7 - 13 OCT 2019

Rail week is organised by the Young Rail Professionals (YRP) association and supported by organisations from across the rail industry. This year's theme is "Connecting the Past with the Future". "The dedicated week of activity aims to address the skills shortage in rail-related roles and inspire a generation of young people through a series of events, visits and talks. The events for people at schools, colleges and universities aim to encourage them to consider careers in this great industry. Rail Week will also include a widespread schools outreach programme, facilitating ambassadors to get into the classroom and deliver inspirational activities designed for Rail Week." (Quote taken from **www.railweek.com**.)

Future Engineers

The Future Engineers festival is being held in the National Railway Museum in York and will include demonstrations, live shows and events, all designed to inspire young people about rail and engineering and getting them to use their imaginations to solve problems.

Events such as the UK initiatives described in this article are not only exciting experiences for our young visitors, but hugely rewarding continuous professional development for those engineers lucky enough to get involved.

Tomorrow's Engineers Week

Tomorrow's Engineers Week

Tomorrow's Engineers Week is part of the Tomorrow's Engineers group's wider programme of events and activities and provides a platform for employers and engineers to work closely with schools to inspire more young people to consider careers in engineering.

Tomorrow's Engineers targets young people aged 9-16 years, teachers and parents and is led by engineers. It gives young people the chance to talk directly to engineers and engage in hands-on activities that showcase engineering. This not only gets young people thinking about engineering but also helps them understand how what they learn at school is used in the real world.

We can all do our bit in promoting engineering and educating people about the opportunities a career in rail/engineering provides; becoming a STEM Ambassador and volunteering to participate in one of the above, or many other events held throughout the year; or even just by telling people (young people, parents, teachers or just friends and relatives who will pass on the knowledge) with enthusiasm about our jobs, what we actually do, the wide range of roles in engineering and the rail industry and the wonderful opportunities available for people within these roles.

About the author ...

Jennifer is a senior telecoms project engineer for Network Rail Infrastructure Projects, Northern Programmes (Eastern Region) as well as being a STEM ambassador and is very involved with encouraging young people into engineering. She holds a bachelor's degree in electronic engineering.

STEM and CPD – a rewarding way of continuing your professional development whilst making a real difference to the next generations of engineers.

Are you involved in STEM activities, encouraging a future generation of young people to consider a career in science, technology, engineering or maths related subjects?

Don't forget that these activities count towards your continuing professional development, and that you can record the time spent in your CPD record.

Have you a particular experience or initiative you'd like to share with other IRSE members? Is there a particular success story in your region, country, railway or company that you'd like to tell us about?

Email **editor@irsenews.co.uk**, we'd love to hear from you.

Safety and Reliability Society

Peter Sheppard

The IRSE is proud to have close links with many of the professional institutions working in fields allied to railway command, control and signalling. The Safety and Reliability Society is one of those institutions, and this month Peter Sheppard introduces the work of SaRS and its relevance to railway engineering.

The Safety and Reliability Society (SaRS)was founded in the UK in 1980 and is the professional body for safety, reliability and risk management practitioners. The SaRS provides their members with cross-industry learning, CPD and networking opportunities.

So, that's the bit from the website. I am a Fellow of the IRSE, I have been a signalling engineer since starting my apprenticeship at Westinghouse Brake and Signal Co Limited in 1978 and I fell into and have loved being involved in the safety engineering side since the mid-1980s. I joined the Safety and Reliability Society in 1989 and realised I was one of very few railway engineers in the society!

I am the SaRS chair-elect (taking my position as chair in November this year from Emma Taylor, another railway person at RSSB) and recently I have been visiting railway people and railway related companies to see how well known we are. The simple answer is, unfortunately not that well!

I believe there is a great deal of synergy between SaRS and the IRSE. A significant amount of what we do in the signalling business is either safety critical or safety related and that covers both electronic systems that control the movement of trains and the safe systems of work we have for the staff working "on or near the line". SaRS is a society dedicated to safety and reliability (always closely linked) and within SaRS, because we are multi-sector we can learn from each other. I have benefited greatly from my membership of SaRS and the knowledge I have gained from other sectors. Can I suggest you have a look at the SaRS website (**www.sars.org.uk**) and consider what benefit you may gain from joining a dedicated safety and reliability community?

SaRS has a number of active branches spread geographically around the UK and often covers railway related topics. There is a very active London branch and if attendance is not possible in London, these days it is available as a webinar live or can be viewed later. All our events are free to attend.

A SaRS 'Derby Day' will be held in Derby, UK, on 30 October 2019 and I am very grateful to Ricardo (on Pride Park), who have offered us rooms for the afternoon and evening. The intention of the afternoon is for potential members of SaRS to come along and, subject to meeting the criteria for membership, discuss the requirements and benefits of becoming a member and people could actually join on the day (there will be members of the membership committee present).

In the afternoon, there will be discussions and presentations on the benefits of Professional Registration and a paper on safety/reliability (topic and speaker to be confirmed) in the evening.

If you have any questions, I am always happy to speak to people face-to-face, on the phone or by email and my contact details are **peter.sheppard@wsp.com,** telephone +44 (0) 7583 041598.

SaRS is just one example of the many and varied organisations we work with worldwide – we'd very much like to hear about similar sister groups in your part of the world or sector of the industry Email editor@irsenews.co.uk.

Industry news

ETCS levels 1 and 2 for La Encina – Xátiva – Valencia

Spain: Infrastructure manager ADIF has awarded a consortium of Thales and CAF Signalling a contract to design, supply and maintain signalling equipment for the La Encina – Xátiva – Valencia section of the Mediterranean route.

The scope includes the provision of ETCS levels 1 and 2, with interlockings and train detection, protection and traffic control systems, power supplies, and telecoms for both broad gauge and future standard gauge services. The contract consists of six months for design works and 30 months for installation, followed by 25 years of maintenance for the 1 435 mm gauge, and 20 years on the 1 668 mm gauge network.

Trans-Pennine Route ETCS L2

UK: Network Rail has begun the process of appointing a contractor to supply and maintain ETCS Level 2 for the line between Stalybridge near Manchester and Cottingley near Leeds as part of the Trans-Pennine Route Upgrade Programme.

The selected contractor will be expected to maintain the ETCS equipment over its anticipated 30-year service life and be responsible for upgrading GSM-R systems, and providing maintenance during a two-year defects and liability period.

The ETCS is required to integrate with other civil works, track and railway system enhancements on the route. These are being designed by the Transpire alliance of BAM Nuttall, Amey and Arup under the West of Leeds Alliance contract awarded in April 2017. Interlockings and trackside equipment would be provided by other suppliers, with the exception of balises and signage which would be included in the ETCS contract.

The contract may also include provision for Automatic Train Operation at Grade of Automation 2, with trains starting and stopping automatically under the supervision of a driver. Four bidders are envisaged to tender for the contract, which is estimated to be worth between £180.5m and £210.5m (€198m to €230m, $220m to $256m).

The Trans-Pennine Route Upgrade Programme requires the line to support a Leeds – Manchester Victoria journey time of 44 minutes with one stop and a York – Manchester Victoria journey time of 67 minutes with two stops; 92% of trains must arrive at four key stations within 5 minutes of the scheduled time.

The route must have the capacity to accommodate inter-city trains comprising eight 24m-long vehicles and local services formed of up to six 24m-long vehicles.

Czech Republic ETCS

Czech Republic: Infrastructure manager SŽDC has begun the installation of ETCS Level 2 on the 108km Česká Třebová – Přerov route which connects the country's two principal corridors 1 and 2. The work is being carried out by AŽD Praha at a cost of KC386m (£14m, €15m, $17m) with €11.9m (£11m, $13m) from the EU's Connecting Europe Facility. Completion is due in mid-2020. All vehicles operating the corridors will be required to have ETCS from 1 January 2025.

ETCS installation is also underway on the 54 km section of Corridor 4 between Praha-Uhříněves and Votice. This project is costed at KC211m, with 65% EU co-funding. Completion is scheduled for late February 2020.

Resignalling at Přerov

Czech Republic: SŽDC has awarded a consortium led by Eurovia CS a KC3.22bn (£110m, €130m, $140m) contract for Phase 2 modernisation works at Přerov, including double-tracking, 3kV DC catenary upgrading and resignalling to raise speeds to 160km/h.

ETCS Level 1 for Bulgaria

Bulgaria: Infrastructure manager NRIC has awarded the ERTMS CA Voluyak DZZD consortium, consisting of AER and CAF Signalling, a contract to modernise signalling and telecoms on the 12km route from Sofia to Obelya and Voluyak.

The scope includes design, installation, testing and commissioning of ETCS Level 1 and GSM-R, as well as CAF Signalling electronic interlockings, with the work co-funded by the EU's Connecting Europe Facility.

Wherry Line resignalling scheme

UK: Network Rail is replacing the semaphore signalling on the Norwich-Great Yarmouth/Lowestoft routes in England, and a 23-day blockade will be required next February to complete the Wherry Line resignalling scheme, which will be delivered nearly a year late. The revised completion date is now February 17 2020.

Originally expected to be completed in March 2019, the postponement of the re-signalling work to allow for additional testing has allowed Network Rail to look at the works planned over the next five years and to bring them forward. The re-signalling work has been combined with a set of planned renewals in Control Period 6 (CP6) to deliver a package of work over 23 days in February 2020 which will transform the Wherry lines in one significant phase of work.

The blockade will now include the replacement of a life-expired bridge at Postwick and track renewals at Buckenham, Acle and Lowestoft. Both of these projects will remove speed restrictions that have been in place for many years.

Boston resignalling

USA: Massachusetts Bay Transportation Authority has awarded Fischbach and Moore Electric a $26.5m (£22m, €24m) contract to resignal 1.6km of complex tracks around Boston's North station, to increase capacity and relocate equipment above the 500-year flood plain.

Positive Train Control

USA: Wabtec has been awarded a $55m (£45m, €50m) contract to implement Positive Train Control PTC on the 160km New Mexico Rail Runner Express route from Belen to Albuquerque and Santa Fe by late 2020.

Locking GRP User Worked Crossing demonstration

UK: On Wednesday 30 October 2019, Park Signalling Ltd and Haywood & Jackson Fabrications Ltd are demonstrating their new GateLock User Worked Crossing at Ecclesbourne Valley Railway, Derbyshire, DE4 4FB. The GRP gate has a secure locking system which can only be opened after receiving a unique code from the signaller. To request a place at this event, email sales@park-signalling.co.uk.

Level crossing elimination

Australia: Laing O'Rourke, Jacobs and Metro Trains Melbourne have signed a A$89m (£50m, €54m, $60m) contract to elevate the line at Toorak Road in Melbourne to eliminate a level crossing.

New barriers in Croatia

Croatia: HŽ Infrastruktura has awarded Končar KET a €9.9m (£9m, $11m) World Bank funded contract to supply lights and barriers to modernise 49 level crossings.

Removing unprotected level crossings

Austria: Rail infrastructure manager ÖBB-Infrastruktur is improving safety at level crossings, especially in Upper Austria. Each year, €25m (£23m, $28m) is invested in closing unprotected level crossings, equipping them with the boom barriers, light and sound signals, or constructing underpasses. In Upper Austria, ÖBB-Infrastruktur operates 759 level crossings, 261 of them equipped with technical protection.

Since 2016 ÖBB-Infrastruktur has equipped more than 40 level crossings with solutions to improve safety, including six crossings blocked for automobile traffic. The company has constructed two underpasses in Upper Austria for €2.33m (£2.1m, $2.6m), with the latest one opened recently on the Summerau Railway running from Linz to the Czech border.

ÖBB-Infrastruktur is constantly reducing the number of level crossings in the whole of Austria and since the year 2000 they have reduced from a total 6100 to 3214 crossings.

Hong Kong MTR to resume Tuen Ma Line CBTC testing

Hong Kong: MTR have resumed dynamic testing of CBTC on the Tuen Ma Line following a derailment and collision on the Tsuen Wan Line on 18 March during non-traffic hours, which prompted MTR to immediately suspend all further testing.

MTR says that following the resumption of dynamic train tests for the East Rail Line's new signalling system at the end of May, the comprehensive safety review of the signalling system for the Tuen Ma Line has also been completed and confirmed that the system meets the safety requirements for dynamic train tests.

Under the Shatin to Central Link project, the Tai Wai to Hung Hom Section will connect with the existing Ma On Shan Line and West Rail Line to form the Tuen Ma Line. The signalling system for the Tuen Ma Line is an extension of the existing signalling systems used for the Ma On Shan Line and West Rail Line.

While the system design is different from that of the new signalling system for the Tsuen Wan Line, testing of the Tuen Ma Line signalling system was temporarily suspended since the Tsuen Wan Line incident in March as a prudent measure.

Thales and Alstom are installing Thales' Seltrac CBTC system across seven metro lines in Hong Kong under a €330m (£301m, $366m) contract awarded in 2015. They are replacing existing Automatic Train Supervision (ATS), interlocking and automatic train control technology in the control centre, onboard trains and at stations.

China's Nanjing Metro traction and train control systems

China: Nanjing Metro in China has signed a contract with Alstom to procure traction systems and a train control and monitoring system (TCMS). The €50m (£46m, $55m) contract will install the systems on 318 metro cars that will operate on Line 7, the first driverless metro line in the city. The line is expected to become operational in 2021

Alstom has been involved with the development of the Nanjing metro system by delivering trains, traction systems, signalling and other services, in addition to signalling systems for the Ningtian Intercity Line, and traction overhaul services for Nanjing Lines 1 and 2.

China unveils next generation driverless metro train

China: CRRC Corporation Limited (CRRC) has announced an automatic metro train which it has developed for China's Next Generation Metro Vehicle Technology Research and Demonstration Application project, being led by the Ministry of Science and Technology.

The metro train is designed for unmanned operation conforming to GoA4, the highest level of automatic train operation. The train features a panel imbedded in a window which can be used to provide passenger information or display advertising.

CRRC says all the tasks are completed by the train itself and do not require human involvement. For example, the system will wake up the train in the morning, carry out a self-check, exit the depot and enter passenger service. At the end of the day, the train will return to the depot and pass through the train washer automatically.

Mumbai driverless trains

India: BEML has started assembling 378 metro cars for three driverless lines being built in Mumbai. The 63 six-car trainsets are to operate on Mumbai metro lines 2A, 2B and 7. Equipped with air-conditioning, regenerative braking, CCTV and real-time track monitoring equipment, the 25kV 50Hz trainsets will have four sets of doors per car and capacity for 1800 passengers.

Driverless trains for Milano metro line

Italy: Hitachi Rail Italy (HRI) has delivered the first driverless train for the future metro Line M4 in Milano to the site of Linate Airport station. Once complete by July 2023, Line M4 will serve 21 stations on a 15km alignment. Ridership is forecast at 87 million passengers a year.

The forty-seven 50m four-car trains are being delivered from the HRI Reggio Calabria factory with a capacity for 600 passengers, along with a maximum speed of 80km/h and will draw power at 750V DC from a third rail.

HS2 driverless people mover in Birmingham

UK: Designs for a new automated people mover in the West Midlands have been released by HS2. Driverless vehicles will transport passengers between HS2's new Interchange Station in Solihull and Birmingham Airport. When in full operation, the people mover will be able to carry over 2000 passengers per hour, with the average journey time just six minutes.

The approximately 20m-long people mover vehicles will depart from each stop approximately every 3 minutes. They will pick up passengers from Interchange Station, and then travel across a 12m elevated viaduct, stopping at Birmingham International Railway Station at the National Exhibition Centre, before reaching Birmingham Airport.

LTE-R and 5G solutions for next-generation rail wireless communications

Sweden/China: At the UITP Global Public Transport Summit 2019 held in Stockholm, Huawei and Tianjin 712 Communication & Broadcasting Co Ltd (TCB 712) jointly released their LTE-Railway (LTE-R) solution for next-generation rail wireless communications, which has already been deployed in China.

The LTE-R Solution supports 5G-oriented evolution and interconnectivity with GSM-R. The solution's features include multiple trunking services such as Mission

Critical Push-to-Talk (MCPTT) voice, video, and data, with one LTE-R network to enable train control, train dispatching, passenger information system (PIS), CCTV, and other rail services. It is claimed that, together with 5G, the solution will enable a future of intelligent railways where all things are connected.

Huawei also released its Urban Rail Light Cloud solution, which utilises virtualisation technologies to convert computing, storage, network and security resources from physical devices into virtual resources. They can then be allocated to application systems through virtual hosts, network or security devices.

The solution allows integration of data centre devices, reducing device procurement and deployment costs. It is designed to support rail transport networks with low and medium passenger capacities.

Also announced was their latest 5G digital indoor solution (DIS), called 5G LampSite, which leverages multiple advanced technologies to support both LTE and 5G, and is designed to offer intelligent communications services to enable passenger flow management, security checks and ticketing.

Software for LTE-R development

Germany: Siemens Mobility has selected Softil's BEEHD cross-platform client framework software development kit (SDK) to develop an advanced communication solution for Long Term Evolution-Railway (LTE-R rail) networks. Siemens will also use BEEHD software to develop mission-critical push-to-talk (MCPTT) radio system for metros, tram buses and similar applications.

Softil said that its software is compatible with LTE-R and will allow Siemens Mobility's solutions to deliver stable voice and data communications on trains running at speeds in excess of 400km/h.

4G for London Underground in 2020

UK: Transport for London (TfL) has announced that 4G will be available on parts of the London Underground from March 2020. The eastern half of the Jubilee line will get full mobile connectivity within station platforms and tunnels for the first time, removing one of the most high-profile mobile 'not-spots' in the UK. The 4G phone signal will allow commuters to check emails, talk to friends and browse social media while travelling through the tunnels or on Jubilee line platforms in east London.

TfL says that hundreds of miles of cabling is now installed across the network and they are in discussion with mobile network operators to ensure their customers can benefit when the first section goes live. The next stage of procurement will allow the whole of the London Underground network to have mobile connectivity by the mid-2020s.

5G technology piloted on Seoul subways

South Korea: The UK and South Korean Governments are funding a £2.4 million (€3m, $3m, 4057m South Korean Won) project to support businesses in the two countries and develop 5G technology. The project will live test content and services on the Seoul metropolitan subway system.

The trials will enable businesses and researchers to investigate and address a number of user and technical challenges for the future roll out of 5G on rail. These could include: Augmented Reality (AR) experiences in busy public spaces, giving tourists and commuters a dramatic new insight to the city and the way in which they experience it; optimisation of traffic management systems, to better manage commuter flows, reduce overcrowding, improve safety and better protect the environment; and providing uninterrupted infotainment services for commuters such as interactive content, video streaming and gaming, with more reliable and faster services across the subway network.

Additional benefits the innovative collaboration will deliver include new industry partnerships between UK and South Korean institutions, new South Korean investment opportunities in the UK, and greater access for UK Industry and academia to South Korean technology, hardware, software and intellectual property.

The funding competition is part of the UK's 5G Testbed & Trials (5GTT) Programme, which aims to maximise the opportunities for UK businesses to develop new 5G applications and services.

GSM-R to be maintained for another 10 years

Europe: At the first FRMCS (Future Railway Mobile Communication System) conference held on 14-15 May 2019 at the International Union of Railways (UIC) Paris headquarters, Jean-Pierre Loubinoux closed his last major conference as director general of the UIC, by confirming that UIC will continue to be engaged in the maintenance of GSM-R for the next 10 years. In July Francois Davenne took over as director general UIC.

Asset monitoring via GSM-R:

Europe: Kapsch CarrierCom is planning the first trial deployment of KUBE, an industrial internet of things device which can be used to collate and preprocess data from a range of asset monitoring sensors before using existing GSM-R networks to send the information to an infrastructure manager's data hubs. Staff on the ground can also access data directly from KUBE devices.

A full laboratory demonstration system is now running, and a proof of concept deployment is to be undertaken on a railway in western Europe this year. The company hopes to deploy a 'few hundred' KUBE devices by the end of the year, and has an 'ambitious target' to deploy 20 000 over the next few years.

Kapsch CarrierCom says that KUBE was developed specifically for the rail industry, unlike other IoT products which are re-purposed from other applications. Their focus is on the secure communication technology rather than the sensors, and users will not be locked into using only Kapsch CarrierCom systems. KUBE is intended to work with asset monitoring equipment from any manufacturer, and third parties can also develop applications which will use its connectivity.

The main focus is on infrastructure, but rolling stock applications are also envisaged, with some operators in eastern Europe having expressed interest in using KUBE to monitor the temperature of wagons.

Westermo acquireds Neratec

Switzerland: Beijer Group company Westermo has acquired 100% of Neratec Solutions, which supplies wireless communication products for on-train and trackside applications. Bubikon-based Neratec has 25 employees and recorded sales of SFr6.5m (£5m, €6m, $7m) in 2018.

With thanks and acknowledgements to the following news sources: Railway Gazette International, Rail Media, Metro Report International, International Railway Journal, Global Rail Review, SmartRail, Shift2Rail, Railway-Technology and TelecomTV News.

News from the IRSE

Blane Judd, Chief Executive

Blane's World

Ensuring that the voice of our Institution is heard is one of my main goals. There is a wealth of knowledge and expertise within our organisation that has not been fully recognised within the wider engineering community and I want to change this. As a result a proportion of my time is spent engaging with other Institutions and professional bodies to raise the profile of the IRSE and boost membership as a consequence.

In August I met with the CEO of the Society of Operations Engineers (SOE) to explore opportunities to collaborate. The interaction was very positive and we will be meeting again to take discussions further. Later that month I met with the heads of other professional engineering institutions (PEIs) where we looked at next steps in the debate about international academic recognition of Washington accord signatory countries. The Washington Accord is an international accreditation agreement for undergraduate professional engineering academic degrees between the bodies responsible for accreditation in its signatory countries and regions. Established in 1989, the full signatories as of 2018 are Australia, Canada, China, Hong Kong, India, Ireland, Japan, Korea, Malaysia, New Zealand, Pakistan, Peru, Philippines, Russia, Singapore, South Africa, Sri Lanka, Taiwan, Turkey, the United Kingdom and the United States.

As a strong advocate of professional recognition, I have been invited by the Engineering Council to chair the meetings that have been set up to discuss the values surrounding the EngTech proposition, the first of which was held recently. We are also looking at being part of the End Point Assessment process for apprentices so they can be recognised as EngTech ready. Having the post nominals "EngTech" shows your colleagues, employer and future employers that your knowledge and competence have been assessed against independently defined criteria which are internationally recognised.

Update your contact details

Do we hold the correct email address for you? If you have just joined the digital community or recently changed your email address you will not be receiving important membership information or IRSE e-communications.

Don't miss out. Please email your new contact details to **membership@irse.org** to enable us to update our database.

IRSE Examination

Good luck to all taking the IRSE Exam on Saturday 5 October at 16 centres worldwide.

Membership subscriptions

If you haven't yet paid your membership subscriptions, please do so. The online payment system is now fully functioning and can be accessed via the IRSE website. Non-payment will result in the withdrawal of membership benefits and, if you are professionally registered, removal from the Engineering Council's register of technicians and engineers.

Events listings

Keep an eye on the IRSE website and social media feeds for details of forthcoming IRSE events across the world. We're not mind readers though, so unless you let HQ know about your local section's plans, we can't promote them! We've set up a single point of contact for event notification: **events@irse.org**. Please send as much detail as possible together with the date, venue, associated flyer, image (if available) and booking details to this email address and we'll get details of your event 'live' within two UK working days.

Our new president, George Clark's 'Delivering Change' themed presidential programme kicks off on 1 October with a lecture in London from Andy Bourne of Arcadis entitled 'Delivering change through intelligent traffic management'. This will be followed on 5 November by a lecture in Copenhagen about delivering change through national ERTMS programme presented by Jens Host Muller. Then on 7 November, London is the venue for a major technical seminar on future communications systems, where some of the most prominent experts from Transport for London and Network Rail will be joined by senior representatives from control and communication companies to look at the technological challenges facing the signalling and communications industry.

October sees the tenth ASPECT Conference in Delft (22-24 October) and spaces are filling up fast. Some of the technical visits are already fully booked so visit **www.aspect.nl** to ensure you don't miss out. The fourth "CBTC and Beyond" Conference on 28-29 November in Toronto is also likely to be a sell-out. For other events in October and beyond please see **irse.info/events**.

Did you know .....

IEng CEng EngTech

Did you know that the IRSE is an approved body for professional registration? Did you know that we are assessed to ensure we meet the same rigorous standards as other bodies such as the IET and IMechE?

Find out more at **irse.info/registration**.

Professional registrations

Congratulations to the members listed below who have achieved final stage registration at the following levels:

EngTech

Paul McCarthy, Siemens, UK

CEng

Artur Waszkiewicz, WSP, UK

Professional development

Demystifying IRSE membership, Engineering Council registration and IRSE licensing: working in partnership to help your career

IRSE membership, registration and licensing are frequently mentioned in the same breadth, but what are they? Are they one and the same, or completely different? This article clarifies the relationship between them.

Membership

IRSE membership is open to anyone with an interest in train control systems, railway communications and data management and railway systems engineering.

There are various levels of membership available recognising experience, responsibility and qualifications, as shown in Figure 1.

IRSE members around the world benefit not only from a wealth of technical papers and publications containing industry news and views from across the globe, but also from the many opportunities to share and discuss ideas that are provided by the Institution's conferences and local events. Membership of the IRSE also provides an excellent framework for professional development with recognition of competence and achievement, including the opportunity to take the internationally recognised IRSE professional exam. Members can also apply for professional registration with the UK's Engineering Council, more on this later.

To apply for membership, or to transfer from one grade to another, you must complete an application form (available on the website) and provide relevant documentation such as copies of qualification certificates. Membership and Registration Committee review all applications and make their recommendations to Council for their approval.

Our corporate members (Associate Members, Members, Fellows and Honorary Fellows) can use the post-nominals AMIRSE, MIRSE, FIRSE and Hon FIRSE and can vote in elections for Council membership.

It is a condition of membership that IRSE members abide by with the IRSE code of conduct and are expected to maintain and develop their competence (known as continuing professional development, CPD).

Affiliate

- For those in relevant education or the early stages of their career
- For those who are on a relevant formal training programme
- For those who are engaged in, connected with or interested in the profession

Accredited Technician

- For those who are actively engaged in the profession, have current responsible experience and can demonstrate competency through holding an IRSE licence or relevant qualification

Associate Member (AMIRSE)

- Typically, Associate Members have at least three years' practical training/experience, hold a relevant qualification, have responsible experience for at least seven years and hold relevant licenses and/or have passed the IRSE professional exam

Member (MIRSE)

- Typically Members have at least seven years' senior responsibility and hold a relevant degree or have significant technical experience and passed the IRSE professional exam

Fellow (FIRSE)

- For those who have met the requirements for Member and can demonstrate at least five years' superior responsibility

Honorary Fellow (Hon FIRSE)

- For those who have undertaken outstanding or exceptional services to the profession or IRSE, nominated by local sections/committees and approved by Council

Companion

- For eminent people associated with the profession nominated by Council

Figure 1 – Levels of membership within the IRSE.

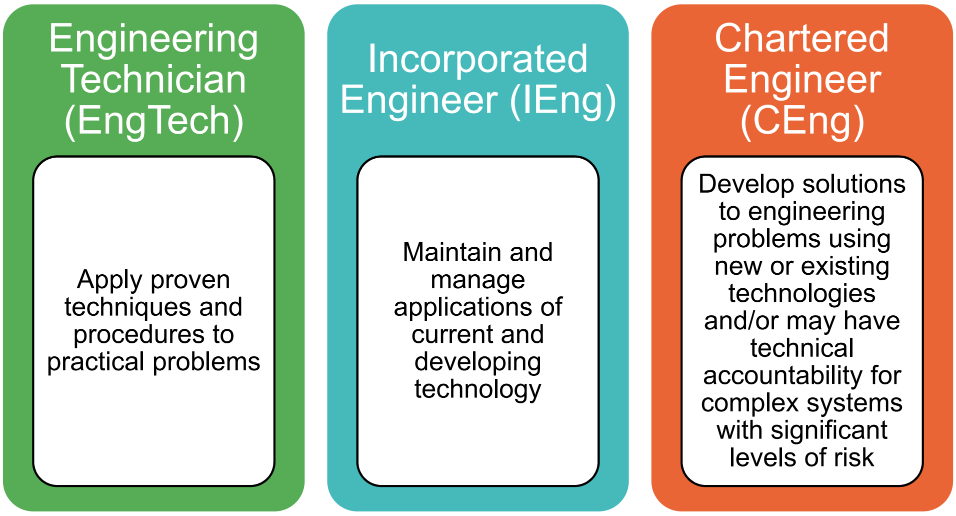


Figure 2 – The three grades of professional registration.

Subscriptions are required to be paid annually and reductions are available for those who are studying or on a career break. Concessionary rates are also available for those who have retired completely from employment, subject to length of membership.

Professional registration

The Engineering Council is the UK regulatory body for the engineering profession and sets and maintains internationally recognised standards of professional competence and ethics. IRSE, along with other engineering institutions, is approved to award registration at three grades: Engineering Technician (EngTech), Incorporated Engineer (IEng) and Chartered Engineer (CEng) as shown in Figure 2.

Professional registration demonstrates a commitment to professional standards and to developing and enhancing competence. It provides employers and clients the assurance of knowing that their employees/contractors have had their competence independently assessed, their credentials verified and their commitment to CPD established. Where the applicant does not have the full qualifications expected by the Engineering Council, other routes are available for demonstrating their engineering knowledge to the same level, including passing the IRSE professional exam.

Before applying for registration, you must be a member of one of the professional engineering institutions accredited by the Engineering Council, of which IRSE is one.

You must complete an application form to demonstrate your qualifications, experience, competence and commitment. For some IRSE licences, the EngTech application is part of the licence application. All IEng and CEng applicants are interviewed. The Membership and Registration Committee review all applications and make their recommendations to Council for their approval.

Subscriptions to Engineering Council are required to be paid annually (collected through an engineering institution, such as the IRSE), there are different levels of subscription dependent on the level of registration. Reductions are available for those who are on career breaks or who have retired completely from employment. Some IRSE members are professionally registered through other institutions and will therefore pay their Engineering Council fees through that institution. If you are professionally registered through another institution it is possible to transfer your registration to the IRSE if you wish.

IRSE Licensing

The IRSE Licensing Scheme is a scheme for certifying the competence of a range of signalling and telecoms engineering roles, from assistant installer/maintainer/designer through to senior engineer.

The scheme was developed by the IRSE in conjunction with industry in the early/mid 1990's at the request of the then two major railway operators in the UK, British Rail and London Underground, following the shortcomings identified in the judicial inquiry into the Clapham Junction rail crash in December 1988. The aim of the scheme was to ensure that people operating in safety critical and safety related roles in S&T engineering were competent.

The scheme has developed since then to meet the needs of the industry and there are many licence categories covering safety critical and safety related roles including maintenance, design, installation, testing, technical investigation and engineering management. People can hold more than one licence, dependent on their experience and work role. Some companies mandate that those working in safety critical roles must have an IRSE licence or similar demonstration of competence.

Those applying for a licence category fill in a log book with details of their training and work experience and apply to an Assessing Agency, a company approved and audited by the IRSE, in order to demonstrate to two separate assessors that they meet the requirements of the category standard. The assessment consists of reviewing evidence supplied by the applicant, asking questions about that evidence, and in many cases, observing the candidate carrying out specific types of work.

The licence card, which lists the specific licence categories authorised, is issued by the IRSE on receipt and review of the documentation from the Assessing Agency.

Licence fees are paid to the Assessing Agency by the individual or their employer, dependent on the contractual arrangement, the IRSE then recoup the fees from the Assessing Agency. These are one-off fees for the validity of the licence.

Licences are valid for ten years, subject to a surveillance check that the candidate is still working to the required standard, carried out at the five-year stage, at which point the licence is re-issued.

IRSE licence holders do not have to be IRSE members, although all are encouraged to apply, to gain the benefits of membership and to assist them in proving their CPD.

In summary

There are differences between these three ways of demonstrating your professionalism and competence, however there are many similarities, including the need to continue to learn about developments in engineering along with some form of assessment. They can work in partnership to develop your career and demonstrate your competence as shown in Figure 3.

IRSE membership provides an environment for learning, professional development and networking with other professionals at all levels in the industry.

Professional registration provides a means of gaining international recognition from an independent body for your professional engineering competence and experience.

IRSE licensing provides a means of demonstrating an ability to do a specific job in accordance to standards in railway signalling, train control and telecommunications engineering.

Thanks to Colin Porter Hon FIRSE for his inspiration and contribution to this article.

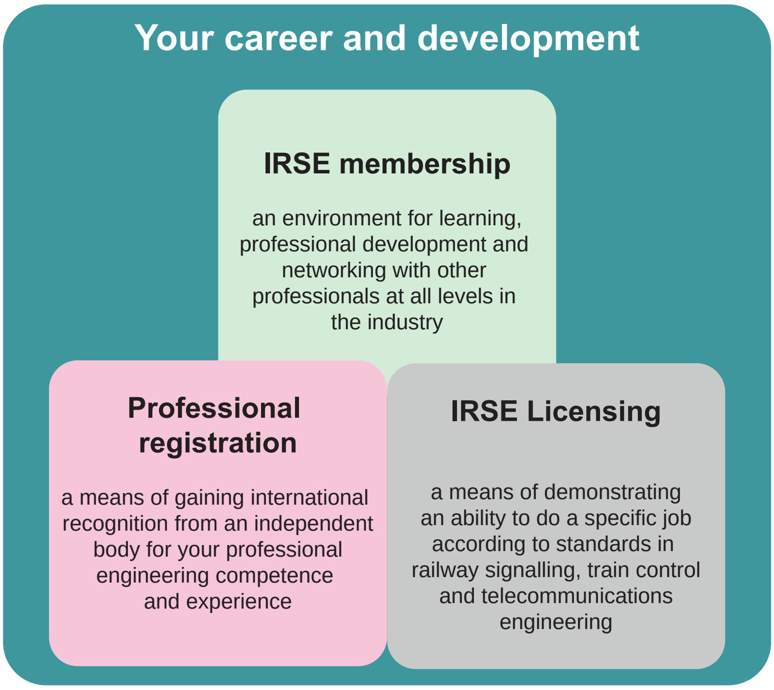


Figure 3 – The link between IRSE membership, professional registration and IRSE licensing.

IRSE Professional Examination changes

Hedley Calderbank and Judith Ward

IRSE Council has given the go-ahead for the first changes to the structure of the IRSE Professional Examination in 25 years. The changes are intended to modernise and simplify the module structure, to introduce modern assessment techniques and to encourage a much wider population of railway professionals to learn about control and communications principles and practices whilst maintaining the high status of the exam.

The most significant change is the creation of a new module "fundamentals of railway control engineering" which covers all aspects of railway control engineering at a foundation level. This will also provide a stand-alone qualification with the aim of making the foundation qualification attractive to a much wider group of people working on or around railway control and communications systems.

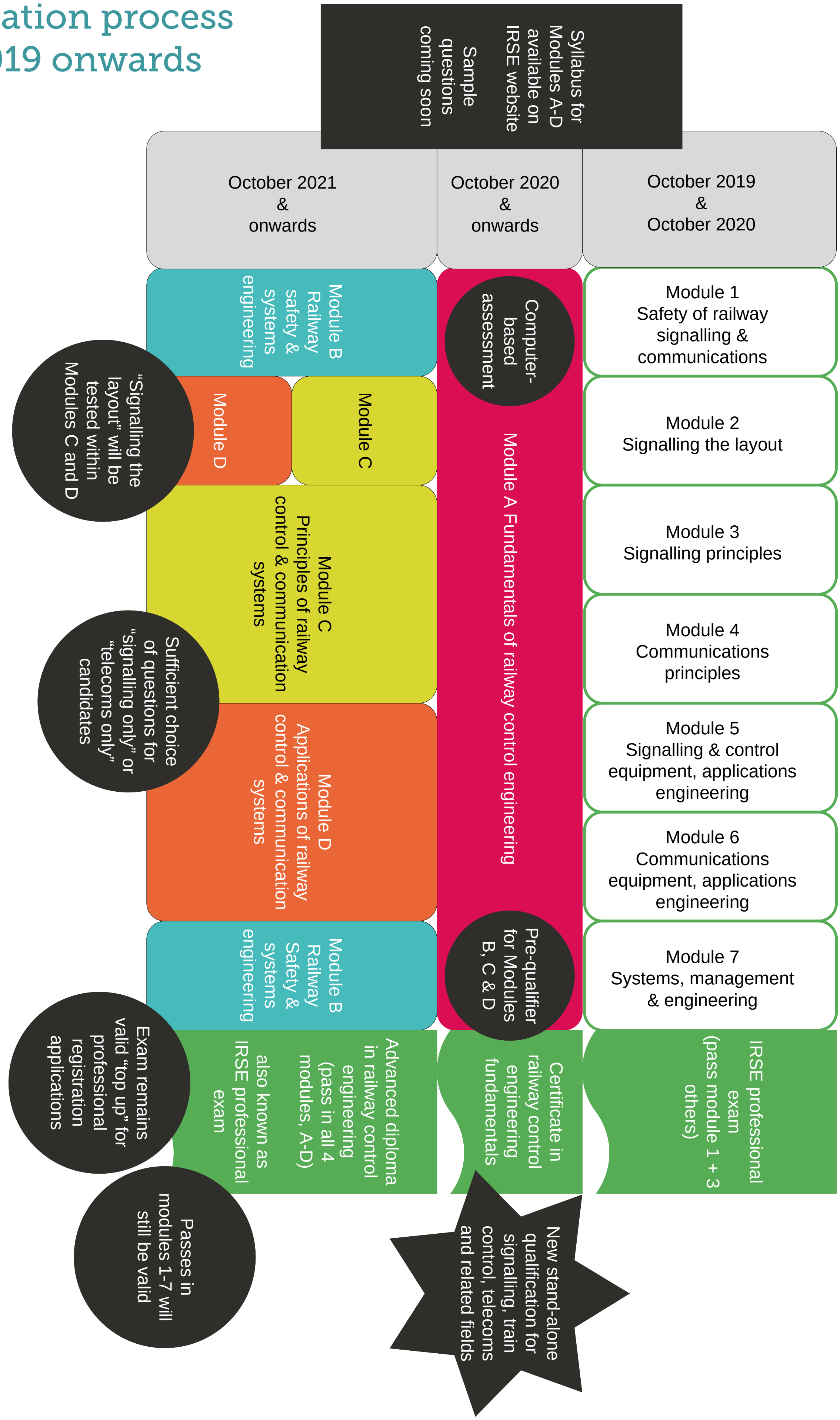
The full exam will consist of four modules. A 'foundation' exam (module A) to test a breadth of knowledge and understanding across all aspects of signalling, control and communications engineering. This will be a pre-qualification for sitting the more advanced modules, modules B, C, D formed by combining the present 7 modules, while offering a wide range of questions to enable candidates to answer questions relevant to their own specialisation.

Passing all four modules will lead to the present qualification of the "IRSE Professional Examination". To be formally known as the "Advanced Diploma in Railway Control Engineering".

Candidates will be able to mix old and new modules to achieve a pass in the IRSE Professional Examination irse.info/exam. Full details are available on the website irse.info/946zx and sample papers will be made available soon.

The infographic overleaf summarises the changes.

IRSE Professional Examination process from 2019 onwards



Your letters

Re ETCS optimisation

I found the article on ETCS headway (IRSE News May 2019) very interesting and it reminded me of undertaking similar studies for the Phase 1 network of HS2 [the UK's proposed new High Speed Rail Link). I also found the RailPlan system useful as it allowed one to see the effects of moving the axle counter heads. This allowed us to see the effect of lining up the axle counter heads and radio masts with maintenance access points for ease of access and power provision. I was surprised about the effect that small movements in tunnel ventilation shaft position had on the headway approaching stations. I was also concerned about the effect of temporary and emergency speed restrictions. It was well understood that they would have an effect on journey times but the effects on headways on a high capacity high speed line was one area I did not have time to explore. Perhaps others have.

Trevor Foulkes
Chair London & South-East Section, UK

Re September issue

Just a note to say how much I enjoyed this month's edition. In about 1982 a 'proper' member of the IRSE at Crewe got me in as an associate member of the IRSE. I enjoy the visits I've been on with the North-west section and the minor railways and of course the Channel tunnel tour many years ago. I was the one on crutches, I was not going to miss that trip. Whisper it soft, I'm really a train-spotter! I worked as a computer programmer at Rail House Crewe and a few years ago, a volunteer signalman for the East Lancashire railway.

The in-depth coverage about Southend pier was marvellous. The re-inventing the token machine article made me think that in a way it's good that things are so expensive on the railway, as assets can be adapted to keep going. I can sympathise with 'Ruth's' problems. IT on the railway is similar, I was always frustrated by on-line spec amendments!

Dave Stuttard, UK

Re HF and automation

Roger Ford's letter, September IRSE News, regarding the ITC article on HF and automation correctly states that fail-safe can lead to safety risks at the system level. We said only that (in rail) "For many years 'fail safe' has been used to secure safety", which is the case. Two out of three (2oo3) and duplicated two out of two 2x(2oo2) multi-lane systems are intended to deliver at least the same level of functional safety with higher availability, reducing failure management risk. However, the suggestion that a 2oo3 system could have prevented the 737 Max failure is misleading. There was no processor failure. We understand that on each side of the aircraft a single sensor fed a multi lane system. Change over between the two systems was manual with a 'disagree alert' an optional extra. Single source inputs to, or single lane outputs from, any multi-lane system risk introducing single point failures that make the redundant system a 'false friend'. We have seen similar failures in rail. More complex technologies and solutions require that we all learn from each other and make thorough 'whole system' assessments including human factors in failure management. The ITC intends to publish an article on this in the near future.

Rod Muttram, UK

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at irsenews@irse.org.

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Help needed! CPD reviewing

Judith Ward, Director of Operations, IRSE

Through the professional code of conduct, all IRSE members and IRSE licence holders sign up to maintain and develop their professional competence to retain the safety and efficiency of our railways.

The IRSE encourages members and licence holders to record the regular planning, doing, reflecting and reviewing of these development activities. This maintenance and development of competence is called "Continuous Professional Development (CPD)" by the IRSE and is sometimes known as "Professional Development (PD)".

For those who are professionally registered through the UK's Engineering Council as Engineering Technician (EngTech), Incorporated Engineer (IEng) or Chartered Engineer (CEng), it is mandatory for you to keep records and submit them to the engineering institution which you are registered through when required.

Help needed from IRSE volunteers

Council has requested that the IRSE office provides a "review" service, to give advice and guidance for any member who would like it, and to provide this service we need help from our volunteers.

So, do you have time to spare to review CPD records? Guidance of what to look for and comment on will be given and this will be an anonymous service, with the IRSE office being the contact point for all queries and comments.

Those who have already reviewed our professionally registered members' records have found it useful to improve their own CPD records having seen good, and not-so-good, practise in action. If you have a few hours' free time over a few months or year and would like to help, then please let me know by emailing **judith.ward@irse.org**.

Photo Shutterstock/Dizain.

IRSE News

Institution of Railway Signal Engineers

November 2019

Delivering change
in traffic management

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for ERTMS hybrid level 3

Wi-Fi 6
the next step?

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Institution of Railway Signal Engineers

Issue 260
November 2019

In this issue

Feature articles

News and opinion

From the IRSE

From our Sections

Cultural adaptation

A year ago, I moved from Melbourne to Bangkok to be embedded with an Alliance partner signalling supplier to deliver interlocking and CBTC technology for a Melbourne project. It is imperative to adopt and promote the Alliance values and behaviours amongst all project participants. I moved to a workplace where the national culture is strong, and very different from my own, so I knew I had to do this mindfully and in a culturally-sensitive way.

My early cultural awareness preparation included reading Geert Hofstede et al's "Cultures and Organizations: Software of the Mind". This book describes six 'dimensions' that characterise different collective cultures (e.g. Power distance, individualism/collectivism) and presents the findings of different cultures, using 1970s IBM international employee data, in an engineer-friendly way. Hofstede's work describes national collective cultural preferences and cannot directly be translated to the preferences of individuals or the workplace collective.

Power distance is the "extent to which the less powerful members of organisations accept and expect that power is distributed unequally." Power distance is impacted by population size, wealth and proximity to the equator (affecting climate stability and reliance on hunting-gathering or agriculture). Confucian philosophy also influences power distance (and other dimensions) for many Eastern countries, shaping how people earn respect and the way a society generally receives, analyses and uses information.

Individualism/collectivism is the extent to which people in a society are integrated into groups. Collectivism is characterised by the "we" and what is good for the collective. The sociological concept of saving face is also imperative. The "I" dominates in an individual society and it's considered a civil right to have privacy and speak one's mind. This dimension affects an organisation/task responsibility assignment, performance incentive schemes and delivery of performance feedback.

Embracing cultural differences, by having an appreciation for how people think, work and are motivated, is essential to integrate in diverse teams and to produce the best results from each individual for the project.

Cassandra Gash
senior signalling project manager, Rail Projects Victoria

Cover story

Grand Central Terminal in New York USA is a commuter rail station located at 42nd Street and Park Avenue in Midtown Manhattan. It is the third-busiest railway station in North America, after New York Penn Station and Toronto Union Station, as can be seen by the number of members of the public using the station. The purpose of the IRSE includes the promotion of improved safety standards for the protection of the general public. In addition to providing safe, reliable and efficient train paths, this also includes public address, CCTV, and customer information systems together with facilities systems such as Wi-Fi, passenger footfall counting and analytics for retail purposes.

Photo Paul Darlington

Delivering change in traffic management systems

Andy Bourne

This article is based on the first Presidential Paper of the 2019/2020 year and was presented in London on 1 October.

Taking up the 2019/20 Presidential theme of Delivering Change [1], this paper considers the experiences of the introduction and evolution of traffic management (TM) systems for Network Rail in the United Kingdom (UK). TM is a key component of the group of technologies and programmes that comprise the Digital Railway in the UK, aiming to bring a step change in capacity, performance, safety and cost efficiency to the main line railway network.

The first TM systems delivered as part of the Digital Railway are now in service in the UK, following the introduction of similar systems in other countries. Their introduction has been challenging, but key lessons have been learned along the way which are being fed into the next tranche of system deployments. This paper will share some of those lessons.

As well as telling the story of introducing a particular technology to a particular infrastructure, the paper aims to offer more general insights into delivering change in railway technologies which are new to a railway or other undertaking.

This paper also shares some of the thinking undertaken within the Digital Railway Programme about what national coverage of TM looks like in the UK and some of the developments being planned for the future.

As will be seen, what starts out as a discussion about introducing a technology inevitably ends up being a wider discussion about the people who use that technology and the processes they follow. Changes to culture and working practice within the constraints of organisational arrangements and precedent often prove to be harder to deliver than functional and operational system requirements.

"Changes to culture and working practice constraints often prove to be harder to deliver than functional and operational requirements"

The starting point

A key part of two hundred years of UK railway evolution has been the progression of technology, processes, competences and organisations to manage the resultant train service. As such, traffic management is not a new concept. What has changed is the growth of the railway network to accommodate the multitude of passenger and freight services now provided, the organisational arrangements in which the services operate and the technology which supports control and operational management of the railway.

The nature of railway renewal programmes, asset lifecycles and pace of technology change means that there exists in the UK a range of railway control technology; from a modern railway operating centre (ROC), equipped with VDU based signal control supported by automatic route setting, all the way to a rural signal box still operating mechanically and fully manual in operation. On the business systems side sit timetabling systems, attribution systems (such as TRUST – a train running reporting system for the source of information for fines or compensated for train delays by operators in GB) and customer information systems, all with their own histories and pedigrees. So, at any given location a signaller or controller of train services has a whole eco-system of information and control systems which provide the toolkit to deliver a train service that meets the needs of their customers.

The drivers behind the Digital Railway programme

The UK railway has seen a doubling of passenger numbers in the last twenty years, with an expectation of continued growth going forward (despite some signs of a downturn in the last few years). This growth has created capacity constraints on many sections of the network.

> "Safety on the UK network is strong, but there is no room for complacency"

Against this backdrop perturbations to the train service can propagate around the system, so that overall delays have increased despite some reduction in primary delay causes. The delays are all the more unpalatable to rail users because costs have continued to increase with much of the increase passed to farepayers.

Safety on the UK network is strong, but there is no room for complacency with the rate of improvement in safety slowing. [2]

> "Digital control technologies are seen as a means of increasing capacity and improving performance"

Digital railway control technologies are seen as a means of increasing capacity, improving performance (especially secondary delays) and reducing whole life costs in the industry, whilst continuing to improve safety. By digital railway technologies, we are referring to ERTMS and TM in particular with the supporting technologies of automatic train operation (ATO) and of crew, stock and driver advisory connectivity to traffic management systems. Ultimately these technologies will become an integrated 'system of systems', but there is the need to transition from today's mix of systems to this future, which itself will be a staging post to further evolution.

A modern traffic management concept and architecture

The goal of modern traffic management is to harness the rich data on the railway about plans, geography, train performance and current real time status. This can then be used to:

1. Identify conflicts in future plans (prior day deconfliction).
2. Identify conflicts in the current plans (on the day deconfliction).
3. Identify options to re-plan the train service after an incident.
4. Communicate the new plan in each of the above cases to a range of users and systems (including signalling systems).

Recognising the legacy state of the railway systems which a TM system can interact with, there are essentially three options for a TM Implementation in terms of degree of integration.

The simplest form of traffic management is to provide an online decision support tool (ODST), a variant known as Isolated traffic management. Isolated means that the TM system is not connected to the signalling control system (See Figure 1), so planning decisions will need to be manually implemented. This constrains aspects of the TM capability but does mean that this type of TM can be overlaid on any underlying technology. It is also useful as a confidence building step in a programme where a more sophisticated type of TM is the end goal.

Where the underlying signalling control technology allows it (which means interfacing via some form of automatic route setting), it is possible to connect the TM system to the signalling control (See Figure 2) to give Interfaced traffic management. This means that planning decisions can be implemented automatically (upon signaller acceptance of the plan).

Figure 1 – Traffic Management – Isolated (often also called Online Decision Support Tool or ODST).

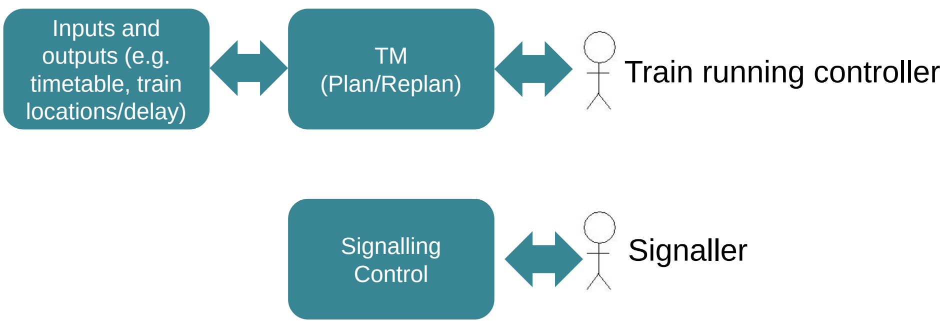


Figure 2 – Traffic Management – Interfaced.

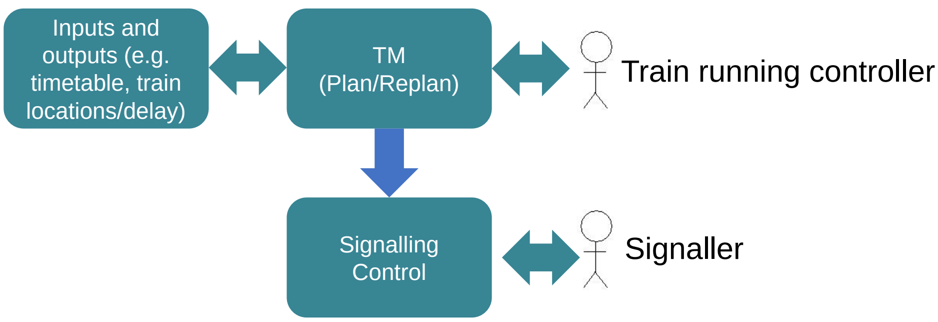


Figure 3 – Traffic Management – Integrated.

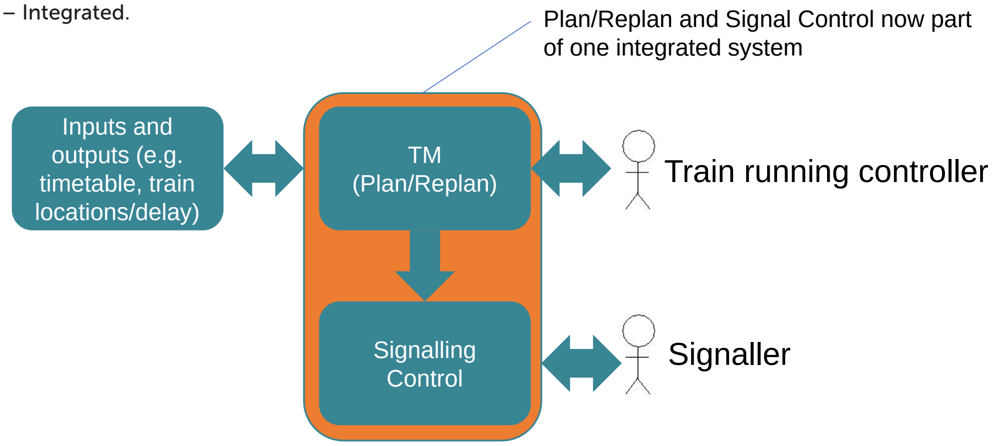
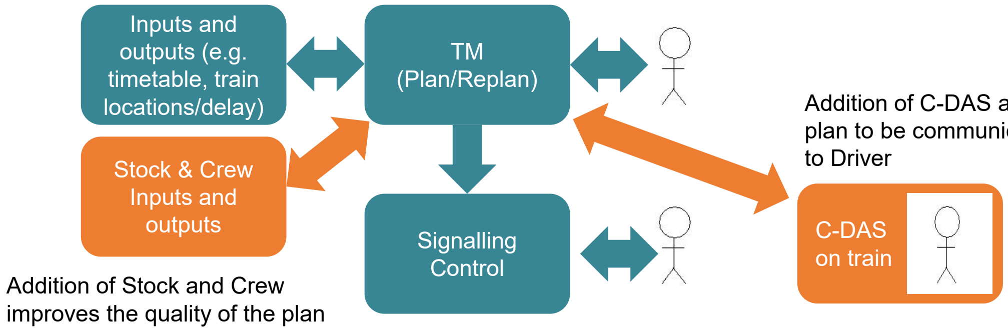


Figure 4 – Addition of Stock & Crew and Connected Driver Advisory System (C-DAS).



“Management of data throughout the lifecycle of a TM development is vital”

The final stage of TM is Integrated traffic management, where the TM and signal control layer are effectively combined (integrated as in Figure 3). In conjunction with flexible communications systems this means that additional flexibility in railway control is also possible (for example, being able to dynamically switch areas of control). TM is also seen as having potential in its more advanced stages to implement other functionality such as possession management to enhance trackworker safety.

The connectivity of TM systems can be further enhanced by interfacing to crew and stock systems and to driver advisory systems (Figure 4). These systems are being introduced by train operating companies for day-to-day management of their train crew and rolling stock fleet (hence crew and stock) and to assist with economic and professional driving in the case of driver advisory systems. Connection to the former increases the quality of planning within TM by providing real time availability of crew and stock (one of the most critical factors in severe disruption). Connection to the latter means that train operators can have access to and act upon information about the latest plan, including the awareness needed to drive optimally (for example reducing speed of a freight train slightly to avoid having to come to a halt at a subsequent red signal).

Data is king

Having described the architecture of traffic management, the final critical step is to discuss the data which brings the system to life. A TM system is only as good as:

1. The quality of data that informs its internal map of the railway.
2. The quality of data received about the state of the railway.
3. Its ability to process this data to produce insights about the railway that will ultimately form its plan/re-plan capability.
4. Its ability to output the resultant data to the systems that depend on the revised plans, which include business systems, customer information systems and signalling control systems (in the case of interfaced and integrated TM).

Management of data (both static and dynamic) throughout the lifecycle of a TM development is therefore vital, with dependencies on both the supplier and infrastructure manager. It relies on clear definitions of data and protocols for the collection, exchange, cleansing and change of data which will last for the life of the system.

In terms of the transfer of dynamic data between TM and business systems, a specific information exchange layer has been developed (the Layer Information Exchange or “LINX”) to avoid bespoke connections between each TM implementation and every business system which provides or consumes TM data. LINX message flows also allow for communication between TM and neighbouring TM systems, crew and stock systems and C-DAS.

Early deployments

The TM concepts described above were tested in model office work with three suppliers which reached a peak of activity around 2012/13. This work also evolved the LINX message catalogue and early versions of the generic Digital Railway TM requirements and developed systems using Leeds as a model location for testing concepts.

Out of this work a First Deployment programme was established in 2013 with the Thales Aramis system selected to provide TM in two routes; Wales (focused on Cardiff and the Valley lines) and Anglia (on the Essex Thameside line operated by C2C). This delivered isolated TM systems in Cardiff ROC and Upminster IECC in the early part of 2019, with further system updates during this year.

At the end of 2013 a contract was let to Hitachi for its Tranista TM system to provide the Thameslink programme with the TM operating tools to support a 24 trains per hours service in either direction through its core area. At the time of writing this paper, the system has entered an operational proving phase.

Both these programmes have experienced common challenges which are explored further. It is the author's experience that these are not unique to TM or even rail!

Learning the lessons from the early deployments

As the first TM deployments in the UK, the early deployments were the first implementation of the respective suppliers' solutions in the UK, procured against a relatively immature requirements set with an emerging operational concept. As such they were development projects and yet in first instance were probably treated too much like conventional signalling contracts in their procurement and delivery. Development projects such as these inevitably end up with emerging and changing requirements as the understanding of the technology and their use increases. Yet if this is not explicitly recognised at the outset it is likely that these changes will not be allowed for in schedules or commercially which creates challenges for both client and supplier.

> "Business change was another area where the effort required was probably underestimated"

With a two routes implementation in the case of Wales and Anglia and a large complex geography in the case of Thameslink, the early deployments also had a scale which added complexity to their developmental nature.

Business change (those aspects of the programme which relate to getting people and processes aligned with the technology) was another area where the effort required was probably underestimated on these programmes. On the face of it, user roles (typically the Train Running Controller and Signaller) were not fundamentally changing, but the way processes were executed was and this required more effort to understand and implement than was recognised at the outset.

> "Delivery of TM systems works best in a collaborative, partnering environment"

The mix of development and business change requires a high level of collaboration, which again needs to be built into the delivery schedule at the outset. Time spent on this up-front pays dividends in the difficult phases of the project where tough decisions and trade-offs are being made.

Some standardisation was created by the use of LINX and a generic requirement set, but without standard approaches to the TM-signal control interface and user interface these have evolved on a proprietary basis.

The systems were procured against a set of functional and non-functional requirements which evolved from the previous model office work. However, the mapping of these on to operational outcomes and scenarios was limited and this manifested itself in late changes to software as testing became more focused on operational scenarios. These outcomes and scenarios need to be established in the requirements set and scheduled from the outset to avoid this late pressure on rework.

The Western trial

In June 2017 a project was initiated for a trial of Resonate's Luminate TM system on the Western Route between Paddington and Bristol in the UK. The was based on a market-led proposal to undertake a twelve-month development project at the end of which the system would be brought into use. This would be followed by a twelve-month trial after which the system would be left in with payments based on results, or the trial would be ended and the system removed.

Learning the lessons from the Western trial

From the outset it was recognised that the Western Trial was a development project and the programme was therefore set up to deliver an initial basic implementation with some enhancements planned to follow.

This allowed more collaboration in the evolution of the product, with an NR operational subject matter expert based in the supplier offices and providing daily input into the development.

Interfaces were simplified on the Western project by virtue of building the Luminate TM on top of Resonate's IECC Scalable automatic route setting system. This allowed the rapid deployment of TM interfaced with the signal control functionality in an integrated platform.

These approaches allowed the initial deployment of TM one year after contract award as planned, with further improvements to functionality and message flows to other business systems following. The trial period of twelve months has been successful and has been extended to finalise benefits analysis.

What have we learned overall?

Firstly, delivery of TM systems works best in a collaborative, partnering environment where there is a recognition of the developmental aspects of the system and progressive maturing of the product with end user input during development

Related to this is that requirements need to be closely linked to operational outcomes. This means a clear operating concept and understanding of the operating scenarios where TM is expected to make a difference.

There is more to do on standardisation. Figures 5 and 6 show TM in the context of its technical interfaces and how a number of these are fulfilled

Figure 5 – Traffic management interfaces.

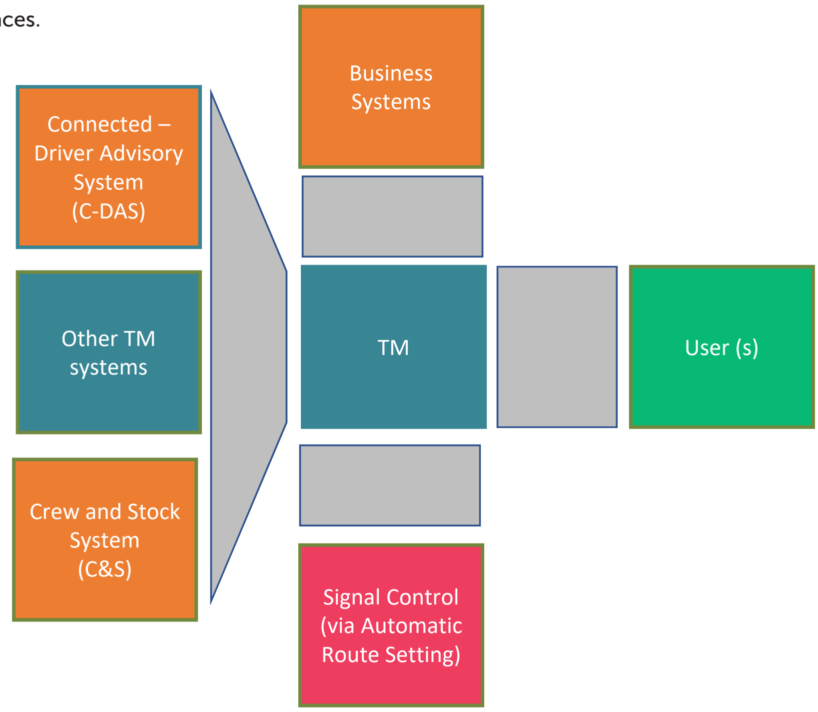
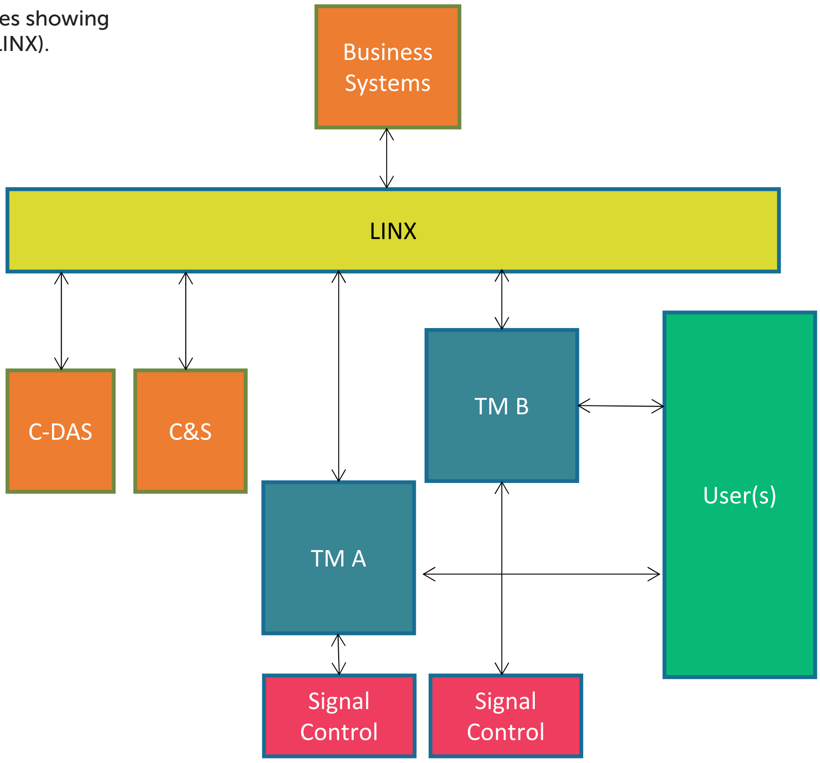


Figure 6 – Traffic management interfaces showing role of layered information exchange (LINX).



"Business change is a major component of a TM delivery programme"

using LINX. The LINX interface to business systems helps but will probably evolve as functionality develops. Bespoke interfaces from different suppliers' TM systems to different signal control systems are undesirable in the longer term and some standardisation of user interfaces (without stifling innovation) would also be helpful.

Business change is a major component of a TM delivery programme. As discussed above the fundamental roles of signaller and train running controller do not change with TM, but the way they execute these roles and the communication flows that result do change and this needs to be designed in to yield the expected benefits of the system. There is now much better understanding of what that entails and how to execute the resultant training.

There is still work in progress to quantify the benefits of TM. Anecdotally, it can be seen how TM interventions avoid conflicts and assist with recovery from disruption, but turning this into definitive quantified outcomes that can satisfy project sponsors is less straightforward (for example analysis is needed to understand what would have happened if a TM intervention hadn't taken place).

"Data needs early consideration and proactive management on TM delivery projects"

Data needs early consideration and proactive management on TM delivery projects. TM systems need a level of data granularity that may not yet exist on a particular route, and data exists in a number of diverse formats and sources. Up front consideration is also needed as to how data and resulting TM system changes are managed when there are changes to the railway during the lifetime of the system. Failure to manage this well means that in-service changes become expensive. There is now a good understanding that this workstream needs to start well before a contract award.

Finally, system assurance needs to be tailored to the TM system, which is more of an operational information management system than a signal control system. A lot of TM functions are SIL0 and assurance activity shifts from considering safety related software towards managing risks such as cyber-security and operator workload. Having been successfully negotiated on several projects, this is becoming more of a known entity.

"Aligning TM deployments with renewal activities can minimise duplicated effort"

Towards a national TM implementation

The early deployments of TM in the UK largely chose geographically separated areas of railway. As new deployments were considered it became necessary to think more strategically about how national coverage would be achieved. As a result, a set of National Principles were developed and endorsed at Network Rail board level in 2018. These are described below.

There are many ways that the UK could be divided into TM system areas, but Network Rail's organisational goal is to maximise devolution to the Routes, this being supported by the partially implemented National Operating policy of focusing railway management operations on a small number of Railway Operating Centres (ROCs). The agreed approach is therefore to align TM areas with Routes, and with ROCs where a Route has more than one. This creates operational boundaries which are aligned to the Routes and usually well-established operationally.

The LINX interface already exists for TM to Business System interaction and work has been undertaken on standardising the interface to Signal Control System via an Automatic Route Setting (ARS) system. Further work is needed on this and also on standardised user interfaces. The goal here is to avoid proprietary interfaces which create long term complexity for asset renewals and to minimise the training requirements of different TM systems.

"Careful consideration is needed to ensure that requirements for a particular Route deployment of TM clearly articulate the goals"

This principle focuses on the fact that, given there is no single agreed standard for TM systems, the underlying philosophy, functionality and strengths of proprietary systems differ. Therefore, careful consideration is needed to ensure that requirements for a particular Route deployment of TM clearly articulate the goals of the deployment for the Route so that procurement focuses on obtaining those attributes.

TM systems need to align with the underlying resilience of ROCs, and their deployment needs to consider failure modes and their impact on operations including on people and processes. Key areas to consider include cyber-security, avoiding single points of failure and user workload in normal, abnormal, degraded and emergency modes.

Where possible, aligning TM deployments with renewal activities can minimise duplicated effort from multiple changes to the same areas of railway and maximise the operational benefit of TM by taking advantage of interfaced TM deployments.

There is now an opportunity to consider the formation of a national planning layer of Traffic Management which would be closely aligned to the timetabling process and could also provide an additional layer of optimisation for cross-country routes passing through multiple TM areas. With an ability to identify and correct conflicts and a strong geographic model of the railway, TM could be used to improve the quality and timeliness of timetable production and work is starting to engage with industry stakeholders about how this could work.

The next set of deployments

There are two main areas of activity at present.

- In the North, Traffic Management Partners are in the process of being procured for York and Manchester ROCs to support the Trans-Pennine Route Upgrade (TRU) and East Coast Main Line (ECML) programmes. These partners will assist the routes in finalising business cases and requirements before implementation phases to support these programmes. This collective TM approach is sometimes referred to as 'Northern TM'.
- Meanwhile in the Southern region, an outline business case has been approved to extend the Thameslink system to cover Sussex and there is also business case development work around the Kent area.

Alongside these a number of other opportunities are being considered around the UK. TM is deemed to be an enhancement to the network and hence potential programmes are subject to the UK Treasury Green Book business case process unless a self-funding proposal is made.

The next set of challenges

Although the LINX message catalogue contains messages for the exchange of information between TM, Crew and Stock and Connected-Driver Advisory Systems, a formal deployment of such an interface is yet to be undertaken. Crew and Stock systems are typically the domain of train operating companies (TOCs) so under the present franchising model there needs to be good alignment between a franchise period and a TM programme for a mutually beneficial scheme to be viable. Work is underway on a potential trial of Crew and Stock/TM for Sussex (Network Rail are working with the franchisee, GTR, on this).

“The pace of technology change continues to accelerate”

Similarly, the connection of Driver Advisory Systems to TM systems (called Connected-Driver Advisory Systems or C-DAS), needs good alignment between Network Rail and TOC programmes. A number of trial projects are currently being discussed.

The pace of technology change continues to accelerate and we see increasing opportunities around deeper intelligence in analytical systems such as TM, the use of big data to see patterns not previously visible and increasing intelligent assets. Josef Doppelbauer outlined some of these possibilities in his Command and Control 4.0 paper in the last Presidential series [3]. These exciting opportunities will be easier to realise in green field environments and harder to graft onto 200 years of railway technologies and practice, but the present status quo on TM will not remain and so a future challenge will be to continue to deploy systems where new system technology is advancing faster than the surrounding asset base.

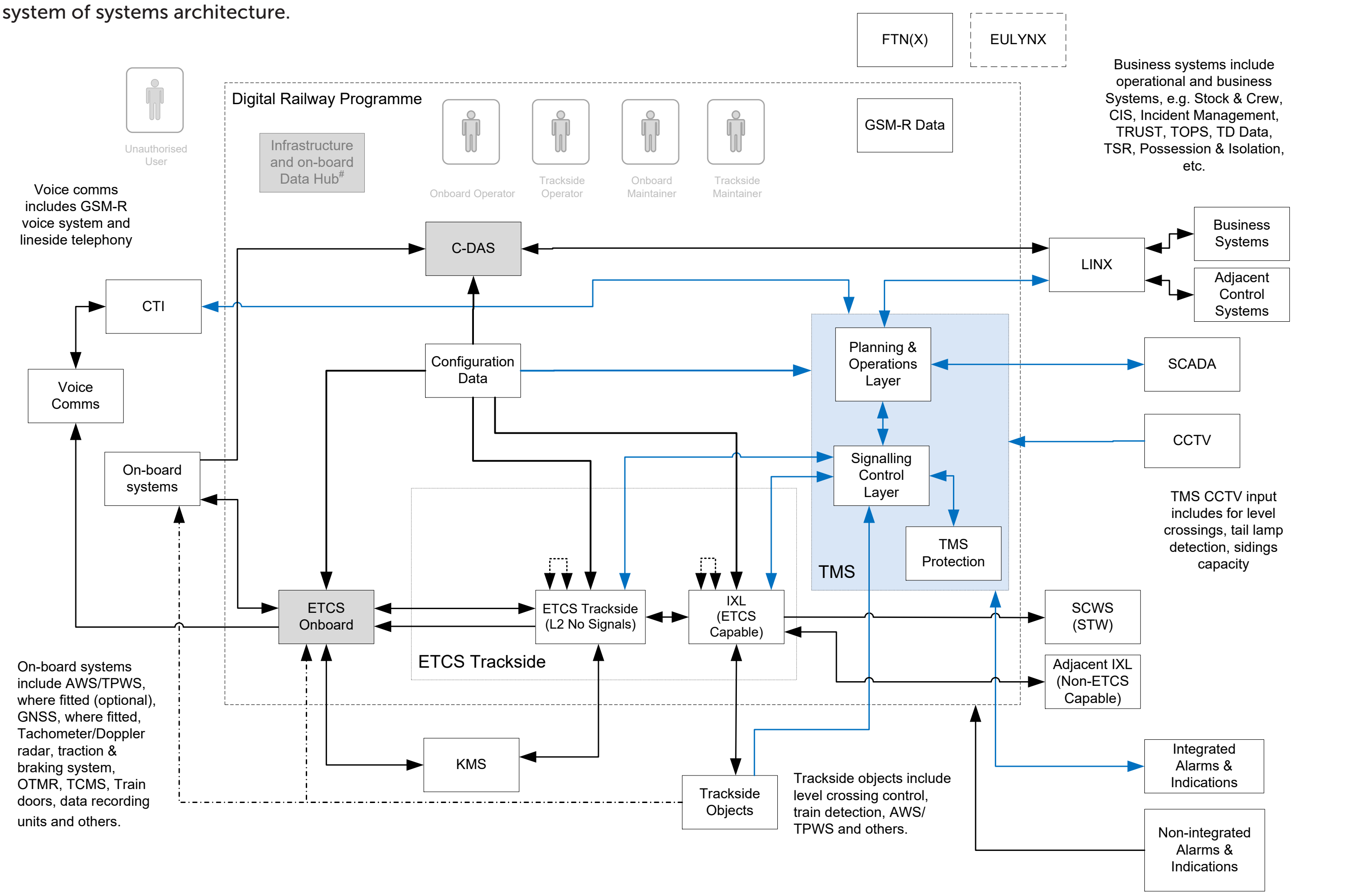
Network Rail has not yet experienced a full TM asset lifecycle, so there will be learning on maintenance and mid-life changes to the system (for example where the underlying railway is changing as well as the traditional obsolescence issues with electronic systems). Additionally, industry structure changes could offer opportunities and challenges around the systems, who uses them and the ease of future integration with crew, stock and C-DAS systems.

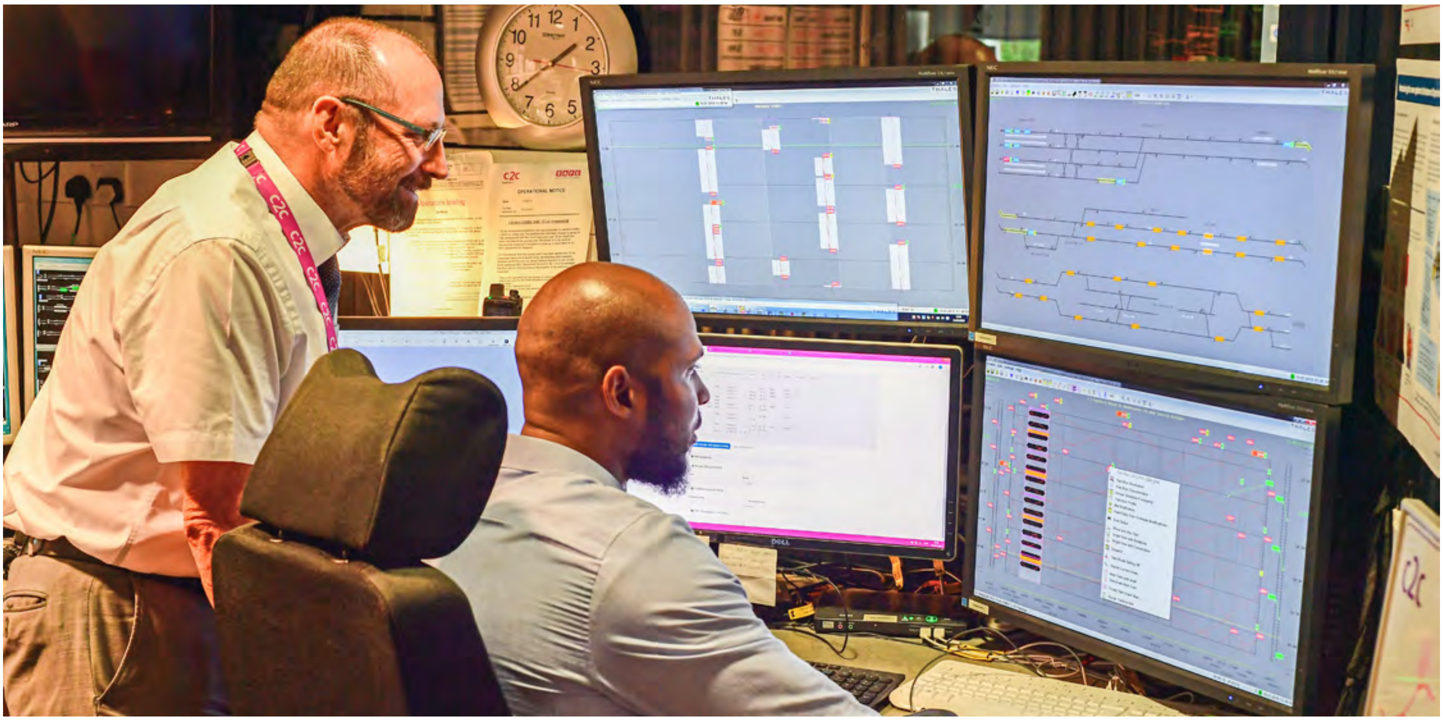
Integrated TM is the assumed default in Digital Railway’s System of Systems architecture (see Figure 7), but has yet to be fully implemented in the UK (progress was made towards a working concept in the Anglia early deployment programme). There are business and functional drivers that could lead to a future demand for it. Potential greater operational flexibility and new functionality will give rise to further business change challenges as there is further change in the way job roles are undertaken. The need for alignment with the renewals programme becomes greater because in its Integrated form TM is being introduced and simultaneously replacing the signal control layer. Requirements may also end up placed in Integrated TM system by future changes to ETCS (management of speed restrictions and control of which stock types can operate on which parts of the railway are two examples).

There is much discussion at present on improved timetable planning for the UK’s railways. TM’s ability to deconflict timetables provides a useful tool to improve timetable resilience and feedback issues. It becomes logical to build this into the overall timetable planning and generation process leading to creation of a National Planning Layer.

This layer would also offer the opportunity to further optimise multi-route journeys such as cross-country and freight.

Figure 7 – TM in the context of the wider Digital Railway system of systems architecture.





Traffic management has a major part to play in the roll out of the digital railway.
Photo Thales.

"TM systems will continue to evolve in the future"

"TM implementations are not just technology projects, but business change programmes"

Conclusions

Significant lessons have been learned from the early deployments of TM. These are being fed into the emerging schemes. The key is to continue to be alert that the risks don't re-materialise on the new schemes. This is an area where the digital railway programme is active as the custodian of lessons-learned reports. Much has also been learned from other national implementations of TM. These may have quite different drivers and starting points to the UK but nevertheless provide rich sources of learning.

TM systems will continue to evolve in the future. This needs to be reflected in contracts that are more balanced for the whole of the TM system life and can therefore cope with changes to the railway or timetables and with opportunities to continue to improve a system where the business case exists. One option being considered is to actively incentivise a supplier to do this, for example by giving them a percentage of the savings from performance improvements.

Ultimately TM implementations are not just technology projects, but business change programmes, and hence managing the total change to people, processes and the product is critical.

Many of these lessons are broader in application than just to TM projects.

Despite the challenges and over a number of years of project delivery, TM has moved off the drawing board and into UK service. With the next tranche of projects moving forward with business cases and procurement, TM can therefore be seen as here to stay in the UK. The picture is not static, with new projects now emerging, changes happening in the industry and technological change accelerating. This will remain an area of intense interest to improve railway performance and of challenge to deliver it!

Acknowledgements

Many people in the Digital Railway Programme, Network Rail Routes and Programmes, suppliers and Industry Partners have been involved in getting Traffic Management to where it is now. The journey continues but they deserve credit for their contribution to delivering change on the UK's evolving main line railway network.

The author would also like to thank Arcadis for giving the time to prepare this paper.

Opinions expressed are those of the author rather than any particular organisation.

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About the author ...

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Wi-Fi 6

Paul Darlington

Radio communications have been used in railways for many years for emergency and routine operational purposes, and more recently for train movement authority. Indeed, Radio Electronic Token Block (RETB) was first used in the UK in the 1980s, and radio communications will be essential for the next generation of train control systems. Passengers on trains now expect on-board Wi-Fi as part of their rail journey experience, and a lineside data connection is essential for managing both track side and train infrastructure for performance and efficiency purposes.

> "A lineside data connection is essential for managing both track side and train infrastructure"

The two main technology choices currently available for railway radio communications are GSM/LTE and Wi-Fi. GSM/LTE has been discussed in IRSE News many times, so this article predominantly covers Wi-Fi and in particular Wi-Fi 6. Other radio technologies such as Bluetooth and LoRaWAN are available for some short distance applications, but these are not covered in this article.

GSM/LTE/5G

The first generation of mobile radio systems used analogue multiplexing with no roaming between networks. Second generation mobile radio systems introduced digital encoding for the speech path, with GSM the most popular technology choice throughout the world. 2G GSM formed the basis of GSM-R main line railway track to train radio system, which provides the radio link within the European Railway Traffic Management System (ERTMS).

> "Wi-Fi is one of the world's most valued and widely used technologies"

The next generation of mobile radio, 3G GSM, provided faster data rates until 4G fourth generation mobile radio was introduced. The International Telecommunication Union (ITU) issued a requirements specification for 4G, with LTE (Long Term Evolution) the chosen technology for 4G using IP for both data and speech. LTE did not quite meet the 4G requirement, which is why it is known as 4G LTE.

5G is currently being launched around the world and will introduce "New Radio" (NR) with improvements in efficiency over LTE, with more use of multiple input multiple output (MIMO) and new millimetre-wave-very high frequency-spectrum offering even greater data throughput and scale of devices. From the mid-2020s GSM-R will be replaced by Future Railway Mobile Communication System (FRMCS) which is likely to use LTE/5G.

Wi-Fi

Mobile radio GSM and LTE originated from the telephony industry, and in fact 2G was originally launched with only voice capability and no data. Wi-Fi however was developed for wireless computer data communications, and this year celebrates its 20th birthday. Today Wi-Fi is one of the world's most valued and widely used technologies, and there are now more Wi-Fi devices in use than there are people on Earth. It is estimated that more than half the world's Internet's traffic traverses Wi-Fi networks.

Wi-Fi is found in most homes and offices. Wi-Fi networks include systems for general business communications, passenger data communications on trains and at stations, together with station customer information systems. Wi-Fi is used by some train operators to supplement the public GSM/LTE internet connections to trains and some Communication Based Train Control (CBTC) systems use Wi-Fi for train control purposes.

While GSM mobile radio started with voice then introduced data, Wi-Fi started with data but with 'Wi-Fi calling' now available both mobile radio and Wi-Fi are capable of speech and data communications. Today seamless handover between the two technologies is possible.

Wi-Fi 6 is designed to host existing and emerging uses for high speed mobile data transfer, potentially including rail applications. *Photo Shutterstock/ IvanMarc.*

"Wi-Fi 6 will offer speeds that are roughly 30% faster than Wi-Fi 5"

"The objective of Wi-Fi 6 is to provide full indoor coverage into every space within a building with the same high data rate.

The Wi-Fi Alliance IEEE 802.11 standards group developed Wi-Fi in the unlicensed frequency bands. These have been allocated on license free arrangements based on a set of rules, such as limited power so that interference range is limited. The bands are called ISM (industrial, scientific and medical) and exist in the 2, 5 and 60GHz spectrum bands. Wi-Fi's capability has been supplemented with the introduction of range extender technologies and, more recently, distributed Wi-Fi (Wi-Fi Mesh) technology.

In the USA the Federal Communications Commission (FCC) is making up to 1200 MHz of spectrum available for use by unlicensed devices in the 6GHz band (5.925-7.125GHz). This could double the amount of spectrum available for Wi-Fi. The FCC say that unlicensed devices that employ Wi-Fi have become indispensable for providing low-cost wireless connectivity in countless products used by consumers.

The UK telecoms regulator (Ofcom) also supports the possibility of adopting 6GHz for use in future Wi-Fi. This is included in their proposals for the World Radiocommunication Conference 2019 (WRC-19), which takes place 28 October to 22 November 2019. The WRC event is held approximately every four years and enables countries to better identify, as well as harmonise, useful bands of radio spectrum.

Wi-Fi 6

Wi-Fi Alliance is introducing higher speed versions, IEEE 80211n and IEEE 80211ac, and is in the process of completing IEEE 80211ax – also known as Wi-Fi 6. Both 5G and IEEE Wi-Fi 6 will be able to deliver high data rates (Gbps) with 5G claiming that it will have "way better indoor penetration" although that may be difficult with the higher frequency spectrum that is planned for some 5G networks.

Wi-Fi 6 is designed to host existing and emerging uses, from streaming ultra-high definition movies, to mission-critical business applications requiring high bandwidth and low latency, with the ability to stay connected and productive while traversing large congested networks such as airports and railway stations. 5G offers similar speeds and latency, although in the 5G networks launched to date the claimed low latency is behind that offered by some Wi-Fi offerings. This may change in the future as 5G is developed, but Wi-Fi is already there. It is understood that Wi-Fi 6 will offer speeds that are roughly 30% faster than Wi-Fi 5, with a theoretical maximum transfer speed of around 10Gbps.

The IEEE 802.11 working group has also decided that only Wi-Fi 6 devices will be permitted to operate in the new 6GHz Wi-Fi bands in the USA. This means that future clean and legacy-free 6GHz bands will only be used by the latest, most spectrally efficient, and highest-performing Wi-Fi technology. One chipset manufacture has said this will likely lead to an unprecedented boost in Wi-Fi quality and capacity.

This means that Wi-Fi 6 will be defined for operation in all current Wi-Fi bands including 2.4GHz, 5GHz, and in the future 6GHz. With Wi-Fi 5 (802.11ac) continuing to operate in 5GHz only, and 2.4GHz to support older Wi-Fi versions (predominantly Wi-Fi 4 or 802.11n). The FCC has also reopened the case for releasing the 5.9GHz band to Wi-Fi – a band currently reserved for vehicle-to-vehicle communications.

Using 6GHz the reach of Wi-Fi will be reduced, although this will be mitigated with distributed Wi-Fi (Wi-Fi Mesh) architecture and the use of multiple channels to connect multiple access points in different locations to a main router. The objective of Wi-Fi 6 is to provide full indoor coverage into every space within a building with the same high data rate. This will not be easily achieved with 5G.

5G's proposed higher frequency bands also create a penalty on its range. It is anticipated that range will probably decrease to less than half, forcing the number of base stations to more than quadruple, due to the square nature of coverage. 5G NR (New Radio) will allow mobile networks to deploy base stations in frequencies above 6GHz, with

Yes, but isn't Wi-Fi just Wi-Fi?

The official 802.11 Wi-Fi specifications based on a number sequence can be confusing and quickly lose their meaning. To address this the "Wi-Fi Alliance" (the organisation responsible for creating and designating Wi-Fi standards) has simplified the way Wi-Fi will be referenced and branded, based on which 'generation' of Wi-Fi the standard belongs to. The convention started with Wi-Fi 4 in 2009, with Wi-Fi 1 to 3 named retrospectively.

802.11a (1997): [Wi-Fi 1], 802.11b (1999): [Wi-Fi 2], 802.11g (2003): [Wi-Fi 3], 802.11n (2009): Wi-Fi 4, 802.11ac (2014): Wi-Fi 5 and 802.11ax: Wi-Fi 6.

"Both 5G and Wi-Fi 6 will use orthogonal frequency division multiple access"

"4G LTE is able to do all that railways require"

many small cells with very small ranges capable of serving thousands of users concentrated in a small area, such as a busy railway station. The base stations will be smaller, but adding more base stations to a railway already equipped with GSM-R will not be easy or cheap, and the migration from GSM-R to LTE/5G will be particularly challenging.

6GHz band and Wi-Fi 6

The release of the 6GHz band is likely to coincide with the commercial availability of Wi-Fi 6 devices and routers. Wi-Fi 6 has already been designed to meet a steep rise in the number of personal devices as well as connected machines and 'things'. The possible new spectrum for Wi-Fi 6 may vastly increase the connectivity capabilities of Wi-Fi even further.

The FCC suggests that a large part of the 6GHz spectrum should be managed by applying an 'Automatic Frequency Control' (AFC) system that would protect current point-to-point radio and satellite users of the 6GHz band from interference, with the rest of the 6GHz spectrum restricted to indoor use and operated at lower power without an AFC system.

Both 5G and Wi-Fi 6 will use orthogonal frequency division multiple access (OFDMA) to increase efficiency and to lower latency for high demand applications, together with multi-user multiple input, multiple output (MU-MIMO) allowing more data to be transferred at any one time. They will also both use beamforming to enable higher data rates at a given range to increase network capacity.

The improvements will deliver comparable performance for both 5G and Wi-Fi 6. It is argued by some that Wi-Fi 6 will have more proven methods for sharing spectrum in overlapping networks, along with simpler network and device management. Wi-Fi 6 is also likely to reach the market in advance of any wide-scale deployment of 5G New Radio. 5G is going live now, but only in some cities in the world and its use in railways is likely to be some years away (2025?) with 4G LTE able to do all that railways really require for some time.

Wi-Fi 6 routers from Cisco, Netgear, Asus and TP-Link are already rolling out, including mesh options for the Netgear Orbi and TP-Link Deco. The Samsung Galaxy S10 is reported as being the first phone to support Wi-Fi 6, and other devices will quickly follow, such as the iPhone and the next generation of laptops and Wi-Fi smart building devices.

Wi-Fi interference

Wi-Fi has been used successfully for a number of metro railway CBTC systems. Although a few CBTC systems have been deployed using alternative radio bearers, such as waveguides or induction loops, the majority of the CBTC implementations since 2013 have used Wi-Fi based radio systems to bridge the train-to-lineside gap.

The limitations that Wi-Fi presents to CBTC systems – on range, quality of service, mobility and (especially) interference – have made some rail operators and suppliers look for alternatives. A series of incidents in China on CBTC systems resulted in the China Association of Metros to stipulate in 2014 that all future Chinese CBTC deployments would use LTE as their radio bearer. 2018 saw the first wave of CBTC over LTE projects enter service, almost all of them in China.

CBTC over LTE projects currently in development include Shanghai Metro Lines 15 and 14, as well as the Automatic Train Control (ATC) project in Perth, Australia, currently scheduled for 2024. The deployment in Hong Kong, however, continues to use Wi-Fi as the primary radio bearer, with a mobile network operator (HKT) providing an LTE radio backup. Interference is not such a problem for metro systems that operate completely sub surface.

Wi-Fi was developed to provide connections to static locations, whereas GSM/LTE/5G has always been designed for efficient handover from node to node, such that a moving transmitter/receiver always has a reliable connection. Handover to a moving object is possible with Wi-Fi, but it's not what it was designed for.

So, is the future 5G or Wi-Fi 6?

Both 5G and Wi-Fi 6 will have very particular characteristics that will be beneficial for data connections. What is likely to happen, therefore, is that operators and system engineers will exploit both technologies to their advantage, with seamless migrations between the two standards when necessary. The ultimate winner therefore may be not be 5G or Wi-Fi, but is likely to be system integrators and the end user, with the two technologies able to seamlessly connect and roam, supporting services such as fixed and mobile broadband, voice, massive IOT and low latency Artificial Intelligence (AI) applications.

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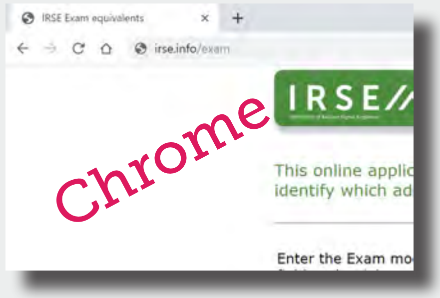

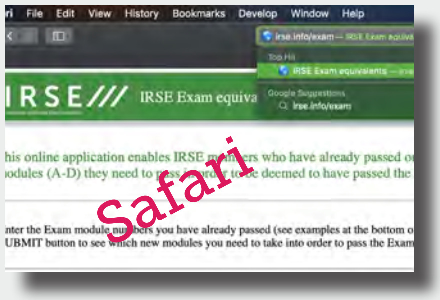

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Institution of Railway Signal Engineers

The use of formal methods in specification and demonstration of ERTMS Hybrid Level 3

Prepared on behalf of the International Technical Committee
by Maarten Bartholomeus, Bas Luttik, Tim Willemse,
Dominik Hansen, Michael Leuschel and Paul Hendriks

Software has become an essential component in signalling systems. Writing clear, precise and accurate specifications is of course important for these systems. Can formal methods help in this process? An interesting case is the recent development of the Hybrid Level 3 for ERTMS/ETCS. This paper addresses the specification and demonstration of ERTMS Hybrid Level 3.

Hybrid Level 3 and formal methods

During development of Hybrid Level 3 it was realised that a pure functional specification did not provide enough insight into possible degraded scenarios and their impact on current operational processes. The list of generated scenarios kept growing and growing. A more precise method to specify the system behaviour on a functional level was required. For this purpose, a specification with state diagrams was developed describing the possible states of the track sections and transitions, see [1]. This allowed the railway specialists to evaluate the operational impact and the system specialist to check if a system could be made according to these specifications.

The number of operational scenarios implicitly described by the state diagram is very large. Hence, there is a high risk that unsafe operational scenarios are missed in a review of the principles by railway experts. Using formal methods, computer tools can be used to exhaustively analyse all operational scenarios for a given track layout.

Formal methods are already well established to avoid errors in the software coding phase, but this does not guarantee that software safety requirements themselves are correct. The formal methods can also be used to prove that the software specification and its implementation satisfy the expected system properties.

The Hybrid Level 3 specification [1] was selected as a case study for the formal methods conference ABZ [2]. One of these cases was an implementation in a real-life test environment and was one of the successful demonstrators of Hybrid Level 3 in the UK on the ERTMS National Integration Facility (ENIF) test track in 2017 [3]. The Hybrid Level 3 specification was also analysed in cooperation with the University of Eindhoven [4]. This paper will reflect on these studies and the benefits of using formal methods in this project.

ETCS Hybrid Level 3 offers an interesting alternative approach to realising the benefits of new technology on existing lines. This extract from Maarten's video [5] of testing at the UK's ENIF facility shows that it is very real.

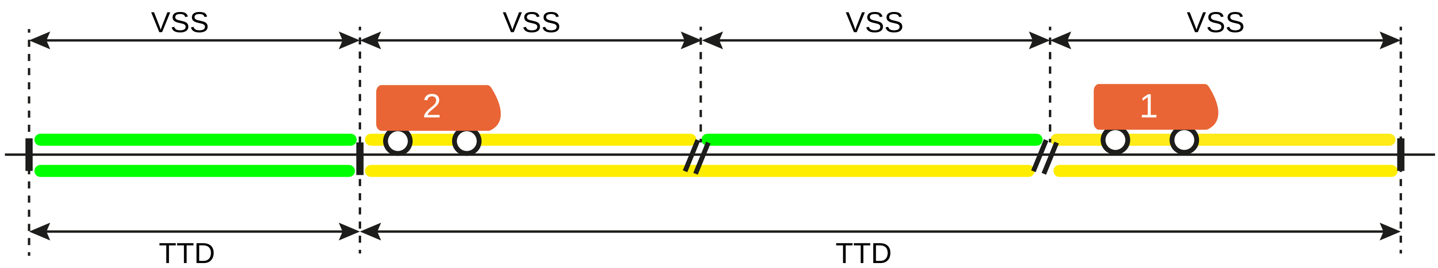

Figure 1 – The principle of ETCS Hybrid Level 3 is to divide trackside train detection sections into several virtual sub sections, increasing capacity.

Hybrid Level 3

Hybrid Level 3 is a development that allows ERTMS trains to follow each other based on the train positions reported by the on-board systems providing an optimal performance without the 'pure' Level 3 drawbacks: a 'pure' Level 3 system requires that all trains are fitted with a Train Integrity Monitoring System (TIMS) and that the RBC (Radio Block Centre) knows at all times the position and integrity status of each train or vehicle that is physically present in the area under its control. The problem is that in practice these conditions cannot always be fulfilled considering the wide range of vehicles and scenarios, for instance switched-off trains, parked wagons, communication failures, when performing shunting operations or after a restart of the system. Procedures to overcome this lack of train information would cause a significant operational disruption.

The Hybrid Level 3 concept combines on-board train position information, on-board train integrity confirmation and trackside train detection, and supports trains with and without on-board integrity proving. It mitigates operational risks in degraded scenarios and allows for fast and robust system recovery.

Thus, it provides a migration path for trains operating on the line while increasing capacity and providing robust operation.

Hybrid Level 3 principles

For Hybrid Level 3, trackside train detection sections (TTD) can be divided into several virtual sub sections (VSS), see Figure 1. As the VSS are software-defined, they can be configured to a size providing a performance comparable to the 'moving block' concept. The status occupied or free of the VSS section is based on both on-board derived train position information and trackside train detection information. A VSS section is reported free if the underlying trackside train detection is reported free or if all conditions are met to safely clear this VSS based on information reported by a train. A VSS section is reported occupied if a train reports itself inside this section (based on reported front-end position and train length).

Because the timing and spatial accuracy of the trackside train detection and ERTMS train position vary considerably, two additional internal VSS statuses are introduced: "ambiguous" and "unknown". These two additional statuses can be represented as occupied to avoid new requirements and/or operational procedures. The trackside train detection occupancy information is used only as an input for the VSS status. This feature allows the Hybrid Level 3 solution to interface with existing systems.

The different VSS state transitions are defined based on reported train information and trackside information; this is explained in more detail in the Hybrid Level 3 Principles [1]. For instance, the transition from "occupied" to "free" takes place if a train with confirmed integrity reports that it has left this VSS. Another example is the transition from "occupied" to "ambiguous". This happens when a train loses its integrity or does not report integrity. VSS sections left by a train without proven integrity in an ambiguous VSS section will become "unknown" until the underlying trackside train detection reports free. The transitions between VSS statuses are described meticulously in [1]. See for instance transition #1A below:

#1A : (TTD is occupied) AND (no FS MA is issued or no train is located on this TTD)

This specification detail allowed the Hybrid Level 3 specification to be analysed and tested with formal methods.

Using a Formal B model in a demonstration of ETCS Hybrid Level 3

In 2017, Thales contributed to a field demonstration of the Hybrid Level 3 concept by providing the Trackside System supporting the new Hybrid Level 3 specification. The Thales approach was to develop an add-on for the RBC, called Virtual Block Function (VBF), which computes the occupation states of the VSSs according to the Hybrid Level 3 specification. From the perspective of the RBC, the VBF behaves as an Interlocking (IXL) that transmits all signal aspects for the virtual signals – introduced for each VSS – to the RBC. This architecture provides the benefit that the RBC can be used without modification to its core functionalities (see figure 2).

Two main tasks were identified for the development of the new VBF component:

1. Providing evidence that the Hybrid Level 3 specification is consistent and complete to handle possible hazards and to allow the desired operational behaviour.
2. Building software that conforms to the Hybrid Level 3 specification and can be used in a field demonstration by supporting the existing interfaces to the other components of the system (RBC, IXL).

The high level of detail within the Hybrid Level 3 specification, which describes the expected behaviour in every situation, eases the development of conforming software but increases the challenge of providing evidence that the specification itself is correct and complete.

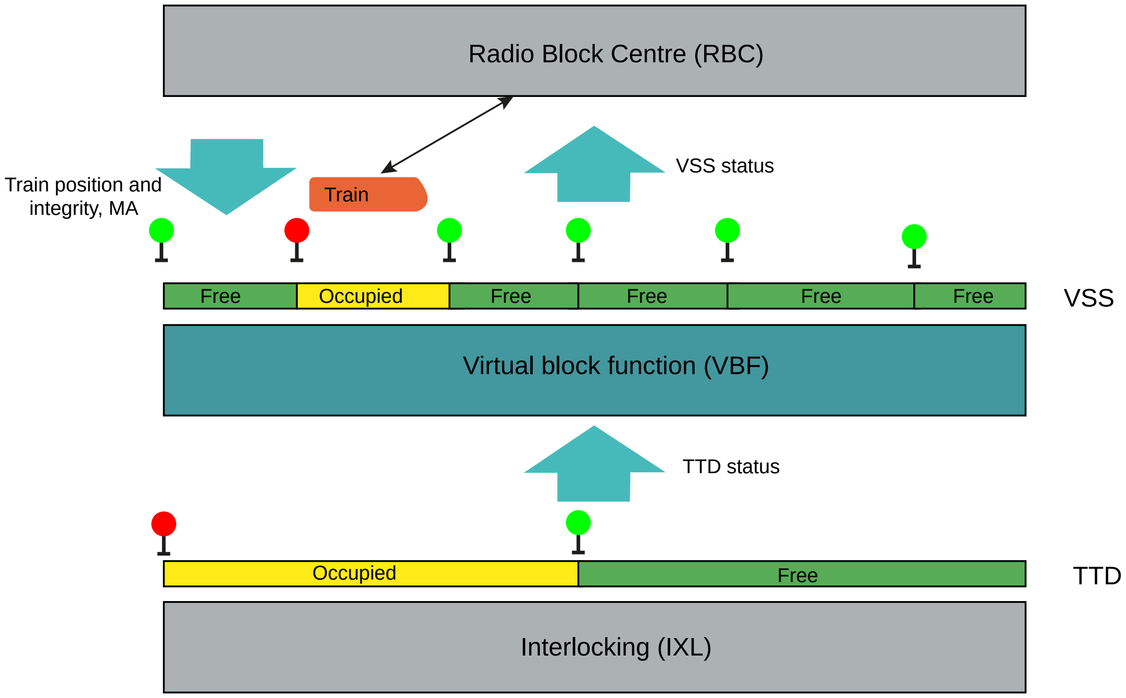

Figure 2 – The role of the Virtual Block Function (VBF).

For this Thales developed a formal B model of the Hybrid Level 3 specification in cooperation with the University of Düsseldorf.

The formal model allowed an analysis of the specification before a single line of interface code was written. The ProB model checker and animator allows the interactive replay of all operational scenarios contained in the Hybrid Level 3 specification as well as the derivation of new scenarios.

A non-deterministic environment model provides all possible input events for the state machine, which could be interactively selected by a user or automatically selected by the model checker to search for violations of generic invariants (e.g. a train should never be located on a free VSS). The developed graphical visualisation (similar to the picture in Figure 1) even allows a domain expert without a formal methods background to inspect the behaviour of the Hybrid Level 3 specification and perform their own 'experiment scenario analysis'. Moreover, scenarios can be stored and used as regression tests in case of modification to the state machine. Indeed, this was very useful as several issues were found in the Hybrid Level 3 specification and it was necessary to adjust either the state machine or the scenarios. In resolving such issues, the model combined with the visualisation served as an unambiguous, interactive specification to communicate the problem within the team.

To accomplish the second task of developing a demonstrator the formal model was used in real time (executed by ProB) for the field demonstrations. This was possible as the model covers the entire Hybrid Level 3 specification with all necessary details so that it can be combined with the manually produced interfaces. The visualisation, which was also used during the offline analysis, was reused during the field demonstrations to check the correct functioning of the trackside system in real time. Moreover, the observed real-life events (e.g. train position reports of real trains) were captured by ProB and could be replayed (step by step) by a domain expert in the ProB animator at a later stage (instead of inspecting large log files).

Thanks to this innovative approach, the field demonstrations were successfully completed within a tight time schedule in the UK [5] and Germany [6] .

Modelling and analysing ERTMS Hybrid Level 3 with the mCRL2 toolset

Eindhoven University of Technology develops the formal specification language mCRL2 and an associated toolset. The toolset comes with a simulator and with a model checker. With the simulator, operational scenarios can be executed. The model checker can be instructed to exhaustively search for operational scenarios that violate a property, which is also formally specified. If such an operational scenario is found, then it can be visualised.

The Hybrid Level 3 principles defined by the VSS state diagram, together with the table that specifies the conditions for transitioning between statuses, turned out to be precise enough to admit a fairly direct translation into mCRL2. Formal methods researchers without extensive railway expertise could, in fact, do an initial translation without consulting a railway expert.

For a meaningful formal safety analysis, it is necessary to also specify to some extent the context into which a Hybrid Level 3 system is embedded. To this end, the mCRL2 model includes an abstract description of the operation of a trackside system and the behaviour of trains.

The trackside system implements the Hybrid Level 3 principles, computing new VSS statuses on the basis of events (e.g., a train reports its position, the train detection system reports a change in occupancy of a particular section). Although in a real implementation one would have to determine in which order VSS statuses are updated in response to an event, this is not necessary in formal specification languages, such as mCRL2, that include a facility to specify non-deterministic behaviour. Non-determinism can be used to avoid committing to one particular implementation of the update mechanism, and thus the formal analysis done with mCRL2 is not limited to one particular implementation. The trackside system issues movement authorities to trains based on information regarding the statuses of the VSSs.

The specification of the behaviour of trains also makes use of non-determinism to generate all possible movements of trains through a network. Trains can receive movement authorities from the trackside, can move from one VSS to the next, and report their position to the trackside. Furthermore, they are also indirectly detected by the trackside through the train detection system.

The mCRL2 model can thus be thought of as an abstract description of all trackside systems implementing the Hybrid Level 3 principles. To actually simulate operational scenarios, or perform an exhaustive search for unsafe operational scenarios, it is necessary to add a track layout, specifying how many trains and track sections are controlled by the trackside system and how the track sections are subdivided into VSSs. For simulation purposes, track layouts of the size considered by the inventors of the Hybrid Level 3 principles (three sections, each subdivided into three VSSs, with three trains) are unproblematic. For a complete exhaustive analysis, currently only smaller track layouts have been considered. Nevertheless, analysis of smaller track layouts has already revealed issues in earlier versions of the Hybrid Level 3 principles.

Conclusion

The use of formal methods proved to be very useful to analyse and validate the Hybrid Level 3 specification. Whilst the two tool sets that were used have very similar capabilities, the approaches had a slightly different focus. The goal of the developed B model was to obtain a reference implementation which conforms to Hybrid Level 3 specification with all necessary details to be used in the field demonstration. In contrast, the mCRL2 approach focused more on analysing the correctness of the principles independent of the implementation strategy.

We summarise the benefits of using these formal methods:

Eliminating ambiguities in the natural language phrasings. Formal languages provide an unambiguous mathematical notation with well-defined semantics. Thus, the formalisation alone led to improvements of the principles, by eliminating ambiguities.

Visualisation and tooling. To execute scenarios and analyse the behaviour of the model these tools provide useful visualisations of issues and inconsistencies in the model and allow a simple demonstration of the identified scenarios. Visualisations help to get a common view within a heterogeneous team where members had different backgrounds.

Model checking. As the number of operational scenarios implicitly described by the VSS state machine is enormous, review of a number of example scenarios by experts would not be sufficient to reach the complete coverage of the state machine. By model checking it is possible to exhaustively search through all operational scenarios associated with a known track layout in order to determine whether there are violations of a particular safety property. Using this method, a safety invariant such as "no train shall have a normal authorisation over a section occupied by another train" was verified for various track layouts. In the early stages of development, the application of this approach typically quickly produces interesting operational scenarios that require further consideration and yields fast feedback on proposed changes. In later stages, it significantly increases confidence in the correctness of the principles.

Fast feedback on changes in specification. It was very valuable that the model checking allowed fast feedback on changes in the specification and regression testing. The tools can quickly produce examples of interesting operational scenarios.

Bridging the gap to the software level. By converting the formal model into an executable prototype, it was possible to perform field demonstrations with real trains. This shows that formal methods can be used for the creation of rapid prototypes to test not only at the component level but also on the system level. There are also appropriate tools available to generate low level code – which can be used within SIL4 capable product development – from a formal model.

The ITC and the authors thank ProRail, Thales, and the involved universities that contributed to this article.

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Railway signalling in the cloud – the new normal?

André Rodenbeck

“Building new tracks isn’t an option in areas where space is scarce and expensive”

If you use German highways, you may have seen a slogan on a truck that says, “As long as you can’t e-mail apples, we’ll have to share this road.”

We can see every day that freight and passenger transportation volumes are continuing to grow. Let’s take a closer look at railways. Relative to 2005, main line rail traffic is estimated to increase by 108% until 2025 on a global scale. Urban rail traffic worldwide will grow by 180%, meaning that capacity has to nearly triple (irse.info/ptn2d).

How can we in the rail industry manage this growing volume? How can we avoid making huge investments in hardware, software, and the lifecycle of rail signalling?

Remote operation, local control

For the most part, building new tracks isn’t an option in areas where space is scarce and expensive. That’s why some infrastructure managers are daring to make a paradigm shift: They’re increasing the capacity of rail signalling by putting it in the cloud.

Switzerland is the role model: In 2017, privately run Gornergratbahn celebrated a world premiere, the first rail control system provided as a service. The proven Iltis system, its trackside applications, and the IT infrastructure are now running remotely in the Siemens cloud in Wallisellen, 170km away from the control centre in Zermatt. Via a secure, redundant direct line, the train dispatcher still operates the control system and monitors the railway system.

1.8 million tourists annually use Gornergratbahn (irse.info/yvj6b) to pose in front of icy giants like the Matterhorn. However, the technology is anything but picturesque. The operator benefits from the latest standards in hardware, software, cyber security, and maintenance without ever risking technological obsolescence. Being always up to date at a fixed monthly rate – that’s the way to go. But is it secure?

Never compromise on security

Until a few years ago, rail technology in the cloud appeared to be rocket science. For good reasons. Rail infrastructure is categorised a critical infrastructure within the European Union, i.e. “essential to maintain vital societal functions” (irse.info/tfqal).

Today, remote control centres in the cloud can be operated as securely as on site. From redundant data connections to fallback computers in the data centre, the entire data chain is well protected against outages. All security-relevant tasks have to undergo parallel tests and confirmations. The latest crypto box technology – including Data Capture Units, Siemens’ data diodes – makes sure only authorised persons can access the system. And even in the very adverse case of all computers going down in the data centre, an emergency computer in Zermatt could take back full control.

The revolution goes on

Good ideas spread easily. Another example comes from Germany, where one of Europe’s first digital interlocking (DSTW) started operation in March 2018. On the Erzgebirgsbahn, a regional subsidiary of Deutsche Bahn AG, the dispatcher’s switching commands are transmitted to the points, signals and track contacts via IP network technology.

It’s exactly this technology that resolves a huge problem of complex rail infrastructures: Today, all trackside components such as axle counters, track circuits and signals are connected to interlockings. Limits on cable length can limit an interlocking’s coverage. For the German main line railway this is around 16km, leading to the network having 2500 interlockings of various technological generations, all of which have to be maintained and modernised over time. This required huge infrastructural efforts and investments – until recently.

Digitalisation of railway networks is increasingly becoming the norm, is a 'move to the cloud' also the new normal? *Photo Siemens.*

With digitally connected rail infrastructure, it's about to change. All components except for point machines will be virtualised and connected via the Internet of Things (IoT). The underlying control logics – the interlocking – will be located in the cloud. The technology is and remains compliant with Safety Integrity Level (SIL) 4, thus providing the same level of safety and security as today's wired infrastructure. The number of components can be drastically reduced, while operators have full transparency of their entire system at any time and from anywhere.

Key to new business models

Very soon, we'll see further examples like Gornergratbahn and Erzgebirgsbahn. Be it on main lines with heavy traffic, major hub railway stations, or simpler applications in rural areas: Digitalisation has just begun to unfold its potential. With digital transportation chains, we can leverage the power of data. New business models will help operators focus on their core business. They can increase the performance and attractiveness of rail systems without building new tracks. And they can drive the intermodal solutions of the future.

But that's another story for another article some time.

"Digitalisation has just begun to unfold its potential"

What do you think?

Internet protocol-based communication between interlockings and trackside equipment is commonly used in an increasing number of countries as previously described in IRSE News. However the concept of a complete move to cloud-based computing for vital processing brings both opportunities and new threats. What is your experience of introducing such technology? Have you experience of new business models based on the use of digitalisation that you'd like to share? Email us at **editor@irsenews.co.uk**.

About the author ...

André is the CEO of Siemens Mobility Management. André earned a degree in industrial engineering and over the last 15 plus years he has held various positions with Siemens in Germany, Thailand and Spain. His expertise spans a wide range of rail and mobility-related topics, including main line signalling technology, mass transit, electrification, turnkey projects, and intermodal mobility management.

IRSE
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Independent safety assessment – new standards, new challenges

Aryldo G Russo Jr

CENELEC is the European Committee for electrotechnical standardisation and responsible for standardisation in the electrotechnical engineering field. Standards 50126, 50128 and 50129 are generally accepted as the worldwide references for railway safety, and are the base reference for assessments performed by Independent Safety Assessment (ISA) bodies. Since the first publication the standards have focused on the pragmatic concept of safety, and all studies and analysis were done with the objective of demonstrating that all possible measures were taken in order to avoid hazards related to injuries or fatalities.

The analysed causes of hazards were generally self-contained in the system under assessment and did not take into account attacks that could come from external sources.

As the world evolves the standards have evolved, and as a result the new version of CENELEC EN50129:2018 includes, in a simple but effective way, a new chapter (6.4) that requires cybersecurity to be dealt with as part of the safety demonstration case and included in the safety case.

Cybersecurity is a vast area of discussion, and can be treated in different levels of depth and application, such as:

- Enterprise wide: where the attacks are company related and targeting company assets.
- Product/project wide: where the attacks intend to disturb the operation of some process.

At different levels different standards also exist, some of them more related to the company-specific issues, like the ISO 2700x series, others more related to the product/projects, like the IEC 62443 series. A study performed by one of the Shift2Rail initiatives concluded that the IEC 62443 series copes with almost all the railway domain requirements and should be the application choice for rail.

Figure 1 shows the different aspects that can be related to Cybersecurity aspects, and emphasises the relation between EN50129 and the aspects that should be evaluated in an ISA submission from now on.

EN 50129, now creates a new need, or a new task to be performed by ISA bodies. This is the

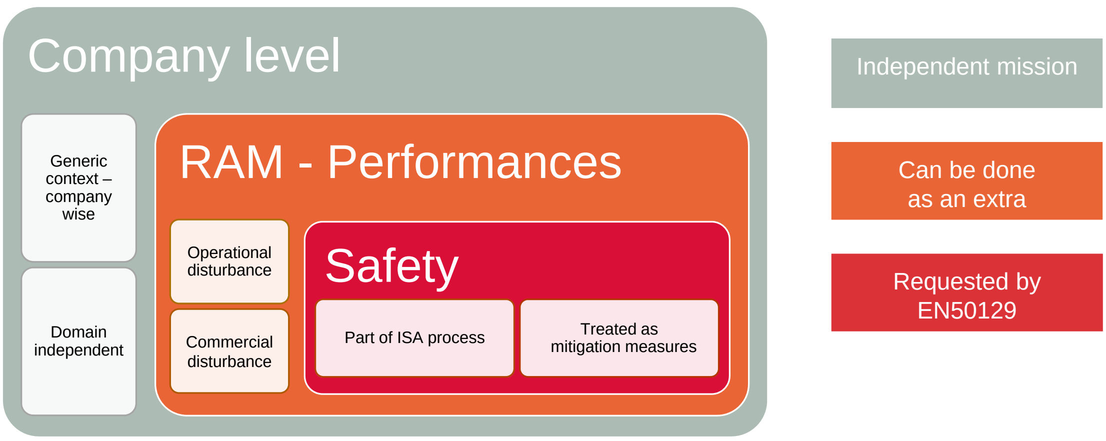
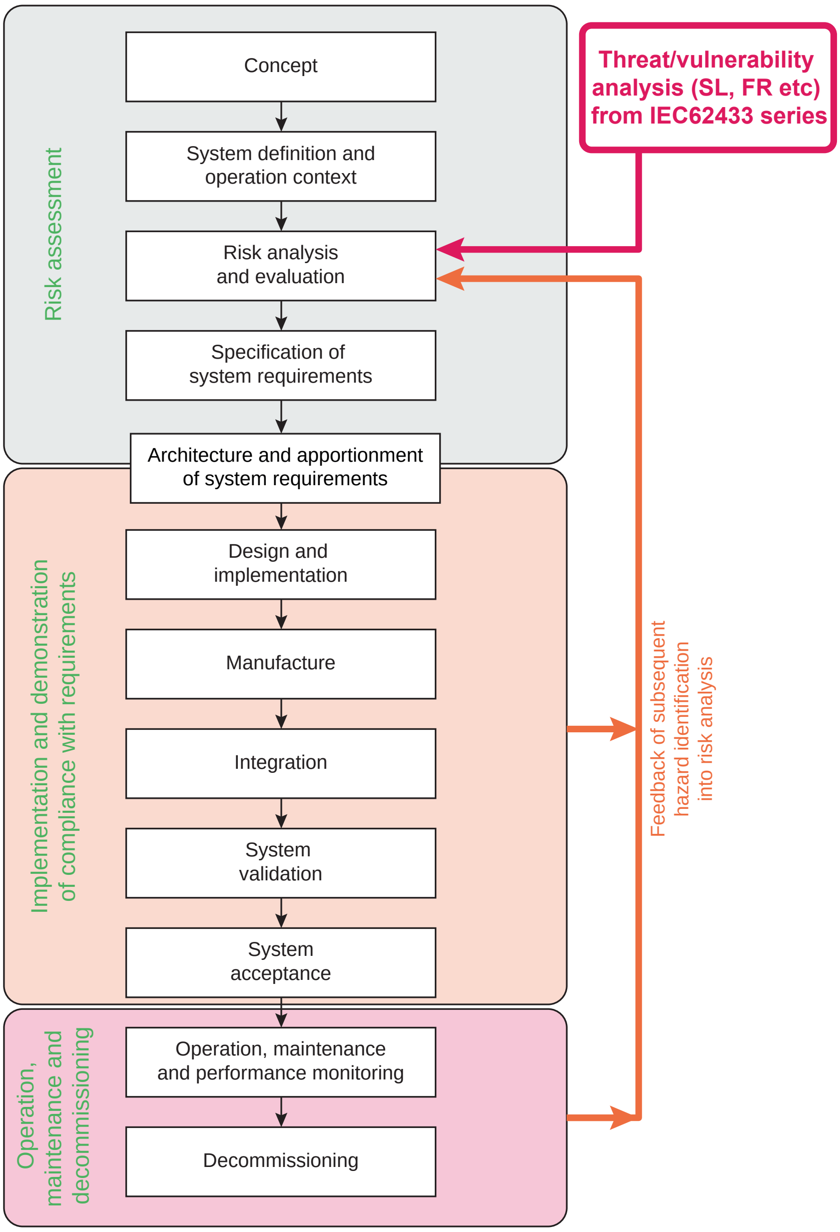


Figure 1 – The different aspects that can be related to cybersecurity.

Figure 2 – A simplified view of the system lifecycle from EN50129, showing the point at which cyber security requirements should be included and the feedback loop from hazard identification to risk analysis/evaluation.



evaluation of cybersecurity (as causes) which needs to be taken into account during the safety demonstration process. One possible way to integrate the new requirements is into the system lifecycle, as demonstrated in Figure 2.

So, in an abstract way and as a minimum, the points below should be checked during the assessment to guarantee the consistency of the safety demonstration:

- Top level assessment
  - Was cybersecurity taken into account during the initial development phases (conception and risk analysis)?
  - Were top level cybersecurity plans prepared?
- Technical assessment (taking into consideration that the IEC 62443 series were defined as the reference)
  - For each sub-system, were the functional requirements (FR) evaluated and the security level (SL) allocated?
  - Each of the sub-tasks for FR coverage were correctly applied?
  - Is the evidence consistent?

As technology moves forward, new threats arise, or become more important, as is the case with cybersecurity. The standards bodies are aware of this, and the updates of the current standards take account of these new aspects.

It is important to be rigorous during the assessment stages of a safety submission to be sure that the new requirements are all well covered. A good assessment strategy should be in place, such as the one discussed in this article.

About the author ...

Aryldo G Russo Jr is director of innovation at CERTIFER, France, and a senior lead assessor. He has been working on safety related projects since 1999, and has accumulated relevant experience of both research and development, and validation of industrial safety-critical projects, particularly in the railway domain. He has been responsible for the complete RAMS activities of several SIL 2, 3 and 4 railway projects, and contributed to the remaining safety and validation activities. Aryldo is CEng and a Fellow of the IRSE and SaRS (Safety and Reliability Society).

What do you think?

Is cyber-security adequately addressed in every project? Do current standards make sense and are they fit for purpose? Have you successfully incorporated cyber securities into your system design? Let us, and other members, know of your experience and views, email us at **editor@irsenews.co.uk**.

Industry news

Russian Railways demonstrates driverless train

Russia: Deputy prime minister Mr Maxim Akimov and the chairman of Russian Railways (RZD) Mr Oleg Belozerov recently took a test trip on Russia's first driverless passenger train, a Lastochka (Swallow) EMU, on the Shcherbinka test track near Moscow during a railway exhibition.

The ES2G Lastochka train is fitted with systems that identify its location on the track, and enable it to communicate with the dispatch centre, detect obstacles and brake automatically.

The train can be controlled automatically from the cab by a driver, or from the control centre by an operator. In an emergency, the operator in the control centre can take the train out of automatic operation and control it remotely. RZD said they believed they were a year ahead of other railways in developing an autonomous train.

ETCS for suspended railway

Germany: The Wuppertal Suspension Railway has deployed Alstom's Atlas European train control system (ETCS). The railway's full name is "Electric Elevated Railway (Suspension Railway) Installation, Eugen Langen System". It is the oldest electric elevated railway with suspended cars in the world and a unique system.

Designed by Eugen Langen to sell to the city of Berlin, the installation with elevated stations was built between 1897 and 1903. The suspension railway runs along a route of 13.3km, at a height of about 12m above the River Wupper between Oberbarmen and Sonnborner Straße and about 8m above the valley road between Sonnborner Straße and Vohwinkel.

As part of the agreement with WSW mobil, Alstom fitted the suspended route with ETCS, including 31 new trains and a 100-year-old wagon Kaiserwagen. This was Alstom's first full train contract in Germany and the scope includes radio block centres, line-side equipment and other required elements.

The Atlas system was developed in Charleroi. Belgium. Other components of the system were made in France and Italy at Alstom sites. The upgrade replaced three 40-year-old electrical interlocking units.

London Underground CBTC

UK: Over the weekend of 31 August - 1 September 2019, a second section of London Underground's Circle Line was converted to automatic train operation, with the commissioning of CBTC signalling under the Four Lines Modernisation programme. The work was the first section of the resignalling programme to include some of the busy flat junctions on the underground.

The first Thales CBTC commissioned in March covered a pilot section of the outer end of the Hammersmith & City Line between Hammersmith and Latimer Road. This was a relatively simple two-track railway, apart from the Hammersmith terminus and depot connections. The second section extends the ATO operation further along the circle line from Paddington to Euston Square.

Transport for London expects to continue operating the existing service of 28 trains per hour in each direction east of Baker Street for the time being, but the resignalling is intended to facilitate a future increase to 32 trains per hour. The electro-mechanical signal box at Edgware Road, originally commissioned in 1926, is to be donated to the London Transport Museum for preservation.

First driverless train for Shanghai metro Line 14

China: The first of 49 driverless metro trains for the new Line 14 of the Shanghai metro have been produced by CRRC Nanjing Puzhen. The eight-car Type A trains are equipped with Bombardier's Mitrac propulsion and control system, which is being supplied by Bombardier's Chinese joint venture, Bombardier NUB Propulsion System, under a contract awarded by Shanghai Shentong Metro Group in 2018.

The trains will operate at Grade of Automation 4 (GoA4) on the new 38.5km Line 14, which will run from Fengbang in the west of the city to Jinqiao in the Pudong District in the east of Shanghai. Thales SEC Transport (TST) is installing a communications-based train control (CBTC) automatic train control system on Line 14.

Mumbai Urban Transport CBTC

India: Mumbai Rail Vikas Corporation (MRVC) Limited has started preliminary work towards the implementation of a CBTC system on the Mumbai Urban Transport Project (MUTP-3A).

The project will be implemented on the three slow and fast corridors of the Western Railway between; Churchgate and Virar, Chhatrapati Shivaji Maharaj Terminus and Kalyan, and on the Harbour and Trans-Harbour Lines. Currently, suburban lines have a train frequency of approximately 3.5 minutes in the peak hours, which once the project is implemented, will be brought down to around 2.5 minutes.

The Harbour and Trans-Harbour Lines will be undertaken first as there are no long-distance passenger trains or goods trains sharing track access with local trains.

CBTC for Ottawa Confederation Line

Canada: Ottawa's 13-station O-Train Confederation Line, is now in revenue service, operating with Thales SelTrac CBTC (Communications Based Train Control). The system is claimed to provide energy savings while carrying up to 10,700 passengers per hour in each direction, with the potential to grow up to 24,000 passengers per hour in each direction in the future.

SelTrac was originally developed in the 1970s by Standard Elektrik Lorenz of Germany for the Krauss-Maffei Transurban, an automated guideway transit system proposed for the GO-Urban network in the Greater Toronto Area in Canada. Although the GO-Urban project was never built, the Transurban technology was acquired by an Ontario consortium led by the Urban Transportation Development Corporation (UTDC), and adapted to become its Intermediate Capacity Transit System (ICTS). The technology was first used on the SkyTrain network in Vancouver, B.C. and the Scarborough RT in Toronto.

SelTrac was primarily supplied and developed by Alcatel, through a Toronto-based subsidiary, but is now supplied by Thales Canada, after it purchased many of Alcatel's non-telecommunications assets. New versions have been developed for different markets and have been provided around the world. The original SelTrac system was based on inductive loops to provide a communications channel as well as positioning information. In newer versions, the control signal is transmitted inside the running rails at radio frequencies using IEEE 802.11 (Wi-Fi) access points.

Route modernisation in Hungary

Hungary: A US$2bn (£1.6bn,€1.8bn) contract to modernise the 150km route from Budapest Soroksár to the Serbian border at Kelebia and install ETCS Level 2 to permit 160km/h operation has been signed by the CRE consortium of RM International (50%), China Tiejiuju Engineering & Construction and China Railway Electrification Engineering Group.

Sri Lankan Level Crossings

Sri Lanka: Kernex Micro Systems (India) has won a US$8.2m (£6.5m, €7.3m) contract to supply and maintain 200 bell and light level crossing protection systems.

Interlocking commissioned in Kazakhstan

Kazakhstan: Integra Construction KZ has commissioned a Bombardier EBILock 950 computer-based interlocking covering 34 turnouts and 48 signals at Zhezkazgan.

ETCS L2 in service on Spanish high speed

Spain: ETCS Level 2 has been commissioned on the 163km Valladolid – León high speed line, as part of a signalling, train control and telecoms upgrading programme being undertaken by Alstom, Bombardier and Indra under a contract awarded by ADIF Alta Velocidad which includes 20 years of maintenance.

Increase of trains passing red signals in Great Britain.

Great Britain: The rail industry's independent safety body, the Rail Safety and Standards Board (RSSB), has asked if enough is being done to reduce the risk of a train accident from trains passing red signals. July saw 41 trains pass red signals, the highest number in a single calendar month since October 2007.

In the last 12 months, 10 trains passed red signals and reached the position along the track at which a collision could theoretically take place. This is higher than the five-year average of between four and five, and the total for the last financial year 2018-9 which was seven. The risk from signal passed at danger (SPADs) has not been as high since September 2014.

RSSB chief executive Mark Phillips has written to all managing directors in Network Rail and train and freight operating companies, to highlight the latest data and ask if enough is being done, or whether more effort is needed in managing SPAD risk. The warning was made close to the 20th anniversary of the Ladbroke Grove train crash, SPAD incident which killed 31 people and injured more than 250 people.

In the last 20 years, the industry has reduced SPAD risk by more than 90%. It has been over 12 years since the last train accident involving fatalities, hence today Britain has one of the safest railway networks in Europe. However, RSSB has been keen to avoid any sense of complacency, and is asking its members whether enough is being done to address SPADs.

Early Contractor Involvement in South Wales

UK: Transport for Wales has awarded Balfour Beatty, Alun Griffiths and Siemens Mobility early contractor involvement contracts ahead of procurement for the first stages of the South Wales Metro project. These cover planning and design of the control systems, trackwork, stations and the maintenance depot at Taff's Well.

Minor signalling frameworks awarded

UK: Network Rail has awarded Amaro, AMCO Giffen, Amey, Balfour Beatty, Linbrooke, OSL and Volker Rail a total of 17 framework contracts for minor signalling works with a total estimated value of £215m (€241m, $269m).

New company to implement ETCS in Germany

Germany: Deutsche Bahn DB is to form a new subsidiary to manage the digitalisation of the country's railway network. From January 2020, Digital Rail Germany (DSD) will be responsible for planning and implementing digital interlockings and ETCS, both onboard and trackside. DB expects these technologies to increase the capacity of the network by up to 35%.

DSD's work will begin with the rollout of ETCS through three so-called starter packages: TEN-T Scandinavia-Mediterranean corridor (Rostock–Berlin–Leipzig/Dresden–Nuremberg–Munich–Austria), Cologne–Frankfurt high-speed line, and Stuttgart S-Bahn network.

DB will spend €570m (£507m, $625m) on the three starter packages by 2023. According to a feasibility study by the federal government, an investment of €4.7bn (£4.2bn, $5bn) will be required to deliver the overall digital railway programme, which will equip around 80% of the network by 2030.

DSD will be responsible for coordinating the rollout of onboard ETCS and are currently discussing with the federal government how this can be financed. DB has already awarded Alstom a contract to equip 17 class 407 ICE high-speed trains with ETCS Level 2 by 2022.

European Union Agency for Railways issues first Single Safety Certificate

Europe: From 16 June 2019, The European Union Agency (ERA) has been mandated to issue single certificates valid in multiple European Member States, and on 16 September, Josef Doppelbauer, Executive Director at ERA signed the first Single Safety Certificate.

ERA has received two pre-engagement requests and is currently assessing five more applicants for Single Safety Certificates. More applications are expected leading up to June 2020, when the remaining Member States will introduce the new regime.

Bangkok ETCS

Thailand: The State Railway (SRT) has awarded a consortium of Thales and River Engineering a contract to install ETCS Level 1 on four lines with 48 stations around Bangkok, along with the electrification of all lines within 500km of Bangkok. Automatic Train Protection will be provided on sections of the Northern, North-Eastern, Eastern and Southern lines. The project is due to take two years to complete and the 21-station Hua Mak-Laem Chabang stretch will be the longest to be equipped with ETCS in Thailand.

Positive Train Control in Iowa

USA: Iowa Northern Railway has awarded Wabtec a contract to provide integrated I-ETMS PTC, digital video recording and data transfer and analytics capabilities across its fleet by late 2020. The order is the first won by Wabtec since its merger with GE Transportation.

Greater Anglia to improve train punctuality

UK: Toshiba Digital and Consulting Corporation (TDX) and Mitsui, which part-owns Greater Anglia train operating company, are providing 'digital twin' software to the train operator to plan its rail timetable more efficiently. Currently used by railway operators in Japan, a digital twin identifies timing or platform conflicts and will enable Greater Anglia to adjust its timetable accordingly to try to reduce delays.

Having been trialled on Greater Anglia's West Anglia route from Cambridge to London Liverpool Street, it is now being rolled-out across the network to build on the improvements made in the last six months.

TDX data engineers spent five months collecting data for the trial, including the existing timetable, train acceleration and braking performance and information about the position of signals, curves and the gradient of the line.

Welsh investment

Wales: Transport for Wales (TfW) has pledged to invest in every railway station in Wales to improve Wi-Fi, passenger information systems CCTV, shelters and cycle storage. The £194m (€218m, $240m) is planned to improve all 247 railway stations across Wales and the Borders over the next 15 years.

Where possible, TfW will also create new retail facilities, presenting opportunities for local businesses and work in partnership to develop community spaces at stations. The improvements include expanding the Secure Station Accreditation programme – a UK accreditation in conjunction with the British Transport Police – which will make stations safer and more welcoming for customers.

Problems with obtaining radio frequency spectrum

USA: The 2008 Rail Safety Improvement Act (RSIA) required railways that operate or host passenger trains (commuter/regional and intercity) to install Positive Train Control (PTC). The Commuter Rail Coalition (CRC) now points out that, despite PTC requiring radio frequency spectrum for communication, when commuter railways needed to acquire spectrum, the FCC (Federal Communications Commission) turned down requests to recognise the public safety mandate that required it, and told railways to buy spectrum on the open market.

The commuter railway efforts to acquire RF spectrum resulted in inflated prices and further stretched the resources of publicly funded commuter railroads. CRC said that railways were still facing problems obtaining radio frequency spectrum, which is essential to PTC communications.

"Connected vehicles – on roads and on rails – can only operate safely if their communication channels are clear," said CRC Chairman and Metra CEO and Executive Director Jim Derwinski. "That is why the Commuter Rail Coalition supports the American Association of State Highway and Transportation Officials (AASHTO) call to preserve dedicated spectrum for the safety of the emerging autonomous and connected vehicle market."

Commuter railways, all of which are publicly funded, "have long done more with less, which includes introducing safety protocols and systems beyond federal mandates, making rail the safest form of public transportation," said Derwinski. "Conversely, traveling in vehicles on US roadways already carries a significantly higher risk, with lifetime odds of dying in a motor vehicle crash at 1 in 103 (0.97%), with the odds of dying in a passenger train crash 1 in 431,800 (0.00023%), according to the National Safety Council. The FCC's refusal to protect a communications spectrum that would facilitate the future of autonomous vehicles directly puts public safety at risk. The FCC must protect and preserve this spectrum band solely for transportation."

5G 25GB data transfer trial.

China: As part of a 'smart metro' development programme, Shenzhen Metro and Huawei are testing the use of 5G for the rapid transfer of large volumes of data between trains on Line 11 and the control room.

The tests aim to transfer 25GB of data generated by a train during a typical 1 hour journey in around 150 seconds. This avoids the need to manually download data at the end of journey.

It is envisaged that the enhanced data communications could support applications including the use of high-definition CCTV to provide automated lost luggage alerts and searches. In an emergency, the fast data transfer could be combined with facial recognition and intelligent behaviour analysis to identify dangerous activities.

True 5G in the UK

UK: Mobile Network Operator (MNO) Three plans to switch on its 5G network by the end of summer in the UK. While that is later than other operators, Three claims to be the only UK network that will be offering a 'true' 5G experience.

The 5G network will initially be launched as a home broadband service in London, with the network planning to launch 5G mobile by the end of 2019 in London, Birmingham, Bolton, Bradford, Brighton, Bristol, Cardiff, Coventry, Derby, Edinburgh, Glasgow, Hull, Leeds, Leicester, Liverpool, Manchester, Middlesbrough, Milton Keynes, Nottingham, Reading, Rotherham, Sheffield, Slough, Sunderland and Wolverhampton.

Three has more 5G spectrum than other MNO rivals, with a total of 140MHz, 100MHz of which is a single contiguous block. The ITU (the global standards body on 5G technology), say 100MHz of 5G spectrum is required for 'true' 5G, hence Three's claim. Their 5G network is claimed to offer peak speeds twice as fast as rivals, along with a more reliable connection. Costs for the 5G service are unknown.

Their 4G network is also set to improve, as the claim network improvements in the next few years could allow for up to 400% improvements in speed and capacity.

London Underground public 4G

UK: Transport for London has shortlisted four bidders, BAI Communications, Cellnex UK Ltd, Wireless Infrastructure Group, and a consortium of Axia and SC, for a contract to roll out 4G mobile connectivity across the underground sections of the London Underground network. TfL aims to award the contract by mid-2020.

Ahead of the concession award, TfL is working with the UK's four mobile network providers to install 4G connectivity on a trial section of the Jubilee Line between Westminster and Canning Town.

The 4G network will also host the Home Office's Emergency Services Network, which will replace the existing Tetra Airwave network. The underground mobile network will operate alongside existing station Wi-Fi.

Wi-Fi for Greater Toronto and Hamilton

Canada: Metrolinx, the transportation authority serving the province of Ontario, will install Icomera Canada Wi-Fi on their fleet of vehicles operating in the Greater Toronto and Hamilton areas. The project will cover 943 train cars and 532 buses and will begin later this year, with the Wi-Fi enabled fleet starting to roll out in spring 2020 and final completion by the end of 2020.

In addition to onboard Internet connectivity, passengers will be able to spend time on a media channel featuring a wide variety of curated entertainment content. Operationally, media content is hosted locally on the vehicle and not streamed directly over the Internet, reducing the data costs typically associated with such systems. This system opens new revenue streams through which can offset operational expenditures, for example through corporate sponsorship, advertisements and regularly updated media content.

World's first single fibre-carrier terabit-per-second field trial

UAE: Nokia and Emirates Telecommunication Group Company Etisala, have set a capacity record during the world's first field trial of single-carrier terabit-per-second data transmission on a deployed fibre network.

The trial transmitted a record 50.8 terabits per second using multiple wavelengths, each with a net information rate of 1.3 terabits per second, over a 93km fibre route of Etisalat's wavelength division multiplexing (WDM) network. Leveraging a single optical carrier operating at 100 gigabaud, the terabit wavelengths employed Nokia Bell Labs probabilistic constellation shaping, or PCS, to intelligently shape the signal to achieve maximum capacity for the specific fibre route. A terabit-per-second is enough bandwidth to download the entire Game of Thrones video series in HD in under two seconds.

The trial demonstrates that existing networks can support the higher optical wavelength bit rates that will be required to support high-bandwidth services such as 5G extreme mobile broadband (very fast wireless to the mobile), fibre-to-the-premises (FTTP) and Data Centre Interconnect (DCI) cloud services. Higher bit rates per wavelength provide power and space savings, improved network simplicity, increased spectral efficiency and capacity, and ultimately reduced cost per bit compared to optical networks composed of lower rate channels.

Moscow Metro Wi-Fi

Russia: Fluidmesh, working for Maxima Telecom Inc, will deliver Wi-Fi for Moscow Metro train-to-ground network. The technology refresh will involve all 13 existing metro lines with Wi-Fi in Moscow and will expand coverage to the 14th, the Circle Line. The project is scheduled to be completed by 2020 and will employ MPLS-based wireless technology.

The network will be the largest and higher-capacity underground wireless MPLS network in the world, delivering 100s of Mbps per train. The network consists of 440km of track over 14 lines with 260 stations (80% underground). The project will involve 3400 train cars which carry 9 million passengers a day and 2.5 billion passengers a year.

Sri Lankan modernisation

Sri Lanka: The Asian Development Bank (ADB) has agreed to provide a $160m (£128m, $143m) loan to support a railway modernisation and efficiency improvement programme in Sri Lanka. The programme includes various schemes to improve operations, safety and technical capacity of Sri Lanka's railway system, and replacing the antiquated telecommunications system to enable two-way communications with train drivers and to reduce train delays. Every year, Sri Lanka Railways transports around 2 million tonnes of goods and 136.7 million passengers.

Last month, IRCON International signed an agreement to upgrade a 130km-long railway line from Maho town in the Northwestern Province to Omanthai in the Northern Province.

EU commits €600m to Polish rail infrastructure projects

Poland: The European Commission has approved two grants totalling €604m (£539m, $674m) from the European Union Cohesion Fund. The first grant will provide €487m (£434m, $543m) towards the rollout of GSM-R across 13 844km of the Polish network by July 2023. The programme will support more introduction of ERTMS.

The second grant will contribute €117m towards a €171m (£153m, $191m) project to reopen the Tarnowskie Góry – Zawiercie line in Silesia to passenger and freight traffic. The project is due to be completed in May 2022 and will provide a direct link between the regional capital Katowice and Pyrzowice airport, where a new station will be constructed.

Digital enabling technologies in rail at an earlier stage than other modes of transport

Europe: UNIFE, the Association of the European Rail Industry, has released a new vision paper on digitalisation that aims to bring the European rail supply industry's views and objectives into the centre of the digital debate.

"Digital Trends in the Rail Sector" was prepared by the members of UNIFE's Digitalisation Platform. It sets out the main priorities and ambitions of the European rail supply industry in relation to the digital technologies that are shaping the future of the rail sector in Europe and worldwide.

The vision outlined in the document focuses on five major areas – Big Data, Cybersecurity, Artificial Intelligence (AI), New Mobility Services and the Digitalisation of the Freight Logistics Chain.

In the paper, UNIFE states that, while the rail sector is sometimes perceived as being conservative, the truth is that rail transport has always been a frontier of technological progress, with the supply industry leading the way. With digitalisation, the pace of change in the sector has moved up a gear. Roles have been transformed and new companies, as well as business models, have emerged – such as Uber and Mobility-as-a-Service (MaaS). New concepts as well as new technologies create new possibilities, shortening the timeline of innovation and shaking-up the entire transport sector.

This has resulted in the deployment of digital and enabling technologies in rail being at an earlier stage when compared with other modes of transport. Therefore, UNIFE believes it is vital for the whole sector to maintain its commitment to making digitalisation, not merely an objective in itself, but rather a means to achieving more ambitious and overriding goals.

TETRA for ETCS in Brazil

Brazil: Rail operator Kazakhstan Temir Zholy (KTZ) has completed the integration of Teltronic's TETRA solution with the ETCS (European Train Control System) delivered by Bombardier. The system will be used for the Zhetygen-Altynkol line signalling application.

Teltronic Transport Business Development director Felipe Sanjuán said: "TETRA is spectrally more efficient, has a greater range of functions, and is significantly cheaper than GSM-R." In January, Teltronic secured a contract from Trensurb to replace the communications system on the Porto Alegre Metro network in Brazil.

Last year, Indonesia's PT Len Industri and Teltronic signed a memorandum of understanding (MoU) to co-develop rail signalling systems. Under the collaboration, the companies will explore joint development of an interface by integrating LEN's ETCS and CBTC signalling platform and Teltronic's TETRA and/or LTE telecommunication system.

Advancing autonomy in transport

UK/Global: Society stands to gain significantly from the introduction of autonomous transport systems, which will bring about numerous benefits in areas such as safety, flexibility, independence, economic value and sustainability. However, there are a number of challenges that have to be overcome, and opportunities grasped, before society is able to reap these benefits.

The Institution of Engineering and Technology (IET) recently brought together experts from academia, government and across the transport industry – equally divided between road, rail, air and maritime – for a workshop to discuss the potential benefits of the transport sectors working closely on matters relating to autonomy. They also explored the challenges that can be tackled through cross-sector collaboration and the opportunities that inter-modal working can present. The report is available from the IET, irse.info/whaco.

The end for ticket barriers?

Europe: Hitachi Rail is developing and trialling new technology which could replace the need for ticket barriers. The prototype technology would use sensors on trains to detect an app on passengers' smartphones as they board. There would be no need to remove phones from pockets or bags and no need for station barriers, signalling an end to queues at the barrier or ticket machine.

Passengers will be automatically charged the correct fare, and smart ticketing technology has already proven that correct fares will be collected to ensure the passenger will not be overcharged. The technology will now undergo a rigorous testing programme for Trenito Transporti in Trento, Italy, with Hitachi hoping to bring it to the UK for use on buses, trams and trains.

Relationship-based big data analysis and artificial intelligence

Switzerland: Teralytics which uses mobile phone data to obtain information on travel demand has raised US$17.5m (£14m, €16m) in a funding round with participants including Deutsche Bahn's technology investment fund DB Digital Ventures.

With 56 employees and activities in ten countries. Teralytics use aggregated and anonymised mobile data, to see how travellers are moving and what means of transport they use.

Potential railway applications are foreseen by Deutsche Bahn include that if a train stops in front of a fallen tree today, it is not known how many passengers are sitting in it, and what their destinations are. In the future, the use of 'relationship-based big data analysis in conjunction with artificial intelligence could enable the operator to make targeted decisions to tailor schedules or replacement services to match customers' needs.

Vortex IOT launch innovative Rail Sensor System

UK: Internet of Things (IoT) company, Vortex IOT, have launched its Rail Optical Detection of Intrusions and Obstructions (RODIO) solution.

On 9-10 September Vortex IOT, which specialises in creating innovative artificial intelligence (AI) launched their RODIO system. The technology has been designed to automatically and remotely detect and categorise track obstructions and intrusions such as fallen trees, landslides, trespassers, vehicles and maintenance workers.

Funded by Innovate UK, the RODIO solution has taken 18 months to develop from concept to its imminent launch and has been tested the Network Rail RIDC Tuxford (Rail Innovation & Development Centre) facility in Tuxford, Nottinghamshire.

The device is designed to allow the industry to detect any obstacles that may interfere with train journeys in real-time and deal with them in a timely manner. The system also includes an early alert system for theft, trespass and intrusions and offers high precision even in low-visibility and dark conditions.

UK A level science results for girls

UK: WISE, the campaign for gender balance in science, technology, engineering and maths (STEM) has released its analysis of this year's A level results, which show 1,930 more core STEM* A Levels have been awarded to girls in 2019 than in 2018, while the number awarded to boys has dropped by a similar amount (1,792). Girls achieved 130,121 core STEM A Levels in 2019 compared to boys who achieved 169,638.

This year more science A Levels were awarded to girls than boys for the first time and in physics and computing, the percentages of girls who were awarded A* and A grades were higher than the percentages of boys. This is despite reforms to the way in which A levels were tested which, as anticipated, led to a drop in the percentage of students awarded A* and A grades.

More girls got a biology and chemistry A Level compared to last year, with a more modest rise in the numbers of girls being awarded Physics A Level. There was also an increase in girls studying Computer Science, but at just over 250, the number is less than half the increase in boys taking the subject.

Innovation in security surveillance analytics and automated tunnel inspection

UK: Two new Small Business Research Initiative (SBRI) competitions have been announced by Network Rail to drive efficiency and safety in the rail industry.

Working with Innovate UK, part of UK Research and Innovation, up to £3m (€3.4m, $3.75m) will be invested to address two of the objectives identified in Network Rail's funding strategy for research and development .

The competition intends to find out whether security surveillance systems and associated analytics can work in a station environment without disrupting the rail network and will be delivered through two phases. Phase one – up to £960k for development and demonstration of the capability of systems using pre-recorded CCTV feeds, with phase two – up to £500k to support the development and demonstration of new security surveillance analytics for railway stations in a live environment.

Up to £1.5m is also available to support the development and demonstration of new capability in automated tunnel examination. The aim is to improve the accuracy, efficiency and safety of tunnel examinations resulting in a safer and more reliable operational railway, reducing the time taken to complete examinations through improved automation and increased repeatability and reproducibility of data.

UK rail universities to benefit from Network Rail funding

UK: The UK Rail Research and Innovation Network (UKRRIN) is set to receive millions of pounds in investment from Network Rail to boost UK rail research and development. The Network Rail Research Framework agreement will see contracts signed with eight UKRRIN universities to focus research on digital systems, rolling stock and infrastructure.

The funding will be spread across Birmingham, Huddersfield, Southampton, Newcastle, Loughborough, Nottingham, Sheffield and Heriot Watt Universities. The universities are already working in partnership with industry undertaking research and development work and innovation projects that are seeing new products and services being developed and brought to market.

With thanks and acknowledgements to the following news sources: Railway Gazette International, Rail Media, Metro Report International, International Railway Journal, Global Rail Review, SmartRail, Shift2Rail, Railway-Technology and TelecomTV News.

News from the IRSE: Meet the HQ team

Blane Judd, chief executive

If you've ever wondered who the team of people are at IRSE HQ you can find the answers here!

Many members think that there's an army of staff working away at Birdcage Walk to keep the Institution running so efficiently. In fact, the team is relatively small. Just five full-time staff, supported by four part-time and four self-employed external specialists.

Please treat the HQ team with same courtesy as you would expect to receive yourself.

Hilary Cohen

Executive assistant to Blane Judd

Time at HQ: eleven years

Your role at IRSE: I've worked for three chief executives; Colin Porter, Francis How and now Blane Judd. Mostly this is a job of support for prospective members, members and everyone organising or interested in our events. I answer almost all the phone calls so I'm front-of-house. I manage all events both in-house and international and am the face behind **events@irse.org** uploading all this information onto our website.

The IRSE has recently taken over the helm of the Railway Engineers Forum for a two-year period and I provide secretarial support.

Career to date: In South Africa I was an actress, speech and drama teacher/manager, head of props and wardrobe at the University of the Witwatersrand.

Career highlight: 2012 saw a year of IRSE centenary celebrations including the joint ASPECT/Convention in London with highlights including a river cruise, day trip on Eurostar to Paris, evening reception at the Houses of Parliament and of course the gala dinner at The Savoy.

The best bit about working at HQ: Its global nature – working in London and being in touch with people from all over the world every day. Plus having such amazing colleagues!

Something about me that is little known: one of my earliest memories is of being with my mother and being chased by an elephant – we survived.

Judith Ward

Director of operations

Time at HQ: almost three years

Role at IRSE: I support Blane in his CEO role by handling the day-to-day operations of the office and Institution. I also have responsibility for professional development across the institution – encouraging our members, licence holders and others to develop. This means that no one day is ever the same, varying from reporting progress on the strategy, to helping with calls checking that people don't have complaints against their licences, to taking minutes at Council, to CPD monitoring.

Career to date: I have a BEng(Hons) in Electrical & Electronic Engineering and my career has been spent in mainly main line railways, covering signalling design, project engineering, risk assessments, safety cases, design management and training & development before joining the IRSE as professional development manager.

Career highlight: That's a difficult one. I always get a sense of achievement when a project has been commissioned and handed over to the client, no matter how small a part I played – and an additional sense of achievement when I'm using that line as a "normal customer"! Likewise, there's always a proud moment when I see someone progressing who I have helped in their professional development. The common theme? A job well done!

Best bit about working at HQ: The team (of course), and also it is a massive privilege to work with some our industry's legends and superstars who are in our committees, do other volunteering or just generally provide support and guidance.

Something about me that is little known: My granddad also worked on the railways – he was on the operations side, and even wrote a book about his career!

Polly Whyte

Head of membership and registration

Time at HQ: seven months

Role at IRSE: I manage all membership and professional registration activity, provide support to the Membership & Registration Committee, provide guidance to members and prospective members. I also manage the organisation of the IRSE Professional Exam with the help of Judith.

Your career to date: I joined IRSE from the EngTechNow campaign, a two-year collaborative programme between the Gatsby Foundation, the Engineering Council and the three largest engineering professional bodies in the UK (IET, IMechE and ICE). (See September IRSE News for a more detailed profile of Polly).

Career highlight to date? Organising and delivering a three-day conference and exhibition which included a gala dinner.

Best bit about working at HQ: The people and the location.

Something about me that is little known: I am a keen baker and made my daughter's wedding cake.

Karen Boyd

Deputy licensing registrar

Time at HQ: four years

Role at IRSE: As deputy registrar, my role is to support the registrar with the day-to-day running of the Licensing Scheme. I also work closely with our approved assessing agencies, who carry out the licence assessments. I check licence applications, organise interviews for assessors, manage the annual audit programme, and support the Licensing Committee and its sub-committees.

Career to date: Although I have a degree in medieval history, most of my career has been spent in the public and charity sectors, with a particular focus on education and training.

Career highlight: Helping over 2000 young people into work and training placements in the sports and leisure industry, through the Future Jobs Fund.

Best bit about working at HQ? Having St James's Park just across the road so I can go and feed the ducks!

Something about me that is little known: In my spare time I design and make hats.

Anja Laitinen

Admin assistant

Time at HQ: seven years

Role in IRSE: Input data. Input more data. Occasionally extract data. When required disseminate information.

Career to date: Partly technical – courtesy of BT (British Telecom). Partly numerate – having worked as an analyst in the City of London.

Career highlight: In a previous role I predicted bankruptcy of Enron months before it happened!

Best bit about working at HQ: I enjoy having contact with international members and learning about their cultures.

Something about me that is little known: I grow my own food, albeit rather unsuccessfully as evidenced by my low body mass index.

Caterina Indolenti

Membership and registration assistant

Time at HQ: five years

Role at the IRSE: I mainly work in registration and liaise with registrants but also assist with queries from members, interviewers, Membership Committee and Engineering Council.

Career to date: I have a BA from Milan University and a Post Graduate Certificate in Italian and Linguistics from University College London. I started in membership and later moved on to licensing joining the registration team in 2017.

Career highlight: I came to London in the '90s and worked as a temp. Later I set up my agency CI Language Training and Translations catering for City professionals. I sold my agency and went back to Italy for several years.

Best bit about working at HQ: It's the beating heart of the IRSE.

Something about me that is little known: I have an allotment and love being a peasant at the weekend

Debbie Bailey

Human Resources manager

Time at HQ: seven years

Role at IRSE: All matters to do with staffing – I am in the office a couple of times each month and work remotely to support the team.

Career to date: I am a chartered member of the CIPD (Chartered Institute of Personnel and Development), with more than 30 years' experience in HR management in public and private sector organisations. Since 2002 I have been running my own consultancy supporting small and medium enterprises with outsourced HR services.

Career highlight: I have had so many interesting and amusing highlights – my job has never been dull! One highlight was taking part in the BBC TV documentary "Trouble at the Top" as part of Lord Thurso's leadership team at Champneys Health Resort.

Best bit about working at HQ: The team – great group of people who pull together to get through whatever comes their way!

Something about me that is little known: I studied ballet from the age of four to 18.

Lindsay Jones

Communications manager

Time at HQ: almost a year supporting the team from my office in Somerset. I am in the office once a month.

Your role at the IRSE: I look after all aspects of internal and external communications.

Career to date: I am a trained journalist with over 30 years' experience in PR, 25 of those running my own PR consultancy.

Career highlight: Managing to get Prince Charles to make an official visit to a client's organisation and achieving my master's degree in PR at the age of 45 through distance learning.

Best bit about working at HQ: Working with a great group of people and being able to show the nerdy side of my character!

Something about me that is little known: I have a passion for bridges.

Andrew Smith

Treasurer

Time at HQ: five years

Role at IRSE: With Hannah I'm responsible for all things financial.

Career to date: I'm an engineer, working for BR and Signalling Control UK/Westinghouse Rail Systems/Invensys/Siemens since 1983.

Something about me that is little known: It appears I worked for six companies, but I only moved company once. The company's changed its name several times.

David Weedon

Licensing registrar

Time at HQ: two years

Role at IRSE: Pending appointment of a replacement full time registrar, since August 2017 I have been covering the role on a part time basis, dealing with the range of tasks required to manage and run the Licensing Scheme, ably assisted by Karen Boyd and Roger Button.

Career to date: I started 40 years ago as an engineering sponsored student with British Railways S&T Department. During my first year, my intention of becoming a telecoms engineer was significantly 'enhanced' by a growing fascination with signalling. After completing a degree, and a few years later three years University based railway research, I progressed through the department becoming a signal maintenance engineer prior to privatisation, following which for nine years I was the S&T engineer for Amec Rail. In 2004, I transferred to Network Rail and, with the reincarnation of Thameslink, became the principal signal engineer in 2006, remaining in that position until 2014 when I had the opportunity of early retirement. I have been a member of the IRSE Licensing and Membership Committees for many years and was president of the IRSE in 2013/4.

Career highlight: My year as IRSE president.

Best bit about working at HQ: A dedicated and supportive team and opportunity to maintain contact with colleagues across the industry.

Something about me that is little known: I rarely get rid of anything until there is no use left in it so, when we bought another car last year that was only 15 years old, the average age of our cars fell from 40 to 35 years.

Roger Button

Licensing assistant

Time at HQ: 15 years

Role at IRSE: Mainly the processing of Licence applications.

Career to date: I worked for Nat West Bank for 25 years before being made redundant. Then joined IRSE.

Career highlight: Cashing David Bowie's travellers cheques! I was working in Knightsbridge at the till at the time so famous people popping in was a regular occurrence. I didn't actually recognise him as he was just in everyday clothes but he came to the till and politely asked to cash some travellers' cheques. He gave me his passport (which was in his real name of David Jones) and signed the cheques. I still hadn't twigged until I thumbed through his passport and saw the photo which was virtually Ziggy Stardust without the makeup. I did a double take which he obviously thought was funny and he told me he had changed a bit since the picture!

The best bit about working at HQ: Freedom to manage my workload.

Something about me that is little known: I've been hobbling around on a broken ankle for 20 years.

Hannah Mueller

Finance assistant

Time at HQ: nearly six years

Role at IRSE: Day to day financial administration; making sure that all invoices are sent and paid, updating records, issuing and receiving payments, assisting the team with any financial enquiries.

Career to date: I have worked in the music industry, public sector and for charitable organisations before joining the IRSE

Career highlight: Attending the Queen's garden party in a professional capacity.

Best bit about working at HQ: The people, the flexibility and the fact I am contributing to something that is important to the infrastructure of railways!

Something about me that is little known: I have met Darth Vader! My brother won a competition in the local paper and we went to the premier of Empire Strikes back (showing my age!). He was quite formidable!

Blane Judd

Chief executive

Time at HQ: one year

Role at IRSE: To raise awareness of our Institution and encourage stakeholders to see the importance of professional registration in our shared safety critical environment and everything else that the rest of the team don't want to!

Career to date: I started as an apprentice with National Grid, went to University at 31, became a Chartered Engineer at 35 and an IET Fellow at 47. (See January 2019 IRSE News for an interview with Blane).

Career highlight: Getting a Royal Charter for the Institute of Plumbing and Heating Engineering, being awarded an Honorary Fellowship by the Indian Plumbing Association for my contribution to World health, being a Non-Executive director advising on the refurbishment of the Parliamentary estate.

Best bit about working at HQ: The people, we have a really dedicated team.

Something about me that is little known: I was taught to swim by the famous swimming coach Bill Ludgrove whose daughter Linda swam in the Commonwealth games.

We talk your language!

Between the staff at IRSE London Office we can speak English, Finnish, Italian, French, German, Italian, Afrikaans and Spanish.

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French Section

Technical conference on Formal Methods

Report by Jacques Poré and Hugh Rochford

On 15 February 2018, the IRSE French Section (IRSE-FS) held its seventh technical conference at the Alstom premises in Saint-Ouen (North of Paris).

Over 40 people attended, including the organisers:

- Christian Sevestre, former SNCF signalling director (now retired), IRSE Past President 2014-2015 and IRSE-FS Chairman;
- Jacques Poré, senior technical expert at Alstom Transport and former IRSE President 2005-2006 and IRSE-FS Vice-Chairman; and
- Hugh Rochford, project manager at SNCF Réseau and Secretary of the IRSE-FS.

Four presentations were made during the conference.

Formal Methods Overview

This was presented by Fernando Mejia, Alstom.

A formal method is "a technique for describing and reasoning about computerised systems based on a notation which is graphical or textual, whose syntax is defined by a formal grammar, whose construction has a meaning in a mathematical theory involving a logic allowing formal proofs." Examples include numeric expressions, numeric comparisons, Boolean expressions, the associated theory involving arithmetic and propositional logic.

The foundations of formal methods were briefly reviewed, first by defining the formal modelling languages, then model verification, abstract interpretation (already commonly used in the aeronautical industry e.g. Polyspace) and finally, model checking allowing theorem demonstrations.

Formal methods allow three sorts of activities: formal specifications, formal development and formal verifications. Fernando presented these showing 'simple' diagrams as a support.

The 'V cycle' was explained, focusing on the benefits brought by formal methods that cover all phases except the system validation. The benefits were described as:

- With the formal specification, rigorous, non-ambiguous requirements are considered, providing early verification of adequacy and consistency.
- With the formal development, specification, design and coding of programs are made correct by construction.
- With the formal verification, exhaustive analyses of conventionally developed programs of data are provided, as well as an accurate and meaningful identification of errors.
- Automatic coding leads to a reduction of manual activities, unit tests, safety and consistency verifications.
- Capitalisation of knowledge is of paramount importance, for instance, the reusability of formal models and proofs.

However, limitations with using formal methods were also described. These limitations include:

- No formal method ensures completeness of requirements. There is a risk of forgetting important properties as with any language.
- Formal methods do not conveniently cover all aspects of a system, e.g. real-time constraints, continuous phenomena and degraded modes.
- Formal methods demand mathematical skills (in formal specification and formal development) for modelling and for the interactive proof. Moreover, formal methods require engineers to have a 'special taste' for modelling, i.e. having a certain formal way of thinking and a certain way of working.
- Formal methods are sensitive to execution model complexity (during the formal verification phase). Boolean equation programs are easy to formally verify.

Many companies have now developed significant experience using formal methods, including railway and underground operators such as RATP, SNCF, MTA, SL and Trafikverket. This has been alongside suppliers such as Alstom, Ansaldo-STS, Siemens and Thales, as well as other companies outside the railway sector including Airbus, Amazon, Microsoft, NASA, Clearsy, Prover Technology, Systerel, etc.

A vast range of non-profit institutions are now promoting formal methods, including CEA, CENELEC, the European Union and many universities and learning institutions.

Formal Methods across Alstom Signalling

The second speaker, Fabien Belmonte from Alstom, presented the methods used at his company and focused on two examples of formal verification:

- Data table verification tool.
- Interlocking formal verification.

Concerning the methods used at Alstom, there are two aspects; and the associated messages:

- "Do better the first time": Formal development proves that the implementation satisfies its specification (B-method, for instance).
- "Do as will please you, I will check": Formal verification proves that an implementation satisfies its specification and/or system level safety properties by means of a constraint solving tool.

Fabien continued by presenting categories of proof obligations and their benefits, including the reduction of Verification & Validation (V&V) effort.

At Alstom, formal methods started in the eighties with the proof of Modula 2 software by Hoare Logic. This work was done with RATP for the SACEM ATP on the Paris RER Line A, commissioned in 1989. This was followed by KVB ATP for SNCF, with the on-board development and proof using B language. From 2000, Urbalis metro ATP used formal development (B-method). Recently, U400 introduced the use of system data table formal verification with the Data Table Verification Tool and interlocking formal verification (Model Checking).

U400 System Data Table formal verification was presented. From the customer's input data and using U400 system deployment engineering rules, the designer produced a large set of parameters that were verified with a process adapted to the application Safety Integrity Level (SIL) 4.

Then came the formal method modelling and the use of a solver tool to analyse values exhaustively and demonstrate that no value contradicts the safety rules. This was easier to develop and verify since solvers are available with no specific development. The process and tools (solvers) applied to perform the system data table verification were shown. For this purpose, Alstom worked with specialist experts from Clearsy and with the University of Düsseldorf (Heinrich Heine Universität, Dr M Leuschel).

As a second example, the U400 interlocking formal verification process using a model checking technique was described, with a focus on the identification of the safety properties to check.

Among the lessons learnt, most of them were already pointed out in the first presentation:

- There are limitations: Formal methods do not cover hardware validation nor the functional validation. The environment and safety properties must be submitted to validation. Model Checking is sensitive to application complexity.
- The first development of the formal proof specification requires a significant effort. But once this is done, it can quickly be used on several subsequent applications, e.g. interlockings. It has been shown that 30% of overall software tests are covered and development is not required any more (safety-related tests).

In his conclusion, Fabien recapped Alstom's long experience since the first software validation was made nearly 30 years ago. There is certainly a need for educating experts to formal methods. It is a powerful tool for safety engineers. Formal methods provide exhaustive and unfalsifiable demonstrations. They also improve application acceptance. Formal methods provide automation, easily allowing replay of situations.

30 years of Formal Methods at RATP

David Bonvoisin, head of functional safety at RATP, showed how RATP went from a manual approach for the proof of programs to an instrumented demonstration of railway system safety. His paper showed RATP's experiences with formal methods, including promoting and developing formal methods-based approaches and new developments in this matter with the Paris underground.

There have been three key experiences in the history of formal methods at RATP. The first experience came in the 1980s with SACEM, the first signalling system embedding safety-critical software. After unsafe results were shown during site tests, the RATP team decided to look for new ways of working. Jean-Raymond Abrial's retro-modelling with a "pre-B" method was implemented. Experience has shown that it was a good approach. About ten unsafe scenarios were corrected before revenue service. Subsequently, the decision was taken to further develop and systematise the use of formal methods.

In the 1990s, the METEOR project, which aimed to automate the Line 14 metro to Grade of Automation 4/Unattended Train Operation (GoA4/UTO), introduced the first computerised UTO system. 100% fail-safe software was built using the B language with 150,000 lines of code. The industrialisation of the "Atelier B" was made together with INRETS (now IFFSTAR), SNCF, GEC-Alsthom (now Alstom) and Digilog/Steria (now Clearsy). Zero safety-related bugs were found.

In the 2000s, the key experience was PMI development. This was an RATP interlocking renewal programme with computer-based technology. The two different formal approaches previously experienced, B and Model-Checking, were considered. Eventually, Model-Checking has been chosen (and implemented by Thales). This led to the development of the "Prover Certifier" (PERF) workshop that is now widely used at RATP.

David went on to describe how RATP has promoted and developed formal methods-based approaches. Formal methods are now requested in Calls for Tender at RATP. It is no longer possible to precisely specify the use of the "B" method since RATP is linked with the code for public markets. An opening to alternative ways –with similar results– had to be made. RATP continues to assess the safety demonstration by itself, independently from supplier and quality assurance. Now, accordingly, RATP is accredited ISO 17020 as a type C inspection body.

Since 2010, RATP uses a formal proof approach for its own software safety assessment activities. The RATP cartography of formal methods applications was shown, including interlockings with seven pieces of equipment (PMI) that were formally proven; seven CBTC applications on six metro lines and an ETCS (Radio Block Centre) application where SNCF asked for RATP expert advice on the French East High-Speed Line. The RATP team of experts showed that the software meets the 200 safety requirements that were specified.

The lessons learnt by RATP 30 years of experience using formal methods include:

- Formal methods are very powerful techniques for verification. 100% of safety-critical bugs are found.
- Global verification costs can be reduced by 25%.
- Starting the process means heavy costs but demonstrations are then quick and efficient.
- The process allows for focus to be on addressing the requirements and linking them precisely to needs.
- There are (as the previous speakers pointed out) limitations: It is not an all-in-one solution; Formal proof is applicable on a part of the process; Formal models are built upon assumptions.
- For complex systems, it is still difficult (or impossible) to use.
- Formal methods have come to a nearly-standard way of working. They are taught in universities. Competences now exist. This did not exist 30 years ago.

SNCF Réseau Experience with Formal Proof of the PAI2006 Interlocking

Damien Ledoux and Farès Chucri presented the experience of SNCF Réseau after having implemented PAI2006 electronic interlocking with three different suppliers.

Manual verification was made to check the principles and parametrisation. Then, a feasibility study to prove the equipment was carried out, using RATP-generated tools (PERF, etc.) adapted to SNCF's more complex signalling.

The message here is that to get a proof, a model of the system that will be verified has to be built. This must include precisely all properties that will have to be checked as well as the environment and operation rules. In the case of SNCF as a main line railway, two of the key properties were to avoid any nose-to-nose event and never to risk moving a set of points under a passing train. A short video was shown at this stage of the presentation, summarising SNCF's approach.

Two proof solvers were used. More than 25 interlocking types of three different technologies (suppliers) were demonstrated, ranging from 6 to 900 routes. Lessons were learnt: "Errors will always be found; errors have actually been found; actual tests can be replaced by using proofs."

The SNCF team has also launched a research project together with the University of Bordeaux. The thesis will have a duration of 3-4 years and help the SNCF team to improve its ways of working, bringing together signalling specialist experiences and proof solvers algorithms.

In conclusion, SNCF worked all aspects of the process, involving from the start all members of the team that could be part of the design, test and validation. Using formal methods is an important part of proving equipment, and allows easy replay of any situation, rationalisation of work and provides quick tools to use.

Networking questions and answers

Christian Sevestre thanked all five speakers, noting that "we have today considered and understood a complex matter", before opening the questions & answers session.

Among the questions asked, we have recorded some highlights:

Question from Jean-Pierre Auclair, retired, formerly SNCF Director-Signalling: How do they gain confidence in the system they have to validate from the decider? How can they understand how it works?

Answer from SNCF: It is true that the B language is not accessible to newcomers. On the other hand, formal verification does not need any more mathematical competence, but rather signalling expertise– signalling "métier". The decider has to know how the system works via the Model Checking.

Answer from RATP: I would rather say that there are deciders, rather than a decider. The profession is integrating more and more complex systems, with more and more complex sub-systems. The safety demonstration has subsequently to be made integrating several aspects, each part to be traceable, each able to be shared and proven.

Question from SYSTRA: Are there applications of formal proof on non-fail-safe functions e.g. on Automatic Train Operation (ATO) or Automatic Train Supervision (ATS)? If this is the case, is there also a cost reduction in the process for these functions?

Answer from RATP: Only fail-safe parts have been tested using formal methods so far.

Answer from SNCF: SNCF has tried it with ATS referring to ways of working of test experts, but not looking for proving properties such as invariants.

Question from Christian Sevestre: Have formal methods been used for telecommunications?

Answer from SNCF: Telecoms experts have started to use formal methods to specify.

Answer from UIC: UIC has started to work on formalising exhaustive specifications for the future communication systems that will come after GSM-R.

Question from Philippe Le-Bouar, Head of SNCF Signalling-Technical Direction: Could you tell more about the proof on the host machine?

Answer: To build a proof on the application machine, it is necessary to demonstrate it from the top. The graph motor validation has to be OK, (although it cannot be made through formal proof), once for all, allowing then to validate each specific application (i.e. signalling graph) through formal proof.

After the presentations, Q&A and the usual thanks to the entertaining expert speakers, all attendees met for discussion, questioning and networking around drinks and nice "petits fours" kindly provided by Alstom.

For further information regarding the IRSE French Section, please contact Hugh Rochford at **irsefrenchsection@gmail.com**.

Midland & North Western Section

Network Rail digital deployment

Report by Paul Darlington

IRSE
Institution of Railway Signal Engineers
MIDLAND & NORTH WESTERN SECTION

On 25 September the MNW Section held the first of its 2019-2020 programme events with a talk entitled the "Network Rail digital long-term deployment" by Claire Beranek.

An article to support the talk appeared in the October issue and over 30 members and guests attended on the night to hear Claire confidently and expertly explain the process to deliver a sustainably long term ETCS deployment plan, which now has the support of the rail industry. She explained the affordability and deliverability constraints, and that at current ETCS unit rates the budget constraint required by government could not be met.

The plan provides ETCS roll-out for every interlocking in the country from the start of Control Period 7 (CP7) up to 2055, but aligned with train fitment it requires a significant investment in CP6 to fit a large number of trains. The government's latest thinking is a more measured approach to train fitment, but still based on all trains passing through a site being ETCS fitted prior to the interlocking being renewed with an ETCS solution.

The Rail Delivery Group and Network Rail have therefore commenced looking at three early deployments and to recommend the required train fitments to enable infrastructure renewals in CP7, as well as initiating R&D work to reduce the unit cost for ETCS deployment in subsequent phases.

Minor Railways Section

Day out with a difference

Report by Clive Kessell

It is usual for any IRSE visit to concentrate on signalling practices past and present at a new or historic location and the Minor Railways Section has a number of articles to educate members on how to signal a Heritage Railway. Just for once however, the MRS organised a visit in September 2019 to a railway location where signalling was very much a minor element. This was Fawley Hill, near Henley on Thames in England, described by Country Life magazine as the "Most Bonkers Estate in Britain". Home of the late Sir William McAlpine, the grounds contain a standard gauge railway with the steepest gradient in Britain (1 in 13) and a railway museum that contains so many rail artefacts that it would take many hours to assimilate the full contents.

Sir William had a railway pedigree, his great-grandfather being Sir Robert McAlpine noted for the pioneering use of reinforced concrete in a viaduct on the Scottish West Highland Line and acquiring the nickname of 'Concrete Bob' in the process. Sir William pursued railway interests with a fervent vigour, helped by the inherent family wealth of the construction business, and became famous for his purchase of Flying Scotsman in 1973 when it was left stranded in America, and also the saving of GW 4-6-0 Pendennis Castle, the locomotive that proved so successful in the exchange trials with LNER Pacifics in 1924. He was also instrumental in rescuing the Romney Hythe & Dymchurch Railway when that was in danger of financial collapse.

Behind the media publicity, his work to establish Fawley Hill as a rail centre took many years and is only open to invited visitors on selected days each year. The current rail operation is run entirely by volunteers, their efforts dedicated to Sir William's memory.

The Railway

The centre of attraction is the standard gauge line which starts at a restored station at the top of the hill, descending the fearsome gradient to another platform where the line reverses to run along a section of level track to the final terminating point. The 'train' consists of a locomotive, an open wagon with some seats and handrails and a closed four-wheel carriage with an open verandah somewhat akin to a Great Western Railway (GWR) 'Toad' brake van. It operates in push–pull mode with the engine at the rear of the train when descending the hill and at the front after the reversal, with the return journey being the opposite configuration. The locomotive is at the front on the ascent and needs a full head of steam to tackle the fearsome gradient. Such is the risk of sparks being ejected from the chimney that passengers are given safety glasses. To see a steam loco working so hard will bring back memories to our older readers of the Cromford and High Peak line in Derbyshire that had similar inclines.

The steam locomotive is an 0-6-0 saddle tank dating from 1913, built by Hudswell Clarke & Co and appropriately named Sir William McAlpine. A small diesel shunter is also available whenever the steam loco needs a rest or is under repair. Other items of rolling stock include a Great Eastern Railway private saloon in need of restoration and a variety of wagons.

Fawley Hill train ascent. *Photo Clive Kessell.*

Fawley Hill stations and barriers. *Photo Clive Kessell.*

The signalling is, as hinted, rudimentary. A Midland Railway signal box from Shobnall Maltings near Burton on Trent, which at one time controlled the entry to the multitude of brewery lines that abounded in the town, controls the top station movements. A manually operated barrier level crossing restricts movement of the public when a train is leaving or entering the station and a gate fences off the adjoining field to segregate people from deer and emus. The latter can bite so precautions are needed. On hearing a warning bell, the operatives close the gate and barrier, whence lower quadrant ex GWR signals permit train movements. A similar procedure exists at the bottom of the hill where a signal box controls the points and signals to enable the train to reverse. The signalling, however basic, does nonetheless fulfil a functional role.

The main station came from Somersham on the long closed line from Cambridge to March via St Ives and is lovingly restored complete with booking office, waiting rooms and canopy. On the pedestrian side is a spacious concourse where refreshments are served on public days. To cross the line when the barriers are down is the footbridge from Brading on the Isle of Wight.

Networking Fawley style. *Photo Judith Ward.*

The Museum

The inside collection on the first floor of a garage type building near the main station, has to be seen to be believed. Every possible element of past railway memorabilia can be found. Long forgotten posters and photographs, railway china and cutlery, endless models in many gauges all amount to an amazing collection of artefacts that must have taken decades to collect. Outside, there exists a London Chatham and Dover Railway 'Capital' from Blackfriars Bridge in London, a London and South Western Railway stonework that once adorned Waterloo station and a similar one that was at Broad Street.

Not all on view is associated with railways; a stunning collection of electrical insulators show just how large these were in past times and a roundabout of 'gallopers' is sometimes in operation as a reminder of fairground rides

Those from the IRSE who visited in the hope of seeing traditional signalling correctly and professionally installed would have been disappointed but the sheer scale of what was on offer could not fail to impress. If this report has fascinated you, then there may be the chance of a repeat visit next year. Watch this space.

Younger Members Section

IRSE
Institution of Railway Signal Engineers
YOUNGER MEMBERS SECTION

Young rail tours

Report by Keith Upton

A new collaboration has commenced between the IRSE Younger Members, the IMechE's (Institution of Mechanical Engineers) Railway Division, YRP (Young Rail Professionals), and the IET's (Institution of Engineering Technology) Railway Technical Professional Network, called Young Rail Tours (YRT).

This new collaboration will deliver an ambitious programme of UK, European and international study tours designed to be affordable, accessible and relevant to young professionals working in the UK and global rail industry. From this collaboration, YRT has been established to ensure that younger members can witness, learn from and develop their understanding of successful transportation networks across the world. YRT also believes in forging links between future leaders in the UK rail industry and colleagues around the world; building life-long relationships that will benefit the whole rail industry.

YOUNG RAIL TOURS

Origin

The IMechE RDYM (Railway Division Young Members) has run technical tours for several years. However, an opportunity was developed to share resources between the YRP and the IMechE and deliver more ambitious, collaborative tours for the benefit of both memberships.

What followed was the first joint study tour to the Netherlands in 2018, which included visits to Utrecht and Amsterdam. The event attracted almost 40 delegates and received hugely positive feedback.

A second sold out tour to Germany took place in April 2019, with 46 delegates visiting a construction site for Munich's new metro tunnel (Stammstrecke 2), the Bavarian regional control centre and Siemens Mobility's Allach rail service centre, among others.

The success of and demand for the Netherlands and Germany tours demonstrated to the organisers a demand within the industry for rail study tours catering for, and marketed towards, young professionals. What followed was a meeting between the chairs of the young member divisions of the railway sections of the IMechE and the IET, as well as the IRSE and YRP. Paul Case and Ben Vallely (organisers of original study tours) sat down with Emil Tschepp (IMechE), Keith Upton (IRSE) and Martin Halligan (IET) to go over the concept for a series of rail tours for new and young professionals within the railway. This was to lead to the Young Rail Tours programme.

Plans

The Young Rail Tours team has developed a strategy for the next five years. In September 2019, YRT's inaugural UK tour visited several key sites in Glasgow and Edinburgh.

YRT has arranged the first major international tour in March 2020, taking 25 UK professionals to Japan. This is set to provide a unique and outstanding learning and cultural exchange opportunity for our members and delegates.

The IRSE Younger Members Section believes that this is an exciting collaboration with other institutions. It is a chance to pool resources and work together to achieve more ambitious but also relevant tours that are available for Younger Members from across the institutions in the UK and across the world. The Younger Members Section anticipates that in the future they can work with IRSE sections across the world to support the YRT programme, starting with Japan in 2020.

As well as arranging tours, YRT will host reciprocal tours for young professionals visiting the UK from other countries. Historically, the Young Rail Professionals has informally hosted visitors from France, Germany and the Netherlands. Between July and August this year, 41 delegates from CRRC Corporation in China visited the UK for a month as they toured cities and railway facilities across the UK. The group were made up of young professionals aspiring to leadership roles and are currently enrolled in a leadership course at the International Business School Suzhou in China, which has links to the University of Liverpool. This was a fantastic first opportunity for UK organisations and professionals to network and share ideas with colleagues from China, while showcasing the best of the UK rail industry.

Young Rail Tours is currently advertising its tour to Japan so check out the event page here **irse.info/yrt**. For further information please contact Keith Upton at **younger.members@irse.org**.

Past lives: Robin Mitchell

Robin, right, enjoying his retirement with friends in 2004.

Robin Mitchell FIRSE, a well-known New Zealand IRSE member passed away on 16 August 2019 after a period of illness. Robin joined the IRSE as a Student member in January 1949, making him one of the IRSE's longest serving members with 70 years' membership.

Robin joined British Railways (BR) at Crewe as a Signals Engineering Apprentice early in 1949, following his father (Denys L Mitchell) into the signals engineering profession. After he completed his BR apprenticeship, he undertook a period of National Service in the Royal Navy where he learnt about radar and other advanced engineering subjects. On completion of his National Service he found out there was no position for him in BR, so in 1955 joined Westinghouse Brake and Signal Company (WB&S), in their London offices where he carried out design and project work.

In 1958 he was relocated to Southern Rhodesia (now Zimbabwe) by WB&S as project manager for major Centralised Traffic Control (CTC) signalling installation projects between Umtali (now Mutare) and Salisbury (now Harare) and between Gwelo (now Gweru) and Gatooma (now Kadona) worth about £1M at the time. He was married to his wife Dorothy three days before their departure to Cape Town on the way to Southern Rhodesia, expecting to only be away for 5 to 7 years but as fate had it, they never returned to the UK to live permanently.

In 1962 WB&S decided to relocate Robin to New Zealand (NZ) to more fully represent their interests following the death of their NZ agent, and to work alongside their local subsidiary company McKenzie and Holland Ltd (Mc&H), who supplied WB&S signalling equipment to New Zealand Railways (NZR). Robin got to know the NZR signalling engineering hierarchy and fraternity well and in time Mc&H, through Robin's efforts, began to supply more locally manufactured signalling equipment to NZR.

Robin was involved in the development and production of the NZR impulse track circuit equipment for use in long sections between stations, much of which is still in use today. With a centre fed configuration, impulse track circuits could work successfully over 8-9km of line, providing an economical means of signalling long block sections and minimising the use of insulated joints. Audio Frequency Overlay track circuit equipment for level crossing alarm warning systems to work with the impulse track circuit equipment was also developed and manufactured at the same time.

Robin joined NZR in 1972 in a signals head office project role. In those days the Wellington head office signals senior management team consisted of Bob Kill (chief signals & communications engineer - CS&CE), Brian Nash (signals engineer) and Geoff Willson (signals design engineer).

Robin was well known for his expertise in WB&S remote control telemetry equipment, particularly the electronic F1 and S2 systems. He would often go to site and help field engineering staff set up and commission these systems. The F1 systems were widely used in the 1960s and 1970s for remote control purposes and the field stations, installed between Rolleston and Oamaru in South Island under Robin's watch, are still in service after nearly fifty years in service.

Robin succeeded Geoff Willson as signals design engineer around 1980, reporting to CS&CE, with responsibility for the final approval of all detailed signalling layout drawings and circuit designs, as well as management of the signals head office drawing office.

In the early 1980s when planning for the electrification of the central section of the North Island Main Trunk (NIMT) got underway, the then CS&CE Bill Poysden, tasked Robin with the review of the 25kV AC immune signals specifications and tender documents prepared by the BR Transmark Consultants. During the same period, Robin led the work to introduce NZR's first computer based CTC and S2 telemetry system at Taumarunui on the NIMT, replacing earlier first generation systems that he had worked on whilst at Mc&H, and requiring him to diplomatically work through competing tenders submitted by both WB&S Australia and Westinghouse Signals UK!

NZR went through a signalling infrastructure rationalisation mainly on secondary lines commencing in the 1980's. Robin oversaw the development of the detail circuits for the "budget" Track Warrant Control crossing loop indicator signals with motor points circuits, which were designed to use as much equipment recovered from the NIMT electrification as possible.

After retirement in 1990, Robin settled into a relaxed life with Dorothy in a Plimmerton seafront property, north of Wellington, where he was able to pursue his love of jazz and hiking, as well as watching the spectacular sunsets.

Robin was the longest serving IRSE Australasian Section member with 70 years membership and was made a fellow of the IRSE in 1982. He was also a long serving member of the Institute of Engineering and Technology (having joined up concurrently with the IRSE in 1949) and was also a member of Engineering New Zealand since 1970.

Robin was very much a technical person, preferring this to more management focused roles. He took his technical responsibilities seriously and had wide knowledge and experience in systematic engineering procedures, signalling design and equipment knowledge. Robin will be remembered for his willingness to pass on his knowledge to younger colleagues as well as for his careful and meticulous review of signalling designs.

He is survived by Dorothy, his son Geoff and daughter Linley.

Allan Neilson, with contributions from Owen Clenick, Simon Wood and others

Your letters

Global traffic management

With regards to David Palmer's article in September IRSE News you asked for Traffic Management references in other countries.

The Digital Systems Program (DSP) in Sydney, Australia will introduce a new Traffic Management System (TMS) as one of three cornerstones for a new signalling and control system to boost capacity and service reliability on the Sydney suburban rail network. The other of those cornerstones are cab signalling with ETCS Level 2, removing existing lineside signals and optimising block sections for higher capacity using new axle counters; and optional Automatic Train Operation as presently specified for addition to the ETCS standard.

The idea behind this technical concept for DSP is to benefit from the interoperable multi-supplier platform of ETCS Level 2 while creating a solution which closes the performance gap to the global "gold standard" for metro signalling, CBTC.

This aim for CBTC-like performance is, in my view, an essential hint of what is expected from the new TMS. That is functionality and automation presently found in the CBTC subsystem for Automatic Train Supervision and Automatic Train Regulation. I believe the aspiring vendors of TMS could benefit a lot from internal consultancy within their own organisations, talking to the creators of the ATS/ATR subsystems for CBTC.

And yes, traditional main line railways such as the ones controlled by the TM applications in Cardiff and Romford may have different operational characteristics than a metro railway in a big city. But in cases like Sydney where main line signalling needs to support metro-style performance those differences may be less than one thinks.

I hope my remarks contribute to an informative discussion of this interesting field and would love to see them published in your magazine as you see fit.

With best regards from Australia,

'Doc Frank' Heibel

Re Ruth and 'passive provision'

I loved Ruth's story "It's only passive provision" in the September issue of IRSE News. When reading it my husband came in to see what all the 'chortles' were and was surprised to see it was over an issue of IRSE news. A lot of it was too true for comfort!

Well done Stephen Dapré.

Claire Beranek, UK

Correction

The IRSE article on Ferriby to Gilberdyke resignalling in October issue looks great. However, it states that the "SEI can interface with up to 20 MTOR object controllers managing each 20 objects''. In fact, the SEI can interface with up to 100 MTOR object controllers with each MTOR having 20 vital outputs, 26 vital inputs and 8 non-vital inputs allowing each object controller to interface with multiple signalling assets depending on their I/O requirements.

Martin Beeton, Arup, UK

Ed note – We would like to apologise for this error.

"Your letters" is your opportunity to share information, views or ideas about anything to do with IRSE News or our industry.

Our mantra of "inform, discuss, develop" is particularly important in today's rapidly changing command, control, communications and signalling industry, and we know how much work is being carried out globally.

Why not share your experience and views? Email **editor@irsenews.co.uk**.

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Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at irsenews@irse.org.

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IRSE ///
Institution of Railway Signal Engineers

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Membership changes

Elections

We have great pleasure in welcoming the following members newly elected to the Institution:

Member

Haresh Ashara, Siemens, Australia
John Beesley, SBB, Switzerland
Sung Hyun Choi, Alstom, USA
Jakub Marek, AZD Praha, Czech Republic
Ian Alexander Studd, MECX Group, UK
Reneir Tara, REJA Consult, Malaysia
Chi Wing Wan, Alstom, Hong Kong
Bin Xia, Bombardier NUG Signalling Solutions, China

Associate Member

Sofia Maria Angelara, SNC-Lavalin Atkins, UK
Suravi Biswas, Ministry of Railways, India
James Buckland, Siemens, UK
Nathaniel Colman, SNC-Lavalin Atkins, UK
Hon Man Ip, Alstom, Hong Kong
Ricky McKinley, RT Infrastructure Solutions, UK
Moeketsi Mgqwetho, ERB Technologies, South Africa
Firas Moulki, Ramboll, Denmark
Sowmya Parnasala, WSP, India
Shan Pufek, Downer Group, Australia
Shriram Ramesh, Amey, UK
Andrew Skelton, Linbrooke Services, UK
Yunkin (Robbie) Wu, Public Transport Authority, Australia

Accredited Technician

David Martin, Aecom, UK
Nicholas Smith, Translink Northern Ireland Railways, UK

Promotions

Member to Fellow

Ronnie Bignell, Network Rail, UK
Peter Gracey, Bechtel, UK
Terence McIntyre, Alstom, Hong Kong

Associate Member to Member

Firas Al-Tahan, SNC Lavalin, Canada
Chaitanya Botcha, WSP, India
Simeon Cox, The Office of the National Rail Regulator, Australia
David Hersey, Rail Safety Solutions, UK
Io Chong (Jone) Ho, MTR Railway Operations (Macau), China
Forid Uddin, SNC-Lavalin Atkins, UK

Affiliate to Member

Sean Doherty, Siemens, UK
Stephen Faulkner, Siemens, UK
Manish Kalmady Ravichandra, Kinkisharyo, India
Damian Lech, Metro Trains Melbourne, Australia

Professional registrations

Congratulations to the members listed below who have achieved final stage registration at the following levels:

EngTech

Jamie Barwell, Colas Rail, UK
Kai Smith, Colas Rail, UK

IEng

Philip Ingram, Network Rail, UK

CEng

Boris Gabai, Metro Trains Melbourne, Australia
Helen Whitton, Network Rail, UK

New Affiliate Members

Ozenc Akdag, TCDD YHT Bolge Mudurlugu, Turkey
Ali Allahyari, WSP, Canada
Brett Atherton, Self-employed, UK
Alexander Barnard, Frauscher Sensor Technology, Australia
Jaap Bos, Royal Haskoning DHV, Netherlands
Matthew Collinson, Fraushcer Sensor Technology, Australia
István Darázsi, Irish Rail, Ireland
Albert De Boer, ProRail, Netherlands
Kanchana Devi, GGTronics, India
Adam Faulkner, WSP, UK
Emma Haywood, Arup, UK
Jessica Heeren, ProRail, Netherlands
Mark Henderson, Transport for London, UK
Jodi Hurcombe, Amey, UK
Muhammad Iqbal, Alstom, UK
Igor Janev, Mott MacDonald, Australia
Atif Khan, Innovative Contractor for Advanced Dimensions, Saudi Arabia
Andrew Mac, Frauscher Sensor Technology, Australia
Andrew McCarthy, UK
Kevin Morris, Frauscher Sensor Technology, Australia
Amy Muspratt, John Holland Group, Australia
Pavinthra Natarajan, WSP, India
Aimee Nobleza, DOTr-PRI, Philippines
Simon Pettitt, Sydney Trains, Australia
Alan Phillips, UK
Calum Rankin, SNC-Lavalin Atkins, UK
Aneurin Redman-White, Amey, UK
Wayne Rowe, Self-employed, UK
Sajitha Sovis, WSP, Australia
Phillip Stevens, WSP, Australia
Subhakanta Swain, Alstom, India
Abid Uddin, Vital Human Resources, UK
Stephen Vetter, Self-employed, Canada
Lee Walker, Frauscher Sensor Technology, Australia
Brendan Wessling, Metro Trains Melbourne, Australia

Past lives

It is with great regret that we have to report that the following member has passed away: Robin Mitchell.

Resignations: David Cowen and Douglas Moore.

Current Membership: 4946

IRSE News

Institution of Railway Signal Engineers

December 2019

Denmark resignals
to deliver change

Train detection
back to basics

ASPECT 2019
our first report

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IRSE
Institution of Railway Signal Engineers

Issue 261
December 2019

In this issue

Feature articles

News and opinion

From the IRSE

From our Sections

System integration

They say time flies when you are having fun, and I certainly cannot believe that a year and a half has passed since I took up the position of CEO. There have been a number of changes that have needed some careful management including the IT system and the new website. Although they haven't gone as smoothly as we had hoped the staff have gone above and beyond what we could expect of them to manage the difficulties we faced. I feel honoured to lead such a dedicated team with their commitment to all members.

I have been involved in a number of exciting developments over the last year. These have included trialling a different style of engagement workshop, where we partnered with INCOSE to share best practice in a facilitated workshop. The feedback from those that attended was they wanted to see more of this kind of offering from us and so we are developing plans to use this format going forward.

The need to think differently is important as our sector develops more in the way of digital operations. That is why we are working with new partners to create challenging digital railway workshops. As a sector we are managing and moving an ever-increasing amount of data, so we need to be at the forefront of determining how best it can be used, for operator and users of the rail network.

The term Mobility as a Service (MaaS) is frequently being used and we need to get to grips with what that means and how we can be front and centre of data management and systems integration. This is not just a railway issue but wherever transport modes interface. To ignore these developments risks us becoming bypassed or irrelevant. We know that a significant number of journeys start and end with a transport mode other than rail. Our challenge therefore is to ensure that the industry facilitates easier access to rail so that it becomes part of the blended mix of MaaS, not a disregarded part of the solution.

While we remain focused on the present, with a view to the future, however, we must not forget the past. The heritage aspects of the IRSE are important reminders of the contribution that signalling has made to the repeated success of rail and the development of nations. So, I say let us learn the lessons of yesterday, as we travel through today, on our journey to tomorrow, with a vision to deliver safe and sustainable global railways.

Blane Judd, CEO, IRSE

Cover story

This month's Presidential Paper covers the delivery of the ERTMS programme in Denmark, and the issues involved in delivering change.

Nordjyske Jernbaner operate train services in the north of Jutland in Denmark between Skagen-Skørping and between Hirtshals-Hjørring. Services are operated using a fleet of Desiro and LINT trainsets, and operate partly on infrastructure managed by Banedanmark and partly on NJ's own infrastructure.

Banedanmark is in the midst of a total renovation of the Danish signalling installations on both the suburban and main line network. A modernisation of the traffic management systems is also included and the management of railway operations and maintenance in Denmark will be transformed in the process.

Photo Banedanmark

Delivering change in Denmark: operational readiness of successful ERTMS programmes



Jens Holst Møller, Ross Gammon and Ben van Schijndel

This article is based on the second Presidential Paper of the 2019/2020 year which was presented in Copenhagen on 5 November.

Much attention has been given during recent decades on the technical requirements of the new signalling projects in their diverse stages of roll-out across Europe. Delivering ETCS projects has proved to be complex and challenging. Experience shows that ETCS projects are not only about the technology. Many of the contributory factors to these difficulties can be traced back to the human and business change aspects of implementing new technology.

The capacity of the industry to deliver, the transfer of knowledge from projects to the people operating and maintaining the railway, and ensuring the receiving organisation is ready for the new system, are all challenges with the potential to result in change fatigue. In the context of the political wish to speed up deployment of ETCS, this paper attempts to cover these 'business change' or 'people and processes' aspects with reference to lessons learned on the Danish signalling programme.

Although our employers fully support our efforts to produce this paper, some of the views are those of the authors and others that have contributed to the paper with information, and not those of our employers.

Soft issues, human factors and business change

Many years of experience have been gained and much written about the design of systems considering human factors such as user interface design, workload assessments and automation. For example, within the railway signalling domain the IRSE has regularly followed up on papers such as "Have We Forgotten the Driver" [1] and recently "Human factors and ethical considerations associated with automation" [2]. When introducing ETCS and new traffic management systems, whether it is the intention or not, these new systems quite often come with a whole new operational concept compared to the systems that they replace.

On top of the typical needs to improve safety, capacity, reliability and deliver interoperability, many railways are also wishing to utilise the potentially richer dynamic information available in the new systems with other connected business

systems. Furthermore, the impacted users are more than just the drivers, signallers and signal maintainers. The maintainers from other disciplines are quite often affected, as well as shunters and people in charge of track possessions and track worker protection. With the other connected systems, timetable planners, rolling stock and staff rostering managers are also affected. All of these users and more will probably have to work differently in the future. Perhaps some of these people will be relocated to a different work location, or become redundant?

These derived changes can potentially generate opposition and even resentment towards the new systems. The project introducing the new system will need input from these key stakeholders in order to deliver a workable system. There are many examples within and outside the railway signalling industry that have failed to deliver the expected benefits of a new system or failed to commission the system at all (or on time), because the impact on the users and operational (business) processes have not been considered early or sufficiently enough in the project. By treating the project as a business-driven change (business led), and not just a technology change (system led), the impact on the users, their needs, and the required changes to the business (organisational and procedural) in order to deliver the expected benefits can be captured, and the system and business developed in parallel. Satisfied and happy users, and a system living up to expectations (including those of the travelling public) will hopefully be the result.

Short history of the signalling programme in Denmark

Much has been written and presented about the Danish signalling programme, and it is not the intention of this paper to repeat this information. For more information about the signalling programme, please refer to the "Banedanmark (BDK) Resignalling with ETCS" paper [3]. But in short, the Danish Parliament decided in 2009 to fund the signalling programme to undertake a complete renewal of the signalling systems of the whole national rail network.

In 2010, a contract was let with Nokia Siemens Networks for the rollout of GSM-R voice and data. In 2011, Siemens won the contract to deploy CBTC on the Copenhagen suburban (S-bane) network including onboard fitment. The two main line railway ETCS Level 2 contracts were let in 2012. Alstom was contracted to supply ETCS onboard equipment for the Danish train fleet and also ETCS trackside equipment for the eastern part of Denmark. Thales and Balfour Beatty (now Thales-Strukton) won the ETCS trackside contract for West Denmark.

As the signalling programme was a complete system replacement, a new set of operation rules were produced specifically for ETCS lines, and also a new set for CBTC lines.

Current status of the signalling programme

The first CBTC line (Jægersborg-Hillerød) was commissioned in 2016 with reduced functionality. The remaining functionality was commissioned in two phases. In 2017 the full integration with the local line at Hillerød was commissioned and the Delivery of Remaining Functionality (DORF) occurred in 2018. The second CBTC line (Jægersborg-Svanemøllen and Ryparken-Klampenborg) was commissioned in May 2019 extending the CBTC area to approximately 20% of the S-bane.

With respect to the ETCS onboard fitment, the first major milestone was the approval for the ETCS fitted trains to run on the Danish network utilising the Danish Specific Transmission Module (STM-DK). The first trains were the Class MR test trains, and since then sufficient trains for the services on the two Early Deployment lines (East and West). The fitment of each First of Class (FoC) is ongoing, as well as rolling out to the rest of the Danish fleet prioritised according to the operational needs of the infrastructure being commissioned with ERTMS.

In October 2018, the first ETCS Baseline 3 Level 2 line commenced operation on the Early Deployment Line (EDL West) between Lindholm and Frederikshavn in the west of Denmark. The second line in the west of Denmark from just

Resignalling the entire Danish rail network with its mixture of urban, local, regional, intercity and international services presented a unique set of challenges. Operational readiness was 'baked into' the programme from an early stage to ensure the benefits of the programme could be realised.
Photo Shutterstock/ EORoy.

Onboard testing on a Nordjyske Jernbaner train. *Photo Banedanmark.*

short of Struer to Thisted (originally planned as Rollout R8) is currently under test preparing for commissioning at the beginning of 2020. However, before this, the already commissioned EDL West line is planned to be upgraded to the new baseline DK 2.0 from Thales (the first commissioning was with the DK 1.0 baseline). The release candidate for this upgrade was tested as part of the testing of the second line (R8 West). DK 2.0 includes some generic application updates like improvements to possession management, handling of 'out of gauge' trains, and optimisation of level crossing activations. There are also some changes specific to the EDL and R8 lines.

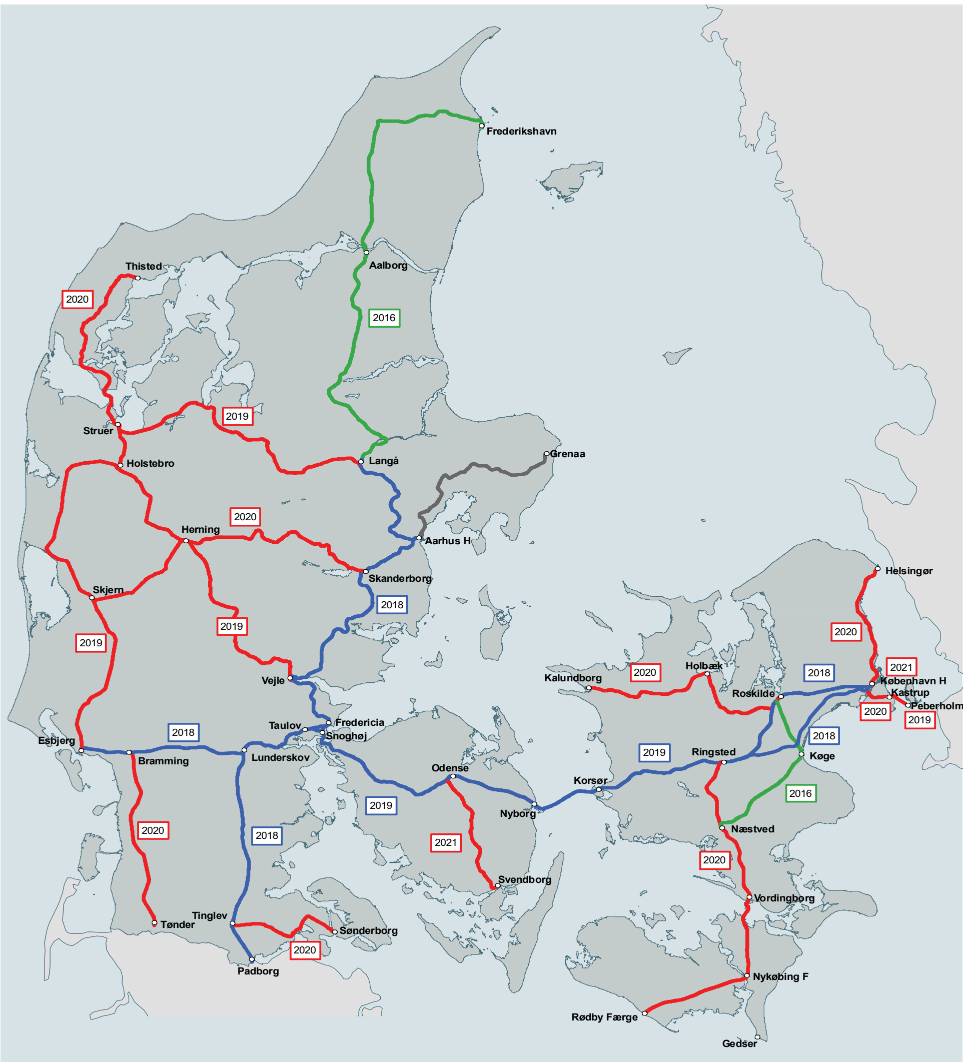
In the east of Denmark, the Early Deployment (North) line from just outside of Roskilde station to Lille Skensved is currently undergoing error correction and operational trials. The current plan is to commission this line at the end of 2019. In addition to this, the new Copenhagen to Ringsted high speed line has been installed with both ETCS trackside and a simplified Danish conventional signalling system. The line was brought into operation in May 2019 with conventional signalling because that there are insufficient trains fitted with ETCS for this new core line. Before this, the ETCS trackside system was tested as far as possible, and the first ETCS fitted train was tested running at the design speed of 250km/h. The current Danish train protection system (ATC) is limited to 180km/h so operation at the higher speed will have to await the commissioning of ETCS. Installation of ETCS trackside is proceeding on the next lines to be rolled out.

Delivering change (human aspect)

It was realised very early on in the signalling programme (during the programme phase 2007-08) that moving to a national ETCS Level 2 network was a complete change of operational philosophy. As there would be no trace of the existing system at the end of the programme, it made no sense to add ETCS rules into the existing rulebook. There would need to be a new set of operational rules and by centralising control into two new control centres using a state-of-the-art traffic management solution, a complete change to operational procedures would be needed. It was recognised that this was a complete change to the operating business of Banedanmark and DSB. Research was carried out into how other railways and other industries go about managing such a significant business change. The Managing Successful Programmes (MSP) framework was identified as containing the best techniques and tools to manage such a large change. The impact on the operational staff and the operational organisation was also recognised. Thus, a new team was set up called Organisational Implementation (OI).

The project teams began developing the concepts for procuring and specifying the technology, and the Signalling Programme (SP) Operational Rules 2020 team (SPOR 20) began working on the new operational concept and the new operational rules. In parallel with this, the OI team began considering the implications for the operational staff. Whilst the centralisation of control, and the delivery of increased automation delivers the benefit of a reduction in control centre staff, the SP studies showed there would actually need to be a recruitment campaign to employ more signallers. The optimum migration strategy from a technical and programme management point of view required a step by step migration, line by line. This means that existing technologies would coexist right up to the end of the programme. Combined with the age profile of the staff experienced in the existing systems, recruiting staff to be trained in only the new system would not be sufficient.

It was necessary to work on retention programmes for senior staff and even recruit people and train them in the existing systems to cover the migration period. The resource studies also identified a need to manage the effects of a decentralised legacy traffic management in the Jutland region. The current traffic management



The signalling programme rollout plan as envisaged in 2012.
Image Banedanmark.

locations in the northern parts (Aarhus and Aalborg) were identified as locations where satellites for the new traffic management system would be built to facilitate the migration to the final state with fully centralised control from Fredericia.

It was also recognised early on that Banedanmark did not possess the spare resources required to deliver such a complex programme. Staff were recruited directly into the signalling programme, and a framework agreement set up with a joint venture consultant team. As word of the Danish signalling programme spread, there was no shortage of people experienced with ETCS and large programmes willing to join the team (e.g. from Switzerland and the Netherlands).

As many experienced people might see the signalling programme as their last big project before retirement, Banedanmark and the joint venture also embarked on a training programme to develop young engineers into the ETCS engineers of the future.

Project collaboration

The first year of the programme was part of the generic design (GD) and called the Concept Design (CD) phase. During this phase, both ETCS trackside suppliers (Alstom and Thales/Strukton) co-located their project staff in the Banedanmark project offices. Each discipline sat together in the same group of desks. The first step was to clarify the customer functional, non-functional and interface requirements to ensure there was a common understanding. Some requirements were adjusted as a result. Then the suppliers could begin the production of their System Requirements Specification.

The aim of this phase was to ensure that whilst both trackside suppliers refined their system concept, that the solutions were as far as possible 'off the shelf' solutions but would not be confusingly different to the users of the system (driver, signallers, shunters etc.). Agreements on the interfaces between east and west, were also required. Several joint design working groups were set up to develop joint design specifications. These topics were key management, hand held terminals, traffic management (e.g. user interface), GPRS, passenger information systems, unified external interfaces (using an enterprise service bus), common time source, event logging, east/west interlocking and RBC interface, training, and management of the ETCS ongoing Baseline 3 specifications.

A common set of engineering rules were jointly developed (e.g. placement of balises, train detection section lengths, marker board positioning). In later phases, both trackside suppliers developed their own engineering rules within the constraints of the common rules.

To ensure alignment of the technical solutions to the new national operational rules which had already been developed to maturity by the SPOR 20 project based on the harmonised European Rules where available, regular Operational Rules Working Group meetings were held to discuss various technical issues and operational scenarios.

In preparation for setting up a Joint Test Lab (JTL), both suppliers and Banedanmark agreed the specifications for the laboratory and Banedanmark located a building with the required space and facilities for the suppliers to install their equipment.

To maximise the collaboration and create a good work environment, all companies participated in providing a social programme of team building events that, in addition to allowing people to get to know each other, included learning relevant techniques for collaboration and preparing everyone for moving into the next phase of the programme over time. Morning singing (a Danish tradition) was used occasionally to put everyone in a good mood for the day ahead!

Naturally, as the programme proceeded into the Preliminary Design (PD) and Final Design (FD) phases, the suppliers began to focus more on delivering their own specifications and design, and the collaboration was less frequent between suppliers. But as testing activities ramped up in the JTL, all companies co-located testing staff there.

Collaboration with the rest of Banedanmark

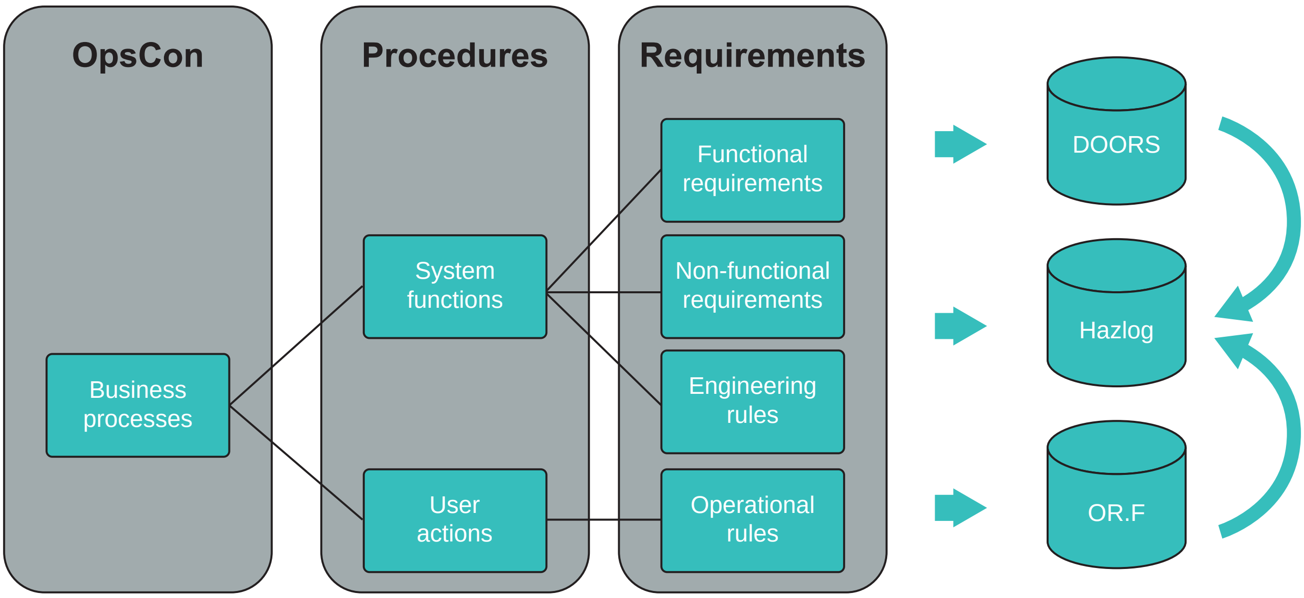
MSP and business change

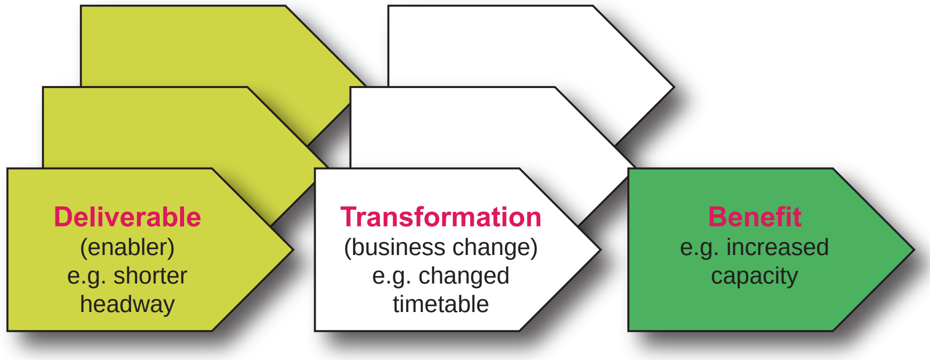
Without going into details here, MSP principles were used to create benefit maps, and a blueprint of the future state of the railway, effectively mapping the vision to the change activities required to realise the imagined benefits. Whilst the technology change was mostly defined by the decision to use ETCS level 2, there was significant software development work required to deliver the step change in the traffic management system to realise the capacity benefits. This included better management of access to the track (possessions using hand-held terminals) and traffic planning with live conflict detection and active re-planning of the production timetable.

It was clear that it was not just drivers, signallers and signal maintainers that would be affected by the change of technology. The maintainers of the track, electrification, structures and IT systems would be affected. Shunters, Persons In Charge of Possessions (PICOPs), dispatchers, timetable planners, passenger information system operators and many others would also be affected. The MSP techniques helped identify all the business changes that would be required for Banedanmark and DSB (the main train operator) in order to receive the new system and successfully operate it in a way that realised the benefits. It was not enough to deliver the new system to provide the capability and train the users. It was necessary to design completely new procedures and migrate to a new business organisation. A set of business change activities were developed, and owners assigned. These activities mostly required ownership by senior and experienced people in the existing organisation. But the signalling programme also needed to take part to help the existing organisation understand the possibilities and capabilities that would be delivered by the new technology.

In the early days of the programme, many 'market days' were held to brief the rest of the Danish rail industry on the changes coming. In addition to helping everyone understand the changes and get excited about the benefits of the new system and the new way of working, it also provided useful intelligence to the programme about problems for people impacted by the new system that would need to be solved (e.g. the interface between track machines and axle counter heads).

Operational concept and functional requirements.





Benefit realisation lay at the heart of the project programme.

Business processes

As part of the tender requirements writing, a Traffic Management System (TMS) concept was also written, documenting the vision for the new way of managing traffic. To assist with the software development process for the suppliers, the programme began describing the new business processes with use cases. As the development work progressed, mock-ups were created, and various users of the existing signalling system were invited to run through the use cases and help design the new business processes. As the suppliers released new versions of their software, Process Verification and Validation (PVV) testing was used to ensure that the new business processes worked with the new system. A significant factor in the success of this work was choosing two experienced and enthusiastic signallers to join the programme and become 'super users'. This not only helped ensure the business processes were realistic and workable, but the two super users kept up their competence by continuing to work occasional shifts in existing signalling system and acted as ambassadors for the signalling programme, informing their colleagues of progress and the changes coming.

Maintenance concept

The procurement strategy for the signalling programme included using Design Build and Maintain (DBM) contracts. So Banedanmark would be moving to a model where the supplier has more responsibility. Although the responsible engineers in Banedanmark (Teknisk Systemansvarlig – TSA – in Danish) are ultimately technically accountable for the new systems, the new contracting model means the maintenance organisation must change their focus to contract management rather than the traditional approach. The previous organisation was based on dividing responsibilities according to disciplines. Whilst Banedanmark and DSB are already experienced with the existing split of onboard and trackside Automatic Train Protection systems (ATC in Danish), the move to communications and IT based systems, and ETCS interoperability potentially introducing more onboard systems from other suppliers and countries, will make working in the existing 'silos' more difficult. A more 'total system view' will probably be required as the rollout of ETCS progresses.

Training

The Training Project was initiated during the tendering phase of the signalling programme, responsible for training approximately 6000 people from a variety of organisations including the train operators in the new technology, operational rules and business processes. The training was designed to be supplementary training on top of the existing competencies. Coming out of the set of change activities produced during benefit mapping, and the training concepts provided by the suppliers, a training needs analysis was produced jointly with the suppliers.

Competence management and training configuration management concepts were produced before going on to the training specification work and acceptance from the National Safety Authority (NSA). Training pilots were conducted, and a 'train the trainer' approach used. This was meticulously planned to minimise the impact of taking staff out of their normal rostered shifts on the legacy systems. Each supplier was also contracted to provide training workstations in the Traffic Control Centres (TCC), including multi-train and trackside simulators, and scenario editors and recording of training exercises. It was necessary for the training workstations and equipment to be separate from the JTL as testing and training would need to be carried out in parallel, and because they served different purposes.

Inserted between the customer system integration tests and the operational rehearsals on site, trial runs were used to validate the training using the real system and real trains.

Rolling out ETCS in Denmark

Planning and flexibility

Rolling out a new signalling technology for the whole country takes good planning and a solid migration strategy. The original strategy for Banedanmark was to start implementation on two lines that had no ATP system fitted and signalling obsolescence issues. Implementation on these lines would immediately bring the benefit of modern signalling with ATP. These lines were also less busy secondary lines, so less likely to impact on the travelling public. As control would be moving into two new TCCs (one in the east and one in the west), the order for the migration of the next lines was chosen to avoid trains continuously

As the rollout started the signs of progress became more apparent.
Left an ETCS marker board temporarily mounted on an existing signal at Havdrup.
Right a new satellite technical object building from Alstom awaiting commissioning at Tureby.
Photos Ross Gammon.

switching between the existing and new control centres. Avoiding forcing the drivers to transition in and out of ETCS frequently was also a factor. In addition to this, after proving the technology on the two early deployment lines, maximising the delivery of capacity benefits where needed and also meeting Denmark's interoperability obligations to the EU meant the main lines were next in the rollout plan.

However, flexibility is required in any complex programme. Naturally, delays began occurring to both the trackside and onboard fitment projects. In parallel, other infrastructure projects like an electrification programme, and speed upgrades were initiated. The signalling programme began to have an impact on these other projects. Re-planning the order of the rollouts has been required as many of these projects needed access to the same tracks as the signalling programme, and particularly on the main lines. The rollout plan for the signalling programme has now been aligned with these other projects which has resulted in the main lines switching to ETCS much later in the programme. This had the added benefit of giving the onboard team more time to retro-fit the inter-city fleet which had turned out to be the most difficult and to ease the impact on the international freight locomotive fitments which are funded separately.

Project processes

For the ETCS trackside projects, the implementation strategies have generally involved the suppliers carrying out subsystem testing in their own factories, and then moving on to system integration tests. Banedanmark have had an opportunity to witness these tests, but generally elected to review the test reports instead and avoid the travel. A Factory Acceptance Test (FAT) was carried out for the first in class of all parts of the system which was the opportunity for Banedanmark to witness the supplier tests or a sub-set of them, and to accept that the sub-system was shipped to site for installation. This was also the case for the system software, before it could be installed in the Joint Test Lab (JTL) in Denmark. If the test revealed significant defects or issues, the FAT was repeated at a later date, or repeated on subsequent manufactured articles until the process was deemed to be under control. The JTL was used by the suppliers to test external interfaces against more realistic representations of the external systems. Banedanmark provided real systems to test against where possible or provided simulators. Banedanmark also had the opportunity to conduct their own testing in the JTL when it was free, using manuals from the supplier and support from testing staff where required.

For the onboard fitment project, the focus was to fit the 'first in class' trains with ETCS onboard equipment, and have the trains approved for operation on existing lines with the Danish STM. The STM is provided by Siemens, and the ETCS onboard by Alstom. Integration tests were conducted in the factory before the fitment programme commenced.

Once an installation readiness review was completed, ETCS marker boards and balises could be installed in the track with the balises initially muted. Virtual balise covers were used to hide the transition balises and prevent operational trains fitted with ETCS from transitioning into ETCS. Axle counters could also be installed without affecting the existing track circuits. The supplier conducted Post Installation Checkouts (PICOs) and Site Integration Testing (SIT). For level crossings and point machines that could not be temporarily taken out of service (which was most of them on the early deployment lines), changeover systems were implemented to allow the objects to be switched between the existing interlockings and level crossing control systems and the new ones.

The plan was then to begin testing the new system with the changeover system in 'night' mode. This was called night mode testing but was also to be conducted at weekends where possible. Static tests were conducted first, with the trains at standstill. Due to challenges in commissioning the changeover systems in the east project, which proved to be more complicated than expected when connecting to existing systems, the decision was made to initiate shadow mode testing. This allowed testing of the new system to proceed whilst trains were protected by the existing signalling system. This required manual synchronisation of route setting (as far as possible), and for a second driver to be present to ensure that restrictive aspects in the existing signalling system were not accidentally ignored.

In comparison to the east project where a comprehensive Change Over System (COS) was used, the west project chose to minimise the use of a COS due to the cost and complexity. The COS was contained in a hut which could manage four sets of points. Where possible, level crossings were closed for several days, and points taken out of use. Most of the point conversions were carried out during the commissioning of the line, which was broken down into small sections with manual transitions. This commissioning approach required extensive consultation with the road authorities and the train and infrastructure operations departments.

Supplier testing culminated in a Site Acceptance Test (SAT) where a subset of already conducted tests were repeated formally for Banedanmark to accept the system. The system was then handed over to Banedanmark to conduct a customer system integration test, and then move on to the trial runs already mentioned. This final stage before commissioning was to conduct an operational rehearsal to prove that the users were ready to use the system (including managing failures and incidents), and that the required train service could be operated.

Commissioning and post-commissioning

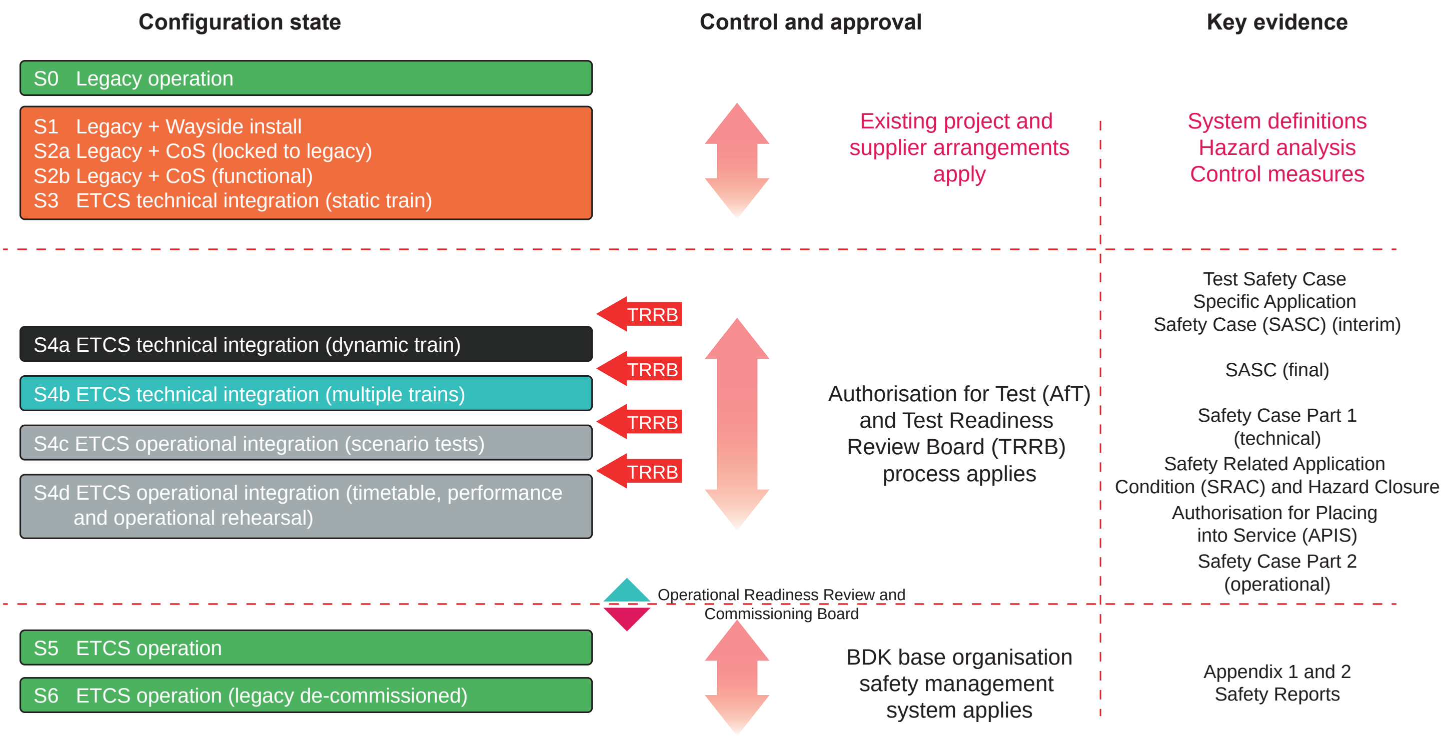
In the lead up to the commissioning the Commissioning Board (CB) was established. The CB was made up of project representatives from the suppliers and the Banedanmark Programme organisation, and all relevant stakeholders in the operations and maintenance departments, including the train operating companies.

The CB met regularly to run through the commissioning checklist which included reviewing the status of training, system documentation, approvals and Safety Related Application Conditions (SRACs), open defects, and any special instructions required for operations. As it is almost impossible to have such a complex system working 100% as intended the first time, temporary workarounds need to be agreed in order to commission the system. It was the job of the CB to ensure that whatever was available was ready for commissioning, taking into account the user workloads for implementing workarounds and manual processes, and ensuring the system was operable and safe.

One of the items on the checklist was a successful Maintenance Demonstration Test (MDT). It is important to involve maintainers during the design of the system. For example, input from the maintainers can ensure that the system is maintainable, and the diagnostic system is still available, even if the signalling system has failed. The MDT was the final check that the system could be successfully maintained.

After the commissioning, the signalling programme continued to support the commissioned ETCS system through the 'hypercare' phase. This lasted for several weeks as agreed before the commissioning. The suppliers and project staff provided round-the-clock support, both on site and remotely. This support was reviewed every few days by the Hypercare Board and the support level reduced as agreed by the board over time. This support was not just to help fix infant mortality failures, but also to advise the users of the correct use of the system in whatever scenarios developed.

Banedanmark railway system states and approvals during the project.



Class MR ETCS test train leaving Roskilde station, March 2017, for a test run during shadow mode testing.
Photo Ross Gammon.

Configuration management

During the design and implementation of the system, the configuration state of the system must be managed carefully. The trackside ETCS suppliers had their own configuration management systems, and this was also the case for the onboard supplier. The suppliers also need to track which versions have been released in different countries and have a roadmap for updates to the generic product in different markets. Knowing which functionalities are tested and ready (including any known defects) and in which versions of software and hardware configurations (e.g. site-specific application at a particular site), and which release is very important. Keeping track of the configuration in the JTL was also necessary, and this included the Fixed Transmission Network (FTN), and simulators provided by Banedanmark. There is the hardware configuration (e.g. wiring and DIP switches), the embedded software, the specific application configuration data, documentation (user manuals), and the test scripts. There is also the current configuration, and then there are the release plans for future updates which continually change as testing progresses. As soon as the system is commissioned the Banedanmark and DSB operating and maintenance organisations became responsible for their part of the system. Everything from the trackside project needed to be transferred into the Banedanmark Safety Management System. But as discussed at the start of the paper, the West project will soon return to the EDL to commission the latest baseline release.

The configuration management task for the life of the system should not be underestimated, and the existing system may need some work to cater for the structure of various supplier products and documentation and software formats.

Lessons learnt and advice for other ETCS programmes

Business change and MSP

Projects fail for many reasons as described in the ITC article "Why do signalling projects fail?" [4]. There are many frameworks that can help guide project delivery, e.g. PMI, PRINCE2. But what matters the most is ensuring the user, business process and organisational elements of a given change of system are managed as well as the technical elements. For projects with significant technological change such as ERTMS and traffic management system projects, the Management of Successful Programmes (MSP) is a very useful concept and offers various tools and methods appropriate for ensuring the end users of the system and the operational business are ready to receive the new system and operate it in a way that delivers the expected benefits of the upgrade.

Collaboration

The temporary organisation set up to deliver a project (the project team including the client and suppliers) generally have the best knowledge of how to deliver a project and understand the capabilities of the new system. They naturally have a more limited experience of what is required to operate a train service, and the needs of the users. Delivering a project to the required quality, budget, and timescales leaves little spare time to try and understand the needs of the users.

The operating and maintenance organisations have the best understanding of how to keep the train service running as efficiently as possible, including during planned and unplanned reductions in functioning of the system. In the case of projects delivering a significantly new or unfamiliar technology, keeping the existing system running safely and optimally leaves little time to understand how the new system works, and the impact on the project of injecting new requests for change.

Dedicating time and resources from both organisations through the life of the project (especially in the early phases), to collaborate on finding the optimum technical solution and the most efficient new business processes, will increase the chances of success. Experience has shown in the Danish signalling programme that embedding experienced operators with forwarding thinking attitudes into the project can have a significant impact. These experienced operators (super-users) can help guide both the project activities and the business change activities. Also, the tighter the project assurance activities are interconnected with the operations and maintenance organisations, the better. This collaboration effort will change over the course of the project and both the temporary and business organisations will probably need to be adapted several times.

Resistance to change

Major changes will normally create resistance among some employees. Dedicated and proactive management, with strong leadership, is required to effectively manage the changes and business readiness process to enable a smooth handover into operation. Involving the various users and stakeholders in the project will help generate confidence in the new technology as these users report back to their operating colleagues as a type of ambassador.

Involving these same users in the development of the new business processes and organisational structure in a pragmatic and mostly transparent way can help reduce suspicion about the future. Having a clear link between the benefits of the new system and the changes in technology and business processes that deliver them will also help generate buy in to the project. In this way the users can see that the new system will probably make their job easier in the long run, or at the very least have a better understanding about the reasons for the change.

It is very important to address the fear of being made redundant that some staff may feel when a new system is being introduced. In addition to good communication to relax these staff and get their input, a retention policy might be required to encourage staff to stay for the long haul.

Training and approvals

Carrying out the project design and implementation, training and approvals sequentially is not efficient in terms of timescales and is just not possible due to the interdependencies between them. Managing system documentation and training material in iterations (baselines) using configuration management techniques is necessary to allow everything to proceed in parallel and allow the status and maturity of all workstreams to be monitored. Being able to easily identify the changes between different baselines is important for all parties to keep in step with the other workstreams.

Whilst it is tempting to discard the old in favour of the new, and this is of course one of the many potential benefits of a new system, for the benefit of the users and the approvers of the system (including safety approval), building on top of existing system documentation and processes where relevant will de-risk the project.

The complete training time schedule is always difficult to estimate until the technical solution is mature and the changes to the business processes and operational and maintenance organisations are also mature. Delays to project delivery also affect the timing of training delivery, which also has an impact on staff rostering. Having a flexible training plan and modular training material which incorporates efficient refresher-training activities is advisable.

'Action-oriented' training rather than 'learn by heart' has proved to be the most efficient training method, although a mix of training formats can be utilised to fit with the available learning environments. Using 'train the trainer' is valuable as it helps avoiding bottlenecks in trainer capacity. The closer the training set up is to the operational reality, the more effective the training will be.

Learning curve

One of the benefits of a large change programme compared to separate smaller projects is the learning curve effect. As the staff move from their work on one line to the next line, lessons learnt are brought forward and improvements to project processes implemented. Using MSP techniques ,for example utilising a Programme Management Organisation (PMO) and Engineering Management Organisation (EMO), also helps to ensure strong governance of the projects, and a transferring of knowledge between projects. For example, although CBTC and ERTMS are sufficiently different systems for some staff to be more expert in one system than the other, many project processes are common. Lessons learnt (good and bad) from the commissioning of the first CBTC line were fed back into the commissioning plan for the first ERTMS line.

New and old signalling at Home Olstrup.
Photo Ross Gammon.

Transitioning to business as usual

It is important to agree the format and content of deliverables required by the maintenance organisation as early as possible. Suitable time should be allowed for this, as it will take time for the maintenance representatives to understand how the new system works and the potential new maintenance processes. Involving these maintenance representatives in design reviews, installation audits and testing activities (in the laboratory and in the field) will help develop this understanding over time and avoid unnecessary work based on the requirements of the previous system.

As discussed earlier, the same goes for other operational staff (e.g. signallers and PICOPs). Involving these staff in process production, mock-ups, testing, and operational trials is very important. There is a need to instigate checklists and regular gate reviews to check that all required drawings, documentation, testing and approval certificates are available, and all staff are competent and have the required information and tools to manage the system after handover.

With a new system that requires significant changes in operating and maintenance/fault finding procedures, it is imperative to include operational trials that prove the users are able to follow the necessary procedures, during the testing and commissioning process. Post commissioning, it is important to plan for project and supplier experts to support the system operation for a significant length of time. It takes time for all staff to learn the new way of working in real operation, and to take the correct action after failure or incidents.

Delivering benefits over time, and prioritising

There are very few projects that can claim to have delivered the full scope on time and to budget. Despite best efforts to use standard products with standard functionality, most ETCS and TMS projects contain a significant amount of product and software development. As a minimum there is always some adaptation of previously approved systems on a new line, including dealing with some unique feature that has not been used before (e.g. a different type of level crossing, or a new track topology). Minimising the degree of difficulty for each commissioning by only implementing the 'absolutely necessary' functionality for a normal train service can de-risk project delivery at the expense of an increased project timescale.

Sometimes it might also be necessary to de-scope the project to keep within time and budget. Having a clear link between the expected benefits, and the technology change deliveries and functions can help in making pragmatic decisions about deferring the delivery of parts of the new system as and when required, so that the business can understand the implications of the timing of the delivery of benefits (e.g. delaying capacity improvements and the impact on the operational timetable). Prioritising the benefits against each other in the early phases of the project can also help when it comes to decisions regarding descoping the project (e.g. delivering capacity might be more important on a particular line than moving to more efficient possession implementation processes).

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Institution of Railway Signal Engineers

Achieving net-zero

David Shirres

Image Shutterstock/Drawii

This article first appeared in Issue 177 of Rail Engineer, Aug/Sep 2019 and is reproduced with the kind permission of Rail Media. At the end of the article, David Fenner adds to the debate by discussing how command, control and signalling engineering can contribute to achieving net-zero.

The 2008 Climate Change Act was the first in the world to make a government legally accountable for delivering its greenhouse gas (GHG) emissions target, which was at least 80% lower than the 1990 baseline. The Act is the basis for the UK's approach to tackling and responding to climate change. It requires five-yearly carbon budgets to be set and established the Committee on Climate Change (CCC) to provide independent, expert, evidence-based advice.

"By 2017 the UK was over half-way to meeting its 2050 target"

By 2017, the UK was over half-way to meeting its 2050 target with GHG emissions 43% below those of 1990. However, this was not good enough as it was largely achieved through the relatively easy measures of burning gas instead of coal and using more renewables to generate electricity. Furthermore, it was becoming increasingly clear the 80% reduction target was not enough.

"80% reduction target was not enough"

In May 2019, the CCC published its report 'Net Zero: The UK's contribution to stopping global warming'. This reviewed the latest scientific evidence on climate change and concluded that the UK should adopt a target of net-zero GHG emissions by 2050 which, if replicated across the world, would deliver a greater than 50% chance of limiting the global average temperature increase to 1.5°C.

The report considered this target was achievable as the technologies and approaches to achieve net-zero are understood. However, it was also considered to be hugely demanding and only achievable if there is urgent government action to drive the significant and urgent policy changes required.

In June 2019, the CCC's net zero 2050 target became legally binding as the Climate Change Act was amended to adopt it.

Achieving net zero will affect everyone in Britain and require some lifestyle changes. Yet, whilst some might believe that reducing emissions requires an economic slow-down, the good news is that it need not make the UK poorer. The CCC report explains the technologies needed to both reduce emissions and maintain economic growth as well as the policies that the government must adopt if these technologies are to be deployed.

The technical report that supports the CCC's recommendation is available online and is a daunting 304 pages. For this reason, we thought our readers might appreciate a summary, especially as this report provides the context for rail decarbonisation, irse.info/3ea57.

Electrify everything

As fossil fuels have a high energy density and can be readily stored and transported in fuel tanks, tankers and pipelines, it is not surprising the modern world is utterly dependant on them. However, if net zero is to be achieved, we must be weaned off them. To do this, the CCC report stresses the need for extensive electrification, particularly in respect of transport and heating.

Some modes of transport can create far more carbon dioxide emissions than others. *Photo David Shirres.*

"Electric cars are increasingly practicable"

"By 2050 there are unlikely to be any commercially available zero-carbon planes"

The obvious reason for this is that electricity can also readily transport huge amounts of energy, albeit only to fixed locations. An exception to this is electric trains, which are thus the only form of high-speed and mass transport that offers potentially zero emissions. No doubt for this reason, the report recommends a rolling programme of railway electrification, otherwise rail transport is hardly mentioned except for the need for modal shift from road and air to rail. Yet any significant modal shift would require a large increase in rail capacity, such as that HS2 (the UK's planned new high-speed line) will provide.

The CCC report considers that the electrification of road transport (19% of the UK's GHG emission) will be by battery and hydrogen-powered vehicles. Advances in battery technology and the provision of the required charging infrastructure will make electric cars increasingly practicable, so that no more petrol or diesel vehicles should be sold after 2030. However, the report points out that the solution for HGVs is not clear and is likely to be a combination of hydrogen and battery technology, such as extremely fast chargers at motorway service stations. It also moots the use of a motorway pantograph system to continuously charge HGVs.

Electrical industrial and domestic heating is also essential to reduce fossil fuel consumption. The report notes that there is an urgent need to engage with the public on a strategy to move away from gas heating as GHG emissions from buildings accounts for 17% of UK emissions. It envisages that electricity should be used to power heat pumps to heat buildings as this would produce three units of heat for one unit of electricity. There is also the potential to use hydrogen in the existing gas distribution system to heat buildings.

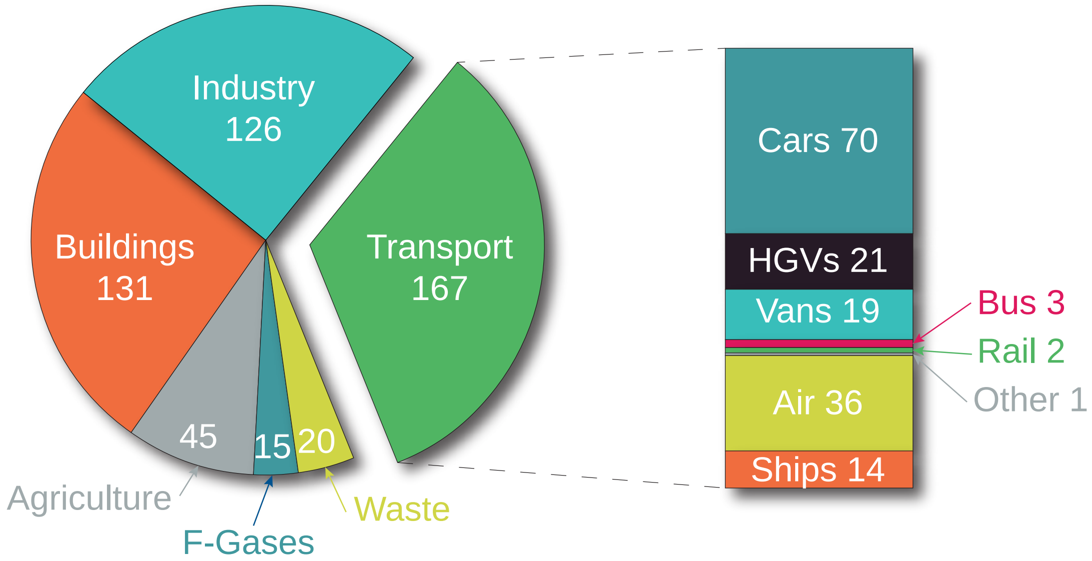
By 2050, the UK will require a low-carbon electricity generating capacity of 150GW to generate a total of 645TWh to satisfy this extensive electrification. This compares with today's 104GW which produces 300TWh. The CCC envisage a vast increase in solar, off-shore and on-shore wind generation. However, its scenarios take a cautious approach, limiting the share of variable renewables to under 60% as these are not suitable for base load and peak power which needs to be supplied by nuclear power and gas turbine plants with carbon capture and storage (CCS).

Aviation and shipping

Aviation and shipping accounts for 10% of UK GHG emissions and, unfortunately, cannot be electrified except perhaps for short distance domestic shipping. Aviation makes up 7% of the UK total, of which 96% is international flights from which emissions have increased from 15 to 35MtCO_2e (Metric tons of carbon dioxide equivalent) between 1990 and 2017.

By 2050, there are unlikely to be any commercially available zero-carbon planes. Measures to manage aviation emissions will therefore include more efficient engines and airframes, improved airspace management, the use of sustainable alternative fuels and measures to reduce growth in demand. While biofuels could be a substitute for aviation fuel, this might not be the best use of this scarce resource for which there are alternative uses that may save more emissions. Synthetic carbon-neutral fuels are another alternative, although it is likely their costs will be very high.

There are a range of options to reduce shipping emissions, some of which may allow shipping to get to near-zero emissions. These include more efficient hull and engine designs, improved operations and the use of alternative fuels such as ammonia and hydrogen.



Total 2017 UK greenhouse gas emissions – 503m tonnes of CO_2e.

CCS and BECCS

One key technology that has yet to be developed is Carbon Capture and Storage. In contrast, the production of biofuels is a well-developed technology and accounts for 3% of road fuels. However, there is a finite limit to its production, given land constraints and the requirement for food production, and growing biomass requires a significant carbon input. Therefore, the production of bio energy with CCS (BECCS) is required if biofuels are to contribute to the net-zero target.

CCS can capture and store up to 90% of the GHG emissions associated with fossil fuel power generation and industrial processes. The UK's first carbon storage facility is expected to be operational by the mid-2020s. This will capture 200 000 tonnes of CO_2 from a gas terminal near Peterhead and use the existing pipelines to store it in a depleted gas field.

“Exhausted oil and gas lines present significant storage opportunities”

By 2050, the CCC expect the annual UK storage requirement to be about a thousand times this amount (i.e. 176 million tonnes of CO_2). Storage potential is not considered to be a constraint for the UK, which has sufficient geological capacity to store CO_2 at this rate for 500 years. Exhausted oil and gas fields and their pipeline infrastructure present significant CCS opportunities.

The net-zero report also envisages that hydrogen should be produced by methane reforming with CCS for the resultant CO_2 emissions. Hydrogen needs to be produced in this way as if it was all produced by electrolysis. This would increase annual electricity production by 400TWh (more than 50% of the projected 2050 demand). It predicts that, by 2050, UK hydrogen use will be the annual equivalent of 270TWh (compared with 27TWh in 2017).

Most of this hydrogen is required for heating, both to satisfy industry's requirement for high temperature gas heating and to be used in existing domestic gas distribution networks. Buses and trains would require respectively 3TWh and 0.3TWh, a small fraction of total hydrogen production. Unlike heating, the hydrogen used in fuel cells must be of a very high purity and so is better produced by electrolysis. This would be a more appropriate option where train depots may be some distance from a large steam reforming plant but could be close to a wind farm and use otherwise unwanted energy during the night, for example.

Land and lifestyle

In 2017, the UK's woodlands absorbed 2% of Britain's GHG emissions or $10MtCO_2e$. The report envisages that annual afforestation rates of between 30 000 and 50 000 hectares would increase woodland cover from its current 13% of the UK's land area to between 17 and 19%, so increasing this carbon sink to between 16 and $36MtCO_2e$ by 2050.

In contrast, the biological processes inherent in crop and livestock production make it impossible to reduce agricultural CO_2 emissions to zero. Currently, agriculture accounted for 9% of all UK emissions, half of which were from ruminant livestock. The report considers that there is significant potential to reduce emissions by more efficient use of nitrogen, better manure management, improved crop productivity, better thermal efficiency of agricultural buildings and low-carbon alternatives for tractors and other machinery.

The report shows how consumer lifestyle choices can help to reduce agricultural emissions as healthier diets rely less on carbon-intensive animal products (like lamb, beef and dairy). Reducing food waste is also a key step that individuals can take to reduce emissions as a significant amount of agricultural land is devoted to the production of the 10 million tonnes of food which are wasted each year, of which 70% is binned within households.

Other lifestyle choices to support net zero emissions are indicated by the current breakdown of average household emissions which are: heating (31%), transport (27%), diet/agriculture (18%), aviation (12%), electricity (9%) and waste (3%). Whilst the reduction of GHG emissions from heating and electricity will largely come from technological improvements, other aspects require changes in consumer behaviour such as diet and waste. The CCC report mentions the

	2020s	2030s-2040s
Electricity	Largely decarbonise, renewables, coal phase out	Expand system, decarbonise peak generation
Hydrogen	Start production with CCS	Widespread industry deployment, HGVs
Buildings	Heat networks, heat pumps	Widespread electrification, expand heat networks, hydrogen gas grids
Road transport	Ramp up electric vehicles, HGV decisions	End sale of petrol/diesel vehicles, zero-emission fleets
Industry	Initial CCS clusters, efficiencies	Further CCS, widespread hydrogen use, electrification
Land use	Afforestation, peatland restoration	
Agriculture	Healthier diets, reduced food waste, tree growing, low-carbon practices	
Aviation	Operational measures, new plane efficiency, constrained demand, limited biofuels	
Shipping	Operation measures, new ship fuel efficiency, use of hydrogen/ammonia	
Waste	Reduce waste, increase recycling	Limit emissions from combustion of non-bio waste
Fridge gases	Move completely away from F-gases	
Greenhouse gas removals	Develop options and policies	BECCS deployment, direct air capture of CO_2
Infrastructure	Industrial CCS clusters, expand vehicle charging and electric grid	Hydrogen for industry, more CCS, hydrogen/electric HGV infrastructure, expand electric grid

An overview of the priorities identified in the report.

"Net-zero by 2050 is estimated to cost 1-2% of GDP"

"Decarbonisation action must progress with far greater urgency"

requirement to make more use of public transport and to fly less, noting that the growth in air travel cannot be unfettered.

Who pays?

Net zero by 2050 is estimated to cost between one and two percent of GDP, which is the same cost of the 80% target which Parliament accepted when the 2008 Climate Change Act was passed. Incidentally, it is also similar to the entire defence budget (1.8% in 2018).

As well as savings from the avoidance of climate damages, the CCC considers there are likely to be significant benefits from the required decarbonisation programme. These include better air quality, energy self-sufficiency, with little demand for imported fossil fuels and their associated price volatility, and industrial opportunities from the UK being the first to adopt such a radical carbon reduction programme. For example, delivering the goals of the Paris Agreement will require annual $2 trillion global investment in low-carbon technologies up to 2050.

Delivering this ambitious net-zero programme will require significant capital investment for which the report recommends that HM Treasury undertakes 'a thorough review of the costs and benefits of meeting a net-zero target and the appropriate policy levers to achieve an efficient and fair transition' to attract sufficient low-cost capital. In this respect, it considers that 'cost-benefit analysis (CBA) is not suitable for climate change action'.

The CCC is clear that decarbonisation action must progress with far greater urgency. Of all its recommendations, perhaps the most urgent is ensuring that the right financial levers are in place. The required investment may not be forthcoming if government investment appraisals do not adequately value carbon savings.

As an example, business cases for projects that deliver the required modal transfer from road to rail are weakened under current rules which require them to take account of the cost of the resultant loss of fuel duty. No doubt such decarbonisation disincentives will be addressed, otherwise there is little chance of achieving substantial carbon reductions.

The net-zero report shows the huge changes that will need to be made across all sectors. It is a bold vision which includes the following issues relating to the rail industry:

- The benefits of electrification generally and for rail the requirement for a rolling programme.
- That there will be far greater use of battery and hydrogen technology in the automotive sector than on rail.
- That biofuels and synthetic fuels are likely to be a scarce resource, the use of which may only be justified in applications for which there are no other zero-carbon options.
- The requirement for modal shift from road and air needs a significant increase in rail capacity, such as that provided by HS2.
- The urgency to act now.

If net zero is to be achieved by 2050, we need Government financial policies that incentivise carbon savings. A credible rail decarbonisation programme must address these issues.

IRSE News analysis: what is our part to play in the road to net-zero?

David Fenner

Reading this article in Rail Engineer gave me a rounded view of the challenge society will face in weaning itself off fossil fuels and other carbon dioxide producing behaviours. The figures quoted are of course UK specific, but the principles apply to many other countries and the solutions may well be similar. It also opens some opportunities for rail transport over the next two or three decades. I therefore felt it merited a wider circulation. It placed a context around much of the work we do.

Expanding on the topic from a rail perspective is worth considering. We should be proud of the relatively small influence rail transport has on CO_2 production. Having said that UK rail transport represents less than 10% of all movements so we need to be aware that increased use may also inflate our carbon footprint unless we are careful. The other major points to take from this report are the focus on using electricity for as many applications as possible and the advocacy of modal shift from air and road to rail wherever practicable.

These two points suggest an increased focus on electrification and the need for a significant uplift in capacity. In both these areas signal engineers have a role to play.

In terms of electrification perhaps we need to think in terms of resignalling projects being 'electrification-ready'. This is considerably less of a problem now than it used to be. The move to axle counter based train detection removes many of the electric traction risks associated with modern three phase drives as does the increasing migration to data systems and especially IP addressing, for trackside equipment. The old risks of interference currents accumulating in long parallel copper circuits are diminishing. From a telecommunications point of view the migration to fibre optic transmission removes similar challenges and opens up the network to much greater data capacity. The move to axle counter-based train detection allows the overhead line engineer to take responsibility for bonding and to design it solely to return the traction current to the substation.

I am sure we are not quite there yet because track circuits are still often easier to use through points and crossings but for much of the plain line life is simpler. It would be good to say we are moving toward an ETCS railway without lineside signals because they are probably the remaining obstacle to the overhead line engineer being able to design his system without worrying about signals and gantries obstructing the positioning. However, we are not there yet and may be sometime before that world arrives. Whilst I am advocating greater "independence" for the electrification engineers I am not suggesting we stop talking. There will still be issues about the relative location of stopping points for trains and OHL equipment such as neutral and isolated sections but hopefully the field will be smaller and the target easier to achieve.

The other major issue arising from the report is the aspiration for modal shift. That means a busier railway and delivery of more capacity. Some of that capacity will be delivered by new infrastructure but some can be delivered by better traffic management on the existing infrastructure and that is where we have a role to play. Can we get more trains through a given unit of infrastructure reliably? The answer is already yes but it is not entirely within the signal engineer's control. The target on simple metro railways is already around 36 perhaps 40 trains per hour but with more complex track layouts come operational risks which diminish this figure. On mixed traffic railways with different stopping patterns served by the same track there are even more operational challenges cutting the number even further. So, we must work with our colleagues across the railway industry to rise to those challenges. But especially with cab signalling (ETCS) and automatic train operation we can address some of those challenges and deliver an increased capacity.

Modal shift will not just occur because we provide more capacity, in fact the need for capacity improvement will be a consequence not a driver in many cases. Modal shift will tend to occur when people are not content with the journey by their current mode and they have faith the railway will deliver them on time, in comfort to their destination. So, traffic management and high quality realtime information will key to persuading people, and goods, to swap to rail transport. Here the basic reliability of the railway, the ability to respond quickly and effectively to disruption and critically the facility to communicate this to our users will be crucial. As engineers we are not perhaps in charge of these functions but as signal and telecom engineers, we do provide the hardware and systems to achieve these aims. We have the tools, but can we use them?

I also note in the report the challenge that the Climate Change Committee raised about UK Treasury project evaluation rules being unsuitable for some projects required to implement the plans. Perhaps the railway as a whole, especially in the UK, needs to make sure similar voices are heard so that real progress can be made to deliver valuable but under current rules unsustainable projects.

So, I take away from this review the prospect of a significantly enlarged electrified railway operating with a capacity we can only just about visualise at present which communicates continuously with our end customer to keep them on side. However, we will only achieve that nirvana if we can deliver the right systems at an appropriate price at the right time. To achieve that objective we need to talk to and understand the issues of our colleagues throughout the rail industry.

Train detection – the basics

BACK TO BASICS


Paul Darlington and David Fenner

This, second of a series of articles on 'back to basics' themes, looks at the essentials of train detection (or more accurately, as we shall see, train absence detection). One of the main safety requirements of a train control systems is the need to know it is safe to establish a route and provide movement authority for a train. In particular, before points or other moveable infrastructure has its position changed or a train is given permission to proceed, the relevant part of the line has to be proved to be clear of other trains. Thus, the ability to detect the presence of a train on a particular stretch of track is a key requirement for modern train control. The principles of train detection will be very familiar to experienced signalling engineers, and so this article is intended for members new to the industry.

"There are two main types of technology generally used for train detection"

There are currently two main types of train detection system, namely the track circuit and the axle counter. Both of them use track-based technology, and although other track-based solutions have been trialled over the years (including mass detectors, infrared and optical detectors), none of these have been widely adopted. We will look at both track circuits and axle counters in some detail in this article.

An alternative approach is to use train-based technology, whereby the train determines its location and communicates this information to the interlocking and control centre on a regular basis using a reliable secure communication link. Various technical options exist, including:

- Satellite positioning (Global Navigation Satellite Systems – GNSS).
- Odometry (counting wheel revolutions).
- Video (by recognition of infrastructure features).
- Proprietary systems offered, in particular, by Communication-Based Train Control (CBTC) suppliers.

These solutions are sometimes used in combination to achieve the required degree of positional accuracy, and they may also be supplemented by equipment such as track-based balises or RFID (radio frequency identification) tags to periodically correct incremental positioning errors. Train-borne positioning systems are a standard feature of modern CBTC systems (which often use moving block technology) and will be for ERTMS Level 3 as well. We will explore this subject further later in this article.

All train-borne positioning systems rely upon some form of train to track communication system so that the interlocking is regularly provided with up-to-date information about the train location. This may be a radio system, or a short-range communication system such as inductive loops in the track, Wi-Fi, or leaky feeder technology.

Despite the growth of train-based technologies, for the majority of railways around the world that use train detection systems, the track circuit and the axle counter continue to be the favoured solutions. There are, of course, also many railways which use little or no train detection technology and rely instead on 'absolute block' methods of working or 'train orders' (verbal communication between the control centre and the train drivers).

Track circuits

The track circuit was originally used simply to remind signallers that a train was present on a particular section of track, not as an integral part of the locking of points and signals. It was the development of the track circuit that enabled the full potential of 'space interval' signalling based on track circuit block principles (continuous train detection between signal boxes). It also enabled signals to be provided that worked automatically with the passage of trains.

The track circuit continuously proves the absence of a train from a given section of track in a fail-safe manner. It cannot prove the presence of a

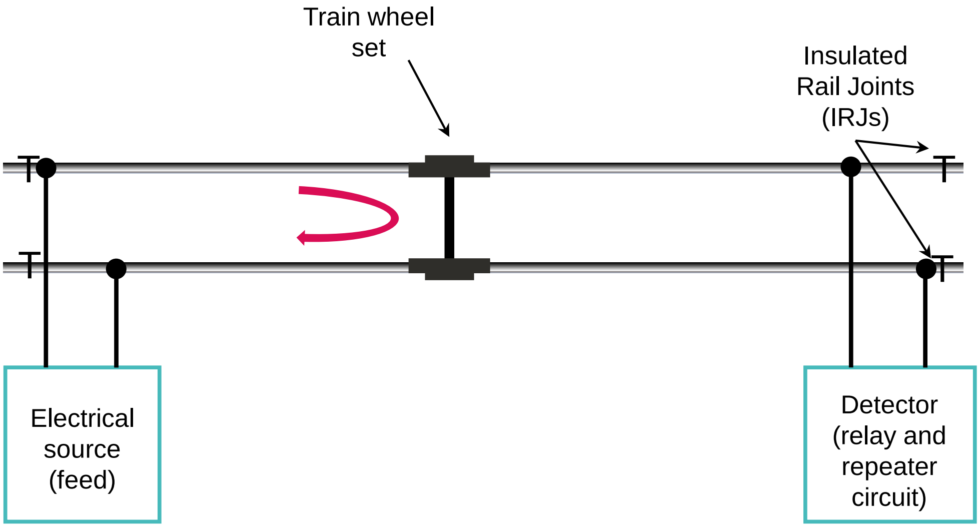


Figure 1 – The fundamental principles of the track circuit are simple. A train travelling between an electrical source and detector shorts out the current flowing between them, and the loss of current at the detector indicates that the absence of trains can no longer be assured. More modern devices use coded, typical shift-keyed, signals to offer more immunity to complex traction systems.

train, since almost any failure mode will give the same indication as if a train is present. By positively proving the absence of a train, a track circuit can be used to confirm that it is safe to set a route and permit a train to proceed. The track circuit should not be confused with a 'rail circuit', which is used for non-fail-safe applications to positively prove the presence of a train.

Fundamental design principles of track circuits

The most basic track circuit consists of a source of electrical energy (a direct current – DC), fed through an impedance and along the rails to a boundary which is defined by a pair of Insulated Rail Joints (IRJs are provided at both ends of the track circuit to define the detection limits of the track circuit). At the boundary a detection device, typically a relay, is connected across the rails and is energised by the direct current provided there is no train present (see Figure 1).

Thus, the track circuit confirms the absence of a train to the signalling system (track circuit clear). The presence of metal wheels and axles of a train within the track circuit boundaries will cause the rails to be 'short circuited.' The increased current flow results in a greater volt drop through the feed impedance which, together with the shunting effect of the short circuit, means the detector no longer sees sufficient electrical energy to remain energised, and so it changes to the 'de-energised' state. This state change informs the signalling system that the track is 'occupied'.

Any electrical short-circuit between the rails, whether caused by a train or not, or any disconnection within the circuit (for example a cable being cut or falling off the rail), or a loss of supply current, will cause the track circuit to inform the signalling system it is occupied. This means that virtually any equipment fault will cause the system to 'fail safe' and thereby maintain signals at red. Although safe, this behaviour can result in unreliability, especially if the track circuit is not set up or maintained correctly. A track circuit operating device (e.g. 'clips') can also be used to protect a train in an emergency. Correct operation of a track circuit also depends upon good electrical contact between a train's wheels and the rails, together with a continuous low-impedance path between each wheel via the connecting axle on the train. This will be discussed later.

DC, AC and coded track circuits

Simple as the track circuit may seem, there are various ways of powering the system and detecting the state of the track circuit (occupied or clear), and all have their benefits and weaknesses.

The source of electrical energy may be any of DC, AC at power frequencies (typically 50Hz), AC at audio frequencies (a few thousand Hz),

Bombardier's EBI Track 400 is typical of modern, microprocessor-based track circuits that use coded waveforms to provide traction immunity and can operate without insulated rail joints. *Photo Bombardier.*

In many temperate climates autumn leaf fall can cause contamination on the rail head, and unreliable shunting of track circuits.

"Tread-braked trains can sometimes give a better track circuit shunt than modern disc-braked trains"

a series of impulses or complex waveforms including digital codes. Similarly, the detector may be a simple relay, an AC 'vane' relay or a more complex receiver tuned to a particular frequency or pattern of signals. It should be noted that the high volume of conductive metal in a rail results in a high inductance and thus track circuits with a high frequency component tend to be short in length. Some track circuits can also act as a carrier for coded signals that are passed to the train. These are usually associated with ATP and early ATO systems, and examples include TVM430, the original ATP system used on French High-Speed lines, and the original implementation of ATP with ATO on the London Underground Victoria line.

The two rails on a railway are in practice not perfectly insulated from each other. There is always a leakage path between the two through the rail fixings, the sleepers, the ballast and the ground itself. This is known as the ballast resistance. Its value is dependent upon the condition of any rail insulation, the cleanliness of the ballast, and the prevailing weather conditions. It is inversely proportional to track circuit length. High ballast resistance values are ideal for a track circuit and may be obtained in dry/clean conditions or during frosty weather, but wet conditions may reduce the value significantly, especially where there is bad drainage and/or contamination from conductive materials in the track-bed. So, if for instance the track is flooded, the track circuit will show occupied and the signal controlling the track section will remain at red. Wet tunnels, sea walls and similar locations can be a particular problem, as the conditions can vary significantly on a frequent basis, which means that the track circuits need to be repeatedly adjusted to keep them working reliably and safely.

One difficulty with adjusting track circuits is knowing the prevailing value of ballast resistance. If a track circuit fails due to wet weather, it may be possible to remedy the situation by reducing the feed impedance. However, a too low feed impedance can lead to trains not being detected (a 'wrong side failure'). This will occur when a low feed impedance allows enough energy to reach the detector despite a train standing on the track. Some track circuits with highly variable ballast conditions may need frequent, often seasonal, adjustment to avoid this risk. This adjustment and testing currently has to be carried out manually, putting staff out on the railway and therefore placing them at risk, as well as being an expensive and time-consuming use of resources.

Rust films and contaminants

The resistance through the train's wheels and axles is also an important factor, as it is the train which shorts out the track circuit. There are several ways in which the resistance of this short circuit may increase, with detrimental effect on operation.

One way is the presence of a rust film on the rail head or wheel. The mechanical strength of light rust films is much reduced by the presence of moisture, when the contaminant tends to be squeezed out from the wheel/rail contact patch. Therefore, lightly rusted rails will only be a problem when dry. Very heavy rust, from prolonged disuse of the track, or after re-railing with new rail, can result in track circuits being incapable of detecting trains, especially lightweight trains as they are not heavy enough to penetrate the layer of rust. Therefore, care needs to be taken after track relaying, when track circuits should not be restored to full operation until a good electrically conductive surface has been created. One positive result from today's crowded railway on some routes is that busy lines have little chance to rust, reducing the problem. However, seldom-used branch lines, particularly in coastal regions where rust formation is exacerbated by salt, are at risk.

Other contaminants that increase the electrical resistance between the rails and the train's wheels can cause the same problems. Those associated with falling leaves are generally limited to the autumn, and are usually confined to known locations, which may include built-up areas. Leaves are drawn into the wheel–rail interface by the passage of a train where they are squashed into a pulp. This contaminates both the rail and wheel, causing wheel-slip problems when wet, and significantly increasing the electrical resistance when dry.

Reasonably dry weather with little wind will cause the leaves to fall gradually over a longer period, and they will be reasonably sap-free when they do fall. But high wind conditions will lead to a sudden fall of sap-laden leaves, giving rise to the worst conditions.

"Direct metallic connection between the rails will cause the track circuit to show as occupied"

"Insulated rail joints are expensive, both to install and to maintain"

Problems with coal dust and other similar contaminants on the rail head tend to be confined to collieries and other loading/unloading areas. Sand contamination can also be a problem, although not so much due to seaside locations, but with slow-moving locomotives using excessive amounts of sand for adhesion purposes. In each of these cases, the effect is similar to heavy rust. Problems can also occur with ballast condition issues associated with carbon-based contaminants, and of course heavy rain causing puddles and floods can short out the track circuits.

Train issues

Where a thin film of contaminant insulates the wheel from the rail, this can often be pierced if there is a rough surface on the running face of the wheel. The older style of tread brakes caused the wheel tyres to be cleaned and roughened at each brake application, whereas more modern disc-braked trains do not, and the tyres may be rolled into a very smooth surface condition. Therefore older tread-braked trains generally provided better track circuit operation than modern disc-braked trains.

Similarly, the axle weight has an effect, as a heavy load will pierce a film more easily. Again, modern lightweight trains, which are designed to minimise track wear, cause more track circuit problems than old-style heavy locomotive hauled trains.

To assist vehicles to shunt track circuits, a device known as the 'Track Circuit Assister' (TCA) is sometimes fitted to modern trains in Britain to induce an electrical potential between the wheelset and the rail head and thereby break down any insulating film. Typically, a TCA consists of a control unit and aerial with associated tuning unit, mounted between a pair of wheelsets close to the rails. These devices tend to be fitted to the end bogies of the train because it is important, especially around point work, that the extremities of the train are detected so that the points cannot be inadvertently moved at the wrong time.

Insulation

As has been described, any direct metallic connection between the two rails will be interpreted by the track circuit as a train and will cause the track circuit to show occupied. Therefore, apart from the insulated rail joints or block joints used to electrically separate sections of line, the reliable operation of track circuits also requires the provision of insulators to stop other track components shorting out the track circuit.

At a set of points, for example, there are many cross-rail connections – stretcher bars, point motors and heating elements – all of which need to be insulated, giving rise to quite complex insulating and bonding arrangements. In addition, the actual running rails cross at the 'frog' or 'heel' of the points, requiring insulated rail joints and bonding in the switch rails to transfer the polarity of the circuit to the other rail. Designing track circuits to work reliably and safely through complex switches and crossings can be quite a challenge!

Concrete sleepers incorporate a rubber pad under the rail foot and moulded insulations where the fixings bear on the top of the foot. These increase ballast resistance to levels significantly higher than can be obtained with timber sleepers. However, the insulations can erode due to the vibration of passing traffic and, consequently, require inspection and periodical replacement – another maintenance overhead. Steel sleepers are even more of a problem. They are also insulated, of course, but any degradation of that insulation will result in severe problems.

Ultimately the maximum length of a track circuit will be limited by the achievable ballast resistance, its variability with prevailing environmental conditions, and the level of reliability required. It will also be influenced by interference from electric traction, which is discussed below. In the UK it would be reasonable to assume that these factors limit a track circuit to a maximum of about 1500m, although isolated examples of longer ones can be found.

Bonding

Bonding is the means by which the individual components of the railway track are connected together electrically for track circuit purposes. The term also includes the additional electrical connections necessary for the proper operation

The black art of bonding in areas with track circuits and third-rail traction is very visible in this view of Clapham Junction in South London, UK. Look out for impedance bonds, traction cross-bonds, and track circuit bonding in this photo. *Photo Shutterstock/ Ian Stewart.*

of electric traction. For a track circuit to fail safe (show occupied) in the event of a bonding disconnection, it is necessary to bond all elements of the track circuit in series, so that any one failure breaks the circuit. In practice, in switches and crossings it may not be physically possible to arrange series bonding of every part of every rail.

Later in the article we will deal with single rail traction bonding (which only provides series bonding for the track circuit signal rail as the traction return is usually bonded in parallel with other traction return paths); and 'double rail traction bonding' (providing total series bonding for a track circuit as well as both rails for the traction return path). In the majority of cases traction bonding through switches and crossings is single rail traction where track circuits are provided.

"Audio-frequency track circuits can be unsuitable unless the point work is very simple"

Insulated rail joints

IRJs are expensive, both to install and to maintain, especially on tracks subjected to high speed, high axle-weight traffic or where there is an intensive service. A rail joint also presents an increased risk of rail fracture, although now with factory made six-hole glued joints this is less of a risk than with older styles of IRJ. As mentioned above, they are also required in areas of points and crossings, which makes the railway less physically robust than track engineers would wish.

It is also possible for the insulation in the IRJ to be compromised, either by failure or by burring of the top of the rail such that it bridges the insulating element. This could cause a wrong side failure because one track circuit supplies power to the detection element of the next track circuit, across the failed IRJ. For this reason, most simple DC and low frequency AC track circuits connect to the rails with opposite polarities either side of the IRJ to ensure that, should the insulation fail, both track circuits will show occupied.

One solution for avoiding IRJs is the use of audio frequency AC track circuits which permit the physical limits of an individual track circuit to be defined by 'tuned' zone, rather than by insulators in the rails. Adjacent and parallel track circuits operate at different audio frequencies and each one is designed to detect its own track frequency but no other. It is possible, with careful design, to arrange a short overlap in the centre of the tuned zone where both track circuits are effectively shunted.

The use of audio frequency track circuits is not always a practicable solution for complex switch and crossing layouts, not least because of the complication of significant rail impedances associated with parallel bonding.

Broken rails

By their very nature of operation track circuits are sometimes regarded as a means of detecting broken rails. However, track circuits will only detect a broken rail that is fractured all the way through and is not bridged by any form of bonding or other electrical connection. So, a damaged rail head or foot will not be detected but could be equally problematic. On an electrified railway the need to maintain a traction current return path through one of the rails and other paralleled conductive infrastructure means that in many cases breaks can only be detected in the other rail. Hence broken rail detection is, at least in the UK, now managed by the routine monitoring of the rail condition including ultrasound scanning, not by dependence upon track circuits. And of course, as we shall see, axle counters are of no help at all with broken rail detection.

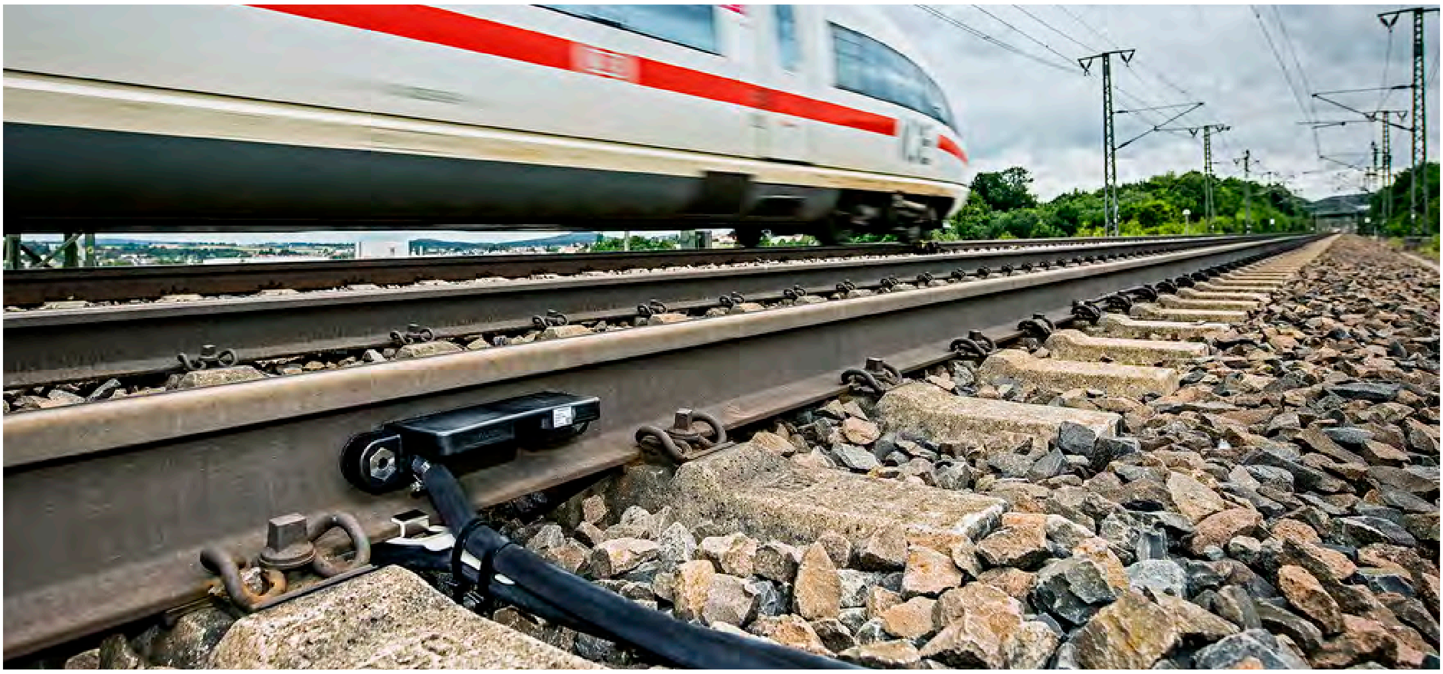
Electric traction

On electrified railways, track circuits must operate despite large traction return currents passing along the same rails. The disparity is substantial, with AC traction currents of 300A or more and DC traction operating at up to 7000A. These values exclude traction fault conditions and are far larger than the track circuit currents which are a few amps at most. This gives rise to the concept of AC immune and DC immune track circuits. There are also some areas that have both forms of traction current supply which therefore require dual immunity.

The initial way of providing immunity was to use DC track circuits in AC territory and AC phase sensitive vane relay track circuits in DC traction territory. Where both types of traction were in use it was not unusual to use a locally generated special frequency to power AC track circuits, such

Below left: Rail breaks are rarely as clear-cut as this example, and not all rail breaks will be detected by track circuits – but no rail breaks will be detected by axle counters.
Photo Shutterstock/ Michael715.

Below right: The introduction of any new or different rolling stock on areas where train detection is a significant part of the signalling system requires detailed analysis of the susceptibility of the trackside equipment to large traction currents.
Photo Hitachi.



Axle counters are increasingly preferred as a less intrusive means of train detection. *Photo Thales*.

as 83.33Hz using rotary converters. This enabled the track circuits to detect and respond to the 83.33Hz frequency but not DC or 50Hz AC.

Today, whilst these arrangements are still common, there is a steady increase in the use of modulated audio frequency track circuits selected for immunity. This move is partly the result of the application of three phase traction drives, which produce many harmonics some of which are present in the traction return currents. In practice the range of frequencies produced by modern three phase traction units makes it a challenge to find immune frequencies suitable for track circuits. This is also one of the reasons why there is a trend to use axle counters as the modern form of train detection.

"Coded track circuits can be used to transmit information to a moving train"

Track circuit arrangements in electrified areas are constrained by the need to ensure safe and reliable operation of both signalling and traction systems. This means that the track circuit must be immune to both false operation and to damage by the flow of traction currents through the rails. This also causes complications because, while the signalling track circuits are separated from each other by IRJs, the traction current needs a continuous electrical connection back to the substation.

This problem has led to the use of impedance bonds on double rail traction track circuits. These are devices that present a low impedance to traction current and a higher impedance to track circuit current. In simple terms, they allow traction current to pass along the rails and around the IRJs, but stop the track circuit currents in order to separate one track circuit from the next.

Although track circuits are designed to be immune to false operation (wrong side failure) from the presence of traction currents flowing in the rails, any significant imbalance in the amount of current flowing in the two rails may be misinterpreted by the track circuit detector as indicating that the track is unoccupied when it is not. In particular any fast change in the traction current may cause a short-term imbalance, which is why track circuits on electrified lines are normally designed to be slow to energise (i.e. slow to show track clear).

In DC electrified areas, the relatively low supply voltage results in high currents returning to the sub-stations via the running rails. In order to minimise voltage drop and consequential power losses in the DC-traction supply, all running rails are used for the return of traction currents wherever possible, and therefore double- rail track circuits are used. There is usually cross bonding between different tracks as well so that the current has as many feed and return paths as possible, again to minimise traction energy losses. As in AC areas, impedance bonds are used to ensure the traction current has a return path to the sub-station, whilst the adjacent train detection sections are kept separate from each other. In switches and crossings, however, it is not usually possible to bond the track in double-rail form, and therefore single-rail track circuits must be installed. It should be noted that 'single rail' track circuit really means single rail traction current return, as both rails are still used by the track circuit.

In AC overhead electrified areas, traction currents are generally lower than in DC systems and, in many cases, single rail traction return is sufficient for electrification purposes. However, increased traffic levels and alternative feeding arrangements may sometimes require that both running rails are used for traction return.

Coded track circuits

Coded track circuits can be used to transmit information to a moving train. The amount of information that can be communicated is limited to simple messages, for example transmitting one of a small number of modulations (14-20) to send maximum safe speed and target speed combination. Such systems can require extensive lineside equipment for each track circuit, especially on bi-directionally signalling lines. For the train to successfully detect the transmitted information before it is shorted out by the train

"One particular advantage of axle counters over track circuits is that they can be overlaid on another detection system"

wheels it must always run towards the transmitter end of the track circuit. Thus, on bidirectional lines it is necessary to switch the feed and detector (relay) ends of the track circuit depending on the direction of travel of the signalled train. This added complexity and the consequentially greater failure risk is one of the reasons that modern train supervision systems are generally moving away from coded track circuits to radio-based communication systems.

Axle counters

As its name suggests, an axle counter system used track-mounted equipment to count axles entering and leaving a track section. This information is evaluated to determine whether the track section is occupied or clear. They perhaps they should be more accurately called wheel counters, since the device attached to the rail uses a magnetic field to detect the passage of the rim and flange of a wheel. But because on most rail vehicles the wheel is connected to an axle with another wheel on the opposite side, they are called axle counters. Each axle counter head usually has two detectors on the rail, so the direction of travel can be identified. The head is connected to an evaluator which counts the number of wheels that pass. To make a train detection section two heads are connected to one evaluator, denoting the ends of the train detection section. One counts the wheels that enter the section and the other subtracts the wheels that have left the section. If the answer is zero the track section is deemed to be clear of trains. Note that because both heads can tell the direction of travel, both can either add or subtract from the total. Typically, one head can communicate with two evaluators, meaning one head is used both to count axles exiting from one section and entering the next.

As can be seen from the above description axle counters depend on the equipment being able to count and store in memory the number of wheels that have passed. Such technology, as well as the communication between the three elements of the system, is much easier with modern computing systems and this explains the relatively recent increase in their use in some parts of the world. Other reasons for adoption are they are very largely (although not completely) immune to traction current interference; there is no limitation on section length, so especially on rural routes the volume of trackside equipment and associated power supplies becomes much smaller; and they are not influenced by rail head or ballast resistance conditions. In addition, the traction supply engineer is able to design the traction return system including all the cross bonding required, as well as the track earthing connections for AC traction, without the constraints of track circuit application rules. Finally, there is no requirement for an IRJ or block joint, which increases the integrity of the track system and reduces costs. Axle counters are now the preferred method of train detection for all new schemes in Great Britain and in many other countries throughout the world.

One particular advantage of axle counters over track circuits is that they can be overlaid on another detection system (whether track circuits or another axle counter system) during a re-signalling, thus enabling the new detection system to be tested and proved to be operational before it is required to control the railway. Compare this with track circuits where only one track circuit can be installed on a section of track at a time.

Axle counters are not without their problems, however. An axle-counter section cannot be made 'occupied' by the use of a track-circuit operating device to protect a train, nor will an axle-counter system detect a broken rail. However, the introduction of train radio for emergency communications has provided an acceptable alternative to the use of track circuit operating clips, and as referred to earlier, a track circuit is not regarded as a reliable means of detecting a broken rail.

More significantly, when an axle-counter system fails it loses track of how many axles have passed through it since the failure occurred. Therefore, for safety, it is designed so that when the failure is fixed, it shows the section of line as being occupied, unlike a track circuit. The section then needs to be proved clear of a train before the axle counters can be reset and restored to operational use, which can take some time.

Another problem with axle counters is that a right-side failure can occur when a wheel stops directly above the inductive sensor, known as 'wheel rock'. When the train leaves there is a high risk the section will remain occupied with no train present and the time-consuming process of reset and restore has to be carried out. That can cause difficulties at a busy station, especially if the platform is configured for multiple short trains stopped at various locations along the same platform. For these reasons, some sections of railway (e.g. Thameslink in the UK) have decided to retain track circuits where there are multiple split sections along the platforms.

Cab signalling systems

Modern signalling has a greater dependence on train-borne systems and communications, with CBTC becoming the dominant form for metro lines. These systems rely on the train regularly reporting its location and other information to the control centre, for which of course it requires a reliable communication link. Wi-Fi or data enabled radio (e.g. 4G/LTE) are used for the ground to train communications, with 4G/LTE now becoming favoured due to availability concerns with Wi-Fi. Together with the use of ATP and ATO, these are the key reasons why capacity can be increased on metro routes.

ETCS is the equivalent of CBTC for main line railways. However, enabling a main line train to define its position accurately is a greater challenge than is the case with metros (the latter invariably having fixed formation trains). Whilst the leading vehicle of a train may be able to inform the control centre of its location and movement, it is much more difficult to confirm the location of the rear of the train (unless the train is a fixed formation). In particular it is difficult to confirm that the train is still complete i.e. no vehicles have been left behind due to detachment (known as 'train integrity'). The lost wagon or coach on a locomotive hauled train remains a significant challenge for main line railways. Thus, although ETCS level 2 can be operated without lineside signals, it still uses trackside train detection based on track circuits or axle counters.

"For GNSS to work reliably there needs to be clear 'line of sight' from trains to satellites"

ETCS level 3 is the conceptual system that will enable trackside train detection to finally be removed on main line railways, but when we will see it deployed extensively is an open question. The option of ETCS hybrid level 3 is one way of gaining some of the benefits of Level 3 whilst avoiding the train integrity problem. In hybrid level 3, fixed formation trains such as multiple units, which can easily be confirmed to be complete, are allowed to operate at level 3 whereas others (loco hauled freight and passenger trains) are operated in level 2. Thus, the infrastructure is equipped with train detection, but more than one level 3 train may occupy a given train detection section at a time. Furthermore, if the trains that are operating in level 2 in a hybrid level 3 area are sufficiently infrequent, it may be possible to have longer train detection sections and thus less trackside equipment on such lines.

ETCS standards currently specify that trains identify their location using a combination of balise reference points and tachometry, supplemented by Doppler radar. However, there is no fundamental reason why this information could not be generated from Global Navigation Satellite Systems (GNSS) such as GPS, or video tracking and position identification, provided it can be proven to meet the appropriate Safety Integrity Level (SIL).

Even in full level 3 areas, some track-based train detection is still usually considered essential in locations where moveable infrastructure, especially points, require locking. The provision of some track-based train detection may also help recovery to normal operations after an ETCS failure.

GNSS and Positive Train Control (PTC)

"Track circuits will still be used for many years to come"

In the US, systems using GNSS are being introduced as part of the requirement to introduce Positive Train Control (PTC) over some 60 000 miles of railways. The challenge of installing PTC is further complicated by the fact that there are ten different systems in use across the US. Some systems use satellite links for train separation and were designed for areas of 'dark territory' where line-side signals and train detection are not provided and instead trains are controlled by train orders and track warrants.

As well as train location, GNSS based systems can also be used for passenger information both on trains and at stations. A further possible use of GNSS is to trigger the warning on the approach to a level crossing with a constant-time lapse regardless of the speed of the train. In a similar way, track workers could be alerted to the approach of a train within a known fixed time.

However, for GNSS to work reliably there needs to be clear 'line of sight' from trains to satellites, which may be prevented by bridges, tunnels, cuttings and on sub surface lines. GNSS also presents a potential problem in that neither the infrastructure manager nor the train operator will have any control over the availability of the GNSS signal.

Remote condition monitoring

Track circuits will still be used for many years to come, not least because of the massive task of replacing life-expired signalling some networks, so clever asset management and maintenance techniques will be required. One initiative that has helped reliability is remote condition monitoring (RCM). By monitoring the track circuit current, potential failure modes can be predicted and interventions planned before failure occurs. It is not something that is easy to automate, but there have been consequential improvements in track circuit reliability, with potentially more to come.

One recent innovation involving the use of RCM allows new jointless track circuits to be inspected in real time from remote locations, thus improving reliability. Prior to its implementation, track circuits had to be checked on site using digital multi-meters, which was a time-consuming task and not conducive to finding faults before they occurred. Axle-counter systems also have sophisticated built-in remote diagnostics, and this is one example of the digital railway delivering results today.

Conclusion

The development of train detection systems has been driven by need, accident and available technology. Increasingly we are seeing the use of train-based location systems, but track-based systems will continue to be important for many railways around the world.

Both of the major methods of track-based train detection, namely track circuits and axle counters, have their supporters and detractors. However, for now at least, axle counters are used more than track circuits for new signalling systems.

Have you got an idea for a future 'back to basics' article? Perhaps an area of command, control, signalling and telecoms engineering that you'd like to understand better.

Could you share your experience of these topics with the next generation? If you could contribute to a future article do let us know, email editor@irsenews.co.uk and we will be happy to consider your ideas.

Cornell Tec Conference, New York – Cuomo's oversimplification

Alan Rumsey

In September this year, New York governor Andrew Cuomo made a presentation to the Cornell Technical Conference in New York. In that presentation Cuomo made a call for a return to the ingenuity displayed by previous generations of railway engineers, saying "I think there is a growing societal disconnect between emerging technology and government projects, and I believe it is hurting this state and this country." He went on "the stark reality is that we cannot succeed long term without new technology and new companies entering the field." In this article Alan Rumsey considers what was said and challenges some of the ideas expressed.

As someone who has personally spent their whole career championing the application of new technology solutions to enhance the safety and operational efficiency of mass transit systems, I can relate to, and indeed be inspired by, much of New York governor Andrew Cuomo's presentation on 20 September 2019 at the Cornell Tech Conference in New York. (A video of Cuomo's presentation can be seen at **irse.info/wre82**.)

However, in his challenge to the high-tech companies to propose new signalling solutions, and to enter into competition with the established signalling system providers, one clear omission in his presentation was any reference to the specific requirements for such a new signalling solution (other than it had to be cheap and easy to implement).

In all of the historic examples provided in Cuomo's presentation – of past New York City Transit innovations – each of the innovations described was driven by a very specific requirement, one that could not be satisfied by technologies available at that time. So, the lack of any reference to the specific signalling system requirements in this presentation was particularly troubling, particularly given that most of the intended audience would have had little prior experience with, or understanding of, the purpose and functions to be delivered by any signalling solution.

In addition, while Cuomo highlighted the exorbitantly high cost of NYCT re-signalling projects, using the existing CBTC (communications-based train control) signalling technologies, he failed to mention that the exact same CBTC signalling technologies, deployed by the exact same system providers, were being successfully implemented in Europe, Asia, South America and elsewhere for a half to a third of the costs being experienced in New York. Surely this suggests that the higher re-signalling costs in New York are not driven by the technology per se, but rather by the New York-specific requirements?

These are requirements driven by: the complexity of the project scope; New York's desire to be able to procure interoperable equipment from multiple suppliers; the need to support 'mixed-mode' operations (a mix of equipped and unequipped trains simultaneously operating on any given line), as the new signalling solution is rolled out; New York's specific delivery model. And so on.

Cuomo's presentation also implied that CBTC is one specific technology – a technology developed in the 1980s. This is clearly not the case. By definition, the term "CBTC" embraces any communications-based, computer-based and software-based technology that is capable of delivering a specific set of requirements (requirements that, for example, are clearly summarised in IEEE standard 1474.1 "Performance and Functional Requirements for Communications Based Train Control (CBTC) Systems").

The specific CBTC communications-based and software-based technologies being deployed around the world today, for example, are very different than the CBTC technologies that were first being deployed 40 years ago. The technology to deliver CBTC functionality continues to evolve.

So, the fundamental questions that Cuomo's presentation failed to address are:

- Is this new-technology signalling solution required to deliver the same functionality and performance as current CBTC technologies (only cheaper and quicker)?; or
- Is this new-technology signalling solution required to deliver additional or different capabilities that currently cannot be delivered by existing CBTC technologies? If the latter, what exactly are these new capabilities, and what is the basis for these new requirements?

Without an answer to these fundamental questions, I frankly don't know how one can possibly assess, or compare, the value of any new signalling solution that may be offered by the high-tech companies.

It is of course possible that a statement of requirements to be satisfied by a new technology signalling solution was included in another presentation. If not, I would offer the following as a set of high-level requirements for the high-tech companies to respond to:

Image Shutterstock/pisaphotography.

The new, non-proprietary signalling solution shall provide for the safe, reliable and efficient movement of passengers both during, and subsequent to its implementation, using interoperable components that can be competitively procured from multiple suppliers using open interface standards.

Providing for the 'safe' movement of passengers requires a signalling solution that prevents catastrophic accidents that could result in passenger fatalities/injuries, such as: train-to-train collisions (rear-end, sideswipe, or head-on), train-to-structure collisions (at the end-of-track), and train derailments (as a result of over-speed, or travelling over an incorrectly set turnout).

Providing for the 'reliable' movement of passengers requires a signalling solution that has to have a high level of system availability, through the provision of appropriate levels of equipment/functional redundancy, with the ability to support degraded modes of working in order to continue to safely move passengers in the event of equipment failures.

Providing for the 'efficient' movement of passengers requires a signalling solution that can maximise the number of passengers that can be carried per hour on a given line, in a given direction; a line capacity that is not constrained by the signalling system, but only by the number, location and configuration of the station platforms; the track layout, particularly at terminal stations; the braking and acceleration performance of the rolling stock; and the number of trains available for service. Providing for the "efficient" movement of passengers also requires a signalling solution that supports high levels of operational flexibility (an ability to safely route any train to any destination on any track in any direction), and that supports high levels of automation, including the automation of train driving functions (to include a driverless capability), automatic train routing, automatic regulation of train service, automated failure management and automatic energy optimisation.

In the real world, achieving any two out of three of the above requirements ('safe', 'reliable' and 'efficient') would be difficult. But the real technology challenge is being able to achieve all three at the same time!

The current suppliers of existing CBTC technology can point to literally hundreds of examples where these high-level requirements have been satisfied, and where today this technology is indeed safely, reliably and efficiently moving passengers around major cities in the world. In other words, the existing technology is both service-proven and safety-proven.

As such, surely the initial challenge to the high-tech companies is for these companies to present – at least at the conceptual design level – their proposals with respect to a complete, new technology signalling solution that not only meets these high-level requirements, but that also can be deployed quicker, and at a lower cost, when considering the NYCT-specific requirements.

Although no timeline was given in Cuomo's presentation for companies to respond to this challenge, I eagerly await such a new technology signalling solution to emerge that meets the above high-level requirements. But what does the New York MTA do in the interim, to deliver existing, readily available signalling technologies more cost effectively? Another very important topic that sadly wasn't even touched on in Cuomo's presentation.

Why I am therefore simply left with the uncomfortable impression that, regardless of Cuomo's bold and ambitious goals, this is really nothing more than the politics of being seen to be doing something that grabs the headlines, rather than a serious attempt to develop a realistic and meaningful plan forward to address the true root-cause issues and deliver the safety and operational improvements that the New York City subway system so badly needs.

About the author ...

Dr Alan Rumsey, principal of Rumsey Transit Systems Consulting, is a licensed professional engineer in the Province of Ontario, Canada, a Fellow of the IRSE, a member of the IRSE International Technical Committee and a senior member of the Institute of Electrical and Electronic Engineers (IEEE). Dr Rumsey was chair of the IEEE Working Group that developed industry consensus standards for Communications-Based Train Control (CBTC) systems and is a recognised industry leader in CBTC for both new-start and re-signalling applications, including driverless systems. He is regularly called upon to provide expert advisory services to rail transit agencies and system suppliers around the world that are seeking to achieve a step-change improvement in rail transit system safety and operational performance through the implementation of advanced-technology systems.

Mobile training facility

Paul Martin

PM Training and Assessing Ltd in the UK has always been known for IRSE licensing but this year we have also developed some apprenticeship technical training and delivery with a difference. We wanted to provide a unique service that was able to be flexible, and able to meet the needs of companies within our sector.

After communicating with the managers from a number of companies, it was realised there was a large issue with staff having to travel for training. This in turn meant that staff were often away from work for long periods of time and was costing companies in terms of travel, accommodation and lost shifts. Our solution was to take the training to the companies.

A variety of ways were considered to achieve this, and converting a bus into a mobile training room was chosen. This meant the technical classroom could be taken anywhere that road access was available. Within our new plan we recognised that the only additional amenities which we would need to complete the training, were room to park the bus on site, and a meeting room to cover the background knowledge. After consulting with our sector contacts, it was realised that the additional amenities would be easily accessible. Like most innovative ideas, it was a simple idea but needed a lot of time, resources and creative thinking to turn it into a reality.

Engineering firm Arup was pleased for their design apprentices to get involved in designing and installing equipment on the bus. We are very keen to develop young people and provide them with opportunities, so we readily agreed.. The apprentices had the opportunity to take the lead on managing a mini project and during the life of the project they had to understand the limitations in space and how everything was to work within the constraints of the bus.

The apprentices designed and installed a fully working relay interlocking with an entry exit NX push button panel that will set routes and operate the equipment installed on the bus. The facility that has been created is ideally suited to teaching signal maintenance testing and also assessing installers and testers. The equipment on the bus includes all the required

cabling, Train Protection & Warning System TPWS, track circuit equipment and a signal head. The circuitry can also drive a double ended set of clamplocks connected externally via plug couplers.

The industry must be committed to creating a skilled workforce for the future and a mobile technical classroom is one way that can be used to deliver this objective. It allows the delivery of a variety of different types of training, both traditional and apprenticeship training. It also gives those in the industry who may not have access to the equipment on their doorstep the opportunity to see equipment with 'hands-on' experience. The bus also saves money for the companies involved, as well being good for the environment and a sustainable solution for training, as there is only one vehicle doing a journey rather than five or six. It also means that a more productive workforce is available for signalling work.

We are very proud of what has been achieved, and we love it when people come onto the bus and are genuinely surprised about how good it looks and the creative way the space has been used by the apprentices in their design and installation.

Industry news

Schleswig-Holstein to fund Niebüll-Tønder upgrade

Germany/Denmark: The state of Schleswig Holstein has announced that it will fund the majority of a project to upgrade the cross-border link between Niebüll and Tønder, Denmark. €9.3m (£8.1m, $10.3m) will be contributed towards the project for the 13km line, which is due to be completed by 2021.

The project will be implemented in two phases. The first will involve upgrading track to raise the maximum line speed from 80km/h to 120km/h. In the second phase the line will be equipped with ETCS. This is to allow for the continued operation of through services between Esbjerg and Niebüll, as the legacy Danish train control system will be phased out as part of Banedanmark's national ERTMS programme.

ETCS for Paris-Lyon high speed line

France: SNCF Réseau has awarded a framework contract to Alstom for the development, installation and maintenance of ETCS Level 2 and GSM-R to replace the life-expired TVM300 train control system equipment on LGV Sud-Est between Paris and Lyon.

Valued at €52.5m (£46m, $58m), Alstom will be responsible for design, manufacturing, installation and maintenance of the Atlas ETCS Level 2 equipment, while Setec Ferroviaire will handle the design verification, project management and testing. The installation forms part of a €607m project to improve France's oldest high-speed line, which currently carries around 240 trains per day.

The scope includes the renewal of 37-year old interlockings and enhancing the power supply network. The ETCS installation will increase the capacity of the Paris-Lyon route from 13 to 14 trains per hour in each direction at peak times, with completion by the end of 2024. Further work including the electronic interlockings and traffic management system will increase throughput to 16 trains per hour by 2030. The package is being partially funded by the European Union's Innovation & Networks Executive Agency under a €117m CEF grant announced in April 2018.

Upgrade of Polish Węglówka line

Poland: Infrastructure manager PKP PLK has awarded two contracts worth Zlotys 1.8bn ($454m, £369m, €414m) to improve passenger operations and significantly increase capacity on the Węglówka line, which connects the Silesia region with the Tri-City ports in Gdansk, Gdynia and Sopot.

Nearly 170km of track will be replaced on the Kalina-Rusiec Łódzki-Zduńska Wola Karsznice section, along with the replacement of 238 points and renewal of more than 200km of catenary. Safety standards at 53 level crossings will also be improved, and 77 structures, including 13 bridges and 15 viaducts, will be strengthened to cope with heavier 22.5-tonne axle loads.

Towards unattended main line train operations (ATO GoA 4)

Europe: Shift2Rail is working on automated train operations (ATO) based on European Rail Traffic Management System (ERTMS) that would allow maximising the performance of train operations throughout Europe. The first pilot line demonstrations at GoA 4 (grade of automation 4) are planned for 2022.

The Shift2Rail Programme is working to bring automated train operations up to GoA 4 for a diversity of rail systems. GoA 4 means that the train operation is fully unattended including setting a train in motion, driving and stopping the train, opening and closing the doors and operation in the event of disruptions.

In the initial development phase, Shift2Rail is focused on ATO on main lines up to GoA 2, where the driver supervises the system and opens/closes the doors while the train drives and stops automatically. ProRail presented successfully its first self-driving main line train (based on GoA2 specifications developed in S2R) in the Netherlands. The full test campaign involving further interoperability tests in Europe is expected to be completed beginning 2020.

However, the teams are now concentrating on developing GoA up to 4 – the fully automated and unattended level of automation. An important factor allowing fully unattended train automation is an adaptable communication system, and it will make use of LTE, 5G, Wi-Fi, satellite communication and/or public networks to offer a high-capacity voice and data communication between the track and the train.

Bane NOR and Adif to share expertise

Norway: Infrastructure manager (IM) Bane NOR and Spanish IM Adif have signed a memorandum of understanding (MoU) to share knowledge and experience, more flexible cooperation and improved opportunities for mutual training within specific fields.

Bane NOR CEO, Gorm Frimannslund said "In certain areas, we have a lot to learn from Adif, for example with ERTMS, where they have the largest network in Europe". Adif said it is eager to broaden its collaboration with Bane Nor and hopes the MoU will help both IMs improve services for their customers.

Edinburgh Waverley development for new approaches

UK: Preliminary work to significantly improve the rail network on the approaches to Edinburgh Waverley Station has been approved by the Transport Secretary, Michael Matheson. A £15m (€17m,$19m) investment will enable the options for the Edinburgh Waverley Western Approaches (EWWA) project to be taken forward to Outline Business Case. This will explore three infrastructure options for delivering capacity and performance improvements.

The western approach to Edinburgh Waverley is a critical location on the rail network and one of the busiest in Scotland. This means that a late running train (even by a couple of minutes) can cause significant delays to other services and often a knock-on impact throughout the wider network.

The three infrastructure options being explored are: a new chord (Almond chord) with flat junctions at both Winchburgh and Almond, the Almond chord with a flat Winchburgh Junction and a grade separated Almond Junction, the Almond chord with grade separated junctions at both Winchburgh and Almond.

The work being funded now will include detailed modelling to provide assurance on the performance benefits and help inform which option is most suitable, weighing up costs against the future needs of the railway.

Interlinked user worked vehicle crossing gates

UK: Network Rail has interlinked the user worked vehicle gates at Jacky Duffin Wood level crossing in Carlton, North Yorkshire, with the miniature stop lights. This means the gates can only be opened when no trains are approaching and it is safe for motorists to cross the railway. This is the first crossing of this type on the Network Rail network. The line has up to 60 freight trains per day which travel up to 55mph (90km/h).

Network Rail installed the power operated gate opener eight months ago to replace obsolete manually operated barriers, as the authorised users were finding them increasingly difficult to use. Working closely with the Office of Rail and Road, Network Rail have developed the interlink between the gates and miniature stop lights, with an output of the lights to the control panel on the gates.

If the red light is displayed and a vehicle user presses the button to open the gates, they will not open. This reduces the risk of a potential near miss, as the gate will only open when it is safe to cross. This does not affect how the gates function if they are open, or opening, and the light changes to red. This is so that drivers who have already entered the crossing can still exit safely.

Gimpo Gold Line automated light metro opens

Korea: The 24km Gimpo Gold Line automated light metro has opened, which runs northwest from Gimpo International Airport in western Seoul via Gimpo City Hall to Yangchon. The line connects with Seoul Metro lines 5 and 9 as well as the Arex rail link to Seoul station and Incheon International Airport.

The Gold Line has 10 stations, all of which apart from Yangchon are underground. It is operated by a fleet of two-car 28m-long train driverless trains. Trains will operate at three-minute headways during peak periods reducing to a 6 to 12-minute frequency off-peak with an end-to-end journey time of 30 minutes. Total cost was Won 1.65 trillion ($1.38bn, €1.3bn, £1.1bn).

‘Digital twin’ simulation centre

Singapore: Siemens Mobility has won a contract from Singapore’s Land Transport Authority (LTA) to design and install a simulation centre for the Downtown Line’s (DTL) signalling system. The simulation centre will be located in the operations control centre at Gali Batu depot and will open in 2020.

The centre will be a ‘digital twin’ of the DTL’s signalling system and will use similar hardware, including Trackguard Westrace Mk2 interlocking and Trainguard CBTC trackside and train-carried equipment. Data analytics and preventive failure predictions that were previously undertaken manually will now be done remotely and without impacting operations or passenger service.

Orange to test 5G in 26GHz band for railway station

France: French telecom regulator ARCEP has approved the use of frequencies in the 26GHz range, with tests now planned by Orange in December for 5G in Châtillon and Rennes. Orange say they will assess the performances of these new frequencies as well as the technical and environmental conditions for their use. They want to evaluate the benefits of 5G in the 26GHz band for applications in busy areas such as railway stations, airports, stadiums and concert venues.

In partnership with SNCF and Nokia the first experiment will trial an almost-instant download service for HD content at Rennes train station. Orange will be using 5G devices from Sony equipped with a Qualcomm modem and processor. If successful from 2020, passengers travelling through Rennes station will be able to connect to 5G hotspots and download videos to their mobile or tablet in just a few seconds.

Trials of new mobile technology to reduce costs.

UK: Vodafone has initiated the first European trials of OpenRAN in the UK with the objective of increasing the number of companies that can supply mobile network equipment. The Radio Access Network (RAN) is the infrastructure of base stations, masts and antennae to carry mobile traffic.

OpenRAN is a technology that reduces the cost of mobile networks by standardising the design and functionality of the hardware and software in the RAN, increasing the number of companies that can supply different components. It was created by industry association Telecom Infra Project (TIP) and is based in part on a ‘small cell’ technology called Open CrowdCell, which is already in use in Spain and Turkey.

Lab trials have already been completed in South Africa and new vendors supplying the technology including US companies, Parallel Wireless and Mavenir, and UK-based Lime Microsystems for Open CrowdCell. Further trials are planned in Democratic Republic of Congo (DRC) and Mozambique.

Public address via GSM-R

UK: Scottish train operator ScotRail has implemented a facility for its control centre to make customer announcements through the trains on-board public address system via GSM-R, along with key messages to customers about engineering works and special events. GSM-R was previously only used as a secure and dependable way for train drivers and signallers to communicate, but customers will now benefit from enhanced information during times of disruption. The rollout follows a successful six-month trial on the Glasgow North Electric Line.

Cab Secure Radio, the previous train radio system used on some routes in the UK, also allowed signaller to on-board public address announcements, but it was only ever used for infrequent emergency communications. The new facility allows improved real time information to customers and makes best use of the investment in GSM-R.

Free Wi-Fi at Britain’s busiest rail stations

Great Britain: telent has been awarded a contract from Network Rail to deliver free Wi-Fi for passengers at Britain’s biggest and busiest railway stations as part of the “Put Passengers First” plan. Rail passenger journeys in the UK reached a record high of 1.759 billion in 2018-9, (see **irse.info/0dc1h**) a 3% increase on the previous year – with almost one billion passengers regularly using the service in possession of a phone, laptop or other connectable device.

Free Wi-Fi was also identified by passengers as one of the key factors that could improve the environment at railway stations. The new Wi-Fi service will offer seamless connectivity and single sign-on, automatically connecting passengers to Wi-Fi in all of Network Rail’s 20 managed stations. The new Wi-Fi initiative, which has already been implemented in Euston and London Bridge stations, will be introduced to the UK’s busiest stations from Spring 2020. The service will be simple to use and can be used on more than one device.

Thales and Vodafone conduct driverless trial using 5G

Germany: Thales and Vodafone are claiming a world first by operating a driverless train controlled remotely via a public 5G mobile network. The driverless trials are being carried out at the Smart Rail Connectivity Campus in Erzgebirge, Saxony, using Thales' Lucy laboratory train, while Vodafone has installed one of their first 5G base stations in the Erzgebirge region.

To enable Lucy to be controlled remotely, 5G 'network slicing' is used which is a technology to enable different virtual networks to share a physical network structure, see September IRSE News "Neutral host networks" for further information on network slicing. Thales claims this means that a railway mobile radio data connection is always available to control the train remotely, even if numerous other users in the area also require data.

The data is processed directly on-site in a small data centre near to the mobile base station via a Mobile Edge Cloud (MEC). Because the data does not have to travel long distances it can be processed with minimal delay. Bandwidths greater than 500MB/second and latency less than 10ms are claimed to be available on the test track. It will be interesting to see a safety argument for such a system to be used on a live railway.

5G mobile radio update.

World: With the roll-out of 5G networks starting around the world there have recent announcements from the main equipment suppliers Huawei, Ericsson and Nokia.

Security and politics affect Huawei in some countries, but the company is pressing ahead with its 5G strategy. This includes supplying over 400 000 5G base stations via 60 5G contracts. In contrast it took them five years to shift 170 000 4G base stations. Their third generation M-MIMO supports up to 400MHz in all spectrum scenarios and transmits power of up to 320W. M-MIMO 'tracks' users from a base station to deliver faster speeds and support more devices. All operators are starting to offer similar products.

Huawei's prospects have been boosted with confirmation it will not be barred in Germany's 5G rollout, and Huawei say they have a desire to work with industry on the issue of security and to continue to play a major role in standardisation of products. Their blacklisting in the US has limited its access to components, but for now, is having little impact on its products.

Ericsson radio system hardware has been 5G-ready since 2015 and can be used for 5G NR (New Radio) with a remote software installation. This means they have already shipped more than 4 million 5G-ready radios to customers worldwide. They have delivered networks in four continents, including multiple operators in both the US and South Korea, as well as in Switzerland, Australia and the Middle East. 70 commercial 5G agreements and contracts are in place, of which around 20 are live networks. Ericsson is also collaborating with more than 40 universities and technology institutes and 30 industry partners.

KDDI Corporation in Japan, has selected Nokia as a primary partner to upgrade its 4G network to 5G with Nokia's radio access product AirScale, which supports both 4G and 5G operations. The 5G network will support KDDI across both cmWave and mmWave 5G frequency bands and can be deployed in both distributed and centralised architectures.

The network will be deployed across Japan and will deliver enhanced Mobile Broadband (eMBB) to consumers and enhanced Machine Type Communication (eMTC) enabling multiple new applications and services for industries. The network architecture will be enabled for 5G Ultra Reliable Low Latency Connectivity (URLLC). Nokia currently has 48 global 5G commercial contracts, including live networks in the US, Latin America, Europe, Korea and Australia.

5G is likely to be the technology to support Future Railway Mobile Communication System (FRMCS), the future worldwide railway radio system designed by UIC, as the successor of GSM-R from 2025.

5G RuralFirst OpenRoaming testbed in Orkney

UK: 5G RuralFirst is the UK's testbed for connectivity in rural areas, to identify 5G practical use cases to benefit businesses and communities. Three testbeds in the Orkney Islands, Somerset, and Shropshire, are identifying and exploring new business models and use cases for 5G in rural areas. The trial project in the Orkney Islands aims to demonstrate the potential and practical use cases that connectivity could bring to rural businesses across the UK.

Wireless internet provider, CloudNet, is enabling Orkney residents and tourists to use Cisco's OpenRoaming services across key locations on the island. The trial is testing how devices can provide a frictionless connected experience and combine the convenience of roaming with Wi-Fi connectivity.

Users' identities are authenticated once before they can access Wi-Fi without needing to login or register again. By linking access providers such as public venues, retailers, ports and offices, together with identity providers, such as carriers, devices and cloud services, OpenRoaming offers mobile users frictionless Wi-Fi access. If proved successful the initiative may be of interest to the rail industry.

5G for drones

Germany: Vodafone has announced it is launching a partnership to provide 5G infrastructure across Europe for Ehang, an autonomous aircraft firm. This includes for 'flying taxis' as well as commercial drones for logistics or postal deliveries. Vodafone Germany's CEO, Hannes Ametsreiter says "Every drone needs mobile radio. Fast networks regulate the right of way in air traffic. They become the traffic control system for airline taxis and drone mail, and they make drones identifiable". Hu Huazhi, founder and CEO of EHang said, "5G is a key infrastructure for the commercial use of drones. Only with 5G can autonomous flying air taxis start and land with centimetre accuracy in the future."

Wabtec Septentrio PTC GPS Receivers

USA: Wabtec is partnering with Septentrio, a Belgian manufacturer of GNSS (Global Navigation Satellite System) equipment, to supply GPS receivers for its GoLINC Edge locomotive onboard mobile data centre platform. This will provide positioning, connectivity and data storage, to enhance Positive Train Control (PTC) with improved positioning technology.

Two GNSS receivers are installed on a locomotive to provide positioning information as part of the GoLINC system. Septentrio receivers are also being installed as position reference modules along 30 000 miles (48 000km) of US freight routes. They will provide GNSS corrections to the onboard "rover receivers" for "reliable and accurate positioning, even in difficult environments such as when tracks run alongside mountains, around cliffs or under foliage," Wabtec said.

Tomorrows Living Station

UK: Arup and Network Rail have published a report on what tomorrow's railway stations may look like with stations evolving to become "mobility hubs". "Tomorrow's Living Station" can be downloaded from irse.info/yn97d. The report says that in the decades ahead future passengers will expect an efficient mobility service, with a well-connected, easy-to-use station at its heart that enables them to control and make best use of their time. The digital railway could be in its second generation, enabling very reliable services with a metro-style frequency. Combined with driverless mobility, the railway could be much more interoperable with on-demand choices and 'Mobility as a Service' providers. This would give customers more choice, and more responsive options.

Virgin Hyperloop One independent third-party safety assessment

France: Certifer have announced they are working with Virgin Hyperloop One (VHO) to perform a third-party evaluation of the company's engineering and safety process. The Certifer independent safety assessment (ISA) team has validated the readiness of Virgin Hyperloop One's technology and organisation in terms of safety.

Certifer says that the VHO technology will be subject to the same process and constraints as those reviewed on all railway and urban transportation projects, such as high-speed trains, light rail transportation systems, and metro systems. They will support VHO across all of the railway disciplines and subdisciplines as well as from several different domains including safety, hardware development, software development, civil and mechanical works, guideways, control command and signalling, magnetic propulsion. Certifer will work closely with VHO's dedicated Safety Certification and Quality Assurance teams.

Virgin Hyperloop One has built a full-scale hyperloop test track and completed test runs using electric propulsion and electromagnetic levitation under near-vacuum conditions. The company is working with governments, partners, and investors around the world and they have projects planned in India, Saudi Arabia, USA and the UAE. To find out more about Hyperloop One's technology see **irse.info/w2eou**.

Challenge for STEM

UK: The 2019 CHILDWISE study completed by the Institution of Engineering and Technology (IET) has shown a decrease in enthusiasm for Science, Technology, Engineering and Mathematics (STEM) subjects amongst children and has highlighted the influence of teachers, especially at the early primary school stage, in selecting a career path. Teachers and others from the education sector indicated that increased time pressures and reduced resources were hindering efforts to increase STEM classes, with a reported 10% decrease in children's interest in STEM subjects. It is particularly clear when students are broken down by gender, the traditional stereotypes are still having an effect on the numbers of girls showing an interest in engineering.

The study also indicates a significant knowledge gap for parents, with parents unable to provide advice if their child were to ask about a career in the field. As a result, the IET has emphasised that increased exposure to STEM subjects early in education is becoming increasingly important as part of long-term efforts to address the skills gap in engineering in the UK.

The CHILDWISE research indicates a need to show the relationship between more popular subjects such as art, design and sport, and STEM subjects, to help students see the possibilities of a career in engineering. This can be done by providing teachers with the resources and tools required to support students who show an interest. The full study and report can be found at **irse.info/nizl3**.

NSW vocational education and training agreement

Australasia: Siemens has announced a partnership with the New South Wales (NSW) Government to develop a vocational education and training (VET) hub in Western Sydney, to bring advanced technologies and innovations in VET to the Western Sydney Aerotropolis, the development surrounding the future Western Sydney Airport.

Siemens, whose portfolio includes rail and signalling systems, is a major investor in VET, training around 8000 apprentices and students in Germany each year. The NSW government has noted Germany's VET system provides trainees with high-level technical skills, making it especially effective at responding to changes in technology and the employment needs of business.

NSW minister for jobs and Western Sydney Stuart Ayres said a strong VET system will be essential for ensuring the success of the Western Sydney Aerotropolis. "The key to ensuring that additional jobs created through the Aerotropolis are sustainable is to provide workers with the skills they need for future industries," Ayres said. "That's why the NSW Government will establish a permanent VET facility in the Aerotropolis with a focus on advanced manufacturing, technology and engineering."

100 Historical UK Women in Engineering

UK: In 1919, the Women's Engineering Society WES was formed to inspire, support and encourage women to become engineers, technicians, electricians, motor mechanics, construction workers, pilots, machine shop operatives, draughtswomen and many more. 100 years later WES are celebrating the many women who excelled – often against the odds – in these professions which often deliberately excluded women. The 100 Years of Women in Engineering campaign has identified the top 100 women engineers who have been influential in the UK in all engineering fields, who lived at some time between 1919 and 2019.

The list includes: Henrietta Bussell (1917-1996), the UK's first female railway engineer, she became one of the senior tunnels & bridges engineers for British Rail Western Region, the pilot and engineer Amy Johnson and Mabel Matthews the founder of the Electrical Association for Women. It includes well-known women from the Second World War period such as Tilly Shilling, who developed the valve that prevented Merlin engines stalling when diving; and Hilda Lyon, who developed the 'Lyon Shape' used for the airship R101, together with the unnamed construction workers who rebuilt Waterloo Bridge during the Second World War, also known as the Ladies' Bridge, and the women of Bletchley Park, the governments wartime code breaking centre.

The Women's Engineering Society is a membership organisation which was established in 1919 and still exists today to encourage, inspire and educate women in engineering (more information at **www.wes.org.uk**). Its centenary campaign includes a Centenary Trail which aims to add the details of many of these women engineers to a map of the UK and feature them all on Wikipedia. To see the full list, with biographies, visit **www.magnificentwomen.co.uk**.

With thanks and acknowledgements to the following news sources: Railway Gazette International, Rail Media, Metro Report International, International Railway Journal, Global Rail Review, SmartRail, Shift2Rail, Railway-Technology and TelecomTV News.

News from the IRSE

Blane Judd, Chief Executive

ASPECT2019///

Institution of Railway Signal Engineers | Delft University of Technology | IRSE Nederland

ASPECT 2019 – the chief executive's view

I had the privilege of joining over 200 delegates from 17 countries at my first ASPECT conference, enjoying the exceptional hospitality of our Dutch local section.

I was greatly impressed not only by the quality of the papers presented, but also by the active engagement of delegates with the Q&A after each of our 19 sessions, discussing emerging themes that we will continue to explore in future events.

Central to ASPECT is this enthusiastic collaborative exchange between colleagues, a sharing of ideas that reinforces the importance of this event not only for our members, but for our sector as a whole. No event in our calendar could be more in line with our "Beyond 2020 Vision" as we seek to grow the IRSE and to build and extend our global network of talented rail professionals. I believe many such new connections were established over the last several days.

It was great to see different local sections come together and offer support to one another as well as enjoying the local social and cultural experience in the beautiful city of Delft.

The generous support of our corporate sponsors is essential to the success of this event and I was pleased to hear from each of them that they found ASPECT a useful opportunity to forge and deepen relationships across our sector.

Top right, our President, George Clark, opens ASPECT 2019.
Right, Blane's first ASPECT conference address.
Below, the event was held in the beautiful city of Delft in the Netherlands.

IET.tv in action.

There was plenty of opportunity for networking during the event.

Great interest was shown in IRSE membership at our stand.

Blane meeting with fellow attendees.

This year's conference included some technical firsts in its organisation, including a dynamic app to replace the traditional printed programme and reduce our environmental footprint. In addition to details and timings for each day, this technology allowed us to provide enhanced detail on each speaker and grant instant access to papers, including the detailed range of reserve papers that could not be presented live at the event.

Parallel sessions offered an increased choice of subject matter for delegates, while this year's use of simultaneous video recording meant that choosing one presentation need not mean missing out on another.

In addition to press, media and promotion for ASPECT, our communications team worked with IET.TV to engage with attendees and provide additional insight into the conference this year – we look forward to sharing a range of delegate stories from ASPECT with you online in the near future.

We are indebted to the organising committee for all their efforts in assembling this year's conference.

Our thanks go in particular to Prof Dr Rob Goverde, TU Delft and the responsive and capable team at the AULA conference centre, which was an ideal venue for this flagship event.

The committee were ably and fully supported by our comms team and the dedicated staff at IRSE HQ and volunteers who are so very central to the impressive range of regular events and activities the Institution is able to provide.

To everyone involved – "Dank je wel"

I look forward not only to next year's convention in Toronto, 7-11 September 2020, but also to meeting many of you at ASPECT 2021 in Australia.

Presentations were given on a wide variety of topics related to the conference theme of Resilience. Here Prerna Sharma presents "Building a resilient railway through its workforce".

The conference dinner was held in the stunning surroundings of the Nieuwe Kirke.

Midland & North Western Section

IRSE
Institution of Railway Signal Engineers
MIDLAND & NORTH WESTERN SECTION

Transpennine Route Upgrade

Report by Ian Mitchell

The 17 October meeting of the Section got off to a rousing start with a promotional video entitled "The North shall rise again", publicising investment in new trains and infrastructure across the North of England. Our speakers, James Hodge and Gregor Dowdy then focused in on the project they are working on to modernise the infrastructure of the main route between Manchester and Leeds via Stalybridge and Huddersfield.

The remit for the investment is to reduce journey times, accommodate additional train services, and improve timekeeping performance. The train service specification is for four fast trains, two semi-fast and two stopping trains in each hour, which proves to be quite challenging as the fast trains are required to run at 'clock-face' 15-minute intervals, on a double track route with very limited facilities to overtake slower trains.

A large number of potential interventions were studied, and the costs and impacts evaluated. The final solution comprises remodelling of the junctions at the west end of Stalybridge, remodelling and new platforms at Huddersfield, and an additional pair of tracks between Huddersfield and Ravensthorpe to segregate through passenger trains from Manchester to Leeds from local services and freight between Wakefield, Huddersfield and Bradford.

One interesting point made by the speaker was that the biggest improvements in journey time come from focusing on low speed areas – the time saving for improving a 500m stretch from 25-30mph is the same as improving 8km from 105-110mph.

The original intention was for the route to be fully electrified with 25kV overhead lines, but following delays and cost overruns on recent Network Rail electrification projects, this has been de-scoped. Electrification will be provided between Huddersfield and Leeds where there will be performance benefits from use of electric traction on local stopping services. This leaves a non-electrified gap between Stalybridge and Huddersfield which will require the longer distance trains to continue with diesel or bi-mode trains.

From a signalling point of view the project was expected to be relatively straightforward with renewal of life expired interlockings and recontrol to the Manchester and York ROCs – that is until it was decided that the route should be a pioneer for rollout of ETCS level 2. This required the Transpire alliance that has the contract for route upgrade to engage with the Digital Railway Programme to determine how to deploy ETCS on the route. The delivery concept is that Transpire will design a 'digital ready' solution including trackside equipment and interlockings and a separate ETCS contractor will be engaged to provide the ETCS equipment.

During the design process it became apparent that the standards defining 'digital ready' require extensive discussions to identify the required design rules. Decisions were required on topics such as length of overlaps (linked to the permitted speed in the ETCS 'staff responsible' mode), provision of ETCS stop markers in cab signalled only areas, and location of transition zones between lineside and cab signalling.

The migration strategy is still under discussion. For the first stages of resignalling (focused on replacing life-expired assets), temporary lineside signals will be installed in a manner that will allow them to be easily removed after ETCS is commissioned. For later stages where a lot of new infrastructure is being installed, it is hoped this can be avoided by commissioning with ETCS from the start, but this will depend on alignment with train fitment and driver training programmes.

The meeting was exceptionally well attended, with 46 members and visitors in the room. The Midland and North Western Section thanks Network Rail for providing the room, and the Transpire Alliance (Amey, Arup, BAM Nuttall and Network Rail) for the speakers.

London & South East Section

Innovating in the rail industry with HackPartners

Report by Benoît Surroca

On 26 June, IRSE London and South East members were invited by HackPartners to talk about innovation in the rail industry.

River Tamoor-Baig, HackPartners' co-founder, explained how a delay in his train journey as an IT consultant led him to create a business aimed at bringing innovation to our industry.

HackTrain is the hackathon that HackPartners run to try to solve industry problems in 48 hours over a weekend of madness and fun. Teams of 'hackers' come up with prototypes that can solve real industry issues. The winning team of the 2018 HackTrain 5.0 took the vegetation infringement problem posed by Network Rail. They developed a proof of concept based on image processing to create 3D structures from motion images provided by Network Rail. This innovative solution received £250K funding from the DfT and made it to the front page of The Times under the headline "Leaves on the line? AI signals end to commuters' train pain".

River also told us how another image processing solution they developed helped Network Rail to save millions in brick crack identification, and HackPartner's most used solution is 'busybot', which has helped 9.5 million passengers to find a seat on trains.

The ease with which the innovators come up with solutions to problems in rail's complex industry in such a short time may be surprising but River also explained how HackPartners collaborates with rail companies to streamline paths to innovation and to prepare data packs that will make the hackers' task a lot easier. The winning vegetation solution may have been created in principle in only two days, but months of development and administrative work also followed to enable trial running.

There are legions of talented people who don't know our industry and may not consider a career in it due to its seemingly archaic reputation. The can-do attitude from HackPartners is extremely refreshing and much needed to ensure that our industry makes the most of available technologies and attract more talent.

If you haven't taken part in a hackathon yet, you definitely should. Being experienced isn't an excuse as hackathons are for everyone who is ready to keep an open mind and put in the extra work. And you can encourage others to give it a try.

Members of the IRSE LSE were energised by HackPartners, leading to many discussions and debate after the presentation as we enjoyed the refreshments provided by our host and the free pizzas offered by the IRSE LSE Committee.

Members enjoying the lecture and the lively discussions that followed.

If you would like to enjoy some interesting transport, rail and signalling related presentations and discussions in and around London, please join us, our events are on EventBrite and **irse.info/nearyou**. You can also contact us on **londonse@irse.org**.

We hope to see you soon.

The FTN/GSM-R story

Report by Trevor Foulkes

Unfortunately, the planned presentation to the London & South-East Section on HS2 on 26 September could not go ahead so instead I gave a presentation on how the FTN / GSM-R programme came about. When I joined the project, the national provision of Global System for Mobile Communications – Railway (GSM-R) for Great Britain had been authorised but there was no approach agreed on how to connect the component parts of the GSM-R system together.

My task was to work out the most cost-effective way to do this. When I started, I thought the solution would be to use non-railway British Telecom circuits to provide 2Mbit/s points of presence along the line. So we worked up three options during feasibility: 1) Use of BT; 2) Use of Global Crossing (the supplier of communication services to Railtrack) and 3) Build and run Railtrack's own network. The third option was based on providing fibre on 11 000km of the 15 000km of route and the use of a Synchronous Digital Hierarchy transmission system (SDH).

I also had to form a view on the condition of the copper cable, which was done by visiting the jointing teams and asking them how maintainable the cables were. This was with a view to assessing their usability as local distribution cables.

Once the feasibility business case was finished, the "build Railtrack's own network" option had a considerably lower whole life cost and so was recommended to be developed. The Fixed Telecom Network (FTN) was born. FTN was the first project to reach GRIP level 4 under the then-new, Railtrack Governance for Railway Investment Projects (GRIP) process. It was also thought prudent to choose a transmission supplier so that a test bed could be set up to test that the network would work as expected. At this point Railtrack went into Railway Administration that meant all funds were frozen for some months.

I then went on to explain the different layers of the FTN network from SDH STM-16 at the top for national circuits to copper cables at the bottom for local phones, etc. I explained that around this time Global Crossing went into Chapter 11 (a form of bankruptcy in the USA) which released many competent ex-railway engineers to come and join the FTN team. During the development of the FTN project we decided it would be best to combine it with the GSM-R project and hence the FTN / GSM R programme was formed. This allowed the two projects to roll out together using the same relocatable equipment housings. We also took the decision to design the systems in house and just buy equipment from suppliers, so I led the system design and integration on behalf of Network Rail.

The project established the Telecoms Engineering Control (TEC) to manage and operate the network and established a team of commissioning engineers to accept the equipment. My idea was to build the network using the approach used for the Crystal Palace in London, i.e. to install lots of pre-tested and similar pieces to construct the whole network to support Network Rail's telecommunication requirements.

GSM-R simulator training.


Telecoms Engineering Control (TEC).

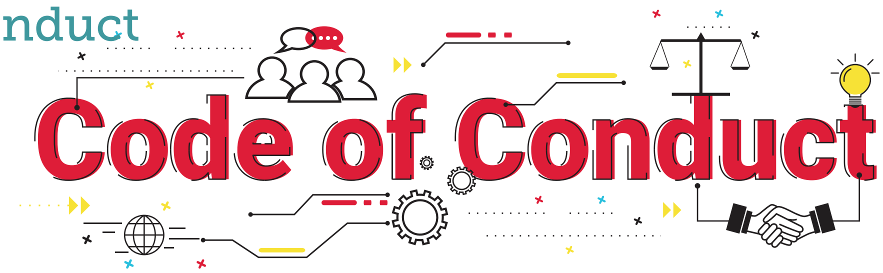
The early roll-out stages were to support resignalling schemes, which we called "synergy" schemes. The most interesting was the Cambrian ETCS trial line where we not only had to provide radio voice and data services but also a switched IP based network to connect the signalling elements. This was one of the first schemes to use IP for signalling. I also actively encouraged the signalling engineers to install their equipment into the FTN/ GSM-R relocatable buildings, which they did.

A fibre cable was developed which did not need to be protected by a concrete cable route, which became known as Double Insulated Super Armoured Cable (DISAC). The innovation saved the programme about £200m.

The programme also had to develop a cab radio to go in every train cab which was acceptable to all the train operators and complied with European legislation. I finished the talk saying how proud I was to be given the opportunity to be part of the programme which has made a real difference to the Railway.

Professional responsibility

Code of Professional Conduct



Every professional engineering institution requires its members to comply with a code of professional conduct. The Engineering Council requires each licensed professional engineering institution to place a personal obligation on its members to act with integrity and in the public interest. It requires the code to be worded in such a way as to encourage member to act in accordance with the Statement of Ethical Principles published by the Royal Academy of Engineering and the Engineering Council. The Engineering Council also requires institutions to ensure that they have appropriate disciplinary processes in place to deal with breaches of Codes of Conduct. The IRSE Code of Professional Conduct is available to members on IRSE website and the current version was approved by the IRSE Council on 13 June 2018.

1. About this Code

The IRSE promotes and encourages ethical and safe behaviour in the practice of railway signalling, telecommunications, train control and traffic management engineering.

This Code of Professional Conduct provides rules, information and guidance for members on ethical and safe behaviour. By being a member of the IRSE, you agree to abide by the current version of the Code.

This Code adds to the general statements made in the IRSE's Memorandum and Articles of Association and the Bye-Laws and is based on the Statement of Ethical Principles created jointly for all engineering professionals by the UK Engineering Council and the UK Royal Academy of Engineering (revised 2017).

Throughout this Code of Professional Conduct, words implying the singular number should be understood to include the plural number, and vice versa.

The following rules for the professional conduct expected of IRSE members were approved by the IRSE Council on 13 June 2018.

These rules are written in general terms, expressing broad ethical principles. They indicate how you are required to conduct yourself in frequently encountered situations.

The IRSE recognises that there may sometimes be conflicts between your personal interests, local laws, and your duty to others. If there is any conflict between your personal interests and fair and honest dealing with the community, your duty to the community shall prevail.

If there is any conflict between this Code of Professional Conduct and local laws, you should comply with this Code to the maximum extent possible without breaching the local laws.

If you fail to observe these rules, you may become subject to disciplinary action under the provisions of the Institution's Articles 17 and 18.

IRSE reserves the right, at its discretion, to publish the details of established breaches of this Code of Professional Conduct. If you are considered to have potentially breached this Code and are registered with the UK Engineering Council, the Institution may inform the Engineering Council of the potential breach. If it is subsequently established that there has been no breach of this Code then, at your request and using any manner of publication that the Institution sees fit, the Institution may publish this conclusion.

Under these rules:

- Any reference to 'member' shall mean any class of member listed in the Institution's Article 3;
- Any reference to 'employer' also includes 'client'.

2. Rules of Professional Conduct

You shall at all times:

- Act with honesty and integrity;
- Have respect for life, law, the environment and public good;
- Work with accuracy and rigour;
- Abide by and promote high standards in leadership and communication.

2.1. General

You shall:

2.1.1. Comply with the requirements of the IRSE's Memorandum, Articles of Association and Bye-Laws insofar as they apply to you.

2.1.2. Accept personal responsibility for all work done by you, or under your supervision or direction, under the authority delegated to you.

2.1.3. Assess your liability for the consequences of your work and, if appropriate, hold appropriate professional indemnity insurance.

2.1.4. Notify the IRSE if you have:

a) Received a criminal conviction, or an adverse civil court judgement, related to any aspect of the IRSE's Code of Professional Conduct (whether in UK or overseas).

b) Had membership of another professional body terminated as the result of a disciplinary procedure.

c) Been declared bankrupt or disqualified as a Company Director or Charity Trustee.

2.1.5. Support a colleague or any other person to whom you have a duty of care who in good faith raises any concern, either within the workplace or externally, about a danger, risk, malpractice or wrongdoing which affects others.

2.1.6. Notify the IRSE of any significant violation of the IRSE's Code of Professional Conduct by another member.

2.2. Honesty and integrity

2.2.1. You shall uphold the highest standards of professional conduct including openness, fairness, honesty and integrity.

2.2.2. You shall:

a) Act in a reliable and trustworthy manner.

b) Be aware of the ways in which your work and behaviour might affect others.

c) Respect the privacy, rights, professional reputations and business of the Institution and of other members, employees, parties and individuals.

d) Respect the confidentiality of other members, employees, parties and individuals; including your current and previous employers.

e) Declare conflicts of interest to your employer.

f) Avoid deception and take steps to prevent or report corrupt practices or professional misconduct.

g) Reject bribery and improper influence.

h) Not imply that you are acting on behalf of, or with the authority of, the Institution, unless you are conducting Institution business in an approved capacity or role.

i) Not knowingly mislead or allow others to be misled in your capacity as a railway signal, telecommunications, train control or traffic management engineer.

j) Be objective and truthful in any statement you make in your professional capacity, including identifying your qualifications as a railway signal, telecommunications, train control or traffic management engineer.

k) Use the appropriate post-nominal for your current classification of membership (HonFIRSE, FIRSE, MIRSE, CompIRSE or AMIRSE) only if you have fully paid any IRSE membership subscriptions that are due.

2.3. Respect for life, law, the environment and public good

2.3.1. You shall uphold applicable laws and regulations and give due weight to facts, published standards and guidance and the wider public interest.

2.3.2. You shall:

a) Ensure that your work is lawful and necessary.

b) Ensure so far as possible that the safety requirements of your work, the work of your associates and the work of those in your charge are correctly assessed and applied.

c) Identify, evaluate, quantify, mitigate and manage risks, both direct and indirect, associated with your work.

d) Respect and maintain the physical and cyber security of systems and data on which you work, or to which you have access.

e) Respect and protect personal information and intellectual property.

f) Protect, and where possible improve, the quality of built and natural environments.

g) Maximise the benefit of your work to the public, and minimise both actual and potential adverse effects for the present and succeeding generations.

h) Take due account of the limited availability of natural resources.

i) Uphold the reputation and standing of the profession and Institution.

j) Inform IRSE, or the appropriate government agency, if you are aware of, or suspect there is risk that, IRSE is being exploited for terrorist or other illicit purposes through the use of assets, premises, employees, members, volunteers or other resources, or through association with individuals or organisations who are engaged in illicit activities.

k) If you are also a member of another institution or professional body, honour the obligations of membership of that body unless these are incompatible with membership of the IRSE.

l) If you are also a member of a trade union, honour the obligations of membership of that trade union unless these are incompatible with membership of the IRSE. You may take part in industrial action provided your actions are in accordance with the constitution of your trade union and the laws of the country in which you are working.

2.4. Accuracy and rigour

2.4.1. You shall acquire and use wisely the understanding, knowledge and skills needed to perform your role.

2.4.2. You shall:

a) Act with care, exercising your professional skills and judgement to the best of your ability, and discharging your professional responsibilities with integrity and fairness.

b) Undertake tasks and responsibilities as a railway signal, telecommunications, train control or traffic management engineer in those areas in which you are competent or are under competent supervision, working within the limits of your authority.

c) Take all reasonable steps to ensure that persons working under your authority are competent to carry out tasks assigned to them.

d) Maintain and develop your professional competence, knowledge and skills by attention to existing and new developments in science and engineering relevant to your field of professional activity, through planned continuous professional development throughout your working life.

e) When presenting or reviewing theories, evidence and interpretations, do so honestly, accurately, objectively and without bias, whilst respecting reasoned alternative views.

2.5. Leadership and communication

2.5.1. You have a duty to abide by and promote high standards of leadership and communication.

2.5.2. You shall:

a) Promote equality, diversity and inclusion, and exemplify professional behaviour generally.

b) Help others understand the benefits of railway signalling, telecommunications, train control and traffic management engineering.

c) Encourage and assist others to develop their railway signal, telecommunications, train control and traffic management engineering competence, knowledge and skills.

d) Challenge instructions, statements or policies that cause you professional concern, and listen to the concerns of others.

e) Take all reasonable steps to ensure that people or organisations overruling or not accepting your professional advice are made aware of any danger which may result, including, as appropriate, raising concerns within the workplace or externally about a danger, risk, malpractice or wrongdoing which affects others.

You are advised to register such concerns with the Institution. The Institution, at its discretion, may pursue the matter on your behalf.

Professional development

IRSE Exam goes digital

Hedley Calderbank

One of the four compulsory modules which are required to pass the IRSE Professional Examination will go online in October 2020. This will be the first time that the Institution has offered an online examination. Computer based testing is now widespread in professional institutions, universities and colleges. Although simple multiple-choice questions still feature, the techniques have become more sophisticated. For example, candidates can be asked to select multiple correct answers, to rank a list of options, or to choose the best and worst options. It is also possible to include manual marking of free text answers, although we do not plan to use this feature initially.

The online format will be applied to a new 'foundation level' module A which will be a pre-qualification for taking the three advanced modules. These modules will stay at the same high level as today.

Machine-marked questions need to be skilfully set so that they present a genuine test of candidates' knowledge, while minimising the marks that can be earned from intelligent guesswork and common sense. This is made more challenging because we also need to be fair to candidates working outside the UK main line industry. Many of our original draft questions had to be rejected because they assumed knowledge of UK working practices and terminology, or because it proved impossible to frame a clear, unambiguous question where there could be no doubt of the correct answer.

Once we were reasonably satisfied with our questions, we set a 'trial exam' which was taken over a period ending in mid-November. Over 100 candidates from across the world volunteered to sit the exam. This included communications specialists and those with a metro background. Also included were volunteers with no specialist railway knowledge to check how many marks could be earned by guesswork. Now we are analysing the results of the trial exam and a subsequent survey of the volunteers. We will use the lessons learnt from the trial when we create a large bank of questions from which the October 2020 and subsequent exams will draw.

Techniques already exist for taking an exam at any time with questions being randomly set from a very large question bank. Remote invigilation techniques are also available. Initially however, we will keep it simple, using a traditionally invigilated online exam on a single day.

The IRSE intends to promote module A to a much wider range of railway professionals working in and around the control and communications area, such as software developers, project managers and installation managers. It will attract a standalone foundation level qualification. A machine-marked exam will enable this expansion without any greater workload for the examiners. Results can also be delivered very quickly.

Around 20 IRSE members have been involved in the work to reformat the syllabus and modules for the IRSE exam. The development of the online module A is the largest job, but a great deal of work on many other aspects has been needed to deliver the changes which were approved by IRSE Council last April.

Full details of the changes to the examination and some specimen module A questions appear on the IRSE website at **irse.info/arwx9**.

Your letters

If you have any views, opinions or experiences you'd like to share with fellow members, drop us an email at **editor@irsenews.co.uk**.

We welcome your letters on any subject, perhaps there's something you've seen in an IRSE News article you disagree with, or you have come across a particular problem or solution that you'd like to share.

We'd love to hear from you.

ASPECT 2019: Attendee feedback

This year's ASPECT conference was a great reflection of the institution's increasing diversity. Attendees came from nearly every continent and shared both experiences unique to their own local operating environments together with new concepts. I have particular respect for those who delivered exceptional presentations outside of their native language. We had more younger presenters than ever before, delivering engaging subjects and this was the first ASPECT with a dedicated cyber security panel. On the subject of gender diversity we heard a range of views of what diversity means to rail industries around the world.

Alex Patton

Error in black and white

In my article marking the 20th Anniversary of the Ladbroke Grove collision (IRSE News October 2019) I inadvertently inverted black and white in describing the debate which went on regarding the ETCS architecture. What the railways favoured was a 'white box' solution with interchangeable subsystems. What we got, and industry favoured, was a 'black box' solution with standardisation only at the 'air gaps'. My apologies, despite many proof reads I only noticed this when I got the printed magazine, and congratulations to Frans Heijnen for also spotting it.

Rod Muttram

Midland & North Western Section

MNW Section 50 years anniversary

IRSE///
Institution of Railway Signal Engineers
MIDLAND & NORTH WESTERN SECTION

Fifty years ago, in November 1969 40 Members of the IRSE met in Crewe to form the Midland and North Western Section of the IRSE.

A committee was elected consisting of H Taylor (chair), R Blyth (vice-chair), B Hesketh, F Kerr, P Dibden, R A Drury, P Stanley, and D Roberts (secretary/treasurer). The inaugural meeting was held in the following year in Crewe on February 4 1970, when the president, O S Nock, wished the section every success and introduced the guest speaker, J Tyler, chief S&T engineer British Railways Board, who gave his paper entitled "Signalling for High Speed Trains" to the 153 persons present. The subject was very far sighted, as 50 years later signalling for High Speed 2 through Crewe may soon be the subject of another paper.

To mark the occasion 50-year anniversary badges and ties will be available for sale at all MNW section events for £15, and the current committee are arranging a dinner at The Crewe Arms on the anniversary of the first meeting, Tuesday 4 February 2020. The menu will be a typical 1970s style meal of prawn cocktail, chicken and black forest gateau at £25 per person, with a vegetarian option available. The intention is that it will be an informal gathering and the opportunity for those involved with the section over the years to 'break bread' and share memories. The section plans a display of memorabilia, and it will be an opportunity for tie wearers to wear their 50th anniversary ties and badges. If you are interested in joining the section on Tuesday 4 February, please contact Peter Halliwell at **peter.halliwell@hotmail.com**.

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at irsenews@irse.org.

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Your feedback

2019 IRSE News reader survey

One of the benefits of membership of the Institution is receiving IRSE News 11 times a year. Our objective is to inform, discuss and develop, and to publish a wide range of industry and section news, topical articles, feedback and information relevant to members. In order to hear what readers think of IRSE News and to identify how we could improve your magazine a survey was organised in the middle of 2019. We received responses from grades of membership from Affiliate to Fellow with 67% of responses from UK members and 33% from non-UK members.

We asked what you thought of the design and layout of IRSE News.

- 98% said they thought the size and appearance of the text in IRSE News was about right, with 97% saying the number of pages was also about right. The other 2% said there were too few. We now regularly publish 40 pages in each issue, compared to 32 a few years ago, and this December issue has 44 pages.
- 80% thought the length of articles was about right, with 20% that they were too long. 84% said we had the balance of diagrams and images right, with the remaining 16% saying they would like more illustrations.
- 75% thought the technical content of IRSE News is about right, with 21% would like more and only 3% less.
- 50% thought the balance of UK non-UK content was about right or had no view, 41% want more non-UK content with 9% less.
- On the question of the amount of industry news, 10% of readers wanted less, 43% want more with 47% indicating it's about right.
- 81% of responses said we should retain the name "IRSE News" for the magazine and not to change it.

The feedback was positive when we asked how we could improve IRSE News, such as "Not much to improve". "Nothing, really enjoy reading as soon as I get my hands on it". "I generally find that the present news coverage is quite sufficient". "Fine as it is, don't tamper with a winning formula". "Nothing springs to mind. I am happy with it the way it is". "It is fine, thanks to all who make it happen". "Not sure, I have enjoyed this magazine for many years".

Some members said they would like to see fewer heritage articles and more on today's railway, but others said they would like historical-related articles as a background to subjects such as speed or route signalling or the fundamentals of point operation, and how signalling has developed from old technology to new. Several responses contradicted each other which is inevitable in an organisation as diverse as ours. One response summed this up perfectly, "The content should reflect the members' interest and in a multinational, multicultural institution, this is difficult if there is only one printed journal."

You told us that you'd like to know more about how projects overcome challenges and constraints, how they are delivered, and more about the project lifecycle. Maintenance, faulting and installation activities were other suggestions for articles.

Another suggestion was joint articles with other professional institutions and their magazines such as PWI News and the IMechE Rail Division. We are already in discussion with the editor of PWI News, with whom we have plans to collaborate with articles. IMechE member David Shirres has an article in this issue.

Members said they like articles featuring members and their careers, personalities and the work of some of the committees, and not the same old faces. We would like to publish more people and careers articles, so if you would like to feature in IRSE News please contact the editor. Articles to support day to day design activities, basic design and signalling principles, how and why we do things, approval processes, R&D, networking, IT, systems engineering, safety and assurance, and projects were other suggestions. We need your content so please contact us with anything which may help. We have experienced engineers to assist writers, especially those who do not have English as their first language.

Mention was made of the level of peer review carried out of articles and papers. We are fortunate to have an international review team made up of industry experts in many fields. This includes several former professional heads of signalling and telecoms, current senior railway engineers and specialist experts in several different fields. The team supplements their reviews with expert advice for subjects in which they are not fully competent. Editorial comments are made on most articles and we work with the authors to confirm details, and sometimes to challenge statements made. If, however, your experience differs from that in articles, or you don't believe that something is quite right, please write to the editor. We value your views and always follow up all feedback.

Several responses amplified the importance of articles covering some of the underlying principles of the profession. We have started what we hope will be a long series of 'back to basic' articles; but we need your help, and in particular from experienced engineers to guide the next generation. So, if you have an article or paper you would like the IRSE to consider for publication on any subject or project, please contact the editor at **editor@irsenews.co.uk**.

The full survey results can be found at **irse.info/q4nhe** and we thank everyone who took the time to provide the feedback received. We are studying all the feedback to improve IRSE News where possible. If anyone else has any other suggestions on how to improve your magazine please do not hesitate to contact us.

IRSE News

Institution of Railway Signal Engineers

January 2020

Delivering CBTC in Hong Kong

Digitalisation improving customer experience

Completions delivering full benefits

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IRSE///
Institution of Railway Signal Engineers

Issue 262
January 2020

In this issue

Feature articles

News and opinion

From the IRSE

From our Sections

Are we realising the benefits?

As I near the end of my presidential year, I reflect on successful changes to the world's railways that I have seen or read about this year. Delivery of change is challenging but, just as importantly, it is essential to be clear about the benefits of change if the benefits of a sustainable change are to be realised in practice. The question 'why are we doing this project?', which is so often not clearly communicated to those delivering a project, or is lost during the drive to achieve project milestones, must be kept at the forefront of our minds at all times.

The theme of this year's ASPECT conference (summarised later in this issue) was "resilience", and while this can be interpreted many ways, one key message was that being clear on the actual customer benefits makes a difference. This was well illustrated by the presentation on the London Underground Victoria Line capacity enhancement project – the customer benefit was a consistent 36 trains per hour (tph) peak service operation. That delivery of a resilient system was as much about competent people and process as it was about the technology. In this case the success has been further built upon by lengthening the peak periods of 36tph running to provide greater capacity to meet ever increasing passenger demand.

Delivery is challenging, and you only need to look at the work being undertaken in Hong Kong described in this issue of IRSE News, or the ERTMS roll out in Denmark that featured in the December 2019 issue, to see that the capacity-driven benefits can be delivered by embracing the latest technology. Railway signalling projects are indeed embracing new technologies, but must look beyond traditional sources to maximise the achievable benefits. Last November I hosted the first IRSE Webinar which focused on the world of communications systems. That focus was as much on the non-rail arena as it was on rail client expectations. The round-table discussion after the event (a video of which will appear in the members area of the web site) showed that we have a lot to learn when our asset strategies span the 20+ year life of signalling systems but technology is moving at a pace which makes those systems out of date in five years.

So, are we realising the benefits? Does the end customer see these in the form of a sustainable solution? I see the need for much wider change, becoming far more pro-active and with clearer goals, if we are to truly realise the benefits of the huge investments in railways being made around the world.

George Clark, president, IRSE

Cover story

The Glasgow Subway is an underground light rapid transit line in Glasgow, Scotland and on p30 we report on the Young Rail Tours visit to the depot at Govan. Opened on 14 December 1896, it is the third-oldest underground metro system in the world after the London Underground and the Budapest Metro. It is also one of the very few railways in the world with a track running gauge of 4ft (1219 mm).

The Subway is currently undergoing a £288m (€336, $370m) modernisation programme that will see the introduction of all new driverless trains, new signalling and 15 stations upgraded.

Photo David Westcough

I R S E ///
Institution of Railway Signal Engineers

Delivering CBTC in Hong Kong – carrying the changes

Gordon Lam

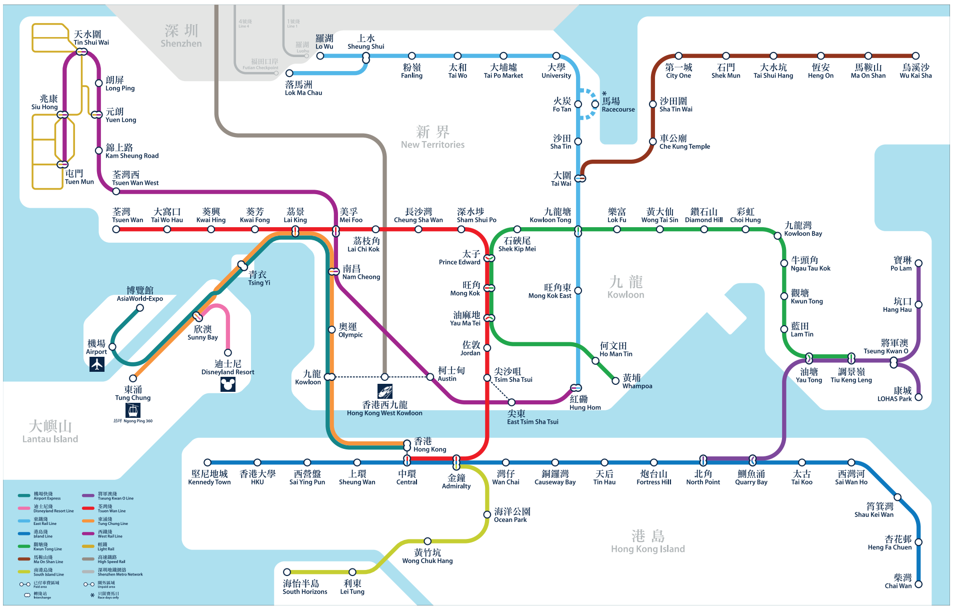
This article is based on the third Presidential Paper of the 2019/2020 year which was presented in London on 5 December 2019.

MTR operates 11 domestic heavy railway lines and a light rail system and carries more than 5 million daily passenger trips on average in Hong Kong. In addition, we also operate high speed rail connecting Hong Kong to the high-speed rail network in China. Reliability of on-time service is continuously maintained at a high level and the railway strives to keep up its high performance. Similar to other railway operators in the world, we are facing a number of challenges including Near Capacity Operation (NCO) and increasing demand for train service reliability.

To meet growing demand for mobility in Hong Kong and further enhance the customer experience, a series of initiatives known as Rail Gen 2.0 has been launched which aims to upgrade and extend the existing network in order to bring superior connectivity, better facilities and services. One important mission is to upgrade most of the signalling systems in our network. The signalling upgrade will bring enhancement to 8 out of the 11 heavy railway lines and cover over 70% of MTR's existing heavy railway route length in Hong Kong.

Key features

The new systems adopt a number of key features with an aim to maximise the capabilities of MTR's signalling systems, enhance reliability and improve operational efficiency.



The MTR network in Hong Kong is complex and carries more than 5 million passengers every day.
Image MTR Corporation.

- Moving block Communication Based Train Control (CBTC): Compared to the previous generation of signalling, trains are able to operate with shorter headways achieved by moving block signalling.
- Enhanced redundancy and resilience: The new systems have enhancement initiatives on service reliability and availability. Fault tolerant design is adopted by providing enhanced redundancy. For trackside subsystems responsible for the train control, for instance, the Zone Controller, which provides integrated functions for interlocking and train control, is provided with warm standby as well as the usual hot standby, giving extra assurance on availability. On the other

"Reliability of on-time service is continuously maintained at a high level"

Lines		Route length	Existing (legacy) signalling system (ATC and interlocking)	New signalling system	Expected completion
DUAT Lines	Tsuen Wan Line, Island Line, Kwun Tong Line, Tung Chung Line, Airport Express	127.7km	Alstom SACEM with relay interlocking/SSI	Alstom-Thales SelTrac CBTC	By phases from 2021 earliest to 2026
	Tseung Kwan O Line and part of Kwun Tong Line		Siemens SACEM with SICAS interlocking		
	Disneyland Resort Line		Thales SelTrac CBTC		
East Rail Line		41.1km (existing) + 6km (extension)	Alstom TBL with SSI	Siemens Trainguard MT CBTC	2020/2021 earliest (extension)

Table 1 – signalling upgrade projects being undertaken by MTR in Hong Kong.

hand, 4G-LTE also serves as a back-up for Wi-Fi communication with a similar consideration of enhancing availability.

- Readiness for Fully Automatic Operation (FAO): The new signalling systems are equipped with facilities to enable Fully Automatic Operation. FAO will bring more flexibility to train deployment and operation, further enhancement in reliability, and hence improved customer service.

"Projects cover more than 160km of route length across eight railway lines"

Signalling upgrade

The signalling upgrade projects cover more than 160km of route length across eight railway lines. Works on four lines are underway concurrently. The current priority is given to the East Rail Line and Tsuen Wan Line (TWL), which are the busiest railway lines in Hong Kong carrying more than 2 million passengers per day. The upgrading of these two railway lines is expected to be completed from 2020 onwards. Further works on a 6km railway extension of the East Rail Line that is under construction is due for completion by 2021 earliest. Signalling upgrade works for the remaining lines are expected to be completed progressively to 2026 (refer to Table 1). The contract sum of the signalling upgrade projects amounts to about HK$4.16bn (about US$530m, £410m). The works have been progressing steadily since the contract award for the East Rail Line and DUAT Lines projects in December 2012 and January 2015 respectively.

Progressive migration – changes little by little

The TWL is the first line to be commissioned as part of the signalling upgrade for DUAT lines. There are 12 migration steps in total for replacement for DUAT Lines. Some key steps are summarised as below. In summary, the migration strategy adopted for TWL is Mixed Mode Operation (MMO).

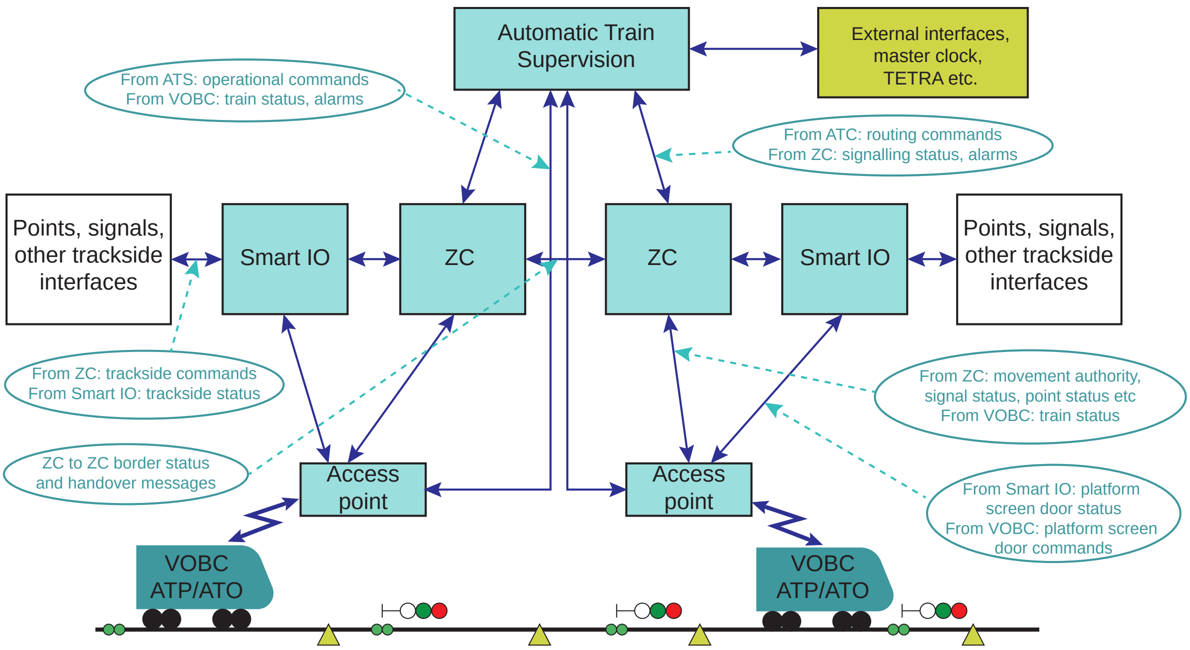
In TWL, 36 existing trains (M-trains) will be dual-fitted with existing and new signalling systems, which enable them to operate in either existing mode SACEM (Système d'aide à la conduit, à l'exploitation et à la maintenance), or with new CBTC controls. The commissioning of the TWL will be performed in three different phases:

Shadow mode

All the central, trackside and on-board CBTC equipment will be powered up in this phase after the completion of acceptance tests on site. The CBTC system will however only monitor the statuses of the trains and infrastructure.

In shadow mode, the new CBTC system is not in charge of the protection of the trains or the management of the infrastructure. Instead, it monitors the status of existing equipment, health of the trackside CBTC equipment and train positioning such that train tracking is performed. Dual-fitted trains operated in SACEM control with

The underlying system architecture and information flows. ZC is zone controller and VOBC is vehicle on-board computer.



communication between the Vehicle On-Board Controller (VOBC) and the CBTC trackside system maintained will also facilitate CBTC functions related to SACEM-Communicating Train (SACEM-CT) testing in this phase.

For trackside subsystems a relay-based trackside changeover mechanism is used to connect or isolate the new system from the field devices (i.e. points, signals, etc.) while allowing the new system to continuously obtain the status of the field devices. Local and remote changeover controls will be provided to command switching of the change-over mechanism. When the trackside control is in SACEM control, the field devices are isolated from the command of the CBTC system. When the trackside control is switched to CBTC, the system can operate the field devices.

"For trackside subsystems a relay-based trackside changeover mechanism is used"

As for trains, dual-fitted trains will operate in SACEM control mode with the train borne CBTC powered on and they will be treated as SACEM-CT by the CBTC system. Communication between the train borne CBTC and the Automatic Train Supervision (ATS), Zone Controller (ZC) and Smart IO (SMIO) can therefore be tested in Shadow Mode. Similar to trackside, train borne CBTC will not command any output and its outputs are isolated from the train by the on-board changeover relay.

The CBTC system in shadow mode will behave as the final system with full trackside elements implemented and configuration i.e. ATS, ZC, VOBC and SMIO will exchange their information but no controls will be issued to field elements, train interfaces and external interfaces.

To ensure no Limit of Movement Authority (LMA) will be issued by the CBTC system, the CBTC system will 'close' all tracks in shadow mode as no LMA will be computed by the train borne VOBC.

In particular the shadow mode will enable the testing of the following:

- Communication robustness between subsystem: ZC-SMIO, ZC-ATS, ZC-VOBC, ATS-VOBC, ATS-SMIO and VOBC-SMIO.
- Primary positioning: VOBC in SACEM_CT Train will establish and maintain its position and report it to ATS and ZC. Trains will be tracked on ATS line overview and by the ZC.
- Performance in tag reading e.g. missed tag or loss of position will be logged to enable investigation.
- Non-communicating train (NCT) tracking: ATS will track SACEM-equipped train (NCT) using secondary train detection devices e.g. track circuits. The ZC will track the SACEM train as an obstruction based on secondary train detection.
- Timetable regulation and automatic route setting: ATS and ZC internal logic only and no commands will be issued to field elements and external interfaces.
- Train launching and reception in and out of depots.
- Trackside equipment including points, signals, platform screen doors (PSD)/Automatic Platform Gates (APG), Platform Emergency Plungers (PEP), Emergency Stop Switches (ESS) and floodgates will be monitored.
- Data Communication Systems (DCS) will be tested and any loss of communication will be logged for investigation.

The in-service reliability performance monitoring can start at this stage. It will be limited to the early monitoring of equipment reliability. Passing criteria for shadow mode operation will be developed with the different stakeholders and will form a confidence basis before the system enters into the next phase.

Mixed-Mode Operation (MMO)

With the trackside changeover mechanism switched to CBTC, the central and trackside subsystems of the CBTC system both control and monitor the trains and infrastructure. The trackside subsystem of the CBTC system (i.e. ZC and Smart IO) also provides information to the existing trackside SACEM allowing existing trains and dual-fitted trains operated in SACEM mode to

Smooth migration is critical to upgrading the MTR network. Kowloon Tong station (below) is a heavily used interchange between East Rail services and other lines.
All photos MTR Corporation.

MTR's network is the life-blood of Hong Kong's thriving economy with high levels of ridership. Keeping the railway running is critical to the area's continuing growth.

continue passenger service on TWL. During this phase, trains in either SACEM or CBTC control mode can be operated concurrently during traffic hours. In the initial stage of MMO, the dual-fitted trains will be switched to CBTC control in traffic hours progressively without carrying passengers. After the dual-fitted M-Train has demonstrated the required stopping accuracy and fault-free operation in CBTC control, they will be operated in CBTC control in traffic hours with passengers.

The concept of MMO applies to migration in TWL, ISL, AEL and TCL, so to realise the change with an incremental little by little approach.

As the CBTC system is in full control of the infrastructure and the trains during this phase, the SACEM-fitted trains and dual-fitted trains operated in SACEM mode require that the CBTC system continues to provide a SACEM movement authority with equivalent protection level. This is achieved by the replication of the safety critical SACEM logic in the ZC and the ZC processes such logic and issues output to the trackside SACEM system through relay contacts for the TWL and Island Line (ISL) and the solid-state interlocking interfaces for the Airport Express Line (AEL) and Tung Chung Line (TCL).

> "The legacy trackside SACEM system is maintained for the whole duration of this phase"

The legacy trackside SACEM system is maintained for the whole duration of this phase and serves as the gateway between the CBTC system and the SACEM train borne system. In MMO, the trackside change-over mechanism will be switched to CBTC control and the dual-fitted trains will be switched to CBTC control progressively for non-passenger operation during traffic hours. Following successful operation, passenger operation on these CBTC-controlled trains during traffic hours will commence after completion of 100km of fault free mileage for each VOBC and the station stopping accuracy for each VOBC under automatic control.

Full CBTC

Once the reliability of the CBTC system finally meets the defined target and the whole fleet for the line is operated in CBTC control for passenger service, full CBTC operation would commence. Headway performance and full CBTC functionalities will be demonstrated during this phase.

A separate strategy has been established to replace the whole DUAT train fleet, 93 new trains (Q-trains) are therefore required to be equipped with CBTC. The CBTC-equipped new Q-trains are to be introduced into revenue operation shortly after TWL MMO commencement as planned. Their introduction would release existing dual-fitted trains from TWL to other lines to continue the MMO migration strategy with proven train borne equipment performance.

There are other steps involving conversion of SACEM locomotives into CBTC-equipped locomotives, optimisation of the number of secondary train detection devices, commissioning of depots, and decommissioning of existing signalling systems to be implemented in subsequent stages.

Implementation – changes step by step

Trackside system

The trackside change-over mechanism is implemented to allow full changeover to be performed between the new ZC and SMIO and the legacy interlocking during the testing and commissioning phase. This switch-over is performed through dedicated Latched N.S1 relays.

The change-over from legacy to the CBTC system can be performed in two different ways:

Train fitment. Left, additional operator's display in existing cab. Right, CBTC underframe interrogator transponder added.

- through dedicated ATS secure commands (from ATS to ZC) with a secondary confirmation to set the logical state of the area to CBTC and to remotely operate the changeover switch inside the respective interlocking equipment room.
- to locally operate the changeover switch to CBTC inside the respective interlocking equipment room.

The change-over from CBTC to the legacy system for a signalling control area can be performed in two different ways:

- through dedicated ATS secure commands (from ATS to ZC) with a secondary confirmation to set the logical state of the area to legacy.
- to locally operate the changeover switch to legacy inside the respective interlocking equipment room.

The local changeover switches only allow operation through a robust system secured with access key. The status of the change-over relay is reported at all times to ATS and ZC and locally through a light indication.

"Modifications on trains are made through multiple steps"

Train modification

Modifications on trains are made through multiple steps which were developed and defined during fleet survey and interface design. A thorough survey was conducted for each train in order to facilitate a successful mechanical design. Following this step, a detailed Vehicle Interface Control document was produced. This step included the following works:

- definition of all cut-in points to allow SACEM/CBTC cutover for dual-fitted trains;
- modifications of the required train schematics to enable the train to support new functions such as FAO mode.
- modifications of existing train door open and closed circuits in order to ensure train doors and PSD/APG synchronisation.
- train mechanical design including but not limited to the CBTC equipment mounting brackets, on-board enclosure, cable conduits, installation of equipment inside the enclosure, under the seat and driver's cab.

Overall, all these changes are implemented in the following stages, with the approach of little by little and step by step, for TWL:

(i) Installation and testing: enabling works, installation of changeover systems, CBTC equipment, train modification, site acceptance tests and integrated tests. The early integration of the CBTC system using part of the main line track was used for pilot integration. The testing was later extended to other main line areas.

(ii) Shadow mode: CBTC system operation in shadow of the in-service signalling system. This phase concluded the works including relocation of relays/frames, installations for trackside CBTC functions, and dual fit of the trains. Meanwhile the testing of Mixed Mode Operation is performed during non-traffic hours.

(iii) Mixed mode operation: The system operates with a mix of SACEM and CBTC trains after the infrastructure has switched the control to the CBTC system. During this phase the trains demonstrate reliability of the CBTC system through the passing of the required fault free mileage and stopping accuracy performances. CBTC trains will be put into passenger service progressively.

(iv) Final CBTC: the CBTC system will provide full CBTC functions and CBTC mode is the normal mode of operation. The CBTC system retains the capability to maintain SACEM traffic until decommissioning of the SACEM system. Removal of the changeover system will be carried out.

(vi) Final CBTC with track circuit optimisation which remains as the secondary detection devices during CBTC operation.

Direct migration – changes in one step

Another form of migration is adopted in another signalling upgrading project to suit the context of the legacy architecture as proposed by the selected supplier.

"SCL will strengthen the current railway by connecting several railway lines"

The Shatin to Central Link (SCL) is a strategic railway line that runs through multiple districts in Hong Kong. It comprises two sections. The first section, the East West Line (EWL), extended the existing Ma On Shan Line from Tai Wai to the West Rail Line through East Kowloon. The second section will bring the East Rail Line (EAL) across the harbour to Hong Kong Island (Hung Hom to Admiralty Section), eventually forming the North South Line (NSL). The SCL will strengthen the current railway network by connecting several railway lines through six interchange stations. It will save travelling time and provide the community with faster and more convenient railway services.

Upon completion of the SCL project, Hung Hom Station (HUH), being one of the six interchange stations, will be transformed into an important railway hub for Hong Kong as an interchange station between the EWL and NSL, benefiting passengers to all destinations in Hong Kong. When the Hung Hom to Admiralty Section is completed, passengers from the boundary at Lo Wu or Lok Ma Chau stations will be able to take trains on NSL to Hong Kong Island directly. Passengers on the West Rail Line and Ma On Shan Line may also change at HUH for trains on the NSL for destinations on the Hong Kong Island.

The signalling system for EAL will be replaced to form a single NSL and cover the new tracks from Mong Kok (MKK) to HUH with an extended section including Exhibition (EXH) and Admiralty (ADM) for seamless operation. The system will be operated with nine-car trains after completion of the NSL.

Migration strategy for EAL – Mixed Fleet Operation (MFO)

"The existing 12-car trains will be replaced by new nine-car trains"

The existing 12-car MLR Trains will be replaced one after another by the new nine-car Rotem Trains solely equipped with the Siemens Trainguard MT (TGMT) and Airlink onboard equipment with replacement to be completed before NSL opens. This leads to a period of around 18 to 24 months duration with MFO. 12-car MLR Trains and new nine-car Rotem Trains will operate simultaneously and terminate at the existing HUH platforms during MFO.

As a result, the existing EAL signalling system needs to be modified to support the trains introduced, MFO, NSL operation and allow running of existing Intercity through train services from mainland China.

The migration strategy depends on overlaying the new signalling system on the existing one and switching over between the existing and new signalling systems to ensure that both 12-car trains and new nine-car trains are supported during MFO. The migration strategy focuses on developing the new signalling system without any temporary interface to existing signalling equipment. This ensures, as required, that the operational system is not affected. Consequently, the new signalling system can run in shadow operation from the beginning and correct configuration, function, availability as well as overall system reliability can be verified by all parties. Test runs after site acceptance tests and integrated tests under real conditions are conducted with switching over to the new signalling system and back to the existing system afterwards.

In order to enable MFO, the existing 12-car MLR Trains are dual fitted with the new signalling system. Accordingly, the final switch over from operation under control of the existing signalling system to operation under control of the new signalling system is made before MFO. Related phases are summarised as: (1) shadow operation, where the existing system is still in operation, (2) non-traffic hour test runs, as necessary to prove system functions and reliability and (3) non-traffic hour trial runs, as necessary to prove operational reliability. Finally, direct changeover and migration to the new signalling system would commence with the final switch-over to the new signalling system, which starts traffic hour MFO.

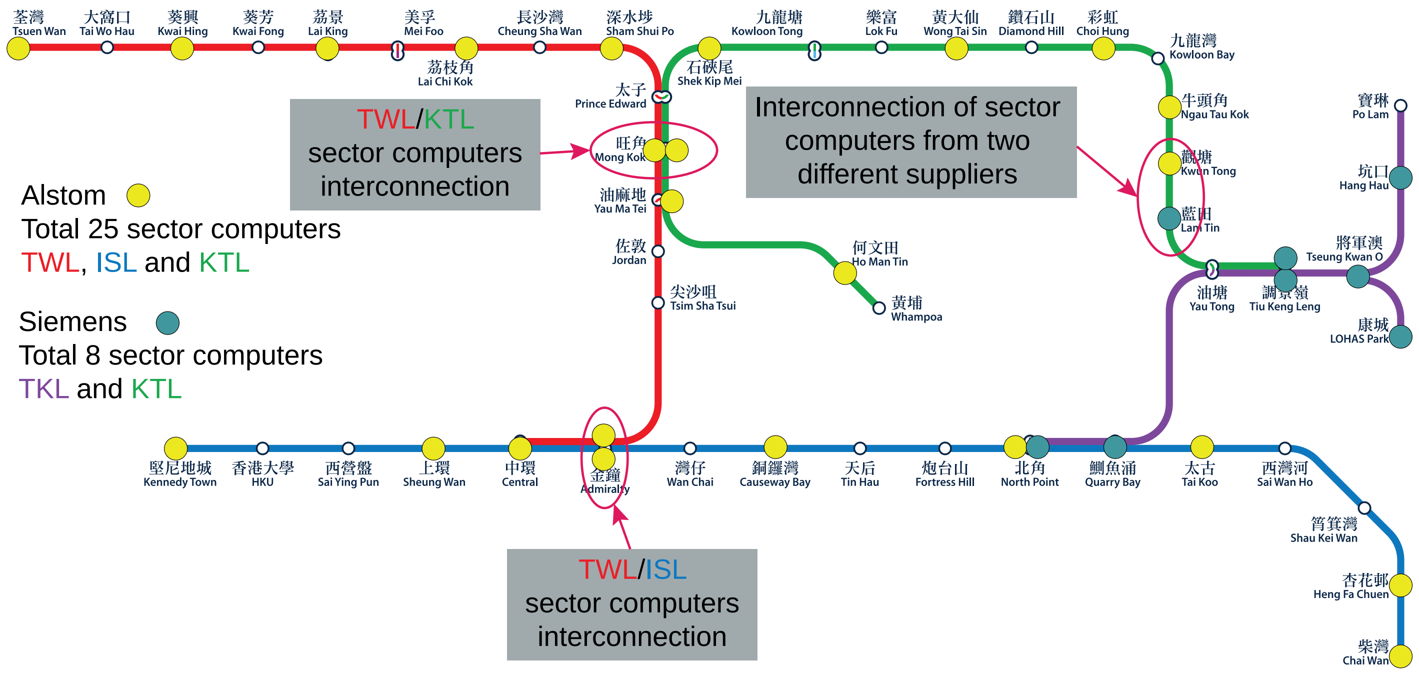
Software – changes in integration governance

While MTR has been implementing CBTC upgrading works, events were also observed in existing operating signalling systems, as well as new CBTC systems works under delivery during non-traffic hours. Both cases of events had drawn further attention to emphasis on software development, which is compelling in carrying the changes in software integration governance.

Case 1 – software integration

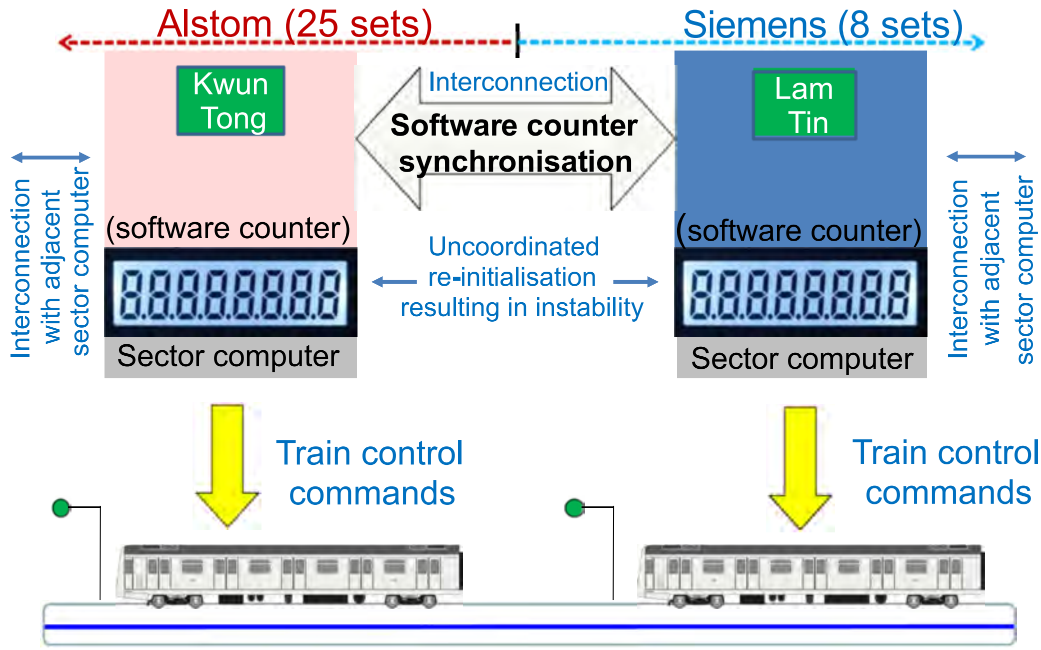
The MTR network in Hong Kong was affected by a signalling system failure on 16 October 2018 that was unprecedented in scale as the failure involved four of MTR's urban lines. From 0528 on that day, the Operations Control Centre started receiving reports that trains on three lines were receiving unstable train control commands. The trains could only be operated in manual restricted mode (RM) during train deployment and preparation before the start of revenue operation. Subsequent to that, about five hours later while recovery on the three lines was underway, trains on a fourth line were reported to be losing train control commands which also resulted in similar manual RM operation.

Normal service on all four lines was resumed progressively from 0920 onwards to 1145. During the incident, all trains in revenue service on the affected lines were operated at low speed with overspeed protection, with all train movements to be authorised by a traffic controller according to procedures. With such an extent of failure, the general public in Hong Kong experienced massive delays and inconvenience in their journeys. Other public transport operators were coordinated to provide emergency support.



Case 1 – Above, the location and suppliers of sector computers on the lines affected by the situation.
Image MTR Corporation.

Right, uncoordinated counter resetting resulted in the propagation of an endless loop.

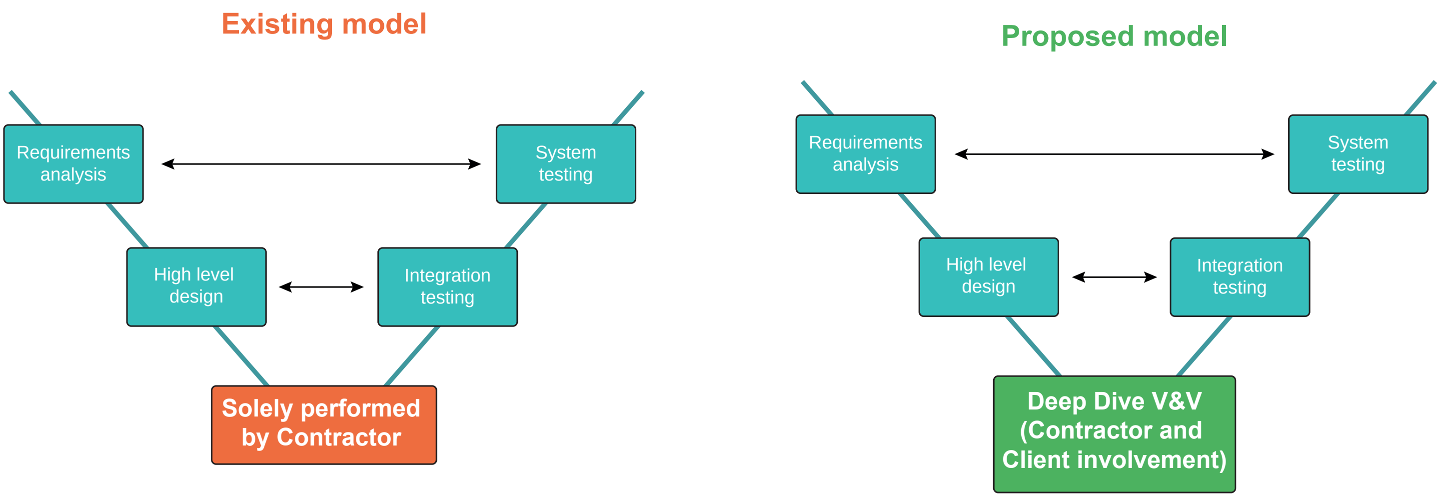


“Re-initialisation arrangements for the two suppliers’ sector computers are different”

How the software behaved

An investigation panel was established and immediate review of the system failure was conducted with both suppliers. Failure scenario simulation was attempted in non-traffic hours and further analysis was carried out shortly thereafter. It was revealed that data transmission between sector computers is always synchronised through an internal software counter in each sector computer. These internal software counters have commenced incremental counting since deployment for revenue operation. Once any individual sector computer is rebooted, its counter will be re-initialised and will immediately synchronise to the higher counter figure for the whole synchronised network. Given this principle, when Siemens sector computers were commissioned and put into revenue operation in 2001/2002, the relevant counters were synchronised to the Alstom sector computers with a higher counter figure, which were installed in 1996. If the counter reaches its ceiling figure, which is bounded by its allocated number of bits, the associated sector computer will halt and need to be re-initialised. However, the re-initialisation arrangements for the two suppliers’ sector computers are different.

The Alstom ones will be re-initialised automatically once their counter reaches a built-in re-initialisation triggering point approximately 5 hours before reaching the ceiling figure. However, the operators and maintainers had not been made



MTR proposes to use an enhanced model in future software governance.

"Our proposed way forward aims to increase vigilance during the lower and deeper parts of the V-cycle"

aware of this internal software function. The Siemens ones do not have an automatic re-initialisation function and therefore need to be manually re-initialised through rebooting on site by maintenance staff.

Counter issues

The investigation found that at around 0526 on the incident day, the Alstom software counters reached the built-in triggering point for automatic initialisation while the Siemens software counters continued counting up, creating an inconsistent re-initialisation situation between the two sector computers at the Kwun Tong (KWT) and Lam Tin (LAT) boundary between Alstom and Siemens. This resulted in repeated execution of re-initialisation in the Alstom sector computer at KWT followed by re-synchronisation with the higher counter figure from LAT, hence the KWT sector computer became caught in an endless loop causing corresponding instability in all 25 Alstom sector computers connected in the system.

When all the Siemens software counters reached the ceiling figure at around 1022, about five hours after the Alstom software counters first passed their automatic re-initialisation triggering point, the eight Siemens sector computers halted as designed.

Among a series of recommendations from the investigation panel, actions completed include regular checking of software counter figures for all relevant lines, and implementation of a maintenance programme for manual re-initialisation of all the software counters in the signalling systems at relevant lines before the software counters reach the relevant triggering or ceiling figure. It was also recommended that a dedicated team with advisors from academia should be established to ensure the integration and performance of modified software-based systems is well controlled.

Comparing the established enhanced model against the original model shows how our proposed way forward in software governance aims to increase vigilance during the lower part and deeper part of the V-cycle, through more coding review and extending coverage of testing extremities in software.

The four-line incident also posed a more far-reaching question to us: as signalling practitioners how do we face the challenge of knowing in-depth coding and its behaviour within the system itself, and also consider its interfaces to connected systems? The assurance mechanism to enhance software performance and integration, in view of the deployment of more and more software-based systems, inevitably turns out to be one of the keys to sustainable and successful operation in the future.

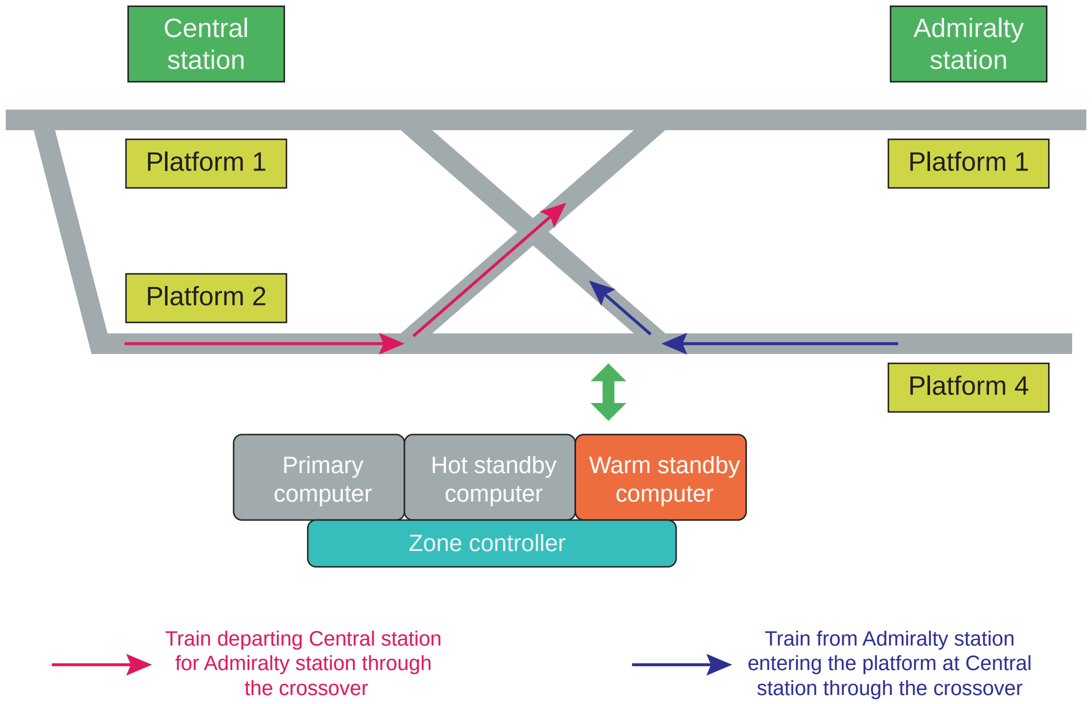
Case 2 – Software development

During the non-traffic hours on 18 March 2019, a drill during the test running stage was conducted on the new CBTC signalling system provided by the contractor on the TWL. The objective of the drill was to familiarise the operators with the system behaviour and the application of operational procedures in a situation in which both the primary and hot-standby computers failed and there was a need to switch to the warm-standby computer.

A software issue was experienced at around 0244. A non-passenger test train which was heading to a platform of Central Station (CEN) through a crossover collided with another non-passenger test train that was departing from CEN for Admiralty Station (ADM) through the same crossover, causing damage to both trains. Both train captains were sent to hospital for medical checks and they were discharged on the same day.

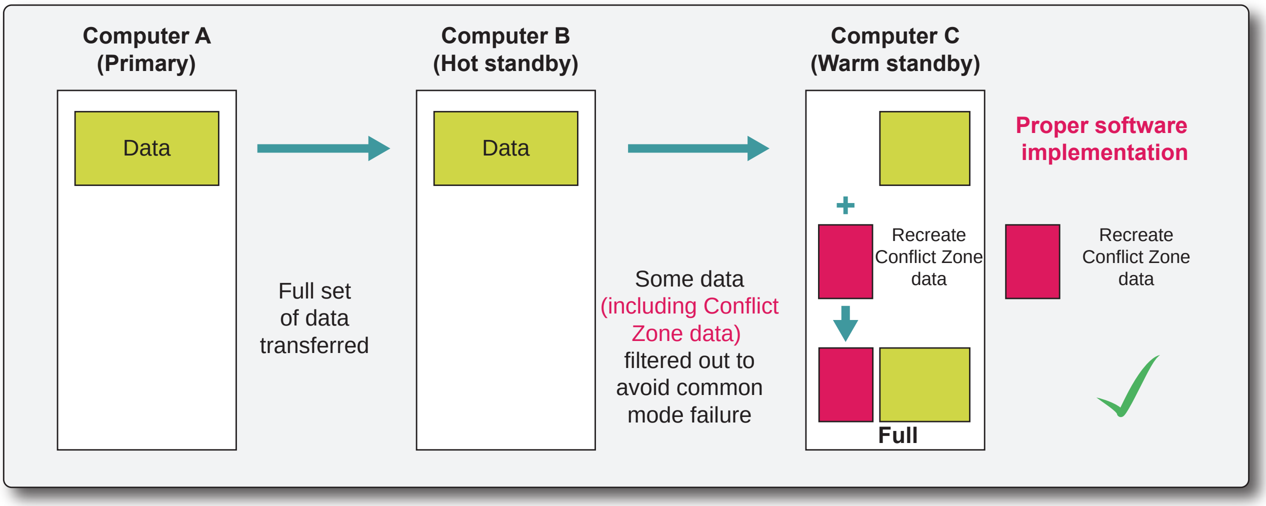
MTR was greatly concerned about the incident and therefore set up an investigation panel with membership consisting of MTR senior personnel and external experts to investigate and identify the cause of the incident, and make recommendations to prevent the recurrence of any similar incident.

The investigation concluded that a software issue existed which led to the missing of conflict zone protection i.e. interlocking in software at the

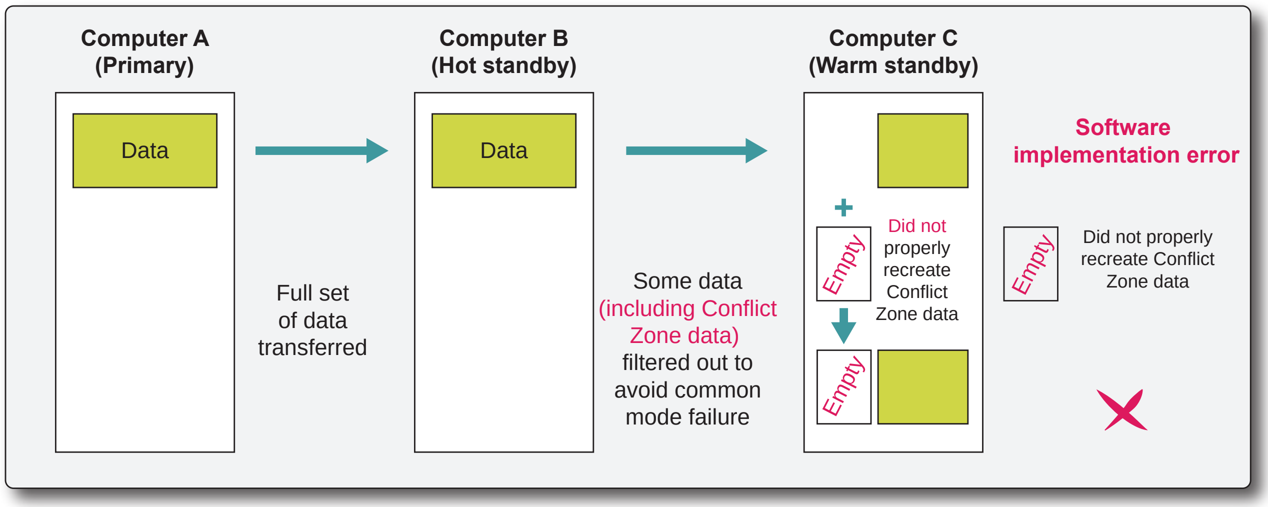


Case 2 – Train movement during drill.

Design intention developed



What happened



Software implementation errors resulted in an unknown software issue.

"Concerted and timely efforts from all stakeholders should be of great benefit"

crossover, resulting in the two trains being allowed to enter into and collide at the crossover. The software issue was created as a result of software implementation errors made during the process of performing a software change.

It was concluded that the software implementation errors reflected inadequacies in the software development process with respect to software quality assurance, risk assessment and the extent of simulation of this software change.

Recommendations were made to fix the software change issue and confirm with substantiation that there are no wider implications in software development quality. Enhancement in the software coding and testing practices shall be made to avoid future programming errors. Extra vigilance would be exercised to strengthen the monitoring on software deliveries, including upgrading the simulator in Hong Kong to act as a testing simulation tool to perform more operational scenario simulation tests as far as practicable.

The two cases of significant software-related events, whether directly related to CBTC upgrading works or unrelated as revealed in legacy systems in operation for over 20 years, drew a common focus again on the significance of software integrity in contemporary signalling applications.

Conclusion

The challenges we have been facing in CBTC upgrading are indeed by no means different from similar upgrading works in other parts of the world. In a nutshell, the works would inevitably bring significant changes to our operation and performance. We have to be mindful, during the whole course of works introduction, to maintain optimised methodology and proper vigilance whether it be from migration strategy to works implementation or in software governance from development to integration. Concerted and timely efforts from all related stakeholders should be of great benefit in guiding us along the pathway of carrying out changes in our railways.

About the author ...

Gordon Lam is the chief signal engineer (operations) overseeing resignalling works and overall signalling development for MTR in Hong Kong. He is a railway signalling engineer with over 30 years' experience covering design, installation, integration and commissioning. He has managed MTR signalling projects in Hong Kong including the Lantau Airport Railway, Tseung Kwan O extension, and Disneyland Resort Line, and also spent over ten years working in MTR's Mainland China hubs including Shanghai, Hangzhou and Beijing covering implementation of CBTC in hubs, E&M project management, operations management and joint venture company management. Gordon is a Fellow of the IRSE and serves on the Education & Professional Development Committee and the Executive Committee of the Hong Kong Section.

What do you think?

What is your experience of delivering upgrades in complex operational scenarios? Have you faced similar issues to those overcome by Gordon and his team? Have you adopted a different approach to the introduction of CBTC on a busy railway?

Our Institution thrives on the exchange of information between our members across the globe. We'd love to hear from you about how you have delivered change, share your experience by emailing **editor@irsenews.co.uk**.

How much of your work counts towards your CPD?

Continuing professional development is an essential part of being a professional engineer and a member of the IRSE.

Had you ever thought about how many ways there are to carry out this CPD though? Here are just some examples of how you can do this – just remember to record your activities!

Additional responsibilities: Increasing or refreshing your skill set and demonstrating your personal responsibilities by volunteering to take on additional duties such as supervising others.

Buddying, coaching or mentoring: Sharing your knowledge of your company, discipline or industry by acting as a buddy, coach or mentor.

Shadowing: Increasing your understanding of your company or industry or widening your domain knowledge through work shadowing.

IRSE events and conferences: Increasing your technical knowledge and widening your network.

Management skills: Increasing and practicing leadership skills by organising sharing knowledge sessions such as 'lunch and learn'.

Developing your career: Increasing your profile by transferring to another grade in IRSE.

Technical knowledge: Increasing or refreshing your knowledge by reading up in technical papers, journals (like IRSE News) and specifications on projects, techniques or equipment being used.

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How digitalisation is delivering improved customer experience

Rob Morris

Digitalisation is driving change in industries worldwide, with the rail sector one of many to take advantage of new technology and processes to deliver operational, performance and value benefits. But if we as an industry are to make the most of this, I think we also need to transform the culture of our industry. To do that, we first need to understand why we are digitalising our railways – quite simply to improve the experience of the railways' passengers and freight users.

"The ultimate aim of our industry is simple … to improve the overall experience of the railways' customers"

Digital solutions are increasingly being applied to rail projects worldwide, with many recent and planned schemes either incorporating digital systems or at the very least ensuring programmes are 'digital-ready' and future-proof. My own company's focus is to use digitalisation to enable mobility operators worldwide to make trains and infrastructure intelligent, to increase value sustainably over the entire life-cycle and to enhance passenger experience.

The technology brings major benefits to network owners, operators and maintainers, but perhaps even more importantly, it brings significant improvements to our customers' experience, whether they are buying freight or passenger services.

The rail industry has an outstanding record of innovation and delivery, with major advances in infrastructure, vehicles, communications and control systems evidenced in recent projects around the world. However, for many businesses involved in delivering engineering programmes, the passenger experience is often seen as a by-product of the project rather than being at its core. It's easy to become so focused on the development and evolution of new technologies that the effect individual design decisions have on the customer's experience becomes a secondary consideration.

If engineers are absorbed and focused solely on writing interlocking data, designing telecoms, control equipment, or a power supply scheme for a major project, then we can lose sight the ultimate aim of our industry. That aim is to improve the overall experience of the railways' customers, be they passengers or those sending freight by rail, recognising the importance of railways in today's world. So whilst change is vibrant and exciting, not to mention vital for the progress of our industry and the businesses that operate in it, we need to continue to drive towards a focus on customer service, For our industry this means putting the passenger and freight user first. There are a number of reasons why this is so important.

Sustainable business

Firstly, as well as being a critical element of national infrastructure, the railway must be a sustainable business, attracting and retaining customers, and making sufficient profit to allow ongoing investment in its maintenance and upgrade.

The socio-economic impact of the railway is enormous. In the UK alone 1.7 billion passenger journeys are made by rail every year, using the network to get to and from work, for education or leisure, and many industries rely on the railways for movement of goods. In addition, the railway is not only a major national employer itself, but it also fuels a supply chain which employs an additional 250 000 people in the UK alone. Rail underpins the smooth running of this country, but we must deliver what our customers need to support this.

This is summarised neatly in the Rail Sector Deal, a new collaboration between the UK Government and the rail industry, which says: "A well-functioning railway is a driver of economic growth, as it allows people to travel more widely

Technology offers huge potential benefits to railways worldwide, but do we always remember why we are digitalising? *Photo Siemens.*

"Safety underpins everything we do as an industry"

for work, makes more effective use of our existing network's capacity, and moves goods between suppliers, manufacturers and customers reliably and cheaply.

Rail is increasingly an environmentally sound means of travel. However, its customers often have other travel options, so we need to stay attractive and competitive, helped by digitalisation which enables us to reduce energy usage and improve our environmental impact – factors which resonate with our environmentally-aware audience.

Safety is often overlooked when we talk about customer experience, but it underpins everything we do as an industry. We have a responsibility to provide safe transport for those who use the railway and ensure the safety of those who work or live close by, or who need to cross the tracks.

Affordability and value for money

We need to remember that in many countries the railway infrastructure is owned by the government and that everyone who uses it is a taxpayer. Quite rightly we expect our taxes to be spent wisely and efficiently, bringing the best possible value for money.

Affordable travel is essential if we are to meet our customers' expectations and aspirations and so fares and private sector profits need to be reasonable. Passenger levels have grown for many years, as has the cost of fares, to meet the cost of investing in and maintaining the railway. To make best possible use of investment we need to tackle the rising cost of maintaining and upgrading railway assets.

"The use of technology allows for capacity to be unlocked on many of these lines"

Using technology to bring change

Technology and digitalisation can improve the efficiency of this investment, with a direct link to the amount of money required to operate the railways and the costs experienced by network providers, train and freight operating companies.

We can also better manage the demand for rail, allowing app-based technologies to better inform passengers about travel costs and alternatives, with the aim of matching supply and demand throughout the day.

In other words, leading to optimising capacity. Much of our railway is significantly constrained by where it runs, and new infrastructure or significant changes to existing routes can be prohibitively expensive. The use of digital technology allows for capacity to be unlocked on many of these lines. More trains mean a more convenient service, and the availability of more seats on potentially less crowded services, all directly improving customer experience.

Digitalisation provides a huge opportunity for us to achieve this, with technologies that have the potential to radically change the way we think about transport. Demand responsive transport (the provision of trains, trams or buses in response to real-time passenger demand) and the concept of 'Mobility as a Service' (where privately owned vehicles are replaced by a fully integrated multi-modal transport system) are real development opportunities for the industry, both of which will see customer experience driving the transport network.

Train control systems are one way of unlocking capacity

There are many ways in which digitalisation can have a positive impact on customer experience, many of which are already being employed. For example, technologies like the European Train Control System (ETCS) have been installed on many rail networks in recent years. Using digital radio messages between trackside and train, ETCS improves the performance and safety of the railway, with on-board systems monitoring speed and position continuously, and applying the brakes if a potentially hazardous situation arises.

One example of recent deployment of ETCS is the technically complex Thameslink Programme, one of the highest profile infrastructure programmes to have been delivered in the UK in recent years. To achieve the programme's performance targets, Thameslink also introduced automated train operation (ATO), which will allow every train to follow an optimum speed/distance profile as it moves through the network.

Through this combination of ETCS and ATO, the digital signalling system has unlocked much of the latent capacity that existed on the Thameslink network and provides the capability for greater numbers of trains per hour to operate in the core area during peak hours. The solution also brought significant passenger benefits, with smoother, more frequent and more reliable journeys together with access to better information – including directing passengers to coaches where there is available seating.

"The Thameslink Programme is a great example of how digital technology can help unlock capacity on a constrained network"

The Thameslink Programme is a great example of how digital technology can help unlock capacity on a constrained network. But it is not unique. The UK is by no means alone in having infrastructure that has to operate on an ageing network with old structures and alignments. And with the provision of new infrastructure or significant changes to existing routes being prohibitively expensive in most cases, the use of digital technology can have a major impact. More trains mean increased capacity, with more seats on potentially less crowded services; all directly improving customer experience.

While ATO provides consistent driving, high-intensity railways need traffic management (TM) to improve regulation and minimise the impact of service disruptions, providing information to operators to better assist them in making the hundreds of decisions they face every day. This technology directly helps both operators and customers, delivering a more reliable, predictable and punctual railway, with improved capacity and better-quality information.

Managing the network

Intelligent software and accurate data are vital; not only to the successful application of TM systems, but also for timetable management systems to become valuable and trusted long, medium and short term tools. The data that underpins these off-line and on-line planning tools opens a real opportunity to not only optimise network operation, but also to revolutionise the provision of information to the travelling public, helping them to make informed decisions and so ultimately improve their travel experience.

Digitalisation has a role to play not only in underpinning these new and sophisticated planning and control tools, but also in the products that have been at the heart of the railway's operation for decades.

For example, interlockings, the cornerstone of safe operation, have benefited from digitalisation, with engineers now commonly developing network-based signalling systems for the world's most complex railways. These systems use ethernet-based networks to connect signalling assets and control systems to deliver significantly improved levels of reliability and availability. This technology reduces the likelihood of delays due to equipment failure and so has a direct positive impact on customer service.

From a service perspective, big data techniques and artificial intelligence will help accelerate the drive to predictive maintenance on everything from trains to structures, signalling to telecoms, as well as the provision of better information for both railway staff and passengers. For example, the latest remote condition monitoring solutions monitor the condition of track assets using the accelerometer sensors that are already present in our latest cab radio.

Using this technology, the capabilities and reliability of this software-based solution have been proven in trials, with asset owners, managers and maintainers all benefiting from monitoring the track network remotely – and passengers experiencing improved reliability and availability.

Real-time connected driver advisory systems (C-DAS) which give route information and speed advice to drivers, or indeed on-board computers on automated railways, allow energy consumption and arrival times to be optimised. This ensures smoother, more reliable and more predictable journeys for passengers. Route data, timetable updates and temporary speed restrictions can all be uploaded remotely to the system, ensuring that operators and passengers benefit from improved reliability, punctuality and performance.

In London ETCS and ATO have been used together to unlock capacity on the tightly constrained Thameslink line across central London. *Photo Siemens.*

Sometimes those involved in railway engineering can get caught in a mindset of 'moving trains around', but the railway exists to move people and freight. Can we be confident that everyone on the concourse has all the information they need to have a safe, smooth and pleasant journey through the network? *Photo Shutterstock/ Willy Barton.*

The end-to-end journey

When we talk about the customer experience, we need to look beyond the train itself – and even the platform – to examine the 'end-to-end' journey. Ticketing and pricing could no doubt warrant an article all of its own, but it is undoubtedly an area where digitalisation can bring significant passenger benefits.

One such approach is the use of mobile-device applications. By providing live information to the railway's customers in return for information about where they are and what their plans are, we can rapidly move towards situations in which a ticket doesn't have to be bought, but a traveller will be charged based on their actual movement through the network.

We have seen the successful deployment of these approaches in major European cities such as Copenhagen and Hanover, where a quick check on a phone can give passengers information about not only the fastest route, but the cheapest alternative mode of transport, updated in real-time and tailored to that individuals' needs.

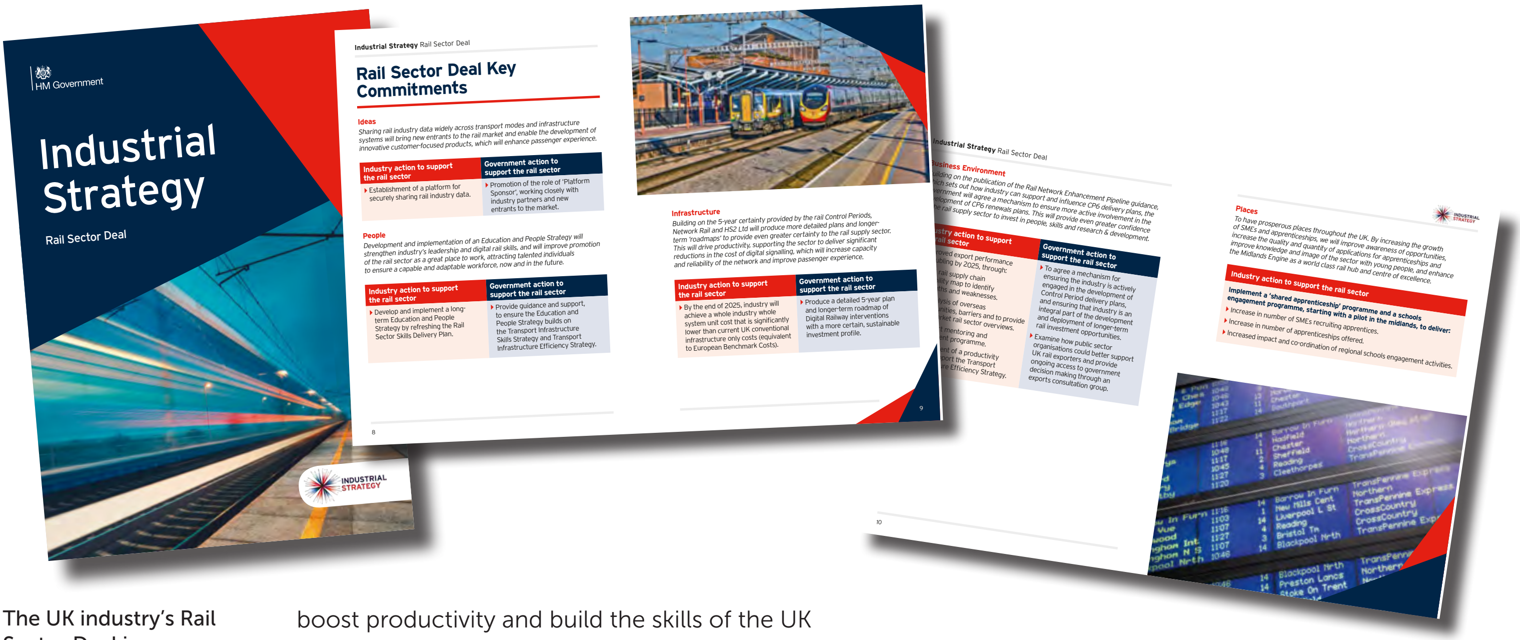
In Dubai, a new app has been launched that brings together all transportation modes from 12 different operators; previously all had their own apps. The Dubai Integrated Mobility Platform (DIMP) is a cornerstone of the city's smart city strategy and the operator's vision of safe and smooth transport for all. The app allows customers to benefit from improved information, integrated journey planning and smartphone ticketing and represents an ideal platform on which to build towards a complete 'Mobility as a Service' solution.

The technology is already making a difference to the customer experience – and is providing more than a glimpse of the future, bringing our visions much closer to reality.

The UK Rail Sector Deal

However, we also need to use technology to improve the way we deliver the railway of the future. In the UK, the Rail Sector Deal (irse.info/h9nbp) is bringing this vision closer to reality and represents a new approach to collaboration in order to increase the use of digitalisation on the railway. The document was created by the UK Government and the rail industry, recognising the importance of the railway to the nation, and the collaboration necessary to accelerate the delivery of a truly innovative network. The Sector Deal sets out how this will

Systems that use "check in/check out" technologies are commonplace today, but smartphone apps can offer yet more to help those travelling to make correct decisions. *Photo Siemens.*



The UK industry's Rail Sector Deal is one country's approach to seek cross-industry commitment to innovation, collaboration and delivery focused on the experience of those using the railway. *Image BEIS/UK Government.*

boost productivity and build the skills of the UK workforce in order to build on the opportunities to improve customer experience of our railways.

Specifically, it recognises that there are many stakeholders in the industry who have access to huge amounts of data. The Sector Deal looks to establish a platform for securely sharing rail industry data, allowing those already in the industry, and dynamic, innovative start-ups and smaller businesses, to use the data to derive value for the network.

Investment in automation is critically important, using one 'single source of truth' to create all the data necessary to configure modern command, control and signalling systems, and we are seeing significant progress across the industry in this area.

Conclusion

Quite possibly we are only just beginning to realise the customer benefits that digitalisation can bring, although we as an industry should be proud of what has already been achieved.

We should look to successes such as the automated trains and ETCS-enhanced safety levels, the implementation of TM and C-DAS technology at locations around the world, and the massive improvements in reliability and availability that many railways have seen and build upon them.

I believe that it's important that to continue this innovation and the exploitation of digitalisation. We should look to countries and industries that have had successes in related applications and recognise the huge opportunity that the global railway industry has ahead of it. We can build on the industry's strong supply chain, world-leading academic institutions, committed infrastructure organisations and innovative operating companies.

This isn't going to be easy, largely because of the rapid rate of change we face. However increasingly governments, the railway supply and delivery industries and all other stakeholders have already committed to use digitalisation to bring a real change in the levels of customer experience.

"Quite possibly we are only just beginning to realise the customer benefits that digitalisation can bring"

About the author ...

Rob is the managing director of Siemens Mobility Limited, Rail Automation, responsible for all of its UK rail command, control, signalling, digital rail and automation activities across rail infrastructure for Network Rail, London Underground and Crossrail.

His career spans four decades in multi-disciplined major projects working for mining, power, general construction and technology-based businesses both internationally and in the UK. He graduated as an electro-mechanical engineer, expanding his knowledge and experience through a multitude of technologies and disciplines throughout his career.

Rob is Industry Champion for Digital Transformation for the Rail Sector Deal and is a member of the Rail Supply Group Council.

What do you think?

Do we as an industry do enough to remember why we're here? Do we tend to concentrate on the physics of moving trains around networks rather than moving people and freight by rail? Do we do enough to collaborate with others in our industry and key stakeholders like government?

Have you got experience of where digitalisation has shown real social and economic benefits on your project or in your country?

Let us know, we'd love to hear from you, email us at **editor@irsenews.co.uk**.

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Delivering change through the completions process

Steve Boshier

With a new generation of people and technologies involved within the rail industry, the need for a high performing and well understood completions process has never been greater. Projects are being pushed to do more work, more quickly, and more smartly, resulting in the completions process being ignored until it is too late. For many project personnel, Completions is viewed as the end phase of the project, a part of implementing new technologies, or the close-out of staff competency requirements. I argue completions is much more than that, and an area that is most often misunderstood.

The completions process starts at the beginning of the works and is only completed when stakeholders are provided with the promised deliverables and outcomes. This means project teams delivering long after physical works are complete. The key to achieving the promised outcomes is proper planning and having the right people accountable for driving the process. In addition, these people need to be supported by clear frameworks and easy to use technology systems.

A completions framework is required that ensures the end users receive the full benefit of their investments, and that the assets being delivered can be properly operated and maintained. The completions process starts at the beginning of the project with the end very much in mind, and success is achieved by using technology and a progressive completions approach. With this process, projects can be delivered on time and within budget. Stakeholders are provided with what they need, and the project team can walk away knowing that they have delivered what they promised.

Completions

"What is completions all about?" I hear you ask. So often, I hear people saying that completions is just about as-built drawings and Operations and Maintenance (O&M) manuals handed over at the close-out of the project. "We will provide it later" really means just before the last person standing on the project disappears into the sunset – never to be seen again.

Similar common sayings are "We are too busy designing and constructing the project and will deal with completions at the end when we have some time" or that "People are rushing around to get things done and just don't have time to consider the end of the project."

Does it all sound too familiar? Completions is much more than as-builts and O&M manuals; it is about assuring that the end stakeholders receive everything they need to efficiently operate and maintain the new assets provided.

Unfortunately, completions is often considered as an end of project activity, and not part of the design and construction phases. This perception results in completions assigned with less time and resources than required, often to the project's serious detriment.

Completions is a process that must commence at the start of the project and finish after all notified defects are fixed, typically called the Defects Liability Period (DLP) or Defects Corrections Period (DCP). For a large project, this is usually recognised by a Final Completions Report (FCR).

Therefore, instead of just talking about completions, we all need to be talking about the 'completion process' and plan for it during the development phase of the project, not once construction has finished!

Completions process

The completion process is a new mind set which is helping to refocus our project team's approach to how they deliver project outcomes in a timely fashion. The process needs to be considered from the start of the project, and not limited to only one department. This sounds to be obvious good planning practice but is so often not occurring.

The aim of the completions process is 'making the impossible – possible' by creating a culture change and focusing the project teams to ensure that they deliver the right outcomes. This means finishing the project off and ensuring that stakeholders receive an asset, which they can both operate and maintain to the required standards. It's very much more than just activating a new project involving bringing a new project into operational service.

The completions process has been around for many years, perhaps even thousands. I bet even the Romans knew how to design, construct and hand over a completed project designed to meet the end stakeholders' requirements.

The process Steve describes in this article has been used to great effect during the level crossing removal programme being carried out across the Victorian network.
Photo Level Crossings Removal Authority.

So why should we care about the completions process, you may well ask. It is the unloved part of the project and is often seen as not being important. However, in reality, the only people who don't care about completions are the ones who have never operated or maintained an asset. Operations and maintenance managers know only too well the cost blowouts caused by poor data or missing technical information which should have been handed over but wasn't. Poor completions can seriously impact the end user's bottom line.

Engineers have a great ability to design solutions to problems and in this day and age the design work is often performed using digital engineering tools. Why tools? Because they provide the benefits of clash detection, collaborative working, and increased productivity. Unfortunately, these benefits often disappear at the construction phase and the Issue of Drawings for Construction (IFC).

The construction team start their work based on the designs provided. They build some innovative infrastructure, mostly in accordance to the IFC drawings. There are always some changes necessary, and any changes are hand marked up onto hard copies of the drawings, then set aside for updating at a later stage. Why not update straight away? Because they are too busy building the work to do it now. The pile of red line drawings just grows bigger every day until near the end of the project, until someone asks for the as-built drawings, so they can maintain the works. The construction works have finished (mostly) and the new asset is brought online so that the users get benefit of it as soon as possible. Trains are back running again. Cars, buses and trucks are using the new roads. The landscaping is still to be finished off, some road and footpath sealing to be completed and stairs finished off, so it's nearly there. Or is it?

One key question that should be asked is "do the stakeholders and asset owners have everything they need to operate and maintain their new works?".

Other key questions are "Have staff been trained on the new equipment provided? Has all the asset data been provided including updates to geographical information systems (GIS), asset registers, warranties, maintenance agreements, certificates and approvals, system safety assurance reports, defects closed-out? Has the as constructed acceptance sign-off been received from all stakeholders?".

Out of the blue near the project's conclusion I often hear "Where are the as-built drawings?". What follows is a mad scramble, and eventually the last few engineers on the project are tasked with sorting it out. As they can't read or understand all the as-built hand mark-ups, these remaining engineers end up spending days back out on site trying to figure out exactly what was built. The site engineer who originally marked up the drawings is long gone, having moved onto their next project that is far more interesting than closing-out the current works. It sounds like a familiar situation, doesn't it? You can imagine the asset owner's frustration trying to operate the asset with incomplete drawings and missing data.

Progressive completions

To have a successful completions process, you need to be looking at where you are, where you want to be, and how you are going to get there, all this with the mindset of progressive completion. Management needs to be planning for completions from the start, which means ensuring there are the right types of skills and resources provided at the right times throughout the project. In addition, there needs to be an adequate level of funding provided for all the completions' activities required, not just a baseless guess.

Often, we talk about delivering a whole life approach, but it's not always followed through or gets forgotten about along the way. This is an area where the completions manager can work closely with the design and construction teams to ensure what was promised is delivered on. Whilst the cost of delivering project outcomes is getting more expensive every year, we are being pushed to do more with less. This can be achieved without cutting corners if the deliverables and outcomes are well defined, and by the appropriate standards.

Progressive completions means working on the completions activities from the start of the project. To drive these activities, a completions manager should be appointed at the start of the project, and this person will be accountable for ensuring the right outcomes are achieved. They will need to work closely alongside the engineering manager, design manager, construction manager and project manager throughout the project life-cycle, and not just be brought on at the end of the project to try and pull together the deliverables to be handed over.

Getting you to the finish line sooner

Completions Process

LEVEL CROSSING REMOVAL AUTHORITY

WORKS COMPLETION (IN OPERATION)

Acceptance
- Stakeholder Acceptance to Operate
- Certificate of Train Running & Cert 36 – Ops & Completions, Driver Training
- Certificate of Occupancy

As Built Drawings
- Red Line Markups (RMU's) & Signalling Test Copies

Asset Data (F24)
- Drawings & Documents Required for Operation & Maintenance
- EACR Asset Data (Ellipse Data)/Asset Registers
- Operation & Maintenance documentation & Training

PRACTICAL COMPLETIONS REPORT (TYPICALLY 12 WEEKS POST WC/OR PAA)

Management Plans
- Completions & Handover Management Plan
- Design Engineering & Management Plan

Completions WBS
- Area/Sub Area/Component

As Built Drawings
- Master Drawing List
- IFC – Issued for Construction
- RMU's – Red Line Markups
- Back Drafting
- Review
- As Built Drawings certified for DMS/VicRoads/Other Stakeholders

Asset Data (F24)
- Drawings & Documents Required for Operation & Maintenance
- Asset Data (PASS Assets, Ellipse Data, GIS, Rail Map, Asset Registers)
- Guarantees, Warranties & Service Agreements
- Operation & Maintenance Documents
- Asset Handover/Maintenance Responsibilities/Access Agreed

Assurance
- Approvals & Certificates (Design & Verification)
- Certified Survey's & Boundaries
- Rail Infrastructure & Rail Service Approvals
- Training Material & Records to support Safe, Reliable & Efficient Operation
- Project Assurance Report (PAR) - Requirements Traceability (DOORS reports)
- System Safety Assurance Report (SAR)
- Audit Reports

Acceptance
- Stakeholder "As Constructed" Acceptance

Defects Correction Period
- Defects Correction Period

POST PRACTICAL COMPLETION DOCUMENTATION (TYPICALLY 12 WEEKS POST PC)

Residual As Built Drawings
- All As Built Drawings accepted into DMS/VicRoads/Other Stakeholders

Residual Asset Data (F24)
- Sustainability Management Plan & Report
- All Asset Data Accepted into Ellipse & PASS (Images)/Other Stakeholders

Residual Assurance
- Data & Information to support the Value for Money Report

Final Close Out
- Final As Constructed Completed Documentation
- All Documents as per the Doc Control & Doc Management Plan
- Landowner/Occupier – handback close out
- PTV Legacy Package

FINAL COMPLETIONS

Close Out
- Final Completions Report – end of 2 year Defects Correction Period (DCP)

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Figure 1 – Illustrating the completions process. A picture tells a thousand words and this example illustrates how the completions process can be applied to a large, complex project in order to show how a progressive completions approach can get you to the finish line on time.

Let's look at some fundamental principles where the completions process can help drive the right outcomes.

At the start of the project, having a clear understanding of the project requirements is really important, as is identifying who the asset owner and maintainer is and getting their sign off on what is going to be delivered. In achieving the sign-offs, it's important that a completions acceptance criterion, which includes a generic list of completions artefacts, is produced against the actual scope of works. These documents will be used as the basis for the acceptance of the completions and handover deliverables.

The above process ensures that stakeholders and asset owners are involved early on in the project, and not forgotten about during the rush to get going. For large projects, which can be spread over many years, this process provides protection on both sides for when people change roles or leave during the project. The approach also helps mitigate the usual close-out challenge where stakeholders and asset owners have different completions expectations to the project team. The resulting reluctance of stakeholders to sign-off can jeopardise the project budget and schedule.

Throughout the project, you will need to ensure that change management is used to track, approve and document the agreed changes with all applicable stakeholders. When you get to the end of the project, there needs to be clear traceability of any modifications made to the agreed handover deliverables.

Progressive completions artefact filing

A progressive completions approach is all about collecting, filing and reporting on the status of the deliverables. Progressive means starting at the design phase of the project, not a week before the practical completion milestone. This way, you avoid the last-minute rush of trying to find the required documentation and evidence, which ultimately leads to missed schedule targets.

Best practice is to file the artefacts (deliverable items or evidence such as documents, drawings and certificates) as they become available, not at the end. This will avoid trying to find items buried on people's desks or in emails a week before a milestone. When changes occur to an artefact, having it in the electronic filing system means that when there is a change, reporting metadata is automatically updated.

Another benefit of the progressive completions approach is that it also drives progressive submission for stakeholder review. This results in flattening out the workload. There is nothing worse than getting hit with a huge wave of details and documents to check all at once. The progressive completions approach is a more efficient way of turning around the reviews and keeping the stakeholders onside at the same time.

Completions milestones

The completions process can be highlighted by including key milestones within the project programme. A good example of what the key completions milestones might look is:

1. Completions & handover management plan
2. Work Breakdown Structure (WBS) – this is based on how the project is going to be designed and constructed. The WBS is used to structure the completion's reports by areas, sub-areas and construction elements.
3. Master drawing list – presents a master list of all drawings that the project plans to use.
4. As-built drawings – Drawings are produced progressively through the Design Phase until they are Issued for Construction (IFC). Red Line Mark-ups are produced during the construction phase through to practical completion. Red line mark-ups are drafted into as-built drawings and then issued for review/certification, before being issued out to stakeholders.
5. Physical works completions – represents the milestone when the new asset is activated and brought into commercial operation.
6. Practical completion is issued along with deliverables including as-built drawings certificated ready for handback to the stakeholder, defects have been closed-out, spare parts, warranties and work lots are all closed-out.
7. Final completions is at the end of the defects correction period (DCP) commencing at the award of practical completion. The project finally ends two years later with the delivery of a final completions report.

How are we going to get there?

The 'Completions process on a page' as seen in Figure 1 was created to:

- Explain the completions process.
- Show how we need to deliver completions deliverables.
- Illustrate that completions deliverables are more than just as-built drawings & O&M manuals.
- Highlight completions activities across the project life-cycle.
- Demonstrate completions commence at the start of the project (it really does!).
- Emphasise progressive delivery.

Conclusion

There are many great challenges for major projects, but by using the Completions Process mindset to change project culture, the result will be projects ending on time, on budget, and with happy stakeholders.

We need to move away from "people just doing stuff" and towards understanding what the project requirements are, what the deliverables are, who the stakeholders and asset owners are, and creating a plan to provide this outcome. Then when it comes time to hand the project over, there must be a clear set of documented completion deliverables for the stakeholders to sign off on. The process is designed to reduce any last-minute surprises, preferential engineering or new requirements being introduced last minute.

We need to be doing the right things at the right time during the project to ensure that a quality outcome is achieved on time and within budget.

My measure of success is:

- Firstly, getting people talking about completions.
- Secondly, people actually performing completions – that is putting in place the plan up front and delivering on it. This includes having completions milestones included in every project programme.
- Finally – the stakeholders and asset owners receive all the details they had signed up to at the start of the project by the time you get to the end of the post practical completion milestone.

Imagine how happy they will be!

About the author ...

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Managing obsolescence in the rail industry

Stuart Broadbent

This article was originally published by the International Institute of Obsolescence Management on the subject of obsolescence in the rail industry.

Obsolescence is a subject that is of particular importance to signalling and telecommunications throughout the world. Stuart Broadbent, obsolescence director of Alstom, and a director of the International Institute of Obsolescence Management (IIOM), describes how the rail industry can mitigate the risk of component and software obsolescence.

The increased use of electronic systems in rolling stock and rail infrastructure has undoubtedly improved operational efficiency and safety for the rail operator (passenger and freight), as well as enhancing the passenger experience. For the rail engineer, however, these electronic systems come with the added challenge of managing obsolescence.

Latest technology vs legacy

There is a simple reason why the rail industry is vulnerable to obsolescence and that is because most electronic component and equipment manufacturers are focused on their next-generation products and on emerging technologies. Moore's law is the observation that the number of transistors in a dense integrated circuit (IC) doubles about every two years, meaning more processing power in less space and using less energy; a five-year-old IC will never be used in the latest consumer product. This reliance on R&D to provide new revenue streams means that today's hot new products quickly become legacy parts as the component manufacturers follow development cycles that are driven by fast-moving consumer markets.

Mobile phone users will expect to upgrade their handsets every 18 to 24 months, whereas the planned life-cycle for rolling stock is usually 30 or 40 years.

There is also a significant difference in the volume of units shipped to the consumer and rail industries. Global shipments of mobile smartphones reached 1.47 billion units in 2017; compare that to the 6000 main line vehicles planned for delivery in the UK between 2014 and 2020, and the difference in the component requirements becomes clear. The difference in the expected operational lifetimes and the production volumes means the focus for manufacturers of electronic components will always be on latest technology components for high volume markets rather than legacy, low volume parts.

The expected lifetime of software also falls short of the life-cycle needs of the rail industry. Microsoft withdrew support and automatic upgrades for Windows 1998 after just eight years and ceased support for Windows XP after 12 years.

As Figure 1 shows, the challenge facing rail engineers is to ensure the continued operation of electronic systems well past the point at which the manufacturers no longer produce or support the components within them.

There are two types of obsolescence that need to be managed: functional obsolescence and technical obsolescence.

Functional obsolescence

Functional obsolescence occurs when installed equipment cannot be adapted to meet new standards or regulations for issues such as quality of service and efficiency. Examples of functional obsolescence include updated regulations for People of Reduced Mobility (PRM); changes in the availability of the radio spectrum for voice and data communication; and the lower processing power of a legacy computer being unable to support greater demand for sensor inputs or system intelligence.

Technical obsolescence

Technical obsolescence means that the correct operation of the equipment cannot be guaranteed because spare parts or technical support is no longer available from the manufacturer. Technical obsolescence may occur when a component manufacturer withdraws a legacy part so that the equipment in which it is used can no longer be supported, or when a supplier no longer wishes to support a product range or goes out of business.

In addition to the obsolescence of electronic components, the rail engineer may also have to consider the obsolescence of materials (regulations such as RoHS and REACH have stopped or restricted the use of hazardous chemicals and some raw materials), changes in production tools and even workforce skills. As older employees retire, younger recruits may not have been trained on the legacy systems and technologies that are still operating in the rail industry.

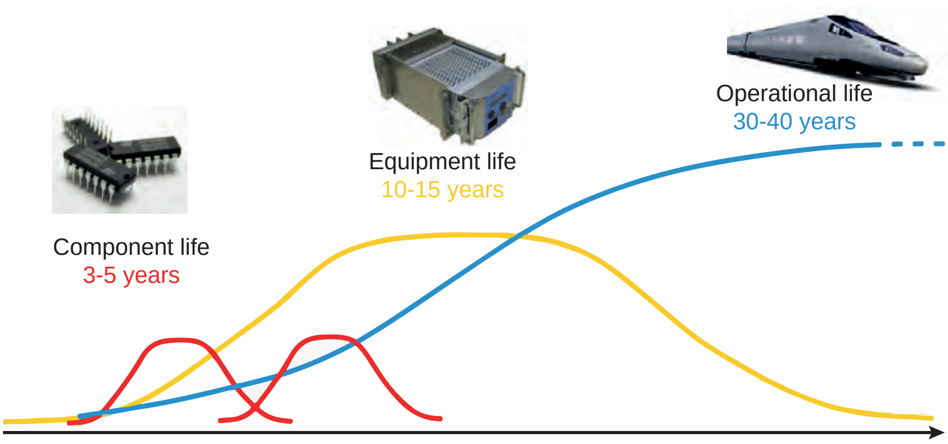


Figure 1 – Short component life-cycles make obsolescence inevitable in equipment with a long life-cycle.

GSM-R, the European standard for rail voice and data communication, and used in the UK for both voice communication and for ETCS, will only be supported by the manufacturers until 2030, and beyond this it will become increasingly difficult, and expensive, for infrastructure managers to maintain the same quality of service.

Managing obsolescence

In order to determine the obsolescence strategy for a product or system, the engineer needs to assess the likelihood and impact of obsolescence during the life-cycle. This assessment takes place at initial design stage and is reviewed periodically.

- If the combination of likelihood and impact of obsolescence is low, a reactive approach can be followed – in which nothing is done until the obsolescence materialises.
- If the combination of likelihood and impact of obsolescence is medium or high, a proactive approach should be followed – in which case there needs to be an obsolescence management plan to mitigate the obsolescence risks.

If the product or system includes software, the likelihood and impact of software obsolescence during the life-cycle also needs to be considered. Within the same product or system, there can be equipment and components that can follow a reactive approach, and equipment and components that requires a proactive approach. These strategies are described more fully in the new standard for Obsolescence Management, IEC 62402:2019.

A coordinated obsolescence management plan is essential for a proactive approach. It is also important to create a business-wide culture of obsolescence awareness, particularly in the R&D, engineering, maintenance, sourcing and supply chain functions.

Proactive obsolescence management should start during the initial stages of product design. At this stage, the risk of obsolescence can be mitigated by using techniques such as Preferred Parts List, obsolescence checks on proposed Bills of Material, dual sourcing, technology transparency (specification of interfaces) and by undertaking technology assessments and risk-mapping. Anticipating and planning for upgrades, and considering the road-map for each technology are also crucial.

When the system is installed and in service, obsolescence should be monitored at component, product and system level. This is achieved by periodically reviewing the market for emerging technologies and generating a watch list of critical parts. By monitoring the availability status of electronic components, the product manufacturer is able to make life-time buys of components based on forecast demand for production, spare parts and repairs when the end of production of components is announced. With good storage techniques, components can be stored for 20 years or more, helping to ensure that the product can be supported for its complete life-cycle.

A reactive approach is applicable to products with low or stable technology, or containing items with low likelihood of obsolescence such as mechanical or machined parts, and where the impact of obsolescence is assessed as low.

Sharing information and best practice

The International Institute of Obsolescence Management (IIOM) www.theiiom.org is the professional body for those involved in, or interested in, Obsolescence Management. The Institute is for professionals worldwide who wish to further their knowledge and understanding of the Obsolescence Management discipline, obtain professional recognition, and network with like-minded individuals from its global membership.

IIOM started in the United Kingdom as COG (Component Obsolescence Group) in 1997 and now has Chapters in Germany, India and USA as well as the UK. Members come from all industry sectors and all levels of the supply chain, and are located in countries around the world; members include asset owners and operators of systems and equipment, manufacturers of systems, equipment and components, and obsolescence solution providers.

Those joining the IIOM are able to network with people from other companies and industries on obsolescence management best practice in both obsolescence management and counterfeit avoidance.

The regular member meetings provide a mix of formal presentations and informal discussions at which obsolescence engineers, buyers and solution providers can exchange ideas on key issues such as REACH, conflict minerals and counterfeiting. The meetings also provide access to the latest tools and systems developed to reduce the administrative costs of obsolescence monitoring and management. IIOM members were heavily involved in the development of the new version of IEC 62402:2019, issued in June 2019, and IIOM has a series of guidance booklets on various aspects of Obsolescence Management.

Conclusion

Effective obsolescence management requires partnership between the asset owner, operator, system integrator and the equipment suppliers, built around a formal obsolescence management plan.

It helps rail engineers to ensure that the operational lifetime of equipment can be extended far beyond the timescales supported by the electronic component manufacturers and software suppliers. So, despite the throw-away culture of consumer markets, the rail industry should still be able to measure the operational lifetime of its equipment in decades rather than years.

Industry news

Main line and freight

DB future plans to control German train traffic

Germany: Deutsche Bahn (DB) have announced that their future plans for train traffic control will be delivered by 280 digital signal boxes. Germany's 33 400km network will feature new digital interlockings, replacing over 2 600 current interlockings of numerous types. The first digital interlocking, on the long-distance rail line between Rostock and Warnemünde is now in service.

Ronald Pofalla, DB Infrastructure Board member, said: "The railway can only make its contribution to the improvement of mobility and climate protection in Germany if it becomes more efficient. Digitalisation will make a decisive contribution to this. Digital interlocking units working in unison with the European-wide uniform train control system (ETCS) intelligently networking all data of infrastructure and vehicles. They enable a completely new organisation of rail operations for all companies. The rail will gain significantly more capacity, become more reliable.

EU funds for Dutch railways

Netherlands: The European Commission has approved funding of €22.2m (£19m, $24m) to equip freight locomotives with ERTMS. The funding is part of the EU's plan improve interoperability without affecting competition in the sector.

The funds will be used to install ERTMS on the 99 cross-border freight locomotives. Approximately 30-40% of the European Core Network Corridors are to be installed with ERTMS by 2023 and the Netherlands is planning to install ERTMS on the majority of its rail network that forms part of the European Core Network Corridors. The EU also noted that owners of the trains will need to upgrade equipment to ensure the effective use of ERTMS and the Dutch state will provide €23.8m (£20m, $26m) to support this

New world record: 375 wagons on single train

South Africa: Transnet SOC Limited has broken its own world record with the launch of a 375-wagon manganese train. The train is 4km (2.49 miles) long and runs over a distance of around 861km (535 miles), from Sishen to Saldanha in South Africa. The number of wagons was increased from 312 to 375 wagons, resulting in manganese volume rising from 19 656 tons to 23 625 tons per train. The previous record was an iron ore freight train carrying 342 wagons, also operated by Transnet.

The extra-long freight train was a direct response to rapidly increasing volumes of manganese export. Transnet's share of this export surged exponentially from 5 million tonnes in 2012-2013 to 15.1 million tonnes in 2018-2019.

Uruguay's Central Railway ERTMS

Uruguay: The Central Railway PPP project has awarded a €50m (£43m, $55m) contract to a consortium of CAF Signalling and Revenga Smart Solutions to install signalling and telecommunications, including ERTMS Level 1. The scope includes provision of an electronic interlocking and centralised traffic control.

The Central Railway project involves the rebuilding the 273km line linking the Port of Montevideo with Paso de los Toros. The line will be designed to allow 22.5-tonne axle load freight trains to operate at up to 80km/h. A 36km section of the line between Montevideo and 25 de Augusto will be used for passenger services.

New ERTMS testing and training centre

Norway: Infrastructure manager Bane Nor and Siemens have opened the Campus Nyland test, training and signalling simulation centre, marking a milestone in Norway's goal of becoming the first country to operate with a single digital interlocking. The centre will prepare staff to work within the ERTMS digital system and when fully rolled out in 2034 the system will cover 4200km of track and more than 350 stations.

Campus Nyland will be an industry centre for digital education and will house more than 5000 employees, who will learn the necessary skills needed to ensure ERTMS is successful when it becomes operational. This will include staff from Bane Nor, train operators, maintenance companies and contractors. The Campus will have simulator training as well as physical training facilities, using new technology such as virtual reality to communicate how lines are equipped with ERTMS, as well as the design of trains and traffic control centres. More than 150 different scenarios are available for training within the highly digitised training hub.

The Roa-Hønefoss ERTMS test line is due to open in spring 2020, with the new signalling technology to be monitored and tested from Campus Nyland, with the next milestone being the digitalisation of the Grong-Bodø Nordlands line, which is due to become operational in October 2022.

Swedish level crossing controllers

Sweden: Swedish rail and road infrastructure manager Trafikverket has contracted EFACEC to develop a new-generation automatic level-crossing system, known as XSafe. XSafe is the latest version of EFACEC's automatic level crossing control system and is based on the SIL4-certified HIMatrix series from HIMA.

EFACEC and HIMA have already successfully deployed XSafe level crossing systems on Portuguese and Polish rail infrastructure, and a similar architecture based on HIMatrix platform is also used in EFACEC's AEGIS Interlocking system, already in service in Oporto Metro (Portugal), Dublin Light Rail (Ireland) and being installed at Odense Light Rail (Denmark).

Leeds and Bristol commissioning

UK: Alstom has recently completed two large signalling commissionings for Network Rail.

West of England (Bristol) Filton Four Track Phase B was signed into use in November 2019. The final commissioning represented a milestone in the area, as the newly commissioned bi-directional signalling was an enabler to the new timetable introduced in December 2019.

Filton Four Track follows on from the commissioning completed at Leeds over the weekend of 26 27 November 2019 for the first commissioning stage for the Leeds station signalling and remodelling project. This project forms a part of the programme of works for providing capacity enhancements at Leeds Station and includes the provision of new platform 0 and the remodelling of the approaches to platforms 1-6 to provide more parallel moves.

The scope included signalling alterations in order to maximise the benefit of the new layout, involving the re-lock of eight SSIs controlling Leeds station into a new Smartlock based in York Railway Operating Centre, and a new auto re-configurable feeder to power the new signalling equipment.

Scotland to upgrade north-east and Highlands network

UK: Network Rail Scotland has announced plans to make an investment of £4.5m (€5.2m $5.8m)to improve performance in the north-east and Highlands rail networks. The Highland main line, East Coast main line, Aberdeen-Inverness line and the Far North line will receive upgrades; with new machinery, equipment and extra staff for depots in Inverness and Perth.

The money will be primarily used to renew or upgrade signalling systems and to acquire remote monitoring systems capable of identifying potential faults. The money will also be spent on track maintenance, new machinery and equipment, as well as line-side vegetation clearance.

Network Rail stated that it has increased the infrastructure reliability in Scotland by 26% compared to last year. It also plans to conclude the £330m (€382m, $426m) Aberdeen-Inverness Improvement Project in December, to cut journey times and increase service levels. Last year, Network Rail announced its plans to invest £4bn (€4.6bn, $5.2bn) in Scotland railways between 2019 and 2024.

Poland's Legnica-Głogów line

Poland: Services on the Legnica-Lubin-Rudna Gwizdanów-Głogów line in western Poland recommenced in December following a Zlotys 200m (£40m, €47m, $52m) reconstruction of Legnica -Rudna Gwizdanów section of the line. The project has renovated the stations at Rzeszotary, Raszówka, Gorzelin, and Chróstnik, and constructed a new station at Lubin. A new traffic control system has been installed, together with the renewal of the track and electrification system, and a new 5m-high viaduct has been built in Koźlice to remove a level crossing.

The investment will increase capacity to allow more trains to operate and will improve services for passengers with limited mobility. It is hoped the extra capacity for freight will also result in a modal shift from road to rail.

New locos for BLS Cargo

Switzerland: Rail freight operator BLS Cargo has awarded a contract to Siemens for 25 Vectron MS multiple-system locomotives. The 6.4MW locomotives have a maximum speed of 160km/h, and will be used to haul trains on the Rhine-Alpine freight corridor connecting the Netherlands and Belgium, Germany, Switzerland, and Italy.

The locomotives will be equipped with ETCS as well as the national signalling systems. Delivery of the locomotives will start at the end of 2020 and continue through to 2025. The order will add to 15 Vectron locomotives which BLS Cargo ordered in 2015.

Metro and light rail

Crossrail opening and cost forecast update

UK: Crossrail Limited (CRL) has advised Transport for London (TfL) that there are some projected delays in the opening of the Elizabeth line and it is likely that additional funding would be required to cover the higher levels of risk contingency.

The latest projections show a central cost forecast (including risk contingency) of approximately £15.4bn (€18bn, $20bn), which is £400m (€467m, $514m) more than the funding committed. Further modelling scenarios consider even higher levels of risk of £650m (€759m, $835m) more than the funding committed.

TfL has been advised by CRL that their latest assessment is that the opening of the central section will not occur in 2020 which was the first part of the previously declared opening window. The Elizabeth line will open as soon as practically possible in 2021. A more comprehensive update is expected early in 2020.

The Elizabeth line will stretch more than 60 miles (100km) from Reading and Heathrow in the west through central tunnels across to Shenfield and Abbey Wood in the east. The new railway will stop at 41 accessible stations, 10 newly built and 30 newly upgraded, and is expected to serve around 200 million people each year. The signalling architecture for the route includes ETCS, CBTC and conventional signalling.

Crossrail is delivering one of the most complex and challenging signalling system implementations in the world, involving the integration of ETCS, CBTC and legacy signalling systems. Technical director Colin Brown explains how Crossrail are delivering the systems and what the benefits will be long term, in a video which can be seen at **irse.info/xzy9d**.

Victoria Line capacity improvements

UK: Following the completion of a signalling upgrade in 2017, London Underground's Victoria Line services have been running every 100 sec between 08.15 and 09.45 and between 17.00 and 18.30.

Transport for London has now introduced a new timetable that doubles the length of time during which services run at 100s headways. In the new timetable this has been extended so that it covers a morning peak of 07.15 to 10.15, and an evening peak of 16.15 to 19.15. Off-peak services will continue to run every 135s.

The Victoria Line currently provides for 250 million passenger-journeys a year and TfL says that the change increases line capacity by 5%. Running peak-hour service frequencies for longer periods is a good way of increasing passenger capacity and to make best use of signalling improvements. It also complements businesses providing more flexible working hours.

Docklands Light Railway signalling contracts

UK: Two contracts for signalling and train control equipment on the Docklands Light Railway light metro in east London have been awarded.

Transport for London (TfL) has awarded a contract to supply upgrades to the signalling software subsystems on the network, which uses Thales SelTrac CBTC, and CAF has awarded Thales a contract for the supply of onboard train control systems for the 43 trains on order to replace the fleet from 2023.

Earlier this year TfL awarded a contract to CAF for £350m (€405m, $452m) to supply a fleet of 43 five-car driverless trains. The order includes 10 trains to enable an increase in frequency and capacity across the network, for which signalling software upgrades are required.

Hurontario LRT contract award

Canada: The Mobilinx consortium, consisting of Hitachi Rail, Astaldi Canada Enterprises Inc., Salini-Impregilo S.p.A., John Laing Investments Limited, Transdev North America, Inc. and Amico Concessions Inc. and Bot Engineering & Construction Ltd., has signed a C$4.6 bn (£2.7bn, €3.2bn, $3.5bn) contract with Infrastructure Ontario and Metrolinx for the Hurontario LRT in Mississauga, Ontario. The Hurontario LRT is an 18-kilometre (11.2-mile), 19-station light rail transit system that will run along Hurontario Street from Port Credit in Mississauga to Brampton Gateway Terminal.

The scope covers 18 stations, plus one underground station, as well as other related infrastructure work, at-grade and elevated guideways, trackwork, operations control centre (OCC) and an operation, maintenance & storage Facility (OMSF), signalling and train control, telecommunications and SCADA, traction power and catenary, 28 Light Rail Vehicles (LRV) together with Operation & Maintenance (O&M) of the infrastructure and LRVs for 30 years.

Hitachi Rail STS will install its Wayside Standard Platform CBTC (communications-based train control), which includes onboard, wayside and central office systems and AI (Artificial Intelligence) technology.

Telecoms

Europe's first 5G 'slicing store'

Europe: Hutchison Drei Austria has partnered with ZTE Corporation in China to demonstrate the first 'slicing store' in Europe and the first end-to-end 5G network slicing operation in the telecoms industry.

With 5G slicing, a predefined service parameter can be selected according to the requirements of the application, such as guaranteed bandwidth, maximum latency. This may be of interest to railway operators for 'mission critical' important low bandwidth low latency applications, and higher bandwidth higher latency secondary applications.

In the Hutchinson ZTE 5G slicing store, designed for a public 5G network, consumers or enterprise customers can select the predefined slice template and set the service level agreement (SLA) parameters according to the characteristics of the user or individual industry requirements. The user can log into the online sliced based service store, and choose services with different SLA. Once the payment is completed, the service is activated.

If the number of users increases or the Key Performance Indicator (KPI) decreases, the system can automatically adjust its resources to maintain KPI. The slicing solution can be used in vertical industries to meet variable requirements.

Ofcom 5G spectrum auction

UK: Ofcom manages the UK's spectrum and has announced updated plans to release additional mobile spectrum through an auction in spring 2020 to support the rollout of 5G.

Ofcom recently proposed rules that would require mobile companies in the UK to increase coverage in rural areas, in exchange for winning discounted spectrum through the auction. In response mobile operators BT/EE, O2, Three and Vodafone have proposed an alternative 'shared rural network' plan. This was aimed at delivering good quality 4G coverage to at least 92% of the UK over the next six years.

The UK government has announced that the companies have committed to reaching this target and also confirmed it will provide £500m (€580m ,$640m) of funding for the plan. Ofcom has welcomed this agreement and will make it a condition within the companies' spectrum licences. The companies' new agreement will achieve higher coverage than the requirements Ofcom could have set through an auction, so Ofcom is no longer proposing to include coverage obligations in the auction.

Ofcom has a duty to ensure spectrum is used efficiently and to ensure companies can compete fairly and customers have a good choice of mobile networks. So, to promote competition, it is still proposing a 37% cap on the overall spectrum that any one mobile company can hold following the auction.

Private LTE and 5G mobile radio network spending to hit US$8Bn by 2023

World: Research from SNS Telecom & IT, a market intelligence and consulting firm with a primary focus on the telecommunications and information technology industries, concludes that private mobile radio networks are expected to become the preferred way of delivering wireless connectivity for critical communications, such as for rail, industrial Internet of Things (IoT), and some public venues.

Annual spending on private LTE and 5G network infrastructure (including radio access, core and transport networks) is expected to increase from US$4.7bn (£3.7bn, €4.2bn) at the end of 2020 to US$8bn by the end of 2023, growing at 19% per year. The report notes that 5G will be the preferred wireless technology for Industry 4.0 automation and industrial premises, such as factories, warehouses and ports. This level of investment should provide private mobile radio network systems that could be used by railway operators, should they wish to invest in private LTE 5G.

The report says that the first private 5G network deployments will span a wide range of use cases. These include connected robots in factories, augmented and virtual reality (AR/VR) applications as well as massive sensor networks that control Automated Guide Vehicles (AGVs). One example is Mercedes-Benz's car production plant in Sindelfingen, Germany, which will use 5G and Wi-Fi to connect machines and production systems throughout the complex. See irse.info/x1vbp.

Spectrum for Indian Railways

India: Telecom Regulatory Authority of India (TRAI) has recommended allocating 5MHz spectrum in the 700MHz band to Indian Railways for its use in areas such as passenger information display system and live feed of video surveillance and other public safety and security needs. The spectrum will be allocated to Indian Railways for implementing Mission Critical Push To Talk (MC PTT) voice, Internet of Things (IoT) based asset monitoring services, passenger information display system and live feed of video surveillance for certain coaches of a train. TRAI said "the spectrum will be assigned to Indian Railways on administrative basis for captive use only and not for any commercial services such as on-board passenger Wi-Fi.

Indian Railways had urged the reservation of 15MHz of spectrum in 700MHz band for the purpose, and for 10MHz to be allocated free of cost, emphasising that the proposal was devoid of any commercial gain, and aimed at enhancing security and passenger amenities. TRAI said that to implement the video surveillance system for all coaches for train for security purposes the railway may explore other communications means, such high capacity Wi-Fi when a train reaches a station via a public telecommunication network.

The regulator noted that the Indian Railways has proposed to install Long Term Evolution (LTE) based corridor for 'train-ground' and 'train-train' communication and added the 1.6MHz spectrum already assigned to Indian Railways in the 900MHz band may be taken back upon migration to an LTE based network.

Greater reliance on 5G equipment makers

Europe: The EU coordinated risk assessment of the cybersecurity of 5G networks is designed to help EU member states prepare for the security threats of 5G (irse.info/h0y8z). It warns that telecom operators will be more dependent on equipment makers in general and this may introduce potential security issues. The report says that in addition of the new technical features of 5G, such as software defined and virtualisation networks, network slicing, and mobile edge computing, it will also raise new challenges, both in terms of changing risks and involvement from new suppliers.

"In particular, they will give additional prominence to the complexity of the telecoms supply chain in the security analysis, with various existing or new players, such as integrators, service providers or software vendors, becoming even more involved in the configuration and management of key parts of the network. This is likely to intensify further the reliance of mobile network operators on these third-party suppliers," the report says.

With greater reliance comes greater potential for attack. "Among the various potential actors, non-EU states or state-backed are considered as the most serious ones and the most likely to target 5G networks", it explains. "In this context of increased exposure to attacks facilitated by suppliers, the risk profile of individual suppliers will become particularly important, including the likelihood of the supplier being subject to interference from a non-EU country." The main 5G suppliers with sizeable market shares are Ericsson, Huawei and Nokia, but the report also lists Cisco, Samsung and ZTE as other large suppliers, none of whom are EU based.

The report also highlights the risk of dependency on a single supplier, the implication being that relying on one vendor for everything increases the risk of problems, which may result in interruption in service from a commercial failure or from a malicious attack.

Safety and standards

Bangladesh collision

Bangladesh: Two trains have collided head-on in Brahmanbaria with fatalities and people injured. The incident happened in the early hours of 12 November when the Chittagong-bound Udayan Express hit the Dhaka-bound intercity train Turna Nishita. Local news publication the Daily Star reported that this crash cut off rail communication between Chattogram-Sylhet and Dhaka-Noakhali. It has been suggested the collision may have occurred because signals were passed at danger by one of the trains.

Three committees have been formed to investigate the incident. Chief mechanical engineer Mizanur Rahman will lead a four-member committee and divisional transport officer for Chattogram Nasir Uddin will lead another four-person team. A third team will be led by the Brahmanbaria additional district magistrate.

Research and innovation

Shift2Rail's Catalogue of Solutions

Europe: Shift2Rail's Catalogue of Solutions see (**irse.info/u1w6c**) brings together the innovative products and methods which Shift2Rail has been working on together with its members and key stakeholders to deliver transformed future-proof rail systems. The Catalogue of Solutions illustrates successful Research and Innovation results in the form of solutions, including their delivery date and highlighting benefits for final users, operators, infrastructure managers and/or suppliers.

The Catalogue of Solutions includes signalling applications such as: ERTMS next generation solution, Automatic Train Operation ATO (up to GoA4), moving block, fail-safe train positioning, adaptable communication systems and integrated mobility management.

Data Sandbox+ research

Great Britain: The GB rail industry's independent safety body, RSSB, Data Sandbox+ research competition is aimed at developing data driven solutions to improve operational rail performance. The Data Sandbox+ competition is part of the PERFORM programme, a cross-industry initiative led by RSSB, to achieve performance improvements.

The cross-industry collaboration is supported by Network Rail and various train operating companies. The budget is £1.3m (€1.5m, $1.7m), of which £650k was contributed by RSSB, with Network Rail matching this figure from its research and development portfolio. Four initial projects, which started in November 2019, have been awarded funding in the first round of the competition. These are:

- "Real time prediction and mitigation of disruption through personalised passenger communications", led by Zipabout and the University of Birmingham, in collaboration with LNER.
- "Data-driven robust timetabling", led by the University of Southampton, in collaboration with Network Rail and Bellvedi/Tracsis.
- "Rail performance modelling for strategic decision making", led by Risk Solutions, in collaboration with City University London, Heriott-Watt University, University of Southampton, Steer and Tracsis.
- "IntelliDoorDwell", led by Porterbrook in collaboration with ScotRail, University of Southampton and Elastacloud.

Data and big data

Indian Railways introduces IT-enabled services apps

India: The Ministry of Railways has released three online applications to improve project monitoring and IT-enabled services throughout the country.

Common Reporting Standard (CRS) Sanction Management System deals with work related to level crossings, such as closures, minor bridges, and manning and shifting. It also speeds up the processing of CRS Sanction cases and improves monitoring of compliance. The system offers a repository of CRS Sanction circulars, checklists, guidelines, and reports.

Rail-Road Crossing General Agreement Drawings (GAD) Approval System was developed to quicken the approval of GADs for roads over and under bridges. The system maintains the accountability of railways and governments at different stages of approvals, as well as facilitate better coordination between the stakeholders.

Track Management System (TMS) for Construction is dedicated to the construction of new assets. Data for the assets can be filed by construction officials before final checks. This application is for source data validation, smoother data entry and checks and accountability on the data.

Data to improve Tube journey estimates

UK: Transport for London (TfL) has analysed 2.7bn pieces of anonymised data since June 2019, which has been gained through tracking people's usage of Wi-Fi networks at stations across the capital. The data has been obtained by tracking passengers' phone usage and is helping (TfL) to improve its travel time estimates.

The analysis has allowed TfL to update its Journey Planner app to better estimate journey times between 55 different stations and the same information will also be used in the future to alter train timetabling to optimise routes. Lauren Sager Weinstein, chief data officer at TfL, said: "we are working to use this data to allow our customers to better plan their journeys and find the best routes across our network."

With thanks and acknowledgements to the following news sources: Railway Gazette International, Rail Media, Metro Report International, International Railway Journal, Global Rail Review, SmartRail, Shift2Rail, Railway-Technology and TelecomTV News.

News from the IRSE

Blane Judd, Chief Executive

Blane's World

Members will have already received the nomination forms for council members and awards, and some have already been returned. I urge all members to get engaged in the election process, full details can be found on the IRSE website at irse.info/governance. We have been in discussions with the Electoral Reform Service who will be helping us with the election process including voting online. In future years we will be looking at online nominations too. All of this is designed to allow a much wider engagement in the election of representatives and to make sure there is a good representation from all our international membership as we move into 2020 and beyond.

In late November 2019 I had the pleasure of attending the annual Scottish Section dinner in Glasgow and enjoyed the warm welcome I received. The guest speaker was Andrew Haines, the CEO of UK infrastructure operator Network Rail, and we had an interesting discussion about the important role of the Institution, professional ethics and competence development. This has been a theme in many of my recent discussions and engagement activities which culminated in a meeting I attended with Keith Upton (chair of the Younger Members' Section. Attended by the CEO of all of the UK professional engineering institutions (PEI), the CEOs of the Engineering Council and Engineering UK, and the CEO and president of the Royal Academy of Engineering, and young members from the PEIs, the meeting was a plenary session addressing, among other things a key question about the relevance of PEIs to younger members. The outputs are to be published and there are some key activities which all the PEIs have agreed to work on together to maximise resources.

On a more personal note I am extremely grateful to all those who arranged a surprise birthday celebration for me in the month. It is the generous nature of the staff here that make the task of CEO even more enjoyable.

Rail Performance Think Tank

The Institution is a key member of the Future Integrated Railway Think Tank (FIRTT) which is a cross industry working party made up of senior representative from the Rail Delivery Group (RDG), the IRSE, WSP and KPMG.

Our remit is to stimulate debate and action in four key areas of rail performance – accessibility, dependability, affordability and sustainability. During the first workshop held at WSP's head office in London on 5 November we had a lively and stimulating discussion on 'accessibility' addressing the question "How can we make rail travel more user-friendly, easy to undertake, and more attractive to people who would not normally contemplate using rail as part of their end-to-end journey?" The resulting paper will be published in a future issue of IRSE News.

Annual Dinner

Booking will open soon for the 2020 IRSE Annual Dinner which will be held for the first time in historic Landmark Hotel 222 Marylebone Road London on 24 April to accommodate larger numbers. The ticket price has been held at £159 and we are expecting another full house at this stunning venue, see the IRSE website for full details.

The Landmark has a railway connection as it was originally built as a hotel in 1899 by the Great Central Railway for passengers travelling through Marylebone station. In 1945 it was owned by the London & North Eastern Railway Company who had a shortage of office space, so they bought the building from Frederick Hotels.

In 1949 the nationalisation of the railways in the UK meant the LNER became part of the British Transport Commission, which later became British Rail. A newspaper article in the 1950s stated that the ballroom was being used as a basketball court and a railway worker canteen, an officers' mess and a senior officers' mess with a bar for meals, in what are now the hotel event spaces.

London & South East Section

IRSE
Institution of Railway Signal Engineers
LONDON & SOUTH EAST SECTION

Acoustic monitoring

Report by Paul Baker

Thursday 28 July 2019 turned out to be a somewhat more challenging meeting than normal, but then isn't that what committees enjoy.... a challenge!

The London and South East Section invited Nicholas Kay, operation director of Track IQ Wabtec to present on a subject a little outside normal signalling matters, trackside acoustic monitoring systems for train axle journal bearings. Having made all the arrangements, the committee hadn't anticipated that the day would be one of the hottest on record and there would be significant disruption to train services. Our guest was a victim of such events, his train was involved in an incident near West Hampstead so instead of a relaxed arrival to meet members and deliver the talk he arrived just in time for questions and answers! This challenge was met with a quick transfer of the presentation file, a rapid rehearsal by one of the committee, who had fortunately worked with Nick on this equipment. He delivered the first part of the evening followed by questions and answers with Nick when he arrived to round off the evening.

Many railway engineers and operators are familiar with the Hot Axle Box Detector, HABD, with some 220 locations around the Network Rail system dating from the 1960s. This system relies on the detection of heat, which means something is going wrong and so is a reactive response to a developing failure and action is needed quickly. The HABD technology does not lend itself to third rail systems and requires significant equipment both within the track structure and lineside. These also only tend to be reliable detectors for plain metal bearings but todays rolling stock is increasingly employing roller bearings and so mechanical collapse can occur before a significant and reliable heat signature can be detected.

The commercial demands of the heavy-haul railway that have developed in both Australia and America, at least, with long trains of roller bearing fitted wagons with only a 'head end' operator. This drove the demand to develop a monitoring system that was far more predictive rather than wait until some 10 000 tonnes of valuable ore was spread all over the railway infrastructure with direct loss of that resource and knock on impact to subsequent service and product delivery, all hitting the 'bottom line'.

From this emerged one such technology product in the form of the Rail Bearing Acoustic Monitoring (RailBAM) by the then VIPAC Company of Adelaide Australia, now Track IQ and part of Wabtec. The principle is simple and with modern technology and communications allows application in such a way that condition based monitoring of fleets can be effectively implemented to deliver significant cost and operational benefits through much improved identification of bearing defects being removed before impending failure.

Our speaker's unorthodox journey involved being evacuated from a disrupted train. *All photos N Kay/TrackIQ.*

Examples of defective bearings.

Located beside the track is a cabinet within which there is a microphone array. The array is protected from the elements by a shutter door which opens with the detection of an approaching train and the system then 'listens' to each bearing as it passes. With RFID (radio frequency identification) readers identifying the rolling stock and rail mounted sensors detecting the position of each wheel, each vehicle and axle bearing can be identified accurately and repeatably. The acoustic signal is analysed for defects at site in the trackside cabinet. Should a defect be detected, the data is transmitted to a server where the users can access the data from any internet connected computer or mobile device. Alarms and alerts are automatically generated by FleetONE providing predictive notification to change the wheelset or bogie, so removing the time-honoured preventative mileage or time-based methodology or routine changing, thus allowing significantly longer bearing life in service with the safety net of regular ongoing monitoring. Where fleets would previously operate a preventative wheelset overhaul at 800 000 miles, fleets are now exceeding 2 000 000 miles without costly overhaul or maintenance. Safety is being improved through continuous monitoring of the bearings

The trackside cabinet with the shutter door open and the microphone array bar just visible within.


Single track array in Norway, cabinets both sides of the track.

in service. Indeed, the author has experience from the first permanent installation shortly after commissioning when a unit passed the site, the IQ engineer detected audibly that an axle-box didn't sound right and within minutes, indeed an alert was raised and the train maintenance planned to remedy the defect some weeks later, and yes, a defective bearing was found.

One factor in deployment is locating the system so that outside factors do not affect the acoustic signature. The optimum operating speed range is between 30 and 80mph, with neither hard acceleration nor deceleration. Ideally the track should be straight and the track structure sound and consistent with minimal vertical movement, e.g. voiding. The ideal is also that there are no rail joints nor welds, especially site cast ones, installed and, if there is conductor rail, it is continuous with no ramps to generate shoe noise which might otherwise interfere. These details minimise any interference that could affect the acoustics output coming from a defective axle journal bearing. These requirements can usually be met at numerous locations on a route, but usually two or three are selected for their ease of access or proximity to a suitable electrical supply. The French TGV fleet has achieved this with installations in depot areas where operating speeds >20km/h are permitted.

The first system of this type in the UK was successfully trialled in 2007 near Three Bridges. The first permanent installation was in 2009, by Siemens, targeting their Class 444/450 fleet. The system was installed between Southampton Airport Parkway station and Swaythling, close to the then newly-built Northam depot, the main maintenance facility for this fleet and where all units return to in due course over a period of a few months, at worst case but quite adequate for such monitoring. Besides the South West fleet, trains from various freight operators pass that location with traffic to and from the Southampton Docks along with infrastructure vehicles from Eastleigh and further afield.

In the heavy-haul world many track miles are single and an acoustic cabinet can be installed either side of the track to enable both vehicle sides to be monitored at the same time. With the typical two track layout of passenger systems and a very limited '6 foot' this is not practical, so this leads to the system being split with a cabinet in the cess of each track and one side of the train monitored in one direction and the other side on the other. The basis of this layout is 99% of the trains passing will do on both sides within a reasonably short time of each other. The RFID tags fitted to the carriage or units which interact with the system identify the orientation.

South West trains then looked to its remaining fleet and a second system was installed at Mortlake on the Reading lines and effectively now all the fleet was covered.

A further system was later installed at Kensal Green on the Great Western Main Line at around the 2 mile post at the side of the up and down main, this enabled monitoring of the GW HST fleet and the suburban and Heathrow Express trains that also passed through the site. The usage there initially surprised the engineers and they queried "over 200 trains a day through the site?", perhaps something they were not used to in heavy-haul but the system was able to cope.

Worldwide RailBAM has been deployed in many countries, and that number is increasing, monitoring freight, metro/interurban and high-speed passenger vehicles through strategically placed installations.

It would be unfair not to mention that other systems are in use. The TADS (Trackside Acoustic Detection System) is an equivalent produced in America developed by the Transportation Technology Centre Incorporated which operates a significant test facility in Pueblo, Colorado, funded by the Class 1 railroads of the US system. The principle is similar but with very different physical architecture trackside. The presenter can recall sitting in the cab of a train travelling north from Denver passing such a site and the cab suddenly being filled with the verbal message saying "Loco NNNN, 26 axles, all good, have a good day".

Nicholas, having been de-trained trackside and required to leave his overnight luggage behind, and having travelled across London was able to join the meeting for a lively question and answer session. He was able to give some more detail on the use of the system in "FleetONE", the management system, and how the information can be used to increase availability and performance. Nicholas commented on the RSSB project T986 that conducted an assessment of the UK network, concluding some 35 sites of RailBAM would effectively capture the whole of the UK fleets. With the HABD system reaching the end of its life perhaps such a system as RailBAM is the next generation with the possibility of developing the hardware of the system to be less intrusive trackside and so more cost effective to install and maintain. With the drive to longer operating days and access only when train movements are blocked this is an important step for the future.

The committee of the London and South East Section thank Nick for his support and sterling efforts to make the meeting and Track IQ for sponsoring the tea and biscuits. By the way his baggage was at his hotel when he got there later that evening, well done East Midlands Trains.

A more detailed technical article on the RailBAM system is available in Rail Engineer Magazine, August/September 2019.

Younger Members Section

IRSE
Institution of Railway Signal Engineers
YOUNGER MEMBERS SECTION

Young Rail Tours – Scotland

Report by David Westcough

YOUNG RAIL TOURS

As reported in IRSE News November 2019 issue, Young Rail Tours (YRT) is a newly-founded organisation that has been collaboratively set up by the Younger Members Section of the IRSE, Institution of Mechanical Engineers (IMechE) and Institution of Engineering and Technology (IET), as well as Young Rail Professionals (YRP), in order to deliver a programme of domestic, European and international railway study tours made affordable and accessible towards young professionals working in the UK rail industry.

On the evening of Friday 20 September 2019, a group of 22 delegates travelled to Glasgow to partake in YRT's first railway study tour to Scotland. The majority of the contingent travelled up from London Euston by train, which provided a fantastic opportunity for the delegates to make acquaintance with one another prior to the start of the tour's activities. Upon arrival in Scotland, there was a brief opportunity for the tour-goers to network further over drinks before heading to bed.

On Saturday morning, the delegates were hosted by Transport Scotland (the national transport agency for Scotland) who delivered two presentations. The first looked at plans to develop Scotland's high speed rail network. The second presentation, delivered by the director of rail at Transport Scotland, Bill Reeves, detailed recent successful rail projects and the future outlook of rail north of the border. The question and answer session that followed allowed the group to gain further insight into the presentation topics, as well as scrutinise Transport Scotland's plans.

In the afternoon, the group travelled to the Govan area for a tour of the Glasgow Subway depot. Opened in December 1896, the Glasgow Subway is a light rapid transit subway system with a circular loop which extends both north and south of the River Clyde. On arrival at the depot, the delegates were given an overview of the history of the Glasgow subway, before a guided tour of the depot and its facilities. During the tour, there was opportunity to look and sit inside the driver's cab of the subway cars.

Touring the Glasgow Subway depot at Govan.

Bill Reeve of Transport Scotland presenting to the YRT group.

The group had a brief outing on a canal boat, in the rain.

As part of Strathclyde Partnership for Transport's plans to modernise the subway, 17 new trains are expected to enter service in 2020. The upgrade will feature the potential for driverless operation, an additional carriage and wider gangways for persons of reduced mobility. However, the delegates were unfortunately unable to view the new rolling stock as they are currently being stored at an alternative site. After a short break back at the hotel, the group attended an evening social at the Hillhead Bookclub, where delegates were able to network with local members of YRP over dinner.

Sunday morning saw the group travel to Linlithgow for a presentation on Scotland's major infrastructure projects, delivered by Rail Engineer magazine editor, David Shirres. This included a discussion on the regeneration of the Levenmouth line, which highlighted the wider benefit that rail provides in connecting communities to ensure access to higher education and employment, as well as added economic benefits. Once again, the group were able to ask questions, in order to develop their knowledge of rail in Scotland. David's presentation was followed by a brief outing on a canal boat, adding a cultural aspect to the tour, as well as developmental.

The tour's final activity included a visit and ride on the Bo'Ness heritage railway. Prior to the train ride, delegates explored the railway's museum and enjoyed the small model railway on exhibit. The 90-minute ride provided a relaxing end to the tour activities before heading back to Glasgow Central station for the journey home.

The trip to Scotland was thoroughly enjoyed by all of our delegates who thought that the tour provided good value for money.

The Bo'Ness heritage railway.

YRT is currently organising an 11-day study tour to Japan in March, where places have now been allocated to 25 lucky young professionals following a ballot. The tour will cover a number of cities across Japan, including Tokyo, Kyoto and Osaka, where main activities include visits to the Shinkansen control centre, SCMAGLEV and Hitachi's Kasado manufacturing facilities.

If you have any questions regarding YRT or its future tours, please get in touch with the YRT team on **youngrailtours@gmail.com**.

York Section

IRSE

Institution of Railway Signal Engineers

YORK AND THE NORTH EAST SECTION

Annual Dinner 2020

The IRSE's York Annual Dinner 2020 will take place at the National Railway Museum, York, on the evening of Thursday 12 March 19:00 for 19:30.

Members or companies interested in booking places or tables are asked to contact Becky Radnage at rebecca.radnage@networkrail.co.uk.

Professional development

Recording your development activities

Judith Ward, Director of Operations, IRSE

All IRSE members and IRSE licence holders sign up to maintain and develop their professional competence to retain the safety and efficiency of our railways.

It is good practice to record the regular planning, doing, reflecting and reviewing of these development activities. This maintenance and development of competence is called "Continuous Professional Development (CPD)" by the IRSE and is sometimes known as "Professional Development (PD)".

There are many forms of recording and the IRSE don't want members and licence holders to create additional work by duplicating records.

Many of our members and licence holders have their annual appraisals, training and some work experience logged in their employer's human resources (HR) records. Others use IRSE logbooks, or similar. Many others make use of the Mycareerpath database which is free to all IRSE members. Others use apps, spreadsheets, documents and even pieces of paper. All of these are acceptable ways of recording, but what should be recorded?

Action plans

When planning to maintain and/or develop your professional competence, you should consider; what skill, knowledge or experience would you like to do/develop/maintain in the next year-or-so?; how will you be able to do this?; what do you need to do?; what support do you need, and by whom?

To do this, you may need to consider where you are at present in your career, and where you want to be, whether that is to remain in your current role, obtain promotion, or move to another employer.

Once you have these in mind, you can formulate SMART (specific, measurable, achievable, realistic and timed) objectives. These might be the same as those discussed with your manager at your annual review, in which case your annual review would be a suitable record. However, you might have some objectives which you do not wish to share with your manager, in which case these need to be recorded elsewhere.

Some examples of action plans are shown in the table opposite.

Action plan title	CPD Plan Objectives
Action plan for 2020	To remain in my current position as xxx at xxx: Need to keep up to date with standards and processes by attending standards briefs and reading briefing notes from my manager. Aim to ask one question per briefing to demonstrate my understanding. Need to keep my trackside competence by going on and passing my training course before end of November. Teach Sam, the apprentice, how to do xxx task themselves. Bring in my training notes to go through together while waiting work allocation. Aim to complete by September.
Action plan to get xxx promotion	Planning move to next position (promotion to xxxx role): Find out what competencies and experience are required for that role. Talk through with my manager and looking at the role profile. Aim to do this in April. Then revisit this action plan to look at next steps – how to gain experience and knowledge required.
Action plan to be recognised as signalling/telecoms/ systems engineer	To increase signalling/telecoms/systems knowledge by taking IRSE professional exams. Will participate in study group and request place on xx course in December. Aim to sit modules 4 and 6 in October 2020 and modules 1 and 7 in October 2021.
Plan to get more management and planning experience to expand my potential career options.	To get management experience, I plan to volunteer to organise xxx IRSE local section seminar with assistance and guidance from other IRSE volunteers. Event takes place in October 2020, I need to start planning this in March.
Action plan to get project management knowledge	To become more efficient in managing projects through attending in-house training on company project management system in February, so will be able to understand the principles of a successful project. Ask for own small project at 6 monthly review in July.
Action plan to improve my communication skills	To improve my communication skills, use in-house company e-training (xxx and xxx courses) in March and April and use this knowledge to write an article for IRSE News about xxxx. Aim to submit article in August.

Activities

It is good practice to keep records of your CPD activities and what you have learnt after reflection on your activities. Producing a record helps to organise your thoughts and experiences; records don't have to be complicated, but we recommend at least:

- Evidence title including a brief description of the activity.
- Date and duration of activity.
- Type of activity (events, seminars, self-learning, formal learning, voluntary work, academic study and/or work experience).
- Any additional information about the activity, such as speaker name, name of training provider, author of book/article.
- Reflection (sometimes referred to as "lessons learnt" and "benefits gained") (see below).
- Follow up, where appropriate, stating what you will do differently as a result/how you will apply what you've learnt (see below).

When recording an ongoing activity, such as committee membership or attending IRSE exam study groups, split this into separate CPD events for recording purpose and link to your main objective. Whilst it may take a little longer to record, detailing each event, even with a few lines, will show your learning, progression and work more easily.

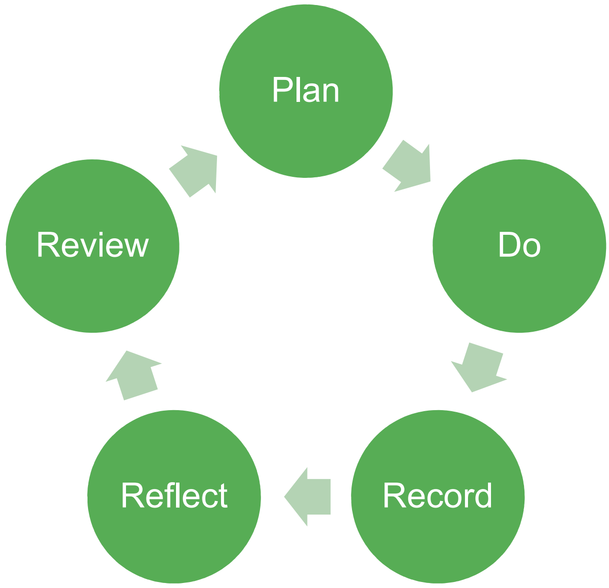
Reflect

Attending a technical presentation or training course should not be considered a 'tick box exercise' to satisfy your manager or someone reviewing your CPD records.

To show that you were thinking about the CPD activity, it is good practice to reflect on it. This is sometimes known as "lessons learned" and "benefits gained". The aim is to recognise and record the benefits and change in experience and abilities.

It is acknowledged, however, not all CPD activities are as useful as may have been expected. This could be because you have developed more quickly than expected when a course was booked, or the article you read was not at your level, or a mandated course to be attended at regular intervals, or another reason. These are still useful reflections to record, as they demonstrate your awareness of your own knowledge and abilities.

If you are recording your CPD using your employer's system, you may find that there is no opportunity to record reflections, so it is good practice to record this elsewhere.



The mantra of plan, do, record, reflect, review and repeat is a useful way of considering how best to carry out your development activities.

Some examples of reflection are below.

- Introduction to xx. Key areas covered were xxx and yyy however should have read up on xx before workshop.
- Repeat of mandatory health and safety training which I took last year – while it helped to maintain my competence nothing new was learned.
- Successful seminar organised and run through team work and efforts of the whole organising committee. I learnt how to plan an event like a mini-project using Project software which I hadn't used before.
- I had already learnt most of the subjects covered in the training. Will recommend for new staff in team.
- Interesting article. Will read references given to find out more about the subject.

Review

Your action plan should be reviewed regularly as it serves to demonstrate how your original objectives have been met and record what you are going to do with your new-found knowledge and skills.

This review might be done as part of your annual appraisal with your employer. However, this might not be applicable or suitable for you, in which case take the time yourself to review your action plan. If you have a mentor or trusted colleague, involve them too.

You should review your progress against your action plan, whether it was to develop or maintain your knowledge, skills and competence, and celebrate your achievements.

It is also an opportunity to re-evaluate your objectives and modify them as necessary or to develop a new action plan with further objectives.

It is very likely that your Development Action Plan will alter during the course of your career, with changes to personal and professional circumstances, interests and technology.

In summary

The maintenance and development of your professional competence should be a key part of your working life, regardless of what career stage have reached. Using technology through apps or online databases such as Mycareerpath may help you plan, record, reflect and review your progress but is not mandatory for the IRSE – use whatever method suits you.

If you are professionally registered with the Engineering Council (that is an Engineering Technician, Incorporated Engineer or Chartered Engineer), then you may be asked for your CPD records at regular intervals for monitoring by your engineering institution. If you do not engage with this monitoring, then you could be removed from the list of professionally registered engineers and technicians.

This is why it is so important that you respond to our requests for your CPD records – your plans, your activities, your reflections and your reviews. CPD helps you to realise your goals and can be so much more than just 'ticking the box'.

IRSE events

ASPECT 2019

Report by Ian Mitchell

ASPECT2019///

Institution of Railway Signal Engineers | Delft University of Technology | IRSE Nederland

After many years as a London-based event, the IRSE's ASPECT conference series is now truly international. The first foray outside the UK to Singapore in 2017 was a great success and the policy is now to hold ASPECT at a different location every two years, alternating with the IRSE Convention so there is a single flagship international event for the institution in each year.

For those who have not attended either, it may be worthwhile to clarify what is the difference between these events – the Convention focuses on learning about the country in which the event takes place, with invited speakers, technical visits and some sightseeing, including a partners' programme, whereas ASPECT is primarily a conference with an open 'call for papers' so it reflects the global range and diversity of current activity in the IRSE's field of interest.

ASPECT 2019 took place in Delft in the Netherlands from 21-24 October. The venue was the splendid AULA conference centre at the Technical University of Delft. The traditional ASPECT format of a two-day main conference, preceded by an introductory day and followed by a day of technical visits, gave plenty of options to participate for all or part of the event. There had been an excellent response to the call for papers, and the main conference was arranged with parallel sessions to allow as many speakers as possible. Over 50 papers were presented in total; this represents quite a challenge for your reporter, given the limited space in IRSE News and my inability to be in two conference sessions at the same time, so what follows is inevitably a selective report based on what I found most interesting.

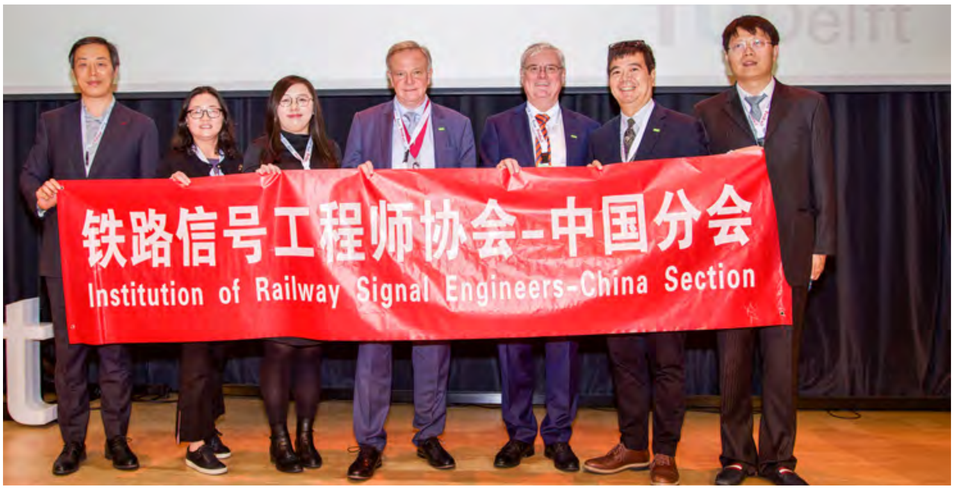
The theme of the conference was 'Resilience' and it was fascinating to hear all the different interpretations of what that word might mean. For example I hadn't expected to hear about pandemic flu as a threat to railway operations, but in his paper "**A whole-railway reliability approach to planning for things that will probably never happen**", Andrew Love (SNV Lavalin) pointed out that the UK government national risk register ranks this as the highest societal risk (likelihood multiplied by impact). How many railway operators have considered a scenario where perhaps 50% of staff are unable to work due to illness?

Another example of out of the box thinking was from Prerna Sharma (Siemens) who spoke on "**Building a resilient railway through its workforce**", in which she challenged us to ensure our recruitment and staff development activities reflect the true diversity of the communities that we serve, not only considering gender and ethnic diversity, but also neuro-diversity – how can we best exploit the talents of those who are dyslexic or autistic?

IRSE President George Clark opening ASPECT 2019.

Several speakers dealt with resilience in terms of the train capacity delivered by the signalling system and rapid recovery of normal service after a disruptive event. Joost Jansen (TU Delft) "**ETCS Hybrid Level 3: A Simulation-based Impact Assessment for the Dutch Railway Network**" compared Traditional Dutch lineside signalling and automatic train protection, with various ETCS options. All of the ETCS options showed a significant capacity improvement, and ETCS Hybrid level 3 additionally allowed much more rapid recovery from disruptions. Jan Hoogenraad (Spoorgloren BV) "**Arrival Time Robustness of Eco-Driving Strategies Under Two ATP Systems**" studied the interaction between different ATP subsystems and an 'eco-driving' driver advisory system that is aiming to minimise energy consumption by avoiding early arrival at station stops.

Maarten Bartholomeus (ProRail) "**No barriers for level crossings with ERTMS**" examined opportunities to optimise road closure times at level crossings by announcing train approach based on speed and position reports from an ETCS fitted train instead of a trackside train detection system. Two further level crossing papers came from Japan. Ryuta Nakasone (RTRI) "**Obstacle Detector for Level Crossing using Infrared Camera and Image Processing**" described how an aging population is increasing the frequency of slow moving pedestrians becoming trapped between level crossing barriers, leading to a need for obstacle detection technology that can detect people as well as vehicles. Akimasa Okada (JR-East) "**Clarifying design guidelines of level crossing logic with functional resonance analysis method**"



Clockwise from top left:
Lively question and answer sessions were a major part of ASPECT 2019. Speakers covered a wide variety of topics, for example Shivani Singh spoke about innovation in delivering a signalling project near Peterborough, UK. Committee member and TU Delft host Rob Goverde. Members of the China Section with George and Blane.

illustrated the use of the functional resonance analysis method (FRAM) to capture tacit knowledge for design of level crossing control logic in complex station areas.

Two of the academic presenters explored the implications of the 'virtual coupling' or 'train convoy' concept, where vehicle to vehicle communication could allow two or more trains to run together with a separation less than the absolute braking distance. Felix Schmid (University of Birmingham) "**Closer Running: Magic Potion or Deadly Poison?**" looked at the safety implications, with an attempt to quantify the risk of a leading train coming to stand so rapidly that the following train would be unable to brake in time to avoid a collision. Egidio Quaglietta (TU Delft) " **Exploring Virtual Coupling: Operational Principles and Analysis**" examined the benefits compared with conventional fixed block and moving block signalling, taking account of scenarios such as station stops and trains entering and leaving a convoy.

There were a number of papers dealing with system architectures. André Radomiak, (Alstom) "**A Fair Signalling Architecture**" and Luke Church (Thales) "**Architecting Railway Systems for Resilience**" both considered issues such redundancy of equipment and communications links, and distributed versus centralised architectures. The use of internet protocol (IP) communications is now widespread in signalling systems and some of the implications were explored in papers by João Martins (EFACEC) "**Moving Safely Towards IP Protocol for Signalling Equipment**" and Jeong-ki Hong (Korean Railway Signal Research Association) "**Development and Commercialisation of IP-based Railway Interlocking in Korea**" – it was interesting to hear how EULYNX interface standards developed in Europe are being adopted in Korea. Natsuki Terada (RTRI Japan) " **Scalable and Relocatable Interlocking Device**" and Matt Slade (CPC Systems) "**Virtualising Railway Control Centres: Can Virtualisation and Cloud Computing Deliver Increased Resilience?**" looked at options where interlockings or traffic management systems are no longer deployed on dedicated hardware in a railway's control centre, but as software in a remote data centre managed by a signalling or IT services supplier. Bob Janssen (Siemens) "**Taking a Legacy Interlocking to the Era of Internet of Things**", described how dynamic and static data can be extracted from an older electronic interlocking system and published via an OPC UA server to allow new applications to discover and consult information without the constraints of the legacy system architecture and interfaces.

Cyber security was inevitably one of the aspects of resilience to be covered, for example by Henry Cheung (Kone Elevator, Hong Kong) "**Protection of a Communication Based Train Control System from Hackers**" and Eylem Thron (Ricardo) "**Evaluating the impact of cyber security and safety with human factors in rail using attacker personas**". Alex Patton (Siemens) "**Developing Cyber Resilience Together: Industry Cooperation for a More Secure Railway**" focused on the need for railways and suppliers to work together to mitigate this threat, how this might be achieved and the challenges that are faced in doing so.

Clockwise from top left:

Disney Schembri presenting about how resilient railways are about a lot more than just reliable electronics. The organising committee with George Clark and Blane Judd. The model railway representing Heathrow Airport Terminal 5 transit system described in Aaron Sawyer's paper.

The challenges of delivering complex projects were addressed by several speakers. Alexandra McGrath (VicTrack) "**The Art of Interrogation – for better requirements capture**" based on her experiences of working with multiple stakeholders involved in the 'Big Build', a decade long programme of transport investment projects across the Australian state of Victoria. Ian Jones (Siemens) "**Providing System Resilience as the Goalposts move**" described how a combination of the traditional 'Waterfall' software development methodology with the alternative 'Agile' approach allowed a more rapid improvement in reliability growth after initial commissioning of a new signalling system.

Another topic of concern was how we manage major disruptions to a train service, both unplanned due to external factors or equipment failure, and planned interventions required to deliver 'brownfield' projects. Wim Coenraad (Movares) "**Business Continuity in Railway Signalling**" reviewed the role of 'secondary systems' that could keep trains moving in the event on a primary signalling system failure. Victor Abbott (Jacobs) "**ROCC and role: Implementation of rail operational control centres for resilience**" examined the critical role of the people and technology in a railway's control centre. Alexandra McGrath (VicTrack) "**Rail's particular challenge with Resilience: Shifting from Controlled Complicatedness to Working with Complexity**" described how experience of the disruption caused by a control centre systems failure in Melbourne was put to good use in planning for an extended shutdown for upgrade of the railway a few years later.

Through the Hewlett-Fisher bursary scheme, the IRSE provides funding for young engineers to attend major events such as ASPECT and the Convention. This year the bursaries were awarded to young members who were prepared to make a presentation at the conference, and these were every bit as professionally presented and topical as the papers from the older generation. Shivani Singh (SNC-Lavalin Atkins) "**Peterborough ground switch panel – a novel design development approach**" covered a seemingly mundane subject – replacing a mechanical ground frame – but in fact not a straightforward project as there was a gap in standards for this type of application. Alessandra Sternberg (Siemens) "**Crossrail integration facility and test automation**" described the fully automated off-site test facility that is being used to test the integration of CBTC, ETCS and legacy signalling systems installed on the trains that will run on the Crossrail route through London. In the following Q&A session, a delegate asked why such a "ludicrously complicated" system had been chosen. IRSE President, George Clark, intervened to provide a reply, pointing out that he was around at the time the decision was made, but the speaker was still at school then! Aaron Sawyer (SNC-Lavalin) "**What building a tangible model taught me about the real railway**" generated a lot of interest by describing the use of model railway and off the shelf micro-controller components to build a physical model of the tracked transit system at London Heathrow Airport Terminal 5, to demonstrate performance and resilience of a proposed upgrade to a client that was not familiar with railway operations.

In his closing address, George Clark said that ASPECT 2019 had certainly achieved its objectives by covering all aspects of resilience (pun possibly intended). It had been a great three days of sharing of knowledge from all around the world. He particularly thanked five presenters who were previously awarded bursaries to attend ASPECT 2017 in Singapore two years ago and had now persuaded their employers to sponsor them to attend and present at ASPECT 2019. He hoped we would be seeing more of this year's bursary winners in future years. The networking opportunities for old and young to meet are a key element of the IRSE's activities. Finally, he thanked the organising committee and the Dutch section for all their efforts in delivering such a splendid conference.

Attendees at ASPECT have access to written papers for all the presentations via the conference app, but we hope to publish a small selection in IRSE News in coming months. If you attended ASPECT, we'd welcome your suggestions of which papers we should choose.

Your letters

An operator's view of headway

Trevor Foulkes (Your Letters, October) is quite right to pick out tunnels and station approaches as an 'area of interest' for headway.

A key example is from HS2 [The new high speed line currently under construction between London and Birmingham in the UK] where tunnel ventilation shafts were initially located simply with respect to emergency services requirements, about 3.3km apart (implying a maximum of a mile for responders to walk to a disabled train). A complication arose when a 'one train between shafts' rule was added to the constraints, to be enforced by aligning signalling section boundaries with ventilation shafts. This introduced longer block sections in the tunnels than in open air, increasing the technical headway, but not beyond acceptable limits – so long as trains are running at speed. But the last shaft to portal section approaching a station becomes the binding constraint on headway as it is traversed at low speed reducing to zero in the station. Finally, an aspiration emerged that braking in tunnels should be planned to rely on regeneration without invoking friction braking, to avoid excessive generation of ambient heat, further increasing the transit time of trains through the critical section.

The learning from this is that shafts should be located evenly in terms of transit time rather than simply distance – just like block posts in Absolute Block signalling, as the Victorians knew very well.

With all due respect to those developing ETCS, as an operator I am not interested in shaving seconds off the plain line headway in open air, as it rarely if ever presents the binding constraint on capacity of a network (still less am I interested in yet another diagram of a cartoon locomotive with lightning flashes coming out of it). What I want to hear is what Level 3 will do to reduce headways at constraints such as this, and I suspect the answer is, in the apt words of Speaker [of the UK Parliament] John Bercow, "the square root of not very much".

But there is a component of headway that bears investigation, and I would be very glad to hear how digital railway in its various incarnations might affect it – the system response time. In our article "Headways – what effect does ETCS have, and how do we know?" (IRSE News, May 2019) to which Trevor kindly refers, a value of 10 seconds was blandly assumed, on the basis of very little evidence. If in practice this were to double, some technical headways would rise uncomfortably close to the maximum tolerable value. If it could be halved, however, a very useful additional performance buffer would be introduced, everywhere and not just on plain line. Quicker-acting turnouts would also have a benefit, specifically in headway critical-areas.

Can I ask the signalling engineering community what values they think are realistic for the system response under ETCS – the minimum time from Train 1 clearing a section to Train 2 being issued with a Movement Authority into it? And, what is being done, and what more can be done, to reduce it, as the risks and potential benefits around response times are probably greater than anything else being offered by advancing signalling technology?

William Barter, UK

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at irsenews@irse.org.

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Membership changes

Elections

We have great pleasure in welcoming the following members newly elected to the Institution:

Member

Simon Clark, VolkerRail, UK
Charlie Dacanay, SMEC International, Indonesia
Olivier Grossin, CERTIFER, France
Bartolo Guggion, Network Rail High Speed, UK
Shashikant Gupta, AECOM, India
Morgan Lachuer, SNCF Reseau, France
Simon Marshall, Network Rail, UK
Abbi-Jo McCaffery, Network Rail, UK
Harry Omorodion, St Claradion Ltd, UK
Yat Lee Frankie Tsang, Alstom, Hong Kong

Associate Member

Afzal Ahmed, Louis Berger, India
Muhammad Talha Ali, TEAM Nigeria, Nigeria
Eric Berntson, Colling Aerospace, USA
Medha Bharti, Network Rail, UK
Bhuvanesh Gupta, Alstom, India
Saruabh Gupta, AECOM, India
Narendra Kumar, AECOM, India
Dezhi Li, Alstom, Hong Kong
Carole Markou, Network Rail, UK
Pavanchander Putta, AECOM, India
Tossaporn Srisooksai, Kyosan Electric, Japan

Accredited Technician

Jodi Hurcombe, Amey, UK
Ryan Van Dort, V/Line, Australia

Promotions

Member to Fellow

Stephen Smith, VolkerRail, UK

Affiliate to Fellow

Stephen Brennan, Transport for London, UK

Associate Member to Member

Ariharan Karunanithi, Alstom, Australia
Niels Neumann, TuMotus, Germany

Affiliate to Member

Gareth Jones, Network Rail, UK
Paul Staines, Bechtel Saudi Arabia, UK

Affiliate to Associate Member

Matthew Hogg, London Underground, UK

Professional registrations

Congratulations to the members listed below who have achieved final stage registration at the following levels:

EngTech

Kevin Njuguna, Network Rail, UK

IEng

Simeon Cox, Sydney Metro North West, Australia

New Affiliate Members

Rama Addala, WSP, India
Puneeth Behanagere Rudresh, L&T Smart World, India
Galvin Chiam, Land Transport Authority, Singapore
Shruthi Chilangani, WSP, India
David Coleman, Irish Rail, Ireland
Leah-Marie Dennett, AECOM, UK
Harry Enright, Arup, UK
Jeremy Goode, WSP, Australia
Subbaiah Gorla Bala, Intermodel and Eotd Engineer, USA
Garrett Gutstadt, Global Signals Group, USA
Alastair Jones, Hitachi, UK
Joel Jones, Arup, UK
Manroshan Jusbir Singh, Metro Trains Melbourne, Australia
Pankaj Kumar, AECOM, India
Ka Leung Lee, Faiveley, Australia
Kelvin Liu, John Holland Group, Australia
Taylor MacDonald, Herzog, Canada
Paul Mannion, VolkerRail, UK
Abhishek Mishra, WSP, India
Mohammad Nazir, Wabtec, Australia
Somto Victor Okonkwo-okom, Siemens Mobility, UK
Jayalakshmi Pasalpudi, ETOE Rail Transportation Infrastructure, India
Alessandro Rocchi, London Underground, UK
Daniel Rodriguez, UK
Mohamed Samra, University of Birmingham, UK
Arco Sierts, InteVice, Netherlands
Poonan Singh, AECOM, India
Ian Thompson, Ineco, Spain
Tanay Verma, Arup, UK

Past lives

It is with great regret that we have to report that the following member has passed away: Craig Longley.

Resignations: Edmund Gerrard, Robert Keates, Dean Simpson, Yihan Wu and Zhiwei Zhang.

Current Membership: 4994

IRSE News

Institution of Railway Signal Engineers

February 2020

George Clark
interview with our president

Using satellites
for safety critical rail applications

Future of radio
world conference

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Issue 263
February 2020

In this issue

Feature articles

News and opinion

From the IRSE

From our Sections

Making connections

As we move to a digital railway, telecoms plays an increasingly important role. I have often pondered what makes railway telecoms distinct from 'ordinary' public telecoms. Many items of equipment can be used for both railway and public telecoms e.g. transmission equipment. But there are items of equipment which are bespoke to the railway such as voice concentrators and GSM-R cab radios. These bespoke items are normally developed to provide a feature which is unique to the railway, for example using the GSM-R frequency bands, or are designed to prevent an activity which may cause risk, such as two drivers speaking to a signaller at the same time.

Railway telecoms is managed in a different way to a public telephone network, for instance railway operators expect any works to be pre-planned, agreed with them and to be told when a facility is restored. If a significant fault occurs it is investigated to ascertain the root cause so that, if necessary, steps can be taken to prevent recurrence.

Railway telecom engineers are required to understand the rules and procedures employed on the railway so that when they are designing systems to support the railway, they can define what functionality is required and understand the safety and performance implications of any failures. If an 'off the shelf item' of equipment is used, the engineer needs to be sure that it is fit for the purpose intended. This may, for example, require additional protection for high induced voltages or vibration.

If an infrastructure manager wishes to use a public telephone system (fixed or mobile) to support a railway application, then they need to understand the possible shortcomings of using a standard public service. For instance, public radio coverage may change over time and not cover areas of the track due to external factors. A fixed telecoms public operator may not be able to provide diversity between two circuits at a reasonable cost. If these shortcomings are acceptable then the use of public services can provide a cost-effective solution, but it requires a competent railway telecoms engineer to manage the risks.

Trevor Foulkes, chair London and South East Section

Cover story

The signals portray a simple graphic "All Stop" message amongst the land uplift as a result of the Kaikoura earthquake in New Zealand on 14 November 2016. The Pines crossing loop illustrated is situated between Clarence and Waipapa Bay on the rugged Kaikoura coast on the northern part of the South Island. Many other parts of the Main North railway line along this coastline linking Christchurch with Picton were also severely disrupted. The use of relevant data through the Internet of Things (IoT) and sensor systems linked to on-board train movement authority systems is an area where modern computer control systems could help in situations like this to determine the extent of rail corridor disruption for safe train movement authority purposes.

Photo Rob Suisted
www.naturepic.com

An interview with IRSE president George Clark

Lindsay Jones

The figurehead of the institution is our president, appointed annually from our Council members. The president for 2019-20 is George Clark, director of engineering at Transport for London (TfL). Lindsay caught up with George and asked about his experience of taking this high profile IRSE role.

What would you say were the highlights of your presidential year so far?

The highlight so far has to be the ASPECT conference in Delft – the event generated so much interest the committee had to work really hard to reduce the number of papers and we still ran as many parallel sessions as we could to enable over 50 presentations of great diversity and quality. The event was a huge success and reflected the great efforts of the organising committee and a special mention goes to the Dutch section who worked closely with the University, who in turn provided a great venue.

Thinking about the theme 'delivering change' what other changes have you seen both in the IRSE and the wider railway world outside?

There has been a lot of change, so much of it technology driven. At the IRSE we had a really challenging summer as the old website failed before we were able to port to the new one. Clearly this change really impacted our members, but I was impressed with the resilience of the IRSE central team who provided a temporary site and worked very hard behind the scenes to get the new site available as soon as possible. This year has also seen the web streaming of lectures being the norm and at ever increasing quality, which has most recently seen our first webinar. I can see these changes making a real difference to our members as on-line viewing of our last lecture peaked at over 300 viewers – really benefiting our global audience.

In the wider industry I see change as being continuous – in my recent visit to Copenhagen and I met those engineers (project, operations and maintenance) who had successfully delivered the newly opened Cityring metro line, making a real difference to the mobility of people in the city. So, change for the passengers and even the company delivering it – what is now part of Hitachi, was Ansaldo not that long ago. Another example of how our signalling and telecoms industry continues to change, as it strives to deliver in an ever-challenging environment.

Are you seeing a change in the way that people on the outside are viewing the IRSE?

I think the IRSE has changed a lot in recent times and whilst our members are seeing that with things like the website and the on-line access to live and recorded lectures, there is still more to do to raise our profile. People seem surprised when I talk about what we have achieved and the modern Institution we have become. So, I see my role very much as promoting the IRSE wherever I am and ensuring we reach out to those people, especially those new to our industry, who I believe would greatly benefit from becoming members.

Have you learned anything about yourself during the journey?

This has been an interesting journey so far; I have found it both challenging and enjoyable. Being the president, and being the 'face' of the Institution for this year has meant more formal speeches and enabled me to talk more about what I think is important as a professional engineer – issues I probably always thought but never really came to the surface until I reflected upon what I should do this year. Issues such as the real skills gap we face in the industry and the need to show the diversity and opportunities that exist within it.

Above, George chairing the Future Communications webinar round table event.
Photo James Leask Frazer/IRSE.

Addressing ASPECT 2019 in Delft.

How does being the president of the IRSE compare with your 'day job'? Are there any similarities?

Being the president and director of engineering are both very demanding roles and I am very fortunate to have the support of my team back at Transport for London in giving me the time to do it. Both roles are about leadership and being able to set out a vision and then deliver upon it. The two organisations though are very different. At TfL the engineering department comprises over 1300 people supporting delivery across a wide range of transport modes. At the IRSE the team employed at HQ is small and the Institution relies upon the support of many volunteers who give their time to ensure we have a truly great global learned society.

How did the reality of being president compare to your early perceptions of what it might be like?

I don't want to deter those who may wish to be president in the future, but it can be really demanding.

However, I must say I am enjoying it. Meeting so many people who are committed to supporting the Institution as well as those who really want to share their experience and move the industry forward.

To many people it looks like an ambassadorial role, travelling the world and enjoying the visits but there is so much more to it. The president has many formal roles, as both a trustee of the Charity and a company director of IRSE Enterprises, our 'not for profit' organisation which underwrites many of our risks as well as the operation of the Licensing Scheme.

It's great to have a chief executive like Blane Judd, who has been really supportive and he and the team at HQ have really helped more than I had expected. He's also introduced an initiative where the chief executive, president, senior vice president and junior vice president meet up throughout the year, ensuring a common approach going forward in making real our new strategy as we seek to continuously improve the value to our members, making best use of technology, combined with our strong heritage.

Was it a challenge to deliver on those goals you set out in your AGM presidential address and how did you find the task of making the presidential programme happen?

The first thing was to consider what would be my theme for the year. That was another thing I learnt about myself because upon reflection, 'delivering change' I felt was the common theme that had influenced my career, building upon the work of Markus Montigel, our previous president. The world of railways, signalling and technology always generates opportunities for change but seeing it occur successfully and to share the lessons was something I could see in our global industry sector. I wanted to ensure that the lessons were not just those close to home in the UK but around the world and so it was a combination of those contacts within the IRSE, supplemented by my own contacts that gave me a series of lectures from around the world. The promotion of live web streaming, the work of our HQ team and the arrangement we have with IET. tv meant that all our members could 'attend each lecture' wherever I could arrange it.

Whilst many of the points I made back in April have been realised, both within the IRSE and in the lectures to date, I still have many things I want to do. There is a seminar on train location technology, which I have been discussing with the IMechE railway division as well, and I want to do more to promote the IRSE with our younger members as well as seek new members, working with our CEO, Blane, in building relationships with such groups as the Young Rail Professionals.

Using Global Navigation Satellite System in safety critical rail applications

Bernhard Stamm

Applications of Global Navigation Satellite System (GNSS) in railways are becoming more and more frequent. So far, the focus has been on non-safety related applications, such as passenger information systems and freight logistics, which are typically also not standardised.

When moving GNSS applications into the domain of safety, such as for train control systems, a much better understanding of GNSS behaviour is needed. This is especially true for standardised applications, such as within the European Railway Traffic Management System (ERTMS), where the performance and behaviour of GNSS receivers and other components of a GNSS solution will have to be harmonised to achieve standardised, guaranteed performance and thus interoperability between on-board units of different suppliers, similar to GNSS based landings in aviation.

Many research projects have already investigated the use of GNSS in safety critical railway applications, such as GALOROI (Galileo Localisation for Railway Operation Innovation), GRAIL (Gravity Recovery and Interior Laboratory), NGTC (Next Generation Train Control), ERSAT (ERTMS and SATellite) to just name a few. These projects had varying goals, from building a simple demonstrator to defining possible architectures. None of them has however attempted to qualify the railway environment regarding impacts on the GNSS performance. For that reason, the STARS project (Satellite Technology for Advanced Railway Signalling) was proposed to GSA, the European GNSS Agency. The STARS consortium included the major European signalling manufacturers, space industry and research centres. This paper describes the project objectives, the setup and the results of that project.

Introduction

As already mentioned, the main objective of the STARS project was the characterisation of the railway environment regarding its impact on the performance of GNSS.

The main work performed in the project consisted of:

- Identifying environmental effects which impact GNSS performance.
- Defining what GNSS and environmental data needs to be collected to later qualify and quantify those impacts.
- Collecting raw data in environments which are considered critical for an application of GNSS.
- Developing methods to analyse the raw data to qualify and quantify those impacts.

Additional work was performed as part of the STARS project, which is however not covered in this paper.

Project execution

Project setup

The logic of the STARS project consisted of three phases as shown in Figure 1.

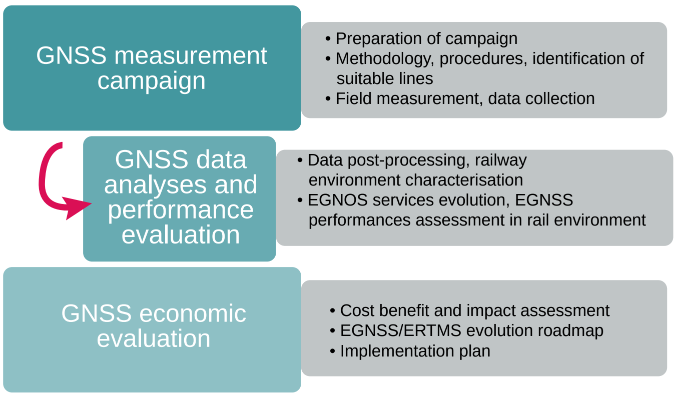

Figure 1 – STARS project study logic. (EGNOS is European Geostationary Navigation Overlay Service and EGNSS is European Global Navigation Satellite Service).

The first phase was to define what reference data is required for the characterisation of the railway environment, and to collect this data through a measurement campaign.

Within the second phase, experts assessed the GNSS performance achievable in this environment as well as the possible evolutions of European GNSS services and ERTMS/ ETCS functions.

The third phase included the analyses of the required changes to ERTMS, a cost-benefit analysis to quantify the economic benefits from the application of GNSS, as well as the definition of a possible implementation plan.

As noted in the introduction this paper only covers the preparation and execution of the STARS measurement campaign, and analysis of the data.

While the work defined for the third phase has been performed within the project, the results are subject to change once the actual solution how to use GNSS within ERTMS is defined. Those results are therefore considered to be preliminary, and subject to change.

Measurement methodology

The achievable performance of GNSS-based train localisation with regard to accuracy, availability and integrity/safety depends on multiple factors. They can be divided into two main categories. The first ones can be influenced (or at least partially influenced) by the railway, and include:

- RF interferences generated by train on-board equipment.
- Multipath resulting from the train itself or from railway related infrastructure.
- The type of traction system.
- The type of GNSS antenna used.
- The positioning of antennas on the trains.
- The type of GNSS receiver used.

Others are the result of the environment and thus more difficult to control, such as:

- Tunnels, bridges, buildings or terrain limiting satellite visibility.
- Foliage and weather attenuating satellite signals.
- External RF sources, generating interferences.
- Non-railway related objects, such as buildings, overpasses etc., creating multipath signals.
- Influences from the atmosphere, ionosphere and troposphere.

Note that the performance of the actual GNSS constellation up to the point where signals are being transmitted by the satellites is relevant too. This has however been out of the scope of the project.

Once the relevant sources of interference were identified the project discussed multiple approaches for detecting their presence and analysing their impact. The presence of multipath can for example be detected by code phase measurements or predicted from 3D environmental models and the presence of RF interference by signal quality indicators calculated from raw satellite signals (carrier to noise ratio, signal to noise ratio and in-phase and quadrature analysis).

These techniques have been explored in greater detail and the most promising ones, which were also within the means of the project, selected and then applied to the data collected through the extensive STARS measurement campaigns (see the next section). Some of the techniques had to be revised during the project execution once the first sets of data had been analysed, to provide meaningful results. For some environmental effects multiple techniques have been applied to assess their suitability and performance.

Measurement campaign

To achieve results representative of the European railway network it was essential to select multiple sites to perform measurements, reflecting diverse types of environments. Selection of suitable test tracks and vehicles was therefore an essential part of the project.

Relevant for the selection of suitable test tracks were for example:

- The environment (mountainous, urban, open areas).
- Diversity along the line.
- The availability of accurate track data, as well as of a sufficient number of absolute position markers.

For the selection of suitable vehicles, the following criteria were relevant:

- The availability of sufficient space to install equipment and antennas.
- The availability of speed sensors, or the possibility to install additional sensors.
- The availability of a reader which detects absolute position reference markers or the possibility to install such a reader and the corresponding antenna.
- Operational conditions which permitted measurements to be made during commercial operation, and which ensured that the train would run a sufficient number of services to get a representative amount of data.

Support from the respective infrastructure managers, the train operators and safety authorities were however the most important aspect, as executing such a measurement campaign would not have been possible without them.

Three test sites were finally selected, which reflected the best compromise between the many factors listed above. They were located in the Czech Republic (one line), in Italy (two lines) and in Switzerland (multiple lines), covering the various types of environments (open environment, urban and mountainous areas etc.) as well as traction systems (15kV/16.7Hz AC electric traction, 3000V DC electric traction, diesel traction).

The lines in Italy represented fairly open, flat country on the island of Sardinia between Cagliari and San Gavino, where most measurements have taken place, as well as hilly terrain in the Tuscany region between Parma and La Spezia, where only a limited number of measurements have been made. While the line on Sardinia is not electrified, the one between Parma and La Spezia is electrified with 3000V DC.

The line and train used in the Czech Republic between Číčenice and Volary represented a typical rural area with the line running through partially open and partially forest country. That line is also not electrified, eliminating one possible source of interference.

The Swiss case differed from the two others in one major aspect. Rather than performing measurements on a limited number of specifically selected test tracks, the equipped train operated on many different lines across the network. The train operated under 15kV/16.7Hz AC traction. The main reason for performing measurements on multiple tracks was that the train, on which the test equipment had been installed, is part of a larger fleet which operates on most lines in the country. Individual vehicles of this fleet are assigned to different depots as needed, which meant that the train operated on lines in different environments through the duration of the project, from mountainous lines as can be seen in Figure 2 to densely populated areas. Selecting such a train for measurements was only feasible as the method of producing ground truth data implemented for Switzerland did not require surveys of tracks nor was it necessary to install position reference markers.

Data was not only collected in different environments, but also under different weather conditions, as the actual measurements were performed over a period of more than one year. This can be seen in Figures 3 and 4, which were taken in the same station in very different conditions.

Figure 2 – Test train and environment in Switzerland.

Once the test trains were equipped with a set of equipment common to all three trains, raw GNSS signals, position, velocity and time (PVT) data from reference receivers and environmental data was collected on all three sites and continuously uploaded to a centralised, cloud-based repository. All data was converted to standardised formats in this process, giving all project partners across Europe easy access to the data, allowing them to perform their assigned analysis across all three lines.

Ground truth

For the evaluation of the performance of train localisation it is essential to establish a ground truth, meaning an accurate 'true' position of the train referenced to UTC time, against which the GNSS position can be compared. The accuracy of the ground truth had to be significantly better than the expected GNSS position errors to produce valuable results.

Care was taken that producing the ground truth within the STARS project was based on technologies independent from GNSS to avoid common cause errors.

To generate a true position the following three elements were identified to be required:

- An accurate track database.
- Absolute position reference markers at regular intervals along the track.
- High quality odometer information to interpolate the position along the track between the reference markers.

Different inputs or techniques were used to cover these three elements on the three sites due to local conditions. They included:

- Track surveys in the Czech Republic and in Italy versus customer supplied data in Switzerland for the accurate track database.
- Eurobalises in Switzerland, Magnetic Identification Balises in Italy and RFID tags in the Czech Republic as position reference markers.
- Wheel tachometers, optical correlation sensors and Doppler radars for the distance measurement.

Ground truth had to be generated for each individual trip for which data was to be analysed. This represented a significant effort, so specific tools were developed to automate the process for each of the three sites, due to the different input data used. The output from these different tools was however in a standardised format, allowing the subsequent data analysis to be performed independently from the origin of the data.

Figure 3 – Airolo station in the summer.

Figure 4 – Airolo station in the winter.

As an example of this process the ground truth generation for the tests in Switzerland is described. The starting point was the availability of an accurate track database as shown in Figure 5 in the form of a node and spoke model, which was provided by Swiss Federal Railways SBB as an extract from their elaborate GIS. This data covers all assets of their entire infrastructure, including the Eurobalises used as absolute position references. Note that the database had to be updated several times during the project due to changes on the network, such as the relocation of tracks, the installation of additional points creating new routes and the installation, removal or relocation of Eurobalises.

When the STARS project started, SBB had just finished replacing their existing national train control systems Signum and ZUB with ETCS Level 1, equipping all 12 000 signals across the network with Eurobalises. These balises not only contain unique ID numbers, but they are also included in the track database, giving ample position references on each track of the network.

A tool was then developed which automatically generates ground truth for each trip, starting with the absolute position of the balises read during each run, then determining the route the train took through the node and spoke model, generating intermediate positions along that route using odometry information, and finally mapping the longitudinal position to GNSS positions using the geo-referenced position of the track.

This resulted in absolute positions generated at regular time intervals and referenced to UTC. Figure 6 shows as an example of the absolute positions (green dots) mapped to the track of the route between the balises read (red dots).

Figure 5 – Track data.

Figure 6 – True position of train.

Data analysis

Once data had been collected and ground truth generated, data analysis was performed with three different procedures:

- Visual inspection of data, overlaid on maps, to identify locations where significant errors occur, followed by inspection of maps, aerial pictures and pictures taken during the trip from the cab of the train to identify possible source of interference.
- Automated analysis of data, mostly with MATLAB scripts, to identify the presence of different environmental effects along the line during each trip. These were then compared for congruence with position errors, in order to detect whether the respective environmental effect possibly contributes to the position error.
- Analysing of data with a tool provided by CNES, the French National Space Research Institute, which permitted merging the recorded raw data from GPS satellites with EGNOS (European Geostationary Navigation Overlay System) data simulating perfect EGNOS coverage, and then calculating PVT from the combined data. This was then compared with both the ground truth as well as the self-estimated protection level generated as part of the PVT calculation.

The three techniques are described below with some examples.

Visual Inspection

Visual inspection of data is tedious, as it must be done manually by panning along each trip on the map where the overlay of ground truth and GNSS position data is shown. This was done with the tool developed to produce ground truth for the Swiss test tracks, as it allowed both visualisation of the path resulting from the ground truth and the GNSS position generated by the low-cost u-blox receiver for each run.

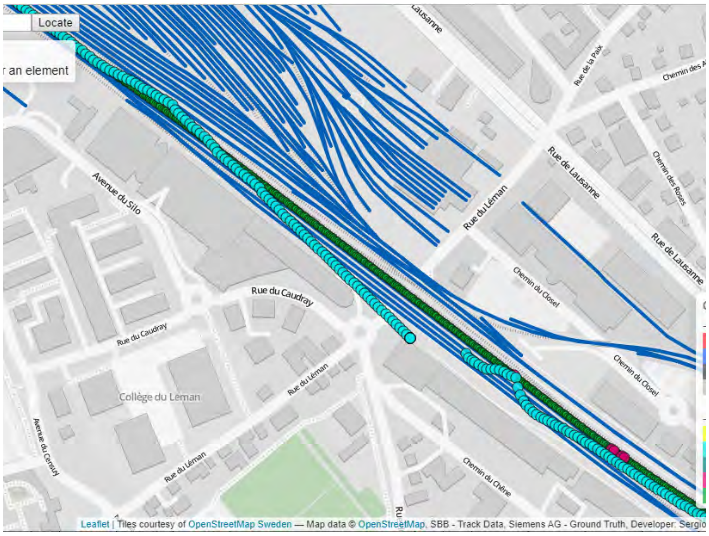

Figure 7 – Position of reference receiver against ground truth in Renens station.

Example in Renens Station

Figure 7 shows an example of a location where the GNSS position of the u-blox receiver showed deviation from the ground truth, indicating that significant environmental effects must be present.

Once a location was identified a more detailed look could be taken at the raw data recorded with the Septentrio receiver, which was used on all three test sites as the main tool to collect raw data. In the above case the number of visible satellites dropped to nearly zero in that area, as shown in Figure 8.

Multipath was also analysed, as shown in Figure 9, but did not reveal any significant anomaly; however the loss of visible satellites could be seen again.

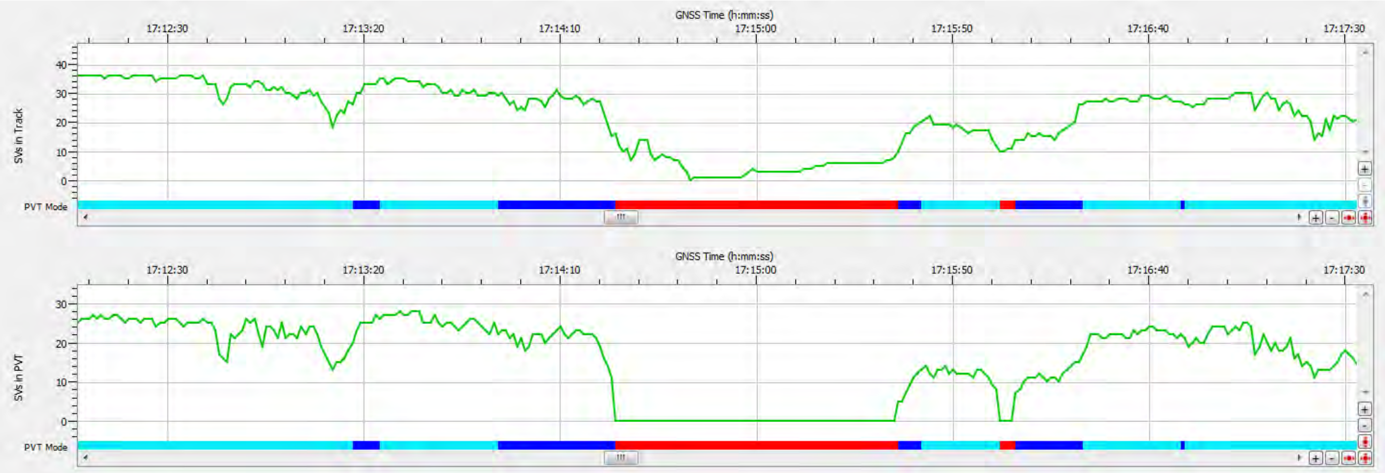

Figure 8 – Number of satellites used.

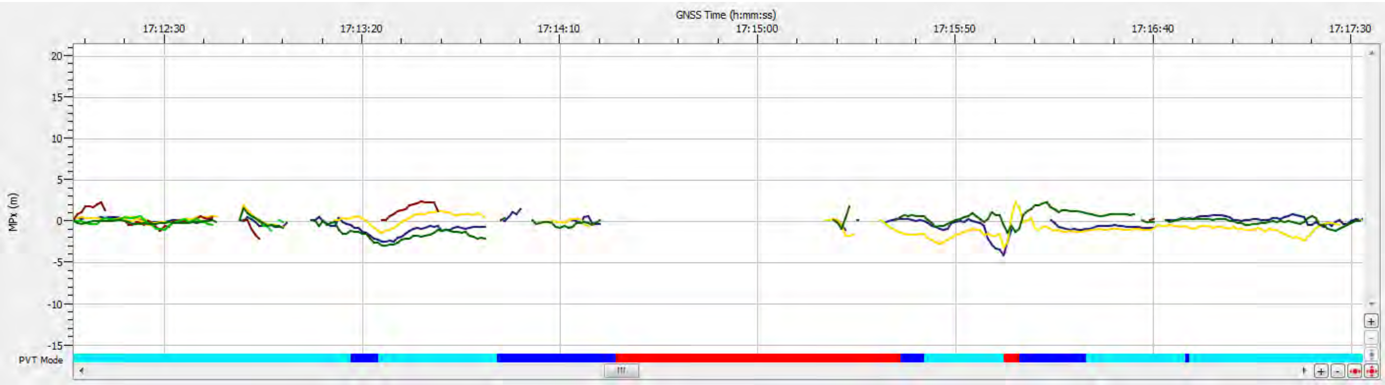

Figure 9 – Multipath indication.

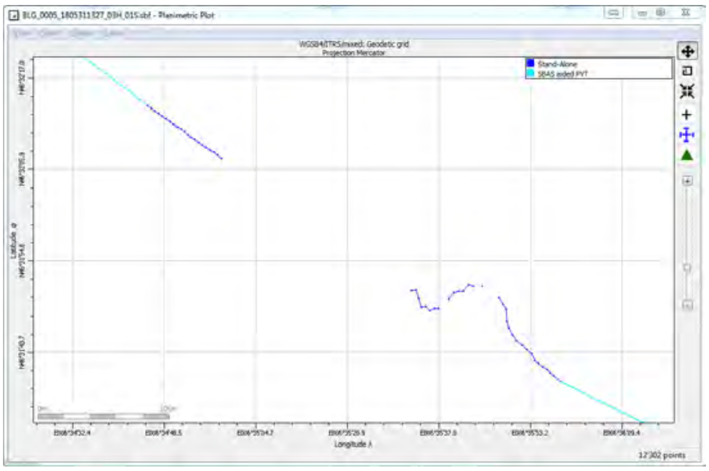

Figure 10 – Planimetric plot.

Figure 11 – Renens station area, metallic grids on right side of track.

The planimetric plot in Figure 10 shows however, that the PVT algorithm of the Septentrio receiver did not produce any position within a section of around 1.3km of the line.

When looking at the environment using the online mapping tool from the Swiss Federal Office of Topography, the area looks as though it has fairly open sky. Such an environment should never result in a loss of position over such a long distance, marked in red in the picture.

While the Septentrio receiver did not provide any position information the u-blox receiver continued to generate partially erroneous results, probably by extrapolating the position after loss of signal, as well as by using data from satellites which was considered not usable by the PVT algorithm of the Septentrio receiver.

Pictures taken every second by the camera on-board the train (Figure 11) showed that in that particular location metallic grids were installed along the track, which is standard practice on construction sites to prevent cranes from interfering with the catenary.

While such grids only result in a small reduction in unobstructed sky visibility, they seem to deteriorate GNSS signals sufficiently to make them unusable.

Similar degradations of performance have been observed in other locations where such grids were encountered.

Figure 12 – Genève-Sécheron, GNSS position deviation.

Figure 13 – Platform roof and buildings in Sécheron

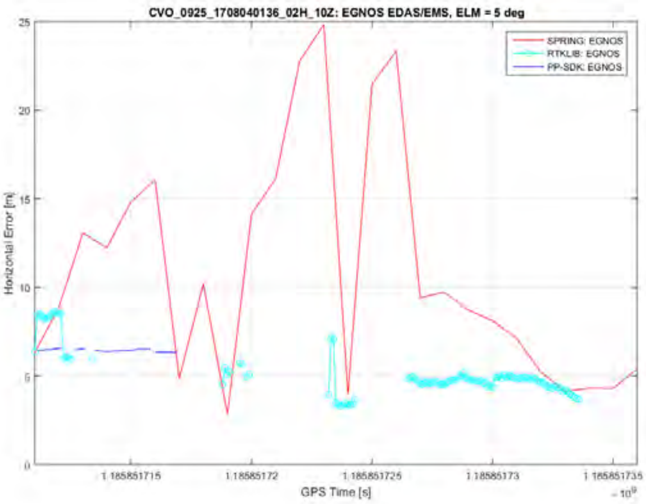

Figure 14 – HNSE (Horizontal Navigation System Error) with EGNOS.

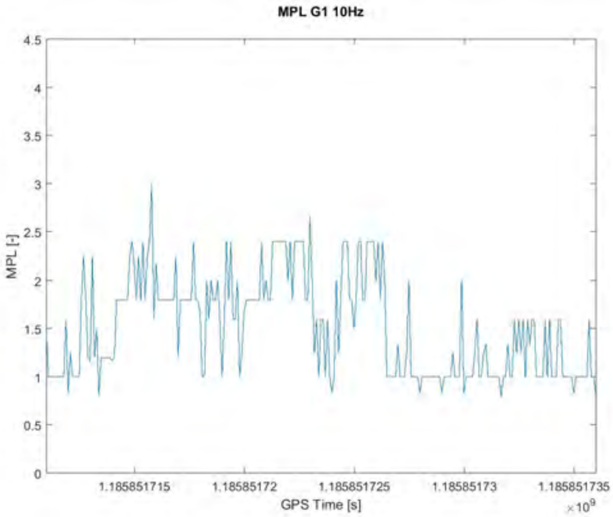

Figure 15 – Multipath derived from pseudo ranges.

Example in Genève-Sécheron station

More significant interferences were detected in the station at Genève-Sécheron. Figure 12 shows the position generated by the u-blox receiver during seven passages through the station over the same track, within a period of several hours. Each of the passages showed a significant but different deviation of the GNSS position from the true position of up to 50 m, each time in a westerly direction.

Figure 13 taken by the on-board camera (heading north to south) shows that in that particular location a wider than usual platform roof significantly obstructs the visibility of satellites, and at the same time modern office buildings with round, reflecting glass fronts on the western side of the line reflect satellites signals towards the train.

The combination of these two effects led to the quite extreme deviation of the position generated by the u-blox receiver. The presence of round surfaces is especially critical. Unlike flat surfaces they make satellite reflections visible over a long distance.

Automated analysis of data

A significant amount of automated analysis of data has also been performed, mostly with MATLAB scripts applied to the pseudorange of each individual satellite (the calculated distance from the receiver to the satellite before correcting for clock inaccuracy in the receiver). This analysis had the goal of identifying the presence of different environmental effects, and comparing their magnitude with the position error in order to detect whether the respective environmental effect degrades the position calculated by the GNSS receiver.

Thanks to the automated scripts, standardised data formats and the common repository this kind of analysis could be performed on large sets of data, with reports generated for each trip highlighting locations where specifiable parameters exceeded thresholds.

Example from Číčenice-Volary line

The Číčenice-Volary line in the Czech Republic passes through flat to hilly terrain, with dense forests interrupted by open sections.

Significant multipath was observed on this line, especially when the train passed through forest, resulting in horizontal position errors up to several tens of metres. It was observed that the horizontal error is highly dependent on the sky visibility, which impacts the number of visible satellites. When stopping the train in a station the impact of the multipath has been found to be much stronger.

RF interference was also observed on that line in the second half of the measurement campaign. As revealed from the analysis the source of the interference was located onboard the train. Probably a new device had been installed on the train or an already installed device replaced or modified. The higher susceptibility of the receiver to the multipath was only observed under RF interference.

Figure 14 shows the Horizontal Navigation System Error (HNSE) of a position calculated with EGNOS overlay. Figure 15 shows the presence of multipath error detected from analysing the raw satellite signals. Both are shown over the same section of the line, which lies within dense forest.

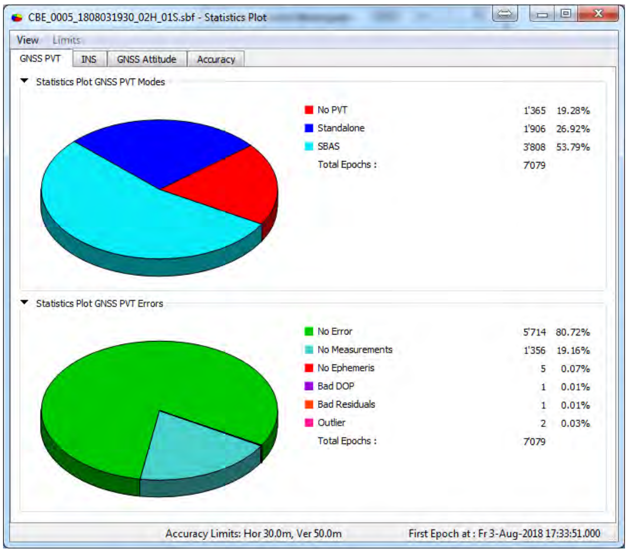

Figure 16 – PVT Statistics from Bellinzona-Erstfeld.

As can be seen there is a similarity between the two curves, with strong multipath correlating with a high horizontal navigation system error.

Similar correlations were found in many places, giving a better understanding of how the different environmental effects impact the GNSS position accuracy.

EGNOS analysis

An analysis was also performed to review the usability of and contribution from the existing augmentation system EGNOS, whose signals are distributed via geostationary satellites. The main work in this analysis was done using the SPRING tool, which was provided to the project by CNES, the French National Space Research Institute, as well as by several MATLAB scripts developed with the project.

This tool chain allowed combining recorded GPS data with EGNOS data, simulating perfect EGNOS coverage, and then compared the GNSS position calculated from the combined data (using the PVT algorithm used in aviation receivers) with both the ground truth as well as with the self-estimated protection level also calculated form the combined data.

Overlaying EGNOS data to simulate perfect EGNOS coverage was necessary as it was quickly detected that the visibility of the geostationary satellites which distribute the EGNOS data is too poor to be used on most railway lines, meaning using EGNOS data actually received by the equipment on the trains would dilute the results of the study.

An example of this is shown in Figure 16 from a run on the line from Bellinzona to Erstfeld. The roughly 20% of the line where PVT cannot be produced (red part) is to be expected due to a significant number of tunnels. The 25% where no EGNOS signal can be used is however significant, especially because this is not distributed as short gaps in coverage but consists of large stretches of track where the geostationary satellites are hidden by mostly terrain. While this effect was less significant on some lines, it becomes more significant in locations further from the equator, as the elevation of the position of the geostationary satellites becomes lower.

The tool chain for the EGNOS analysis was again automated to cope with the number of trips to be analysed. It provided the following figures for each trip:

- For accuracy: figure featuring navigation error over the distance travelled, logs of errors that exceed a fixed threshold, logs with statistical values of the receiver position error (average, max, 95 %...).
- For integrity: horizontal Stanford diagram that shows protection level with respect to the navigation error, highlighting all detected non-integrity events where the calculated horizontal protection level (HPL) is smaller than the true horizontal navigation system error (HNSE).
- For availability: Stanford diagram, instantaneous availability as a function over the distance travelled.
- Keyhole markup language (KML) files for displaying the train positions (receiver and reference) in Google Earth and Open Street maps.

Example from Sardinia

An example of the EGNOS analysis is shown below, with data from a run over the test line in Sardinia. Figure 17 shows the horizontal dilution of precision value (HDOP), in comparison with the number of available satellites.

It is clear that a reduction in the number of visible satellites to below seven results in a significant increase in the dilution of the precision of the position.

Figure 18 shows the maximum position error predicted by the receiver algorithm (horizontal protection level, HPL) in comparison with the true error (horizontal navigation system error, HNSE), calculated from the difference of the true position (ground truth) and the position calculated by the receiver algorithm.

The locations with increased true position error could be correlated mainly with road overpasses, by importing the KML file generated by the tool into Google Earth.

Figure 18 also shows that even in the open sky environment in Sardinia the true error exceeds the predicted maximum error in several places. This is reflected in the Stanford diagram shown in Figure 19.

This graph confirms that the algorithm used to calculate the horizontal protection level (developed for aviation applications) does not safely predict the true error in the railway environment, even under the benign conditions on the line on Sardinia. Much more significant cases were detected on other lines, where the number of cases where the predicted maximum error is unsafe is significantly higher.

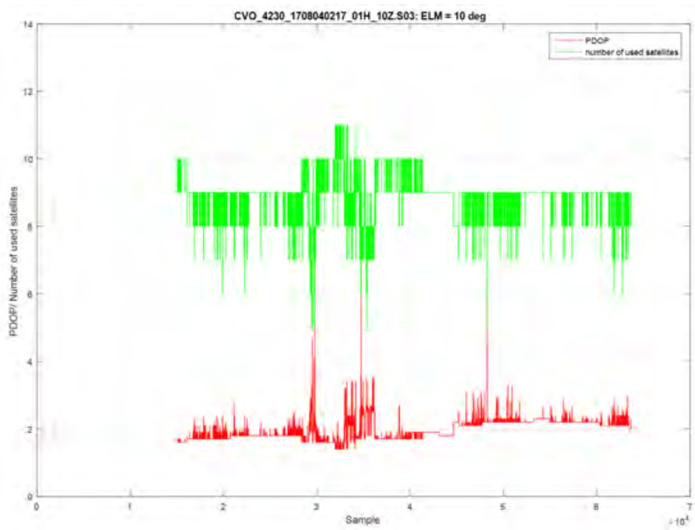

Figure 17 – Number of satellites and HDOP value.

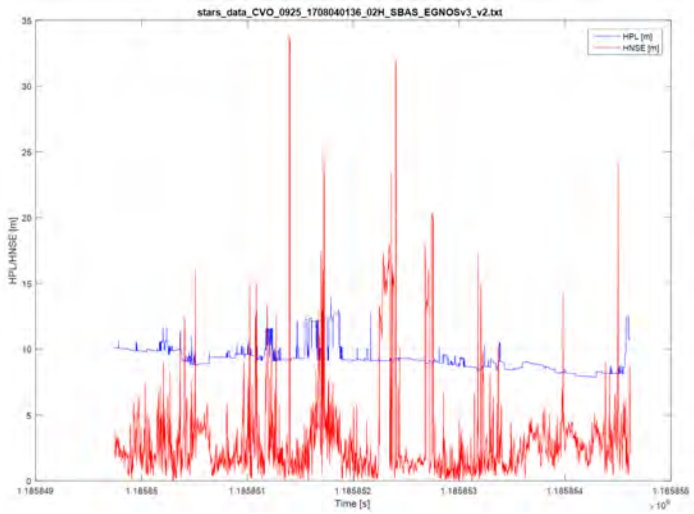

Figure 18 – HPL and HNSE values.

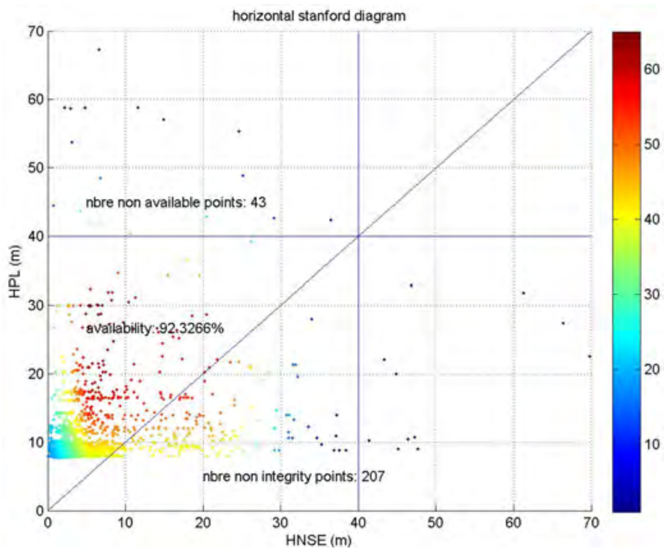

Figure 19 – Stanford diagram of HNSE.

If the true error exceeds the error predicted by the protection level algorithm used in the receiver, potentially hazardous situations can occur, so measures will have to be developed to cope with such cases or the algorithms developed for safety critical applications of GNSS in aviation will have to be improved to cope with the more severe environment along railway lines.

Conclusion

The STARS project has provided a deeper insight into the performance of GNSS in the railway environment, as a step toward an application in safety critical applications where such an understanding will be required.

It has been shown that the degradation of performance due to environmental conditions is more significant in the railway environment than in aviation, where safety critical applications already exist. Both the source of effects and the magnitude of impact have been analysed and understood.

Compared to aviation, the railway environment also makes GNSS in many areas not a continuously working system but one which only provides location information intermittently, requiring fusion with other sensors to bridge the gaps.

The conclusions can be drawn and, in many cases, quantified:

- GNSS can provide accurate speed and position information on a significant part of most railway lines.
- Speed and position information is however degraded, or not available in some places due to environmental effects,
- Most significant in their impact are multipath, as well reduced satellite visibility. Electromagnetic interferences can also have an impact.
- Many impacts result from sources outside the railway, such as from reflective surfaces on nearby buildings or metallic structures.
- It has been shown that the current receiver algorithms result in wrong side errors, as the predicted position error is often smaller than the true error.
- Methods have been developed which have the potential to help a receiver detect where speed and position are degraded, allowing it to switch to alternative data.
- Reduced satellite visibility makes using EGNOS or other augmentation information from geostationary satellites impossible, as the satellites might not be visible over large stretches on many lines.

From this the following recommendations can be made:

- In safety critical railway applications GNSS will have to be combined with other sensors, such as a tachometer or inertial/gyro unit.
- The methods developed to detect and quantify environmental effects might be used in the development of railway specific GNSS receivers, to improve algorithms for PVT, protection level and to switch between different sensors.
- The distribution of EGNOS or other augmentation data via a separate channel to trains, such as via radio will have to be developed and deployed.

Acknowledgements

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About the author ...

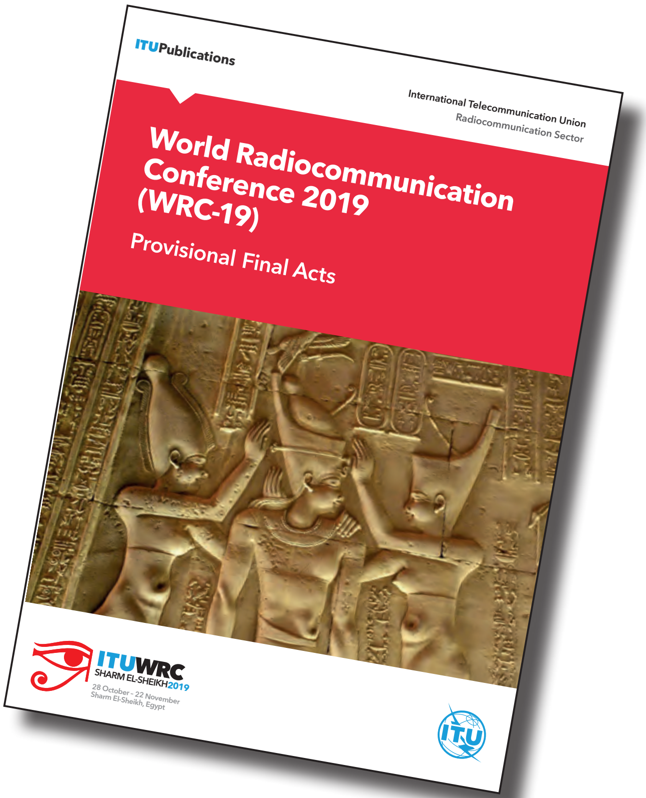
Bernhard has been with Siemens Mobility in Switzerland for over 30 years. In his current role as senior expert for ERTMS he is supporting ERTMS/ETCS related projects worldwide, with a focus on operational issues. He is also involved in a number of research projects, such as NGTC, STARS and Shift2Rail, where future extensions of ETCS including automatic train operation, Level 3 and GNSS based positioning are being investigated and developed.

Bernhard started his career as development engineer for proprietary Automatic Train Protection (ATP) systems and later the European Train Control System (ETCS), later also holding positions in sales and product management.

He has been involved in the development of the ETCS Standard as a member of working groups at UIC (A200), UNISIG and ERA for over 25 years, and worked with the Swiss Office of Transport, Swiss Federal Railway (SBB), and alongside competitors to develop the ETCS migration strategy for Switzerland, which has been successfully implemented.

World Radiocommunication Conference 2019 (WRC-19)

Paul Darlington



The World Radiocommunication Conference 2019 (WRC-19) was held in Sharm el-Sheikh, Egypt, 28 October to 22 November 2019 and was attended by 3400 delegates from 165 Member States around the world. The resulting agreements are available in the Final Acts of the Radio Regulations (the international treaty governing the global use of radio-frequency spectrum and satellite orbits). See irse.info/8o0yk. Some of the agreements made will apply to rail control and communications.

Railway radiocommunication Systems between Train and Trackside (RSTT)

A Resolution was approved for railway radiocommunication systems to facilitate railway train and lineside systems, and in particular for train radio applications for railway traffic control and passenger safety and security.

"Spectrum harmonisation for railway radiocommunication systems between train and trackside (RSTT) within the existing mobile-service allocation" – starts by establishing the social and economic importance of railway transportation, especially for developing countries. It refers to radiocommunication systems providing improved railway traffic control, passenger safety and improved security for train operations, adding that the main categories of applications of RSTT are train radio, train positioning information, train control and train surveillance.

The Resolution lays out "that spectrum harmonisation of train radio application of RSTT may have priority among the four categories of RSTT applications, because train radio application provides for train dispatching, train control and other important railway services which is used to ensure the safety of train operations and passengers, and require high reliability and high quality of services."

The Resolution also says that the implementation of future RSTT "needs to take account of the development of the railway industry" and that "There may be a need to integrate different technologies across multiple bands in order to facilitate various functions, for instance dispatching commands, operating control and data transmission, into railway train and trackside systems to also meet the needs of a high-speed railway environment."

The Resolution recognises that the International Telecommunication Union Radiocommunication Sector (ITU-R) is developing a recommendation to facilitate the spectrum harmonisation of current and evolving RSTT. The Resolution invites ITU-R to continue the development of the Recommendation, preferably finalise it before 2023, and to "further develop and update ITU-R Recommendations/Reports concerning technical and operational implementation of RSTT, as appropriate."

The Resolution also encourages administrations, when planning for their RSTT, to consider ITU-R study results as well as other relevant ITU-R deliverables, with a view to facilitate spectrum harmonisation for RSTT, in particular for train radio application.

It also invites administrations to encourage railway agencies and organisations to utilise relevant ITU-R publications in implementing technologies and systems supporting RSTT. The resolution also mentions, however, that administrations have flexibility to determine how much spectrum to make available for RSTT as well as the conditions for usage at the national level in order to meet their particular national and/or regional requirements.

It also points out that the technologies for RSTT are evolving and international or regional organisations, such as the 3rd Generation Partnership Project (3GPP), the International Union of Railways (UIC), the European Telecommunications Standards Institute (ETSI), the European Union Agency for Railways (ERA), is developing specifications for technologies and new functions to evolve RSTT.

WRC-19 was a large and well-attended event, covering many important telecomms topics.
Photo WRC-19.

The Resolution by WRC -19 for railway radiocommunication systems, and recognising the need for high reliability and high quality of services, is very good news for the rail industry as radio spectrum is a finite resource with lots of competition for allocations by industries far larger and with greater influence and monetary value than railways.

WRC-19 also identified additional globally harmonised (millimetre wave) frequency bands for International Mobile Telecommunications (IMT), including IMT-2020 (otherwise known as 5G mobile), enhanced mobile broadband, massive machine-type communications and ultra-reliable and low-latency communications. The anticipated applications include intelligent transport systems, smart cities, making communities more sustainable, improved health care, sustainable agricultural practices, and greater energy efficiency.

The plans also included the Earth-exploration satellite service (EESS) as well as meteorological and other passive services in adjacent bands, such as the space research service (SRS) for space-based monitoring of the earth and its atmosphere. satellite services supporting meteorology and climatology to safeguard human life and natural resources are to be protected from harmful radio-frequency interference, along with radio astronomers for deep space exploration systems.

Other key agreements

Other key agreements made by WRC-19 include:

- Intelligent Transport Systems (ITS) – ITU Recommendation approved to integrate ICTs in evolving Intelligent Transport Systems (ITS) to connect vehicles, improve traffic management and assist in safer driving.
- Broadcasting-satellite service (BSS) – Protection of frequency assignments, providing a priority mechanism for developing countries to regain access to spectrum orbit resources.
- Additional bands for IMT identified in the 24.25-27.5 GHz, 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 and 66-71 GHz bands, for development of fifth generation (5G) mobile networks.
- Earth exploration-satellite (EESS) service – Protection accorded to EESS with the possibility of providing worldwide primary allocation in the frequency band 22.55-23.15 GHz for satellite tracking, telemetry and control.
- Non-geostationary satellites – Regulatory procedures established for non-geostationary satellite constellations in the fixed-satellite service. This could include satellite systems consisting of hundreds to thousands of spacecraft in low-Earth orbit for global telecommunications.
- Regulatory changes for rational, efficient and economical use of radio frequencies and associated orbits, including the geostationary-satellite orbit.
- High-altitude platform stations (HAPS) – Additional frequency bands for radios on aerial platforms hovering in the stratosphere – for affordable broadband access in rural and remote areas.
- Wi-Fi networks – Regulatory provisions for both indoor and outdoor use and growth in demand for wireless access systems.
- Global Maritime Distress and Safety System (GMDSS) – Expanded coverage and enhanced capabilities for GMDSS.

Agenda for next conference

The agenda for WRC-23 in four years' time is planned to include -

- Earth stations in motion (ESIM) – Conditions to be defined for communications of ESIMs with geostationary space stations in the fixed-satellite service to provide for communications to airborne, water and land vehicles.
- High-altitude IMT base stations (HIBS) – Possible use of same frequency bands as ground-based IMT base stations for mobile broadband connectivity to underserved communities and remote areas.
- Aeronautical mobile applications – Non-safety aeronautical mobile applications for air-to-air, ground-to-air and air-to-ground communications of aircraft systems.
- Global Maritime Distress and Safety System (GMDSS) – Improved communications and additional spectrum and satellite resources to enhance maritime capabilities in GMDSS, such as e-navigation.

Industry news

Main line and freight

ETCS failure

UK: The Rail Accident Investigation Branch has published its final report into the events that happened on the morning of 20 October 2017, when four trains travelled over the Cambrian Coast line, Gwynedd, Wales, operated under the protection of an ETCS level 2 system, while temporary speed restriction data was not being sent to the trains. No accident resulted but a train approached a level crossing at 80km/h (50mph), significantly exceeding the temporary speed restriction of 30km/h (19mph) needed to give adequate warning time for level crossing users.

The temporary speed restriction data was not uploaded during an automated signalling computer restart the previous evening, but a display screen incorrectly showed the restrictions as being loaded for transmission to trains. The independent investigation makes five recommendations and in next month's issue of IRSE News we will be analysing the report and discussing the implications for the industry.

Bidders for Indian Railways ETCS Level 2 pilot project

India: Six companies have responded to an Indian Railways (IR) tender to install ETCS Level 2 on 650km of lines at an estimated cost of Rs 15bn (£164m, €191m, $211m). They are Alstom, Bombardier, CAF Signalling, Hitachi STS, Siemens and Thales.

ETCS Level 2 will be installed on four lines as a pilot project comprising: Jhansi-Bina in North Central Zone, Yeraguntla-Renigunta in South Central Zone, Vijaynagaram-Palasa in East Coast Zone, and Nagpur-Budnera in Central Zone. Depending upon the trial results, IR will decide whether to extend ETCS to other lines.

Maintenance of Switzerland's ETCS

Switzerland: A second European Train Control System (ETCS) equipment maintenance contract has been signed between Alstom and SBB, extending the previously agreed contract by a further 10 years, with the value of the contract now over €25m (£21m, $28m).

The maintenance contract includes logistics management for repair and calibration, overhaul of on-board ETCS components, measurement equipment, obsolescence management, technical support, training and on-site assistance.

FRA PTC implementation status

USA: The Federal Railroad Administration (FRA) has released a quarterly status update on self-reported progress toward fully implementing positive train control (PTC) systems. Based on 2019 (Q3) PTC progress reports which were due to FRA by 31 October 2019, the majority of the 42 railways subject to the statutory implementation requirement are operating PTC systems in revenue service or in advanced field testing as of September 30, 2019.

PTC accomplishes two of the Department of Transportation's (DOT) top priorities, safety and innovation. DOT has supported PTC implementation since the original 2008 mandate, providing technical support and administering over $2.5 billion in funding for freight, intercity, and commuter railroads for PTC through grant and loan programs.

All affected railways have committed to implementing PTC systems on the required main lines by December 31, 2020 at the latest. To date, four host railways and three tenant-only, commuter railroads report having fully implemented PTC. The Q3 Reports reveal that in total, PTC systems are operating on 92.4% of all required route miles.

To view detailed infographics depicting railroads' progress toward fully implementing PTC systems as of September 30, 2019, visit **irse.info/bvj7d**. To view the public version of each railway's Quarterly PTC Progress Report for quarter 3 of 2019, See each railroad's PTC information at **irse.info/vmzd8**.

Liverpool Lime Street-Edge Hill resignalling complete

UK: The final stage of the Liverpool Lime Street resignalling Project, the recontrol of Edge Hill signal box, was signed into use at 03:15 on 4 November 2019. This final stage migrated signalling control of the Edge Hill and Olive Mount Route Relay Interlockings to the Liverpool workstation at Manchester Railway Operating Centre (MROC)

The recontrol involved implanting communications over the IP FTNx network via two Time Division Multiplex (TDM) cubicles, each containing two Siemens Controlguide Westronic 1024 TDM systems. The scheme introduced Train Operated Route Control (TORC) within the Controlguide Westcad system and provided signal overrun protection.

The 54-hour possession involved a large wiring changeover of the Edge Hill interlocking (circa 1800 wires) requiring extensive preparation and pre-testing. Trackside work included the introduction of BR867 medium voltage track circuits within the Waterloo and Carriage Sidings, a new banner repeater signal and new main line routes, including point auto-normalisation. To support the re-control project, network and telecoms alterations were required at the MROC, along with train describer and emergency alarm alterations undertaken at the three fringes of Liverpool Lime Street, Sandhills Mersey Rail and Wavertree West.

ASLRRA a PTC preferred provider

USA: The American Short Line and Regional Railroad Association (ASLRRA) has added Ayers Electronic Systems (aE) as Member Discount Program Preferred Provider for implementing positive train control (PTC).

The products and services provided by aE "join a group of ASLRRA-vetted vendors providing specific services for Class II and III railroads to assist them in meeting PTC deadlines" the association said. More information about short line PTC providers can be found at **irse.info/syx36**.

First two Moscow Central Diameter lines now open

Russia: The Moscow Central Diameter (MCD) lines are being created by upgrading existing lines and building additional stations. The work involves laying additional tracks, and upgrading communications and power supply. Stations are being provided with full-length roofs and elevated covered concourses with access to both sides of the railway.

MCD-1 Belorussko-Savelovsky will be 52km long with 24 stations, of which eight will provide interchanges with the metro and the Moscow Central Circle

(MCC) Line. Another four stations, all of which will be interchanges, will be completed by 2024. MCD-2 Kursk-Riga will be 80km long and will have 33 stations with another five planned. Initially, 11 stations will offer transfers to the metro and the MCC, while four of the five planned stations will be interchanges.

The two lines will be operated by a fleet of 39 Oriole electric multiple units which will operate alongside conventional commuter trains. The end-to-end journey times will be 1h 27min on MCD-1 and 2 hours on MCD-2.

Alstom Spain signalling of Recoletos Tunnel

Spain: Alstom has completed the resignalling of the Recoletos Tunnel in Spain. The 7km-long tunnel is located between the Atocha station and Chamartín station in Madrid. Whilst coordinating with road infrastructure works, work was carried out on the signalling and protection systems (ASFA Digital), as well as on catenaries, and a new fixed communications system was installed. Alstom also updated the telecommunications wiring and replaced contiguous stations cabin equipment with new electronic interlockings.

EVA Sirti train control contract

Italy: Volturno Autonomous Body (EVA), the regional operator in the Campania region, has awarded Sirti's transport business unit a contract to supply a train control system for two local lines, which connect Naples Montesanto and Torregaveta.

Sirti Transportation will be responsible for creating a new traffic control and safety system for EAV, which will control both the coastal Cumana line and the inland Circumflegrea line. The Computerised Multistation Central Apparatus (ACCM) system, which will be controlled by a Train Drive Control System (SCMT), will manage train movements. Sirti will implement its ACC-multi-station, computerised central unit known as Compact SIS-4. The digital system integrates local station control and train distancing functions with signalling management.

Swinderby resignalling contract

UK: Alstom has been awarded a contract by Network Rail to deliver the Swinderby Re-signalling Project. The project is to renew life expired signalling infrastructure including interlocking and control centre controlled by Swinderby Signal Box to Lincoln Control Centre. This will include the transfer and renewal of multiple level crossings and recovery of redundant equipment.

Level crossing incident

UK: At about 19:53 hrs on Sunday 24 November 2019, a 4-coach class 755 passenger train, operating the 19:45 Norwich to Sheringham service, was approaching Norwich Road automatic half barrier level crossing, to the north-east of Norwich. The train was travelling at about 45mph (72km/h) and about 200m from the crossing when the barriers lifted, the level crossing warning lights went out and cars began to cross the railway.

The train was unable to stop before reaching the crossing. A car passed in front of the train around a quarter of a second before the train went over the crossing, but no vehicles or persons were struck.

Investigations are under way and will consider the design, implementation and operation of the crossing system, including any effects of rail head contamination due to fallen leaves, the design of relevant elements of the class 755 train and the process for accepting it for use on this route, together with any underlying factors.

City railways and light rail

Sydney Metro extension

Australia: Plenary Group and the Northwest Rapid Transit (NRT) consortium are to extend the Sydney Metro trains, systems, operations and maintenance as part of the next stage of the Sydney Metro project.

The contract package includes for new metro trains and core rail systems, as well as operations and maintenance for NRT to operate the combined North West and City and Southwest lines until 2034. The project will integrate the Sydney Metro City and Southwest project with the newly-opened Metro North West line to deliver a seamless turn-up-and-go service along a dedicated 66-kilometre line with 31 stations from Tallawong to Bankstown.

Contract award for Perth METRONET

Australia: In Perth an alliance has been announced to build the Yanchep Rail Extension and Thornlie-Cockburn Link to the city's METRONET network. A consortium made up of CPB Contractors and Downer EDI, and called NEWest Alliance, will work with the public transport authority to deliver the projects, which are planned to provide residents of the northern and eastern suburbs with greater access to employment and training, entertainment and recreation hubs, and create up to 3000 jobs.

The Yanchep Rail Extension will add 14.5km to the existing Joondalup Line, with stations at Alkimos, Eglinton and Yanchep. The first trains are expected to be running in 2022. The Thornlie-Cockburn Link will close a 14.5km gap in the eastern rail corridor by linking communities between the Mandurah and Armadale lines. Stations will be built at Ranford Road and Nicholson Road, and significant upgrades made to both Thornlie and Cockburn Central stations.

Crossrail update

UK: A new plan to complete the outstanding works and bring the Elizabeth line in London into passenger service at the earliest possible opportunity has been developed by the new Crossrail leadership team. This, say Crossrail, provides a realistic and achievable plan to complete the Elizabeth line. The two critical paths for the project remain software development for the signalling and train systems, and the complex assurance and handover process for the railway; both involve safety certification.

Crossrail Ltd say they will need further time to complete software development for the signalling and train systems and the safety approvals process for the railway. The trial running phase will begin at the earliest opportunity in 2020, this will be followed by testing of the operational railway to ensure it is safe and reliable. The latest assessment by the project is that the opening of the central section will not occur in 2020, which was the first part of Crossrail's previously declared opening window, with the Elizabeth line opening as soon as practical, possibly in 2021.

Each Elizabeth line station has over 50km of communications cabling, 200 CCTV cameras, 66 information displays, 200 radio antennas, 750 loudspeakers and 50 help points, to be fully installed, tested and integrated. A key focus during 2019 has been finalising the stations, tunnels, portals and shafts, and Custom House, Farringdon and Tottenham Court Road stations should now be complete and the project is on track to finish fit-out of the tunnels early in 2020. The central section will be substantially complete by the end of the first quarter in 2020, except for Bond Street and Whitechapel stations where work will continue.

At Bond Street and Whitechapel stations Crossrail says they now have high productivity and a clear path to completion. Whitechapel station has reached the Staged Completion 1, which is a sufficient level of completion to support entry into Trial Running in 2020 and will support the creation of a standardised requirements checklist.

Significant work has also taken place within the tunnel to support readiness for Trial Running. The central section of the Elizabeth line has been connected to the GSM-R, and the London Fire Brigade has assured the public address system which is now in use in the majority of the tunnel.

Crossrail's key challenge remains the volume of handover assurance and documentation required to bring the assets into passenger operation. Nearly 200,000 documents need to be completed as part of the assurance and handover process and safety certification for the Elizabeth line.

Trafford Park tram testing

UK: The first test tram has traversed the Manchester Metro Trafford Park line track as part of the £350m (€408m, $449m) Metrolink extension project.

Travelling along Trafford Wharf Road between the Pomona Metrolink stop and Warren Bruce Road in November 2019, the short journey started an extensive safety and testing process following the development of the signalling and control systems infrastructure. A team of engineers accompanied the tram and carried out essential safety checks as it travelled at walking speed. See irse.info/46psa.

Testing is expected to last over several months before driver training can take place ahead of the line opening in the first half of 2020. There will be six new stops throughout Trafford Park, as far as the intu Trafford Centre. For more information, visit irse.info/xr05j.

Doha Metro

Qatar: On 10 December 2019 the first phase of the driverless metro network in Doha was completed, with the opening of the third line and two extensions of the first route. The 22km Green Line from Al Riffa in the west to Al Mansoura in the city centre serves 11 stations.

A one-station branch runs from Oqba Ibn Nafie to Hamad International Airport Terminal 1, and a northern extension takes the line from Al Qassar to Lusail. The first section of the Red Line opened on 8 May 2019 with the north-south route now 40km long, including 23.4km underground.

Autonomous tram depot

Germany: The AStriD "Autonomous Tram in Depot" by Karlsruhe Institute of Technology (KIT) and industry is aimed at the full automation of a tram depot, with autonomous tram and digital depot operations. The project will be funded by the Federal Ministry of Transport and Digital Infrastructure (BMVI) under the Modernity Fund (mFUND) program.

The research and development will be carried out at the depot of Verkehrsbetrieb Potsdam (Potsdam transport company), and the feasibility will be demonstrated by autonomous service operations at the depot, such as running trams through a washing bay onto a siding. Depot automation is planned to be made commercially viable as the first stage of full autonomous tram driving.

The AStriD project partners are Karlsruhe Institute of Technology (KIT), Siemens Mobility, Verkehrsbetrieb Potsdam GmbH (ViP, Potsdam transport company), the Institute for Climate Protection, Energy, and Mobility (IKEM), Codewerk and Mapillary.

Communication and radio

Trials of 'login-free' Wi-Fi

UK: Cisco and Canary Wharf Group have announced the world's first commercial trial deployment of 'OpenRoaming'. This is an alternative to 4G and 5G connectivity, which allows mobile roaming with Wi-Fi 6 connectivity and to connect automatically to Wi-Fi and roam from one hotspot to another without the need for the user to log in.

OpenRoaming allows users to easily join a Wi-Fi network and enables the network to securely auto-authenticate end user devices. It is anticipated that there will be many access points provide at busy locations such as railway stations, shops, stadiums, hotels, public venues, and airports. In-station and on-train passenger connectivity may represent another possible application.

GSM-R V4.0 cab mobile upgrade programme

UK: Network Rail has received authority from the Office of Rail and Road to roll-out the national programme to upgrade over 11 000 GSM-R cab mobile hardware and software units. This will include all passenger and freight train driving cabs, including track maintenance and heritage vehicles, across the GB rail network.

The V4.0 upgrade includes eliminating interference from public mobile network operators' LTE networks with the 900MHz GSM-R network. The national programme roll-out commenced in November 2019, with the first upgrades taking place at Selhurst Park depot with Govia Thameslink Railway, and at Leeds depot with Freightliner. The rail industry is aiming to upgrade 100 cab mobiles per week.

Network Rail 5G testbed

UK: The Network Rail Innovation and Development Centre (RIDC) in Melton Mowbray now includes a 5G testbed and what is believed to be the first operational 5G railway test facility in Europe. Simon Atterwell, managing director at Network Rail Telecom, says the centre and test bed will have an important role in the development of technology for the railway, both on-track in stations, in the UK and throughout the world. See irse.info/ltdcj.

SNCF Klas Telecom onboard train communications systems

France: State-owned railway operator Société Nationale des Chemins de Fer (SNCF) has chosen Klas Telecom and its partner Seolane Innovation to deliver an onboard connectivity solution. The firms will install the TRX R6 Connected Transportation Platform on trains managed and operated by SNCF.

TRX R6 is capable of supporting six cellular modems, Wi-Fi and GPS. It also supports third-party virtual machines for information and entertainment, hotspot management, and operational data processing. It supports a range of applications including customer information, CCTV and passenger Wi-Fi on a single platform

SNCF project manager Julien Baratier said "Although new partners for us, Klas Telecom and Seolane have demonstrated their technical commitment by offering a modular, flexible and performing solution. We are very excited to now be working together on a first rollout on regional trains to support a CCTV service."

Politics and industry bodies

Railway Industry Association RAIL 2050 Manifesto

UK: The Railway Industry Association (RIA), the voice of the UK rail supply community, has launched its RAIL 2050 Manifesto, setting out at how a long-term sustainable rail industry over the next 30 years can be developed, and calls for all political parties to provide:

- A long term, 30-year strategy that promotes private investment.
- The smoothing of 'boom and bust' in rail infrastructure and rolling stock investment, and improvement to the visibility of upcoming enhancement upgrade projects.
- A better balance in the train fleet between new and upgraded trains.
- Decarbonisation of the railway, through a rolling programme of electrification for intensively used lines and by using battery, hydrogen, bimode and trimode technology for other lines.
- Digitalisation of the railway through deployment of modern digital signalling technology.
- Commitment to major rail projects including HS2, TransPennine Route

Upgrade, Northern Powerhouse Rail, East West Rail, Midlands Rail Hub and Crossrail 2, amongst others.
- Government to work with the rail industry to set priorities for innovation and collaboration.
- Government to consider the role of the rail industry as a key UK exporter, when developing new trade agreements.

Safety and standards

Risk Management Maturity Model (RM3)

UK: The Office of Rail and Road (ORR) is the independent safety and economic regulator for Britain's railways. IRSE News 238, November 2017, covered the ORR Risk Management Maturity Model (RM3) and following collaboration and consultation with stakeholders from across Britain's rail industry, the latest version, RM3 2019 is now available. In RM3 2019, the ORR has:

- Filled in the gaps in evidence and ensured that evidence builds through the maturity levels.
- Identified evidence of collaboration, continuous improvement and use of technology, to support improved risk control at higher levels of maturity.
- Provided organisational culture evidence throughout all criteria at all maturity levels, rather than just in criteria OC6, as previously.
- Changed which maturity level some evidence sits in, so that the model supports greater stretch and improvement in health and safety risk control. Data, big data and internet of things

Intelligent rail monitoring system

UK: Compound Semiconductor Applications (CSA) Catapult is collaborating with a consortium of organisations to deliver a novel IoT sensing capability for intelligent railway monitoring.

SPECTRAIL is an Innovate UK backed innovation project which recently won funding from the Department of Transport as part of a series of projects under Network Rail's R&D programme. The consortium, which also includes AP Sensing, Pyreos and Lightricity, will develop a low-cost, multi-sensor system which explores new areas of railway monitoring including human trespassing, vandalism, fire, track temperature changes, soil saturation and pollution levels.

The project will offer Network Rail, and other rail infrastructure operators, a cost-effective and energy-efficient way of collecting data to enhance a predict-and-prevent maintenance strategy, through the ability to sense information from track areas previously inaccessible due to lack of power, connectivity or prohibitive costs.

The sensor system will use existing trackside fibre optic cables and AP Sensing's Distributed Acoustic/Vibration Sensing (DAS/DVS) system which 'listens' over a 70km range by detecting changes in light transmission caused by the acoustic disturbances on fibre cables.

Field trials of the system will begin in 2020 under the guidance of Network Rail at their Rail Innovation and Development Centre in Melton Mowbray, with the objective of providing condition knowledge that allows rail infrastructure operators to detect problems like fire and trespass whilst enhancing line safety and security management to previously unfeasible levels.

Innovation and research

Shift2Rail at WCRR 2019

Japan: The World Congress on Railway Research (WCRR), the world's largest international congress on railway research, held its 12th congress in Tokyo from October 28 to November 1 2019. WCRR is dedicated to the subject of innovation in the railway sector, involving both railway companies and industry/research institutions.

The subjects discussed included the Shift2Rail Adaptable Communication System. The aim of the Adaptable Communication System is to deliver an adaptable train-to-ground communications system usable for train control applications in all market segments (e.g. European Train Control System, ETCS), using any kind of IP technologies (LTE, 5G, Satellite communication, Wi-Fi, etc.), making it future proof.

Multimodal Transport aims to change the way passengers use transport. Shift2Rail's programme is building a digital ecosystem to offer passengers the best combination to get from A to B, based on real-time traffic data tailored to their preferences. With a single click passengers will be able to book and pay for multimodal trips across Europe, bypassing the 'behind-the-scene' complexity of the many systems involved today.

Shift2Rail is also working on automated train operations (ATO) based on European Rail Traffic Management System (ERTMS) that would allow maximising the performance of train operations throughout Europe. The first pilot line demonstrations at GoA 4 (grade of automation 4) are planned for 2022. GoA 4 means that the train operation is fully unattended including setting a train in motion, driving and stopping the train, opening and closing the doors and operation in the event of disruptions.

Birmingham to host WCRR 2022

UK: RSSB and the University of Birmingham have announced that they will jointly host the next WCRR event. This is on behalf of the UK rail industry and will take place between 6-10 June 2022 at the International Convention Centre in Birmingham. RSSB (originally the Rail Safety and Standards Board) is a membership-based rail industry body designed to help the railway in the UK become safer and more sustainable.

Bringing together industry leaders and researchers, WCRR is a forum for the global railway research community to share the latest research, innovations and solutions across different topics. Held every three years in a different host nation, the congress carries a mission to promote the value and benefits of railway research, excellence in research and technology development, and worldwide collaboration and sharing of technical knowledge.

Education

Alstom, FS Italiane partnership with University of Bologna

Italy: Alstom and FS Italiane have reconfirmed their partnership with the University of Bologna and the School of Engineering for Integrated Mobility. Alstom says their aim is to collaborate with academia and to align the training with the needs of industry. The school was established in 2017 by the University of Bologna, Alstom, Italian State Railways and a number of other local companies.

The course is open to undergraduates studying engineering, computer science, mathematics and physics. The lessons will be taught by professors from the university as well as business experts, including from Alstom Italia and FS Italiane

With thanks and acknowledgements to the following news sources: Railway Gazette International, Rail Media, Metro Report International, International Railway Journal, Global Rail Review, SmartRail, Shift2Rail, Railway-Technology and TelecomTV News.

News from the IRSE

Blane Judd, Chief Executive

Blane's world

As requested by the Finance committee, treasurer Andrew Smith and I have been looking at how to present the IRSE accounts in a different format from previous years. In order to be able to do that, we worked with an external adviser and most of the last few weeks before Christmas was spent getting this in place before the start of the new financial year in January.

Council has approved the new strategic plan and for 2020 onwards we will be working to help deliver safe and sustainable global railways. We will be doing this by focusing on five key goals to engage with and grow a global network of railway signal and telecommunications engineers in order to develop and assure high standards of ethics, knowledge, competence and safety in all aspects of train control.

I presented our "Beyond 2020" vision to members of the Midland & North Western and London & South East sections on 10 December at the Network Rail offices in Milton Keynes. I will be recording a video of the presentation so that members and sections can get more information. I am looking forward to meeting with UK section chairs to talk about the new strategic plan and other matters and will be reporting on our discussions in a future issue of IRSE News.

IRSE Council elections

All associate members, members and fellows will receive their voting papers shortly for this year's Council elections. Please ensure that you vote as it is important that the IRSE Council is representative of all our members. Council members make decisions on the strategic direction of the IRSE, act as trustees of the IRSE Charity and ensure that the IRSE's objectives are progressed. Council members also appoint the directors of IRSE Enterprises, the company which operates the Licensing scheme.

IRSE Exam

The 2020 date for our professional Exam is Saturday 3 October. If you are thinking of or know someone who is planning to take the IRSE Exam in 2020 please take part in a short survey to help us plan. The survey can be accessed at irse.info/3r10k.

And if you are, or you know someone, planning to take the exam in October 2020 please note an IRSE membership will be required. In order to take the exam all applications for IRSE membership must therefore be received at head office by **14 February**. Full details on how to apply can be found under the **membership** tab on the IRSE website.

Communication enhancements

Following the success of the first IRSE webinar in November, the format for Presidential programme seminars will be changing to make events more accessible to members worldwide. February's webinar on train locations systems takes place 25 February. During 2020 all Presidential events will be live streamed and then available to watch on demand via the webcast page at irse.info/rokms. Already on this page are videos of the keynote presentations at Aspect 2019 and all the Presidential papers presented during 2019. International conferences will not be live streamed in fairness to those who paid to attend, although proceedings will be filmed for members to view after the event.

All the videoed events are available in the 'members only' area of the IRSE website adding even more value to your membership.

Younger Members survey

The IRSE Younger Members section is keen to hear your thoughts on the future direction of the section and a survey was sent out to all members last month. If you haven't yet replied please do so, as engaging with younger members of the railway signalling and communications world is vital for the future lifeblood of our Institution. Please complete the survey at irse.info/fqrld by 29 February.

We'd also like to remind members who are in a position to mentor and influence younger colleagues in the industry to share your experience of being part of our Institution and encourage others to consider joining.

Annual Dinner

Online booking is now available via the IRSE website for the annual dinner which is being held for the first time at the iconic Landmark Hotel on 24 April. Book early to avoid disappointment as the event was a complete sell-out last year. Tickets are priced once again at £159 a head. Please note the 2020 AGM will be held the day before the dinner on 23 April.

Printed tickets will not be sent out this year as online tickets will be generated at the time of booking. If any member needs assistance with accessing the website, please contact the London office where a member of our team will be happy to make the online booking on your behalf.

IRSE events

Future Communications Systems webinar

Report by Clive Kessell

Connectivity underpins future rail investment. Current radio technology will not offer the industry the capacity and reliability it needs tomorrow.

The Institution held its first webinar, on Future Communications Systems, in November 2019. President George Clark asked what drives things these days with the implied answer that it is telecommunications in all its forms. However, with comms equipment having typically a five-year life and signalling looking for 20+ years, it can be a challenge to keep the two technologies synchronised.

Train borne radios

Network Rail is upgrading all GB cab radios over the next two years primarily because GSM-R frequencies are susceptible to increasing interference due to allocation of bandwidth for public 4G systems in adjacent spectrum as the demand for channel space grows. Russell Clarke from Siemens Mobility Limited gave an update on the project. The opportunity is being taken to future proof the radio so that it can be adapted for whatever replaces GSM-R without needing wholesale renewal. This is achieved by incorporating a 4G card with the further option of adding a 5G modem. The radio will incorporate better security, low power, low latency and improved network efficiency. Since any upgrade will take many years, the radio will be capable of GSM-R, 4G or 5G operation, automatically switching to the strongest signal. It has processing capacity to incorporate DAS (Driver Advisory System) and track monitoring measurements (by means of accelerometers) functionality.

The faceplate and operation of the radio remains virtually identical to the present GSM-R radios to minimise operational re-training. If and when 5G is chosen for the future rail radio network, it is almost certain that services will be included such as video streaming for entertainment, data streaming for condition monitoring and predictive maintenance plus the possibility for autonomous trains. The longer term prospects are stated as 'the candy store of opportunities' and 'combatting the bitter pill of obsolescence'.

Shift2Rail

This public private partnership within Europe aims to achieve a 90% increase in reliability, 100% capacity gain and a 50% reduction in costs for main line, regional, suburban, freight and high-speed rail services. Part of this is to produce an Adaptable Communications System specification for all railways with a budget of €920M. Ben Allen from Network Rail explained what is involved. The ability to have different bearers on tap, be they 4G, 5G, (even 6G) or satellite, will dictate the train-borne subsystems required to access the different networks. These will likely be digital apps embracing ATP, ATO, TMS and voice communication with the ability to decouple the digital applications from any particular radio communications system.

Some applications may require more than one simultaneous comms link to achieve the required functionality. The expected benefits are high data rates, application independence, multiple bearer opportunity and a range of business models. Technical prototypes are developed and three technical demonstrators will be available to see shortly including a high speed line, a freight operation and an inner suburban route. Close alignment with the FRMCS (Future Rail Mobile Communications System) project will be crucial.

Questions included the cost of infrastructure enhancement, which if radio frequencies remain at or near the present GSM-R band, would be small. More expensive will be the 'boxes' on the trains. As to whether this would be a private rail network or shared with public networks, it is likely to be both but recognising that the public networks will operate in a higher frequency band with implied increase in the number of lineside masts and consequent cost increase. Whether the system could be used as an 'underlay' for GSM-R will depend on how usage of GSM-R will be maintained, but in essence it is not really practical. Data integrity especially for safety critical applications (such as CBTC, ETCS) is important but whilst the radio link is itself not safety critical, losing it would cause operational havoc. The QoS (Quality of Service) must therefore be specified to the highest order.

Other questions asked about application to metro railways and whether the system could be used for track to track and train to train communications, the need for power supply surety, and where the skills set will come from. This is recognised and must be part of the upskilling initiative.

The reality of 5G

5G has taken 15 years to develop, with one year of deployment so far, so says Volker Ziegler from Nokia Bell Labs. Many 5G sites are already in use worldwide to provide a new digital experience yielding huge increases in capacity. Railway stations are seen as one of the densest user areas and need to be in the first tranche of recipients.

Network slicing will enable multi-user applications within an individual cell. Standards and spectrum availability will be crucial: the 37GHz band is in its infancy, by 2021 3G, 4G and 5G dynamic spectrum sharing is expected and Terahertz (>1000GHz) frequencies will exist by 2030.

The business model will include for wide area networks, indoor networks and dedicated networks, the latter needing very low latency and superb reliability > 99.999%, in both licensed and unlicensed bands. Vertically organised industry applications are seen as part of the package. Current physical networks will move initially to virtual networks, then to manually sliced networks with parallel platforms and finally to automatic sliced networks with no parallel platforms. 5G performance needs to be de-risked if safety critical applications are to be carried.

If all this sounds like some futuristic world, questions from the audience confirmed a lack of understanding. With the railways already having the GSM-R frequencies, can this spectrum be used for 5G; in principle yes but look at options to enhance multi modal usage by piggy backing on other networks. Can signalling ever confidently use 5G? For this, take a look at what is being done in the air transport sector where automation is far more advanced. Can the radio kit be fitted in constrained spaces such as in London Underground; maybe move kit away from LU premises. Perhaps a crucial question is how much would a commercial operator charge to use their network for rail services, no answer being forthcoming to this one.

Sharing network experience

Transportation is changing globally, public transport and especially rail travel is predicted to grow with passengers being ever more demanding. Other mission critical networks such as factories, banks, utilities, oil, gas, mining and automotive are asking for special treatment, which may be unrealistic according to Alan O'Reilly from Cisco. A number of shared comms use possibilities exist – station systems, level crossings, spotting of criminal activity, passenger Wi-Fi, door to door experience, delays and linkage to other transport modes which would include taxis. The provision of high speed networks in rural areas might be facilitated by rail radio systems that pass nearby.

A dedicated 'air gap' does not exist so segmentation into virtual networks makes sense with any security breaches or attacks being confined to one segment. A QoS must guarantee particular traffic sets are never compromised by lower order usage, e.g. public Wi-Fi. Reformation (i.e. the ability of a network to automatically carry traffic between A and B by another path if such as a fibre break occurs) would be part of the operational design. A question asked about the competence of people who control and maintain VPNs: will they have the knowledge to understand the priorities, an example being in high traffic times, where a critical video image of a situation might need priority over sending a signalling command.

Signalling industry standardisation

The present situation where metros use bespoke CBTC and standard rolling stock diverges considerably from main lines that focus on interoperability and a variety of suppliers. The communication to trains via signals, transponders, radio, track circuits and suchlike are all different. Need this be the case asks Duncan Robb from SNC Lavalin? Could future communications technology be the key to bringing them together?

The basic requirements are essentially similar: bandwidth, latency, additional functionality, regulatory compliance and compatibility with non-connected systems, all to produce lower cost, improved reliability and a similar expertise. With GSM-R, a mobile radio costs thousands of £s whereas a typical smart phone costs £600 with much more functionality. Experience from other industries shows wherever possible COTS standard products are used for commercial and industrial business purposes.

The emerging technologies for AI (Artificial Intelligence), air traffic control and autonomous vehicles will be based on COTS products, an example being the Raspberry Pi single board computer. 5G radio should lead to a seamless transition between different systems.

Optimum levels of standardisation need to be established which should apply to rail systems as a whole, not just comms, to achieve better deployment of people, encouragement of more suppliers into the market and increased stakeholder involvement. A current disappointment is the specifying of GSM-R for HS2 but still plenty of time for this to change. The longevity of signalling technology as compared to comms (which can be as low as five years) is a challenge, with signalling of the future needing a specification that links it to different bearer systems as technology advances

Coping with technology and digitisation

In all the maelstrom of engineering change, people aspects are going to dominate says Steve Denniss from WSP. These are harder to solve than the technology. An example from the world of sport is the video assistant referee where the problems are the people who use it. Skills are critically needed for data analytics, software development and cyber security and in all these people will need to produce innovative thinking, challenging of the status quo and creativity in overcoming problems. Knowing the customer requirements has to feature; reach out to the passenger transport executives and train operators and the TOCs, understand the passenger flows, recognise customer experiences, take part in the expectations for rail transport.

How to achieve all this requires a collaborative approach between institutions, academia, suppliers and operators. The training of engineers needs to change, with constant re-training being important. Remember that old skills are as important as new ones but recognise that measuring the skills gap is difficult. Suppliers will be the main source of expertise but they in turn need commitment from the customer.

There are hopeful signs: the Birmingham University digital systems initiative, the National College for High Speed Rail, NSAR (National Skills Academy – Rail) and Rail specific MSc courses are examples. Understanding the nature of the challenge is necessary to maintain momentum. Old Oak Common HS2 station is a good example; provide a virtual reality model of the station and train up the staff before the design is completed.

In summary

The webinar produced lots of words about the challenges ahead but not very much on how these will be taken forward. Some pragmatic solutions are emerging, for example the new cab radio and the reality of how 5G will impact, but while the rest is all important, it is difficult to see where the guiding mind(s) will come from to progress things. Collaboration is a wonderful word, but it is going to need a directing mind from somewhere to pull this all together and move it forward for the benefit of all.

It is nonetheless apparent that robust and fast comms systems are at the heart of everything the railway does, be it signalling, power control, operations, station management and suchlike. Grudgingly, the use of shared networks is slowly being accepted in order to get the bandwidth and capacity required. The mind-set is changing but perhaps too slowly.

Clive's report first featured in the December 2019 issue of Rail Engineer magazine.

Australasian Section

New Zealand, New Generation, New Approach

Report by Allan Neilson

The IRSE Australasian Section held a national technical meeting in Wellington New Zealand (NZ) on 1-2 November 2019 with a theme focused on "New Zealand, New Generation, New Approach". The Friday technical meeting was held at Engineering New Zealand's headquarters, and trade displays were also set up in an adjacent room for attendees to visit.

The organising committee set out to encourage attendance by younger members in the industry and three recipients were awarded a younger members scholarship kindly sponsored by Siemens Mobility NZ and presented by Noel Burton during the Friday session.

The Friday technical meeting attracted a good attendance of 69 members and guests, many having travelled from Australia. The meeting commenced with a traditional Maori welcome – Mihi Whakatau – followed by opening remarks by the Australasian Section chair Kaniyur Sundareswaran (Sundar).

The keynote address was given by Todd Moyle (KiwiRail's deputy chief executive and chief operating officer). His presentation very clearly illustrated the focus KiwiRail was adopting to support Government investment in Rail. John Skilton (KiwiRail's chief engineer – infrastructure since 2018 and previously professional head of signalling and telecommunications) then gave an overview of current KiwiRail signalling assets and some insight to the future direction.

Following this was a presentation by Michael McKeon (KiwiRail's Wellington Metro upgrade programme director) who outlined the current traction and signalling upgrades being carried out and planned, together with proposed procurement strategies. It was noted that apart from some initial resignalling work to facilitate planned timetable improvements, further resignalling work on the Wellington suburban network is planned to use ETCS Level 2 or possibly Hybrid Level 3, in order to both provide improved safety and capacity for both passenger and freight services.

After morning tea Fabrizio Grizzanti (Siemens) presented the paper prepared by Bernard Stamm (senior expert for ERTMS – Siemens Mobility AG, Switzerland) titled "Using Global Satellite Navigation Services in Safety Critical Rail Applications". This paper summarised results from rail trials carried out under the auspices of the European Union STARS (Satellite Technology for Advanced Railway Signalling) programme and illustrated some of the application problems. A key finding was that in safety critical railway applications the Global Navigation Satellite System (GNSS) location data will have to be combined with other sensors, such as tachogenerators or inertial units/gyros in order to provide sufficiently accurate train position information for signalling purposes.

Todd Moyle delivering the keynote address to the technical meeting.

John Skilton being presented with a certificate by Sundar after his presentation. *Photos Les Brearley.*

Members of panel discussion group “Towards driverless trains”. Left to right Noel Burton, John Skilton, Sundar, James Clendon, Simon Wood (chairman), Howard Revell. *Photograph Allan Neilson*.

Next was a paper presented by Richard Ogilvie and Daniel Grivicic from Rail Control Systems Australia titled “Re-usable signalling code – efficiencies in design and validation”. This dealt with code application with respect to common off the shelf (COTS) devices and associated structured software, which are emerging as an alternative to the traditional signalling processing units. Perhaps unusually for an IRSE presentation was Daniel Grivicic’s use of cans of soup as a theatrical prop to illustrate his point that a COTS safety controller running application software that has been validated through an appropriate quality management system, becomes a known and trusted commodity, similar to tinned food, that can then be used in a variety of applications by experienced systems integrators (the “chefs”).

Ben Calcott (KiwiRail’s recently appointed professional head of signals and telecommunications) presented a paper titled “KiwiRail Design Standardisation” where he outlined progress with reducing the time needed to implement level crossings and other smaller signalling renewals projects, which are principally delivered by KiwiRail in-house design and installation teams. Standardised base equipment designs, that both require less design effort and enable concurrent ordering of equipment prior to finalisation of design work, have been developed. Other objectives include equipment rationalisation and the proposed use of COTS industrial grade SIL 4 safety controllers.

Les Brearley (secretary Australasian Section) then gave a brief update on the Graduate diploma of Railway Signalling.

After Lunch Nathan Loriente (signals manager, Metro Trains Melbourne) presented his paper “Signalling from the eyes of a track engineer” and explained many of the track – signals interface issues that he had encountered from past track and recent signals maintenance management experience.

Nick Terry (Shard group) presented his paper “Why brownfield resignalling projects always require a transition state”, which he had also presented the previous week at Aspect 2019 in Delft. This paper was primarily focused on explaining the rationale behind determining the number of stages required for any given project to balance costs and risk to arrive at an optimum solution.

Noel Burton (engineering manager NZ, Siemens Mobility) then presented his paper “Should we forget the driver?” It analysed recent developments in driverless road vehicle automation and the potential threat such technology could pose to the competitiveness of the rail industry. The presentation noted that many railways have heeded the recommendation in Tony Howker’s similarly titled paper “Have we forgotten the driver?” to implement ATP since it was published in 1988, and that these fail-safe ATP systems make self-driving trains much easier to implement than it is to fully automate a truck on a complex road network safely.

Following afternoon tea, a panel discussion – “Towards driverless trains” chaired by Simon Wood (Larswood Consulting) was convened with panel members Howard Revell (Hitachi Rail STS), Noel Burton (Siemens Mobility NZ), John Skilton (KiwiRail) and James Clendon (RIC NZ). The discussion explored various options and included questions and feedback from the audience. Tony Howker suggested that in many cases it will probably be impossible to completely remove a person from the train in the foreseeable future, for emergency and fallback reasons, but acknowledged that opportunities to introduce automation should be pursued. The consensus was that opportunities should be taken where they make operational and economic sense. In his concluding remarks, Simon Wood suggested that possibly there might be an opportunity for KiwiRail to work with the rail industry as a “testbed” to progress the development of main line automation technologies in a similar manner to the way that other industries use New Zealand as a small first world country to trial products ahead of release in larger markets.

The final session paper titled “Kaikoura earthquake and resilience on the Main North Line” was presented by Daniel Headifen (Strategic Projects interface manager). Daniel was deeply involved from the start in the project to reopen the Main North railway line and adjacent highway in the upper South Island following the devastating 7.8 magnitude Kaikoura Earthquake in November 2016. His presentation dramatically illustrated the effects and recovery efforts for both road and rail that were jointly undertaken by an alliance between KiwiRail, the NZ Transport Agency and four national contracting firms called North Canterbury Transport Infrastructure Recovery (NCTIR). Although not specifically an IRSE focus subject, the paper is well worth reading from a railway resilience point of view.

The chairperson (Sundar) then gave the closing remarks with thanks to the authors and sponsors plus the local organising committee led by John Skilton. The Australasian Section committee held a meeting before the commencement of the gala dinner event attended by around 50 delegates, guests and partners.

Papers presented at the Friday technical meeting can be downloaded using the following web link irse.info/sn9p8.

Top, members visiting A Box. Left to right in foreground – Richard Ogilvie (looking sideways), Ken Ashman and Tony Howker. The signaller can be seen working in the background. *Photo Allan Neilson*.
Above, KiwiRail's Walter Escott pointing out equipment on the "A Box" annex relay room rack to a group. *Photo Bill Milburn*.
Right, a group considering aspects of an Alstom CTS22 points machine at the Signals Wiring Shop located in Hutt Railway Workshops. *Photo Simon Wood.*

The Saturday technical site visit programme started with a visit to the Wellington station signal box (A Box), commissioned in 1936 and KiwiRail's last remaining fully staffed signal box, where the attendees were split up into three groups and rotated around the following facilities with a commentary provided by a local knowledgeable person. These were the 'A' Box comprising a 1930s Westinghouse L type miniature lever frame and add-ons including large flat screen visual display units for the third-generation track diagram, platform junction throat area layout, and an annex relay room installed in 1990.

The second site visit was to the Signals Wiring shop based in the Hutt Railway Workshops complex where current level crossing base design and other signalling equipment location racks were displayed together with a range of other signalling equipment including an Alstom CTS 22 in-bearer points machine. KiwiRail staff were on hand to assist with explanations and questions. At the completion of this site visit attendees then were taken to the La Bella Italia Business Centre in Petone for lunch.

On Sunday, a group of 15 travelled on the Interislander Cook Strait rail ferry to Picton. While on the rail ferry an escorted tour to the engine room and bridge for members was arranged by John Skilton. Then the party boarded the Coastal Pacific passenger train for a trip to Kaikoura to stay for the night. Lovely sunset conditions were experienced over the Kaikoura mountain ranges while the group dined at The Pier Hotel.

On Monday, the group were escorted to several local rail corridor work sites either side of Kaikoura to view the very extensive earthquake remedial works, with expert commentary from Daniel Headifen. The extent of damage meant that the rail line was not reopened for ten months and the road reopened after a similar period. Remedial works are continuing. Later in the afternoon the party boarded the Coastal Pacific to complete the journey to Christchurch and the close of the Kaikoura experience.

Swiss Section

Consolidating control in the Port of Switzerland

Report by George Raymond

Some 1000 river-kilometres south of Rotterdam, the Swiss city of Basel and its Port of Switzerland (PoS) mark the end of the navigable Rhine. The river's waterway network is part of the Rotterdam-Basel-Genoa freight corridor, Europe busiest. PoS is a major import gateway for Switzerland whose backbone is its railway.

The Swiss Port Railway (SPR) serves PoS's three Basel-area riverside zones in Kleinhüningen, Birsfelden and Auhafen. In 2018, SPR finished replacing four aging interlockings and centralised control. On 8 March 2019, an IRSE Swiss Section event attended by 36 members and guests reviewed the project. Our main host was port director Hans-Peter Hadorn. Bruno Huber of Projekthaus Herisau, chief project manager for SPR's resignalling, organised the event.

In the photo below Jan Riemek presents the Port of Switzerland's Kleinhüningen zone to IRSE members from atop a grain elevator. We are looking south towards the city of Basel. The 13-track hump yard (centre, behind building) was a focus of the port railway's resignalling programme.
(Photo George Raymond.)

Full spectrum of traffic

PoS's three zones constitute Switzerland's only international port. Its traffic thus reflects the full spectrum of countries and products involved in Swiss foreign trade.

At PoS, imports heavily outweigh exports. PoS data for 2014-2018 show that the import tonnage share for each of these product groups exceeded 81%, reaching 92% for petroleum products. The only exceptions were chemical products (58% import), and vehicles and machinery (67% export).

Tonnage vs value

But freight tonnage only tells half the story. Freight value is often just as important . A 2016 study of Swiss customs data analysed PoS traffic in terms of both tonnage and its value in Swiss francs (CHF).

The table on the next page shows that in 2015, PoS imported and exported 5.7 million tonnes of freight worth CHF 7.1 billion by barge. (As of mid-October 2019, CHF 100 were worth €91 or £78.) This was 8% of total Swiss foreign-trade tonnage.

Tonnage and value of Swiss and PoS foreign trade, 2015.
Port of Switzerland traffic study.

	Millions of tonnes	Freight value in CHF billion	Freight value in CHF per tonne
Switzerland, total	70.3	523	7440
Switzerland, containerised	3.1	13.5	4355
Port of Switzerland barge traffic	5.7	7.1	1246
% of Switzerland	8	1	
PoS barge traffic, containerised	0.61	2.0	3279
% of Switzerland, containerised	20	15	
% of PoS	11	28	

Imports dominate at PoS by weight, but not by value. In 2015, imports were 88% of total barge tonnage at PoS, but only 44% of this same freight's value. The rest were exports. This reflects the Swiss economy's specialisation in the export of higher-value goods. Of the PoS barge tonnage, imports were worth CHF 630 per tonne, but exports nine times that at CHF 5760 per tonne.

Container traffic

In 2015, PoS's four container terminals handled barges containing 102,916 TEUs (twenty-foot equivalent units) of containers holding 610,000 tonnes of goods worth CHF 2.0 billion. Of the freight PoS handled in barges, 11% of the tonnage and 28% of the value thus moved in containers. Barges serving PoS carried 20% of all containerised tonnage in Swiss foreign trade and 15% of its value.

In barged containers, PoS handled freight worth CHF 3279 per tonne. For comparison, all 2015 Swiss foreign trade was worth CHF 7440 per tonne. Imports in 2015 accounted for 42% of PoS containerised tonnage, 44% of its value, and 54% of TEUs; the rest were exports.

In 2015, PoS handled barged containers carrying 5.93 tonnes per TEU. But this figure includes empty containers. In 2018, 42% of the barged containers were 20-foot, the rest 40-foot. Some 33% of outbound and 23% of inbound barged containers were empty due to short-term repositioning between cities.

Port traffic fluctuations and long-term trends

PoS's traffic depends on both total foreign trade and the port's share. Port traffic thus fluctuates with commodity prices, exchange rates, customs tariffs and major infrastructure outages. Examples are the seven-week closure of the main Rhine Valley railway route in 2017 after the tunnel collapse at Rastatt, Germany; periods of high and low Rhine water; refinery shutdowns for upkeep (or bankruptcy in one 2012 episode); and the economic fortunes of the non-European countries on which high-value Swiss exports are particularly dependent. PoS storage facilities serve as buffers that give the Swiss economy extra months to bridge or adjust to foreseen or unplanned closure of major infrastructure.

Traffic at PoS is also subject to longer-term trends such as shifts to road transport, to higher-value goods and to lower energy use from different sources. In 2014-2018, total barged tonnage at PoS was down 27% but barged TEUs up 137% from the same period 20 years earlier.

Future growth

PoS is Switzerland's water-borne connection to the world's oceans. At the other end of the Rhine's waterway network, the ports of Rotterdam and Antwerp have committed to shifting their hinterland traffic from trucks to barge and rail for better capacity use and sustainability.

Switzerland's exports to developing, emerging and industrialised countries outside Europe are expected to grow faster than its exports to Europe. One customer with particularly high-value export goods is Basel-based Novartis, which ships its pharmaceuticals in refrigerated containers throughout the world.

Such exports, which typically travel by ship or plane, are more likely to leave Switzerland by barge than exports for European countries reachable by train or truck. However, rail transport of containers between Europe and the Far East is becoming an attractive alternative to slower ships and costlier planes.

Two-week round trip for barges

A barge's upstream trip from Rotterdam to Basel requires four days and the return downstream trip three. Loading and unloading requires another week, so a barge can typically start a round trip every two weeks.

Along the Rhine, channels undergo continuous dredging to minimise episodes of low water that force barges to reduce loads or stop.

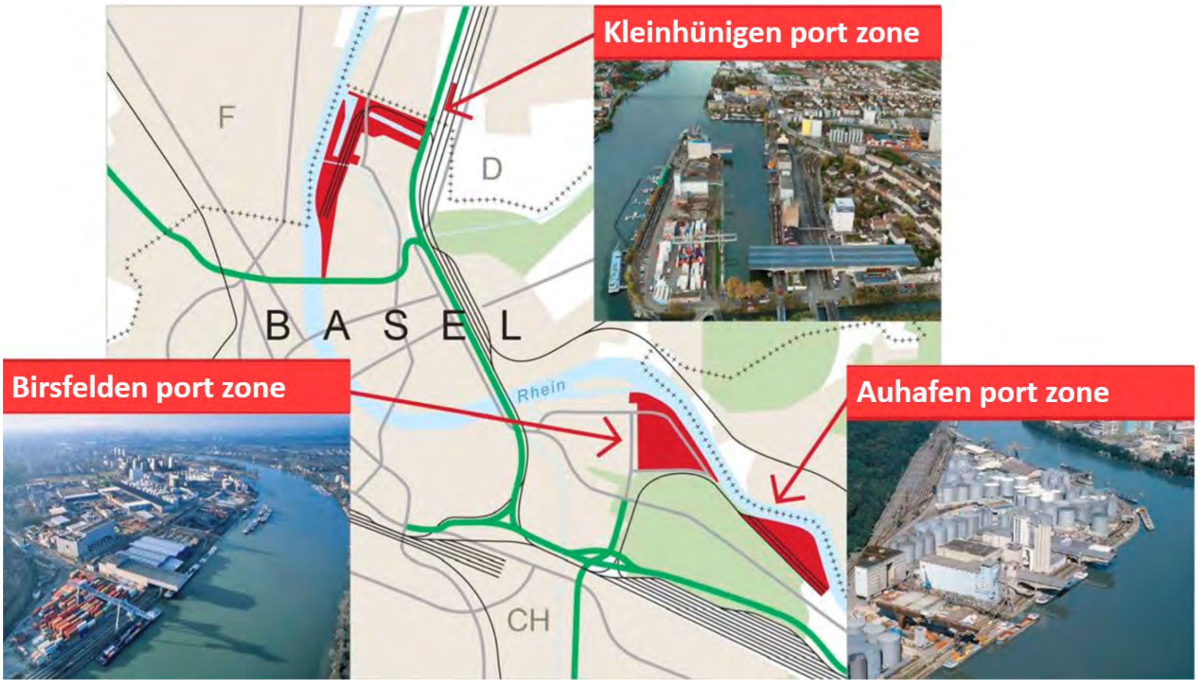
In Basel, buoys separate Rhine ships from the thousands of locals who put their clothes in watertight bags and float down the river and through the city during heat waves.

Most hinterland transport by rail

Over the period 2014-2018, 60% of the net freight tonnes moving on land to or from PoS did so by rail and the rest by truck, an increase from the 57% rail share in the same period 20 years earlier. Reflecting the much lower value and thus shorter hinterland haul distance of imports, the 2014-2018 rail share of tonnage was 55% for import freight headed to the hinterland and 80% for export freight arriving from the hinterland. Trucks handled the rest.

Given Swiss Port Railway's importance, the Swiss Federation contributed CHF 100 million to improve SPR infrastructure between 2017 and 2020. This includes 30 million for resignalling and 35 million for an additional access line.

SPR only operates the port's rail infrastructure; it has granted 20 network access permits to train operators. Most just run trains into and out of the port; the Swiss Federal Railways' freight division, SBB Cargo, performs most shunting. But other train operators have the trained personnel and approved locomotives to shunt in part or all of the port. One operator can even run over SBB Infrastructure's tracks between Kleinhüningen and Birsfelden/Auhafen. Freight customers have 25 contracts for rail spurs within PoS.



The port and thus SPR operate in three zones: Kleinhüningen on the Rhine's east bank just north of Basel's city centre and the twin zones of Birsfelden and Auhafen on the Rhine's west bank in Basel's southeastern suburbs. *Image Port of Switzerland*

The port and thus SPR operate in three zones: Kleinhüningen on the Rhine's east bank just north of Basel's city centre and the twin zones of Birsfelden and Auhafen on the Rhine's west bank in Basel's southeastern suburbs.

Kleinhüningen zone

Of the 2.8 million net tonnes of freight that SPR handled in 2018, 29% was at Kleinhüningen, which saw 58 loaded trains in or out a week averaging 13 wagons plus 49 light locomotive movements. In additional to oil products, Kleinhüningen also handles recycling and metals, and hosts three container terminals.

Kleinhüningen also hosted a terminal of intermodal operator Hupac, which runs rolling motorway trains carrying complete lorries – tractor, trailer and driver – between Kleinhüningen and Lugano in southern Switzerland. Four to five pairs of such trains ran each week in 2018, removing 19 trucks a day from Swiss roads. A reduction in subsidies ended the service in 2019.

The Kleinhüningen zone connects via a 2.1-km line to infrastructure of German Railway (DB) near Basel Badischer station, which lies in Basel and thus Switzerland but is operated by DB.

Birsfelden and Auhafen zones

The other 71% of SPR's 2018 tonnage was at the Birsfelden and Auhafen zones. They currently share a 3-km access track from the west end of Basel's big Muttenz marshalling yard. Together, in 2018 the two zones saw 88 loaded trains a week in and out averaging 16 wagons, plus 61 light locomotive movements.

Both zones handle oil products. Auhafen handles fertiliser, alumina, grain and particularly dangerous goods. Like Kleinhüningen, Birsfelden handles recycling and metals. It offers space for production and logistics and hosts a container terminal. A problem for both Auhafen and Birsfelden is the presence of German residential neighbourhoods just across the Rhine due to a lack of planning coordination in the past.

New interlockings and central control

Bruno Huber of Projekthaus Herisau received a first inquiry in 2013 about replacing the interlockings in SPR's Kleinhüningen and Birsfelden/Auhafen zones. At the time, SPR relied on a "biotop" of electro-mechanical interlockings from makers Bruchsal, Halske, Integra and Siemens that were 60-70 years old and whose technology was up to a century old.

Like most aging interlockings, SPRs suffered from disappearing spare parts and expertise and were very hard to adapt to new track layouts. SPR therefore decided to replace the interlockings and associated field equipment and to create a control centre. Field work required digging in brownfield soil contaminated by heavy metals bought by long-ago floods from early industrial sites. The components of the new control system entered service in 2017 and 2018. It and related infrastructure changes cost about CHF 30 million.

SPR's new control system, based on a Siemens ILTIS system and two Simis W interlockings, features LED signals, four gated level crossings, and both the ETCS Level 1 and German PZB automatic train control systems, which stop a train that passes a signal at danger. This allows locomotives equipped to run on either the Swiss or German network to run into and out of the port without a locomotive change.

Shunting-friendly axle counters

SPR's old interlockings used track circuits to detect incoming trains. The new signalling uses axle counters on all track sections. A key issue was slow-moving axles that oscillate back and forth over an axle counter during shunting. Such situations created five to ten disturbances a day at first, but an "oscillating tolerance" function has reduced these to five to eight a month.

In the diagram on page 29 tracks 46 and 47 on the left are still Auhafen's only connection with Basel's big Muttenz marshalling yard and the outside world. For more flexibility, efficiency and redundancy, SPR is spending CHF 35 million to build a second, 900-metre access track between Auhafen and Muttenz. Expected to enter service in May 2020, it will enter Auhafen on track 81 on the lower right.

The red gates protect a level crossing of tracks 81 to 86. Seven locally controlled swing gates protect the yard on weekends. The interlocking monitors the gate actuators.

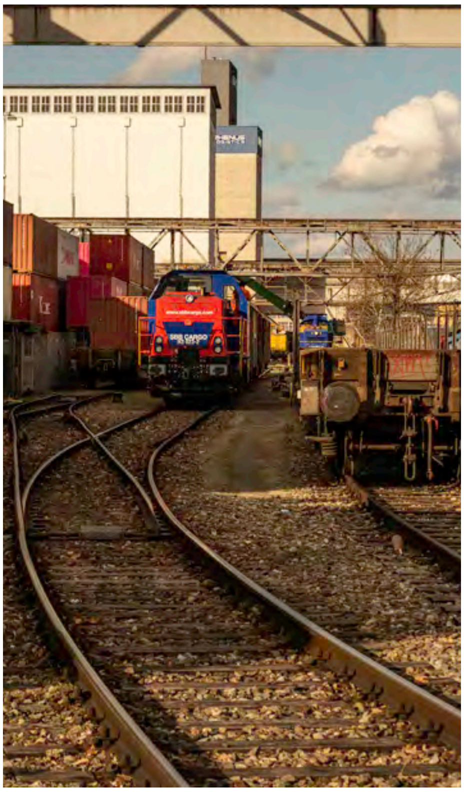
A hump yard uses gravity to sort a string of wagons by destination. Access to Auhafen's nine sorting tracks is from both ends. System designers thus had to take account of the risk that an errant wagon could roll all the way from the hump to the turnouts at the far end of the yard.

Left, recycled materials handled in PoS's Kleinhüningen zone include freight wagon parts.

Below left, looking north toward one of three container terminals in PoS's Kleinhüningen zone and, on the right, facilities that handle bulk freight.

Below, looking north into one of PoS's three container terminals in Kleinhüningen.

Photos Peter Hefti.



	Kleinhüningen	Birsfelden/ Auhafen
Kilometres of track under control of SPR interlockings/total kilometres of track	11/25	11/22
Powered turnouts / total turnouts	84/136	53/108
Tracks in hump yard	13	9
Axle-counter sections	126	59
Dwarf signals	82	47
Miniature home signals showing that the interlocking has set a route out of the port	15	17

Scope of SPR and its resignalling.

Marcel Weyermann shows us the new control centre, whose dispatcher monitors approaching trains in France, Germany and Switzerland and surveillance cameras, for example to check that security staff close gates across the Auhafen yard tracks after hours. Whereas the old, decentralised interlockings required four people, SPR's goal is to station just one dispatcher at the control centre.
Photo George Raymond.

Standard Swiss dwarf signals in the Kleinhüningen arrival/departure yard topped by special miniature home signals indicating that the interlocking has set a route out of the port. Auhafen has similar signals.
Photo George Raymond.

Obsolete interlocking that controlled the northwest end of Auhafen's arrival/departure and hump yard. This area is on the left in the diagram on the next page.
Photo Port of Switzerland.

Local control of hump yard

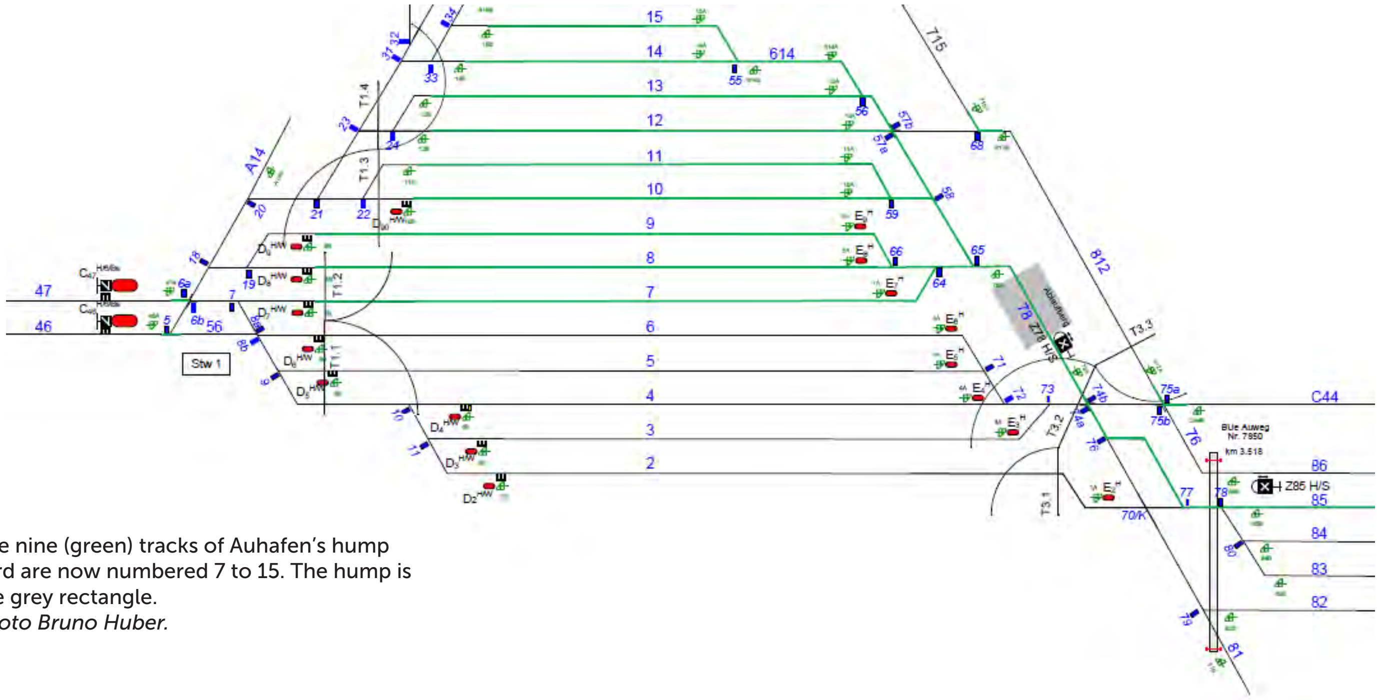
An important feature of SPR's new control system is the option of controlling the railway's Kleinhünigen and Auhafen hump yards either from the control centre or at the hump.

To use the hump control panel, a local operator first obtains control over the hump yard from the central dispatcher. According to the destinations of the wagons to be sorted, the operator then enters a sequence of up to 10 destination tracks. They appear on the panel's small screen. A destination track can appear in the list several times.

To conduct the sorting operation, the shunting manager works in cooperation with the locomotive driver, the people who uncouple the wagons and others who place track brakes on each target track. A signal indicates when the driver can push each group of wagons over the hump.

A Swiss interface to German Railway

Until July 2019, a mechanical semaphore signal of German Railway (DB) governed trains leaving the SPR access line and entering DB infrastructure near Basel Badischer Station. SPR's resignalling project provided a new interface between SPR's ETCS Level 1 and DB's Siemens PZS90 signalling, also known as



The nine (green) tracks of Auhafen's hump yard are now numbered 7 to 15. The hump is the grey rectangle.
Photo Bruno Huber.

The nine-track Auhafen hump yard in 2013, before re-signalling. The project removed the connection between tracks 4 and 5 and renumbered all tracks. *Photo Bruno Huber*.

The re-signalled, nine-track Aufhafen hump in 2019 and its new local control panel, which an operator can use wearing gloves.
Photo George Raymond.

Euro ZUB. To the interface designers, the only common points between the German and Swiss railways seemed to be catenary voltage and track gauge. German signals are on the right, Swiss on the left. The Germans and Swiss often use different German words for similar objects and vice versa. In Germany, an operator must tell the interlocking the direction of travel over a track section; Switzerland allows the interlocking to determine this itself.

Basel's disputed new tri-modal container terminal

Faced with projections of continued growth in container traffic, PoS, Swiss Federal Railways' freight division (SBB Cargo) and two other operators want to build a central tri-modal container terminal for Basel on the former site of a DB marshalling yard. Six tracks at Gateway Basel Nord (GBN) will receive 750-metre trains directly from the parallel north-south rail corridor connecting Rotterdam and Genoa. The terminal's cranes will also unload barges docked in a new, adjacent port basin and load trucks that can then depart on the parallel A2 motorway. GBN's promotors point to the ongoing growth of the ports of Hamburg, Antwerp and Rotterdam and to the Rhine's abundant capacity.

GBN is to become a central gateway for Swiss imports and exports. Its promotors say that GBN will be more efficient in this role than the current network of smaller Swiss terminals in the Basel area and elsewhere. GBN's efficiency should also discourage shippers from placing containers on trains that arrive at points outside Switzerland, then move to their final destinations in Switzerland by road. The goal is for 50% of loading units arriving at GBN by rail or barge to continue their trip into Switzerland by rail.

The current plan is to start GBN's construction in 2020, complete the rail part of the terminal in 2021 and open the port basin in 2024. But Swissterminal, the private operator of two of PoS's four existing container terminals, is challenging GBN in court, saying that the Swiss Federation's CHF 83 million contribution to GBN is unfair. Although GBN's backers point out that Swissterminal's facilities have also benefited from federal funds, Swissterminal may seek compensation before allowing GBN to proceed.

Midland & North Western Section

IRSE Institution of Railway Signal Engineers MIDLAND & NORTH WESTERN SECTION

Radio Electronic Token Block on the West Highland and Far North Lines

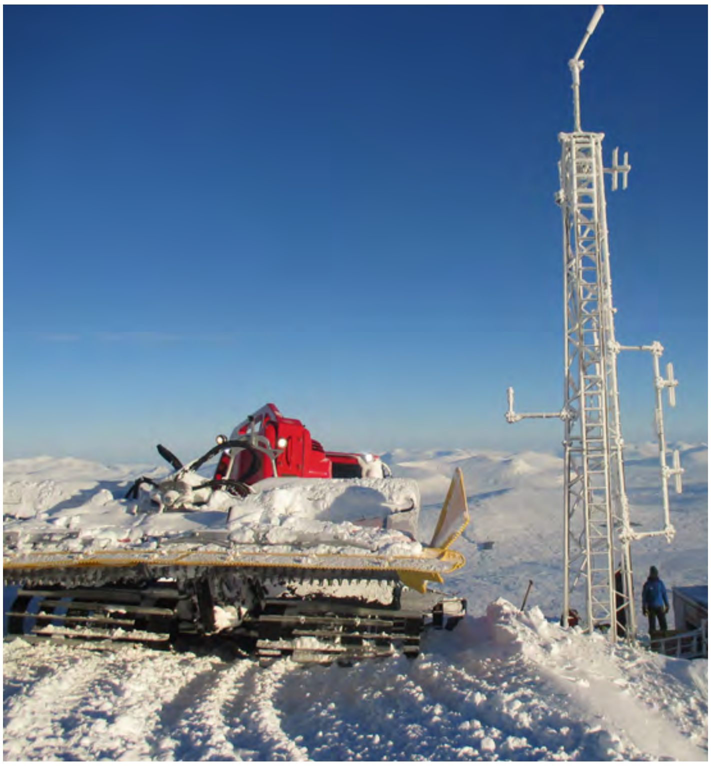
Report by Peter Halliwell

Radio Electronic Token Block (RETB) was a new signalling system for operations over single lines using SSI technology and VHF base stations and on-board radio equipment on four schemes in the 1980s.

RETB offered low-cost operations over lightly used railways. Two of these schemes have subsequently seen the RETB replaced. The Cambrian Line system in Wales was replaced with the European Rail Traffic Management System, European Traffic Control System, Level 2 in 2011 and the East Suffolk Line system was replaced with conventional multiple aspect signalling with track circuit block using axle counters as part of enhancements to increase the line capacity in 2012. In Scotland RETB has been retained and enhanced as the method of working on the West Highland Line (WHL) and the Far North Line (FNL). The re-engineering of these systems to produce what has been named RETB Next Generation (NG) was the subject of the November M&NWS meeting at the Railway Technical Centre in Derby on 20 November 2019 with a talk by Lee Clinton, senior operations manager, telent.

telent has been involved with the RETB upgrade work since 2012 with work ranging from radio surveys through to installation of replacement and new infill towers and transmitters to installation and modification of on-board systems over the whole fleet which operates on these lines. To facilitate continuous operation the changes were phased with the installation of the new fixed equipment, followed by the fitment of the locomotives, diesel multiple units and on-track machines. There was a period of parallel operation of both radio systems whilst the on-board equipment was installed. Once all the trains were fitted and acceptable system performance achieved the legacy fixed and on-board systems were decommissioned and recovered. Subsequently some further system refurbishments and enhancements have been introduced to extend the life of radio towers throughout and to split the FNL interlocking to support more intensive operations.

Each RETB NG system has two SSIs. The WHL signalling centre is at Banavie, near to Fort William and the FNL signalling centre is at Dingwall, near to Inverness. Operation is supported with verbal protocols to request, advise and confirm the issue and return of a token which gives the authority to operate a train on a given block section. In driving cabs the equipment is a cab display radio (CDR) showing the driver any token held. Tokens are requested and returned at token exchange points (TEPs), usually passing loops. Additionally, safe track access can be granted through the RETB system for infrastructure inspection and maintenance by issuing tokens to transportable token units (TTUs).



White Corries in the snow. A snow blower stands by the radio tower, itself encrusted in ice.

The VHF/FM radio system for RETB was originally allocated as part of British Rail's National Radio Network in Band 3 sub-band 2. Owing to reallocation of this part of the spectrum RETB was required to move to Band 3 sub-band 1. This has 16 channels for voice and data comms. Originally RETB required drivers to manually change channels as they moved from one cell to the next. The NG system incorporates auto-tuning to the strongest cell using channel announcement broadcast in each cell every 10 seconds.

The delivery of the works presented many technical, logistical, operational and weather challenges. For Lee and his team nothing was insurmountable. From the outset with the survey activity the approach was to identify as many risks upfront and address them and then refine their plans and resources in the light of experience. Examples encountered were: midges and ticks; the distances away from home, lodging, and site requiring meticulous planning; operating both systems in parallel to permit no disruption to train services; liaising with Network Rail, train operators and their maintainers; and communicating with each other. Getting to radio sites involved using 4x4 vehicles, all-terrain vehicles and road rail vehicles.

Above, cab testing in progress.
Right, telent made extensive use of vehicles that were appropriate to reach remote locations such as Forsinard.

The highest and most remote railway asset in the UK is the White Corries site at the Glencoe Ski Centre and at 3500 feet above sea level. Access here required ski lifts, ski-doos, piste groomers and on foot, the use of snow equipment meant that access was better in the winter, during the ski season. The team quickly learned the need to be self-reliant and able to handle any eventuality in the field. Their adapted Land Rovers become 'life-support machines' with PPE drying, hand washing and drinking water, winches to self-recover, inverters to power mains operated test equipment, and 110V supplies for powered plant. This was supported with enhanced vehicle checks, welfare vehicles, mountaineering equipment and support from mountain guides and enhanced first aid capability. Communications were facilitated with satellite systems, voice over IP, videos links to designers, and temporary site construction networks supporting hand portables with repeaters on the Land Rovers.

With RETB now engineered for long term continued usage on the WHL and FNL, there are a number of potential enhancements that may be implemented. These include: reducing the time taken for token exchange from 9 seconds to 2.8 seconds, facilities to notify passenger request stops from stations, automated train describer, token operated points, semi-automatic signaller cautions to trains, resilient positioning to support automated loop clear notification, automated operation at the fringes between interlockings, collapsing 'super' long token sections, and enhancements for train service intensification with additional passing loops and TEPs.

The way Lee and the team have delivered their work has been recognised in a number of industry awards including two Rail Staff awards, two IOSH awards and the M&NWS chairperson's award last year. Lee is a genuine enthusiast and supporter of these works, of his team and of how they have achieved the works over the last seven years – which showed both in his talk and the excellent turnout in Derby to hear him speak.

How much of your work counts towards your CPD?

Continuing professional development is an essential part of being a professional engineer and a member of the IRSE.

Had you ever thought about how many ways there are to carry out this CPD though? Here are just some examples of how you can do this – just remember to record your activities!

Additional responsibilities: Increasing or refreshing your skill set and demonstrating your personal responsibilities by volunteering to take on additional duties such as supervising others.

Buddying, coaching or mentoring: Sharing your knowledge of your company, discipline or industry by acting as a buddy, coach or mentor.

Shadowing: Increasing your understanding of your company or industry or widening your domain knowledge through work shadowing.

IRSE events and conferences: Increasing your technical knowledge and widening your network.

Management skills: Increasing and practicing leadership skills by organising sharing knowledge sessions such as 'lunch and learn'.

Developing your career: Increasing your profile by transferring to another grade in IRSE.

Technical knowledge: Increasing or refreshing your knowledge by reading up in technical papers, journals (like IRSE News) and specifications on projects, techniques or equipment being used.

Minor Railways Section

IRSE Institution of Railway Signal Engineers MINOR RAILWAYS SECTION

Biennial technical seminar 2019

Report by Kevin Weston

On Saturday 16 November 2019 over 60 delegates representing 24 minor railways gathered at the Kidderminster Railway Museum on the Severn Valley Railway (SVR) for the Minor Railways Section 6th biannual seminar. The theme of this year's seminar was "Ten years of innovation, application and progress in Minor Railway Signalling".

The weekend began with a visit on the Friday evening to the Severn Valley Railway's Kidderminster signal box, organised by John Philips of the SVR. The single line to Bewdley South signal box is worked by track circuit block (TCB) with acceptance levers to control the direction of trains. The interface with Network Rail (NR) is via a connection with the main line (points DR762) controlled by NR from the West Midlands Signalling Centre (WMSCT) but released by Kidderminster signal box. The points are operated and maintained by NR and SVR maintenance staff are therefore, not required to access NR infrastructure.

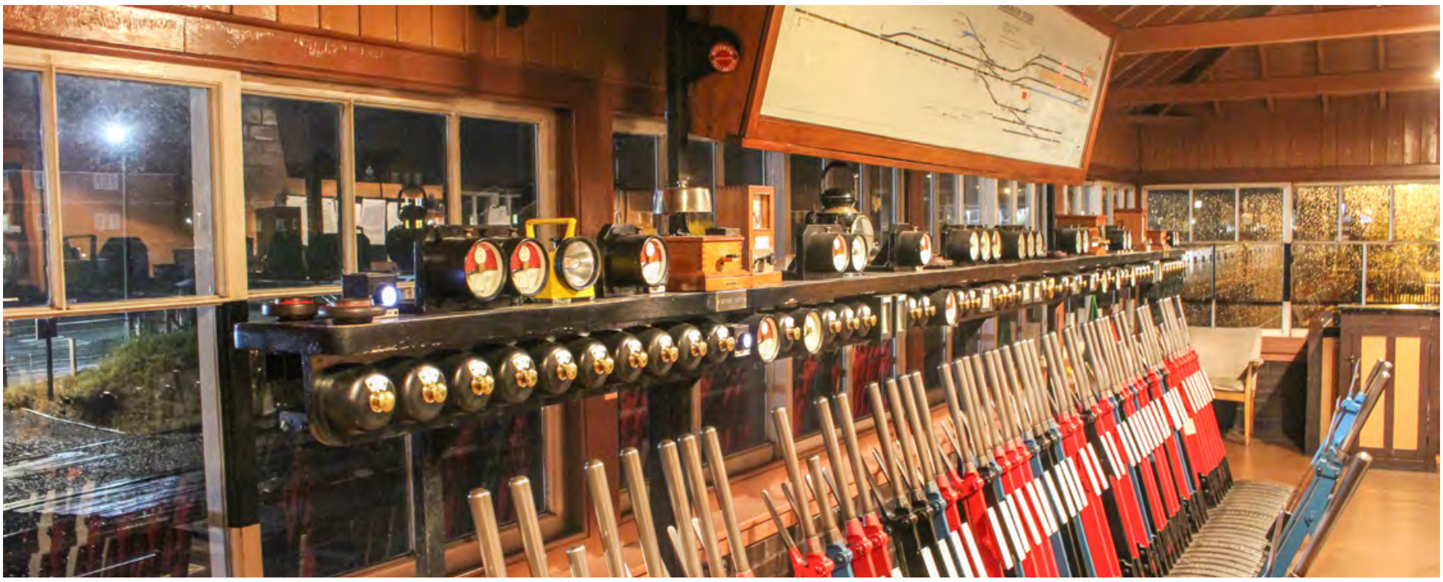
The evening finished with eight of the members walking back into town to adjourn to the Watermill Restaurant for a meal.

Saturday 16 November

Members and guests from around the UK and Europe, as well as representatives from the sponsors, attended the event. Our organiser, Ian Hughes, ensured that everything was kept to time. Daniel Woodland, IRSE vice president welcomed everyone to the seminar and began by thanking the committee of the Minor Railways section, and the organising committee for the honour of being invited.

Daniel reminded us of the IRSE's charitable aims and the aims and objectives of the Minor Railways Section which are "To provide an encouraging forum to support, assist, provide guidance and to learn from the Minor Railway signalling and telecommunications community in the purchase, preservation, restoration, installation, maintenance and operation of all aspects of signalling and telecommunications equipment, installations and buildings".

Daniel then thanked Signal Aspects, Park Signalling, Frauscher, and Green Dragon Rail for their sponsorship of the event and the Kidderminster Railway Museum, all the guest speakers, the organiser and all who attended.



Kidderminster signal box, exterior and interior views.

10 Years of Innovation – Ian Hughes

Ian presented a paper looking at the history of Minor Railways Section seminars. The founding members first met on Saturday 14 February 2009 in Derby and it was a pleasure to see that all seven of the original members were present today. Ian then went on to give an overview of the previous seminars.

2011 – "Signalling the Link". The main theme was about how Minor Railways had made their connections to the national rail network. Five of the 14 papers involved links, either physical or working alongside, at Kidderminster (Severn Valley Railway), Matlock (Peak Rail), resignalling at Grosmont (North Yorkshire Moors Railway), Eridge (Spa Valley Railway), Butterwell Disposal Point and Cae Pawb Level Crossing (Ffestiniog Railway). Other papers included the TERN (Networked Digital Key Token) system and a bespoke level crossing for the narrow-gauge railway at Longleat. The delegates that year were also introduced to the Minor Railway Safety Passport, the first guideline documents produced by the section and a system for disposal of redundant materials from the main line.

2013 – Technology and its Safe Application to Minor Railways. 14 papers were presented to show the use of new technology on Minor Railways, and how some railways have begun to "think outside the box" in the technology they use. This included the development of LED modules to replace conventional SL35 signal lamps, Tycon automation on the Isle of Man, level crossing control on the Romney, Hythe and Dymchurch Railway, solar power on Peak Rail and the SSR/ATC Upgrade programme on London Underground.

2015 – Projects and their Application to Minor Railways. This year saw a reduction in the number of papers to seven, but not a reduction in the quality. There was overview on the management of changes under Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS), the design of Rowsley shunt frame using a turnover lever frame, the development of Porthmadog Harbour station for the Welsh Highland Railway, the main line connection to the Swanage Railway, signalling on rail container terminals and various projects on the North Yorkshire Moors Railway.

2017 – New Technology applied to Minor Railways. Ten papers were presented this year highlighting how new technology can be used, including electric token working over broadband and for level crossings at Norden (Swanage Railway) and on the Romney, Hythe and Dymchurch Railway. There were also updates on TERN (now known as Turnkey), progress on Swindon Panel, LED signal conversions and change management under ROGS.

DiBloC; The digital token machine – John Richmond, Robin Lee, Park Signalling

John and Robin presented Digital Block Controller (DiBloC) which allows a section of single line railway to be controlled without the need for end to end cabling or other on-board equipment. It has been designed to retain the same operational and safety concepts with traditional electric key token instruments which have been in operation on railways around the world for many years. DiBloC is designed to communicate digitally (with an option to do so wirelessly) through IP based systems and includes the provision for TPWS.

Dean Forest level crossing renewal – Roger Phelps, Dean Forest Railway

Roger talked about the renewal of two-level crossings at Lydney on the Dean Forest Railway (DFR). He started by giving a brief history of the crossings. In the 1990s Gloucestershire County Council required to improve the road access to Lydney Harbour

Delegates arrive and collect their name badges. Dave Helliwell and Nick Wellington on duty.

which would sever the DFR's main line connection at Lydney. It was therefore decided to extend from the then southern terminus at Lydney St Mary's to Lydney Junction meaning that the council had to cross an operational railway with its proposed road improvements. The road improvements required full Manned Barrier Crossing (MCB) over Harbour Road and an Automatic Barrier Crossing Locally monitored (ABCL) over the A48 trunk road.

The Harbour Road crossing was to be controlled from the adjacent Lydney Junction (S&W) signal box which was recovered from Heysham. Both installations were designed and installed by Henry Williams of Darlington under contract to Gloucester County Council (with input from DFR) and utilised Smith's BR843 hydraulic barrier machines with standard BR 930 relay interlocking. The A48 by-pass ABCL required an interface with the signalling through the main aspect of signal 9 and a Driver's Crossing Indicator (DCI).

Over the following years the crossing worked well but suffered from the usual road user related incidents. However, the main problem was the hydraulic units which started to fail, as well and faults with the contact boxes and some wire derogation. A failure of the barrier unit was a problem, as they were difficult to change.

It was therefore decided that as the installations are sponsored by Gloucestershire County Council, representation would be made to the Council to renew both sets of barriers. The Project was funded by the Council while the DFR was appointed Lead Contractor for scheme and project managed it throughout. The DFR wished to move away from using hydraulic machines and after going through due process and consideration it was decided to use equipment sourced from Schweizer Electronic from Switzerland based on reliability, cost and having been previously installed a manned crossing at Norden on the Swanage Railway. This would also be the first time that Schweizer equipment would be used on an automatic crossing installation in the UK. Work was carried out in August and September 2018 with Schweizer carrying out the level crossing working and DFR volunteers carrying out the signal installation.

The BR930 relay interlocking associated with the crossings was recovered and replaced at each crossing by a Schweizer Flex system, the BR930 relays associated with the signalling were retained. The Schweizer Flex basically consists of a central processing Unit (CPU) with input/output (I/O) units, batteries and charging equipment and a "Flex Life" monitoring system. The barriers are driven up/driven down by an electric motor through a gearbox and mechanical linkage. The interface with the signalling at Harbour Road MCB was simple but the ABCL over the A48 road proved to be a more of a challenge, which was resolved after many meetings and a few tweaks to the design. The original track circuits were maintained for the signal interlocking but the AHBL operation is initiated by Frauscher train detection equipment, which is believed to be the first use of this equipment on a heritage railway in the UK.

Following commissioning, Roger explained that both sets of barriers have functioned without any hitch for the last 12 months. The main advantage is that the barrier machines are electro mechanical, simpler than the hydraulic machines, both crossings are remotely monitored by the CPU and will send a SMS message to alert us of any problems as and when they occur. The main disadvantage is that if the barriers have to be operated manually, the operator has to kneel down and operate a wheel at the bottom of the unit which is not very convenient. However, this has not yet happened – except during testing.

FAdC® and Dean Forest re-signalling – Oliver Marshall, Frauscher UK

Oliver began his presentation by giving an overview of the Frauscher Advanced Counter (FAdC®) equipment and the system architecture. The system consists of a number of track mounted inductive wheel sensors (RSR123) connected to an evaluator which is located in a location case or room up to 10km away. Its modular architecture provides design flexibility and the output from the evaluator can be via relay or software interface. This allows for a simple and flexible configuration. The system is able to provide Supervisor Track Section (STS), where axle counting transient errors reset automatically without manual intervention. This is achieved by monitoring the axle count over two consecutive track sections to ensure that all three sensors give the same count.

Frauscher were approached by DFR when they were planning their level crossing installation at Lydney with regard to using axle counters for the signalling projects at Parkend and Middle Forge Junction. The Parkend project required six track sections, which was all on jointed bullhead rail requiring bonding of each joint and insulated rail joints (IRJ). One of the sections included two sets of facing points. The success of the Frauscher equipment on the A48 level crossing, together with an estimated timescale of up to four years to install conventual track circuits by the DFR's own volunteer staff, made the axle counter option seem very attractive. The six sections required nine RSR123 axle counters connected to a single evaluator in the locking room of the signal box. The output from the evaluator is to relays for the lineside signalling and the complete system is monitored by the Frauscher Diagnostic System (FDS). This allows the DFR staff to access the remote interface from home.

The nature of the track at Parkend could be a problem with track circuits, such as poor ballast resistance. Additionally, axles counters do not require IRJs, particularly through points, or bonding at all the other rail joints. The system was installed and tested in 6 days, with no disruption (or loss of revenue) to train services and allowing the DFR volunteer staff to continue with other work. Frauscher provided support to the DFR staff in the form of installation training with operational training to follow as well as providing learning experience for Frauscher graduates. The next phase is the installation of five sensors at Middle Forge Junction.

Lunch break and signal box visit

The party was split into three groups; one took lunch while the second went to visit Wrangton signal box (a demonstration signal box in the grounds of the museum) and the third were given a tour of the museum exhibits downstairs.

Wrangton signal box was originally from Devon and has been re-assembled over a number of years and was first opened to the public in 2015. It has a standard Great Western Railway (GWR) 19-lever stud frame from Bersham Sidings, which has been reproduced (as best possible) to show how the signalling was in the early 1900s. It is wired as a demonstration frame to show the public how a signal box worked. Some of the levers are connected to signals and other outside equipment.

Longleat a review of progress – Kevin Weston, Longleat Railway

Kevin gave a presentation showing the upgrade of the railway's signalling over the last 10 years. In 2009 the railway had only four signals, to protect a single crossover forming the junction between the lakeside and Woods lines. The railway used redundant 2-aspect (red/green) level crossing Miniature Warning Light (MWL) units acquired in the 1970s. These units used 12V SL35 lamps and their small size suited a narrow gauge railway. By 2010 these units were approaching 40 years old and were life expired.

Dorman miniature tunnel LED signals were selected to replace the home signals. These units are 110V AC, so some rewiring was required which at the same time the railway then decided to renew the control relays with a more robust type. In the same year, as a result of running longer trains, the turntable which is situated at the end of the platform line was detected in the home signals.

It was also during 2010 that some major alterations were planned to extend the small animals area and provide additional public access to the lakeside and boats. The design of the new layout meant that a level crossing would be situated between the new junction and the station, effectively within station limits for run-round moves and shunting. Although the access was not a public right of way, the railway decided that as the level crossing was essentially a footpath open to the public, it should be designed as a Miniature Stop Light (MSL) crossing, which gives a clear message and would be recognised by the public. The installation was carried out at the beginning of 2011.

A major upgrade and renewal project was proposed at the end of 2015, which would be carried out during the six week closure after Christmas. This was to renew worn out track (some dating from the late 1970s) and signalling, as well as consolidating all the external signalling equipment which had "developed organically" into one location case. The trackwork was carried out by Alan Keef Ltd, who would install all new 14kg/m rail. The signalling work was undertaken by DEG Signal Ltd (now part of Ramboll), who used this opportunity to involve their trainees and allow them to obtain practical experience as to how their designs are installed, tested and commissioned (under mentorship). The work involved refurbishment of mechanical points and rodding, as well as installing replacement LED signals, new cables and a new location case. Despite a number of problems, the work was commissioned on time.

2019 saw further work to provide repeater signals for trains approaching the level crossing and to provide a shunt route from the platform starting signal to allow a locomotive to approach the crossing without activating it and additional shunt signals on the run-round loop. The last ten years has seen the railway's signal box expand from essentially a ground frame controlling a crossover to a fully functioning signalling control centre now requiring a full-time signaller.

Trout Farm level crossing – Charles Weightman, North Yorkshire Moors Railway

Trout Farm level crossing is a user worked set of gates giving access to private land from a nearby minor road over the single running line and a rarely used siding known as "Long Siding". The line is controlled from New Bridge signal box with track circuits and colour light signals but the level crossing is not interlocked. The level crossing would see increased use in the near future, both from the railway and from the road. The increased rail use is because of the provision of a four-road carriage shed and proposed workshop facility to be connected to the Long Siding.

To protect the crossing, consideration was given to three methods:

1. Rural barriers or gates with Miniature Warning Lights (MWL). This is where the crossing is supervised by a signal box but there is no interlocking between the barriers or gates and the signalling.
2. Second generation London Midland Region type on-call barriers. Users operate an "asking" plunger to request the signaller to raise the barriers. Once raised, the barriers will lower after three minutes, preceded by a loud sounding bell.
3. Eastern Region type on-call barriers. Similar in operation to the London Midland Region type, however, these also have instructions that if the barriers do not raise within three minutes to call signaller using the telephone provided. As with the London Midland type, emergency arrangements are provided should anyone become trapped in the barriers and subsequently some crossings have been fitted with basic CCTV.

The preferred arrangement decided on by the railway was a combination of operation by the road user, shunter or as MCB-CCTV by signaller at New Bridge. The three methods of operation are provided. Normal Mode – worked by the signaller as an MCB-CCTV when trains are running on the main line or between the main line and the Long Siding or Carriage Shed. Shunter Mode – worked by the shunter for internal moves when the main line is closed, and User Mode – worked by the road user to raise and lower the barriers after use, although the signaller can still lower the barrier, should the road user fail to do so. The signaller at New Bridge selects the method of operation dependent on the operating circumstances.

DIY Datalogger – Chris Hall, Severn Valley Railway

Why does a minor railway need a data logger? The Severn Valley Railway (SVR) suffers from faults just like the main line, and these can be difficult to diagnose because the signaller can only report the visible symptoms. A number of faults also appear to rectify themselves before testing (known as "intermittent faults"). One of the limiting factors on any heritage railway are the staff resources, particularly with signalling, which on the SVR is a mixture of volunteer and paid. It is therefore not possible to provide the same level of fault cover as that on the main line.

Chris related two faults which were difficult to observe the cause. At Norwood level crossing a recurring "no driver's white light" was reported, which happens when either the main power supply has failed or the crossing was not working correctly. Adding a power monitor was able to prove that the no white light was not caused by a power failure. There was also a recurring track circuit failure on the single line between Kidderminster and Bewdley, and examination of the line was difficult because of a tunnel. This was overcome by adding a separate tunnel track circuit indication to assist examination of line with service train.

The successful rectification of a fault relies on as much data as possible at the time of the fault. This should be individual relay operations, correct sequence, timings and voltage recording. At Norwood Crossing, the fault was usually no longer apparent when the technician arrived, making it difficult to find. The SVR therefore devised its own design of data logger that could record eight channels of digital data (e.g. relay operation), logging the time of each change of state to nearest centi-sec.

The result of the data logger was that adjusting the settings of track circuit "AB" solved the problem. Thereafter, the crossing worked correctly, and no further faults were reported. The SVR has found that using a simple data logger which is cheap to build and easy to analyse, is a useful tool for diagnosing intermittent faults on complex equipment.

Bluebell technician's terminal – Chris Majer, Bluebell Railway

Chris started with a brief description of the Bluebell Railway, which has three signal boxes at Sheffield Park, Horsted Keynes and Kingscote. Kingscote has a Westinghouse Style L miniature lever frame and free-wired BR930 specification interlocking, controlling motorised points, powered semaphore signals and some coloured light signals. A technician's panel is also provided which is an illuminated diagram with hard-wired LED indications. It was proposed that East Grinstead together with the connection to Network Rail would be controlled from Kingscote, and a scheme was prepared for this. Further proposals had subsequently required a design change and to alter the technician's panel would be difficult.

The option chosen was to replace the hard-wired panel with a visual display unit (VDU), which would offer more flexibility, enhanced graphics and the ability to view the display from external sites. It would also allow for the future option of an operator's version.

The system requires a Central Processor Module (CPM) to process the data from the Interlocking and Signalling Input Modules (SIM) to detect the status of the relays to be monitored. A communications network is provided for the SIMs to the CPM. From experience of similar system requirements and practical applications, equipment supplied by Digikeijs was selected. The CPM has several possible interfaces and communication bus configurations. Communication with the "outside world", so that technicians can check the signalling, is by Ethernet.

The project has progressed from a demonstration system, so as to gain the support of the operations manager, to a working system installed at Kingscote Relay Room within six months. The East Grinstead extension will be added as progress is made. The technicians are based at Horsted Keynes and the technician's terminal is live, providing valuable diagnostic information and state of the railway information. An operator's version of the display is to be provided and is currently under evaluation.

The presentation ended with a 'first' for a Minor Railways Section seminar, in that we were given a live feed of Kingscote diagram and were able to watch in real time, the operation of the equipment by the signaller.

S&T volunteer of the year

Since the beginning of the Minor Railways Section, it has presented a "Volunteer of the year" award which, considering the Seminars are biannual, maybe it should be called the "Volunteer of every two years" award. The aim of the award is "to further the section's aims to support and encourage members in the Minor Railway signalling and telecommunications community in all aspects of signalling and telecommunications".

Above, Dave Helliwell receives his Volunteer of the Year award from IRSE vice-president Daniel Woodland.
Top right, a rather shocked Ian Hughes receives his award from the IRSE Section, and right, a close up of the award.

The original criteria for the award were that they should be a volunteer on a minor or heritage railway and, in the opinion of their peers, have significantly contributed to the railway. One of the problems recently experienced with the criteria, is that as more heritage railways get more signalling, some of the eligible volunteers are being employed, either on a part-time or full-time basis, to maintain the equipment and provide better fault cover. The committee therefore decided that from this year, the award to should be open to anyone working on a minor or heritage railway, either volunteer or paid.

This year's award was presented by Daniel Woodland, IRSE vice president, who started by describing the process by which the panel assesses each candidate, describing what they look for within the established criteria. The candidates are from different railways, working in both signalling and telecommunication, all with different technical and operational backgrounds such that it is not always possible to make direct comparisons.

This year, the winner was Dave Helliwell of the Dart Valley Railway, who was selected for his dedication to his adopted railway and his sterling efforts on behalf of the Minor Railways Section serving as a committee member and a lead on the Guidance Notes project and his continuing promotion of the IRSE to new starters and old hands alike.

Special award

This year, the Volunteer committee also decided that an additional award should be given to someone within the Minor Railways Section who had worked tirelessly to make sure everything he had been involved with was a success, failure was not an option.

Daniel Woodland presented the special award to Ian Hughes, mostly for his continued work over the last ten years for the Minor Railways Section, in particular his work organising and presenting the Section's biannual seminars. Ian was obviously surprised at this and said that although the Queen had given him several awards over the years, she didn't know him, and to be appreciated in this way by his peers was an honour, and somewhat humbling. He thanked everyone involved in the presentation process.

Closing address – Ian Allison, Minor Railways Section chair

Ian closed the event by giving thanks to sponsors, Signal Aspects Ltd, Park Signalling, Frauscher and Green Dragon Rail, without whom the event would not be possible, the organisers, presenters, the Severn Valley Railway Museum staff and to all those who attended the event.

There is a general impression that Minor Railways are only about reusing old equipment and maintaining the image of past railways. While the public image is to show the heritage side of the Railway, what happens behind the scenes, out of public sight, can be different. Minor Railways are employing the latest technology, devising new and different ways around old problems, in effect the ability to think outside of the traditional box of railway signalling.

Heritage railways can also be proving grounds for new equipment, whether it is new in design and construction or just new to the UK. This is shown by the use of Schweizer level crossing equipment on the Dean Forest Railway, an innovative design for a level crossing on the North Yorkshire Moors Railway and bespoke equipment for a particular situation the Bluebell and Severn Valley Railways. As well as looking at the past, heritage railways are also looking towards the future.

The next seminar is due to take place in November 2021 so expect the 'call for papers' about February 2021.

Book review

Railway signalling and automation was first published two years ago and explores signalling and automation for main lines, metros and tramways. It was originally written for students on the French "Railway and Urban Transport Systems" master's degree course, but may be of interest to all rail professionals. This new edition corrects some errors and now includes some new material about both main lines and metros.

Part I looks at the general aspects of railway signalling and automation. Part II covers principles of train detection, driver perspective, route control, level crossings, cab signalling and centralised traffic control. Part III covers how track circuits, axle counters, point machines, signals and signalling systems work, with two chapters devoted to ERTMS and CBTC systems.

The book has been supported by the IRSE, SNCF and Paris Metro RATP, Alstom, Hitachi Rail STS, and Siemens, and is based on French practice but also includes solutions from other countries including Belgium, Germany, and UK. It is in two languages, left pages in English, right pages in French; including drawings and keys to all photos.

The book is published in three volumes with the first volume including Part I and the beginning of Part II, the second volume completes Part II and the third volume all of Part III. The book is 220 mm x 270 mm with 300 pages for volume 1 and 2, and 400 pages for volume 3.

The cost is €75 per volume plus postage from Victoria Irizar, Directrice Commerciale La Vie du Rail, 29, Rue de Clichy, 75009 Paris, France. Telephone +33 (0) 1 49 70 12 48 **victoria.irizar@laviedurail.com** or **frederic.demarquette@laviedurail.com**.

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Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at irsenews@irse.org.

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April 2020

Obsolescence
keeping up in the race

Artificial intelligence
the view from India

Interlockings
back to basics

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April 2020

In this issue

Feature articles

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Interconnectedness

I describe myself (humorously) as suffering from "Bipolar nationality syndrome" (being a dual-national of the Netherlands and Brazil). This gives me an overwhelming desire for interconnectedness and co-operation in the world; hence the transport industry and increased urbanisation captivates me. Thus, in 2016, I moved to the United Kingdom with my engineering physics background to work within the railway industry.

Having lived most of my life in Brazil, where railway systems are generally rare, it was a big change to face one of the denser metro systems in the world – London Underground. I found the Crossrail project's magnitude and intricacies, and project cooperation aspects, fascinating.

With three distinct signalling systems from different suppliers, Crossrail heavily relies on co-operation between stakeholders. The Crossrail Integration Facility in Chippenham is a key element for systems integration activities, with employees from different companies constantly working together to achieve a functioning system. I was surprised to realise that this is not common in most projects and systems integration is sometimes only dealt with during commissioning activities.

A deeper understanding of the industry tells me that change can be a slow process, as innovation depends on systems engineering, which by nature involves multiple stakeholders and depends on co-operation. I took this reflection to ASPECT 2019 Conference, held in Delft, Netherlands, that culminated with the technical visit to the Railcenter in Amersfoort. There suppliers perform integration tests with other technologies (even from a different supplier) within the Dutch Railway, run simulations and train staff. The benefits of such facilities highlight how possibly every major signalling project and most countries could gain from this system integration approach.

Systems engineering taught me that just as a product has no purpose if it doesn't fit in a system, a stakeholder has no influence if it is unable to cooperate. I strongly believe that innovation and growth of an increasingly connected and convoluted railway will only emerge from increased communication between parties. I hope I can inspire you with my enthusiasm and suggest that each of us take a step in the same direction, attend one additional industry event and share our knowledge with each other.

Alessandra Scholl Sternberg, ASPECT 2019 speaker

Cover story

A Transport for Wales Class 175 Alstom Coradia approaches Manchester Piccadilly. For complex busy layouts such as this an interlocking is vital to keep trains safe from collision and derailment.

Before a train is given authority to move along a section of track the points must be in the correct position, there must be no trains already on the track and no conflicting train movements already authorised. Once a train has been given authority to move, the points in the section of track must be prevented from being moved, and other trains are prevented from entering the same section of track.

On page 16 we start a two-part 'back to basics' article to explain the principles of interlocking. This month we focus on the technology used for interlocking and in the May issue of IRSE News we will explain the functions an interlocking performs, and how these ensure the safe movement of trains.

Photo Paul Darlington

The race against obsolescence

Wim Coenraad
on behalf of the International Technical Committee

This, the fourth paper in this year's presidential programme, was presented in Utrecht, Netherlands on 7 January.

The world in which we do our signal engineering changes rapidly. We must deliver change more quickly as technology cycles speed up but the demands for assurance and certification of railway control systems slow us down. The latter causes inertia in the development and deployment of systems, products and processes, and can lead to obsolescence.

Speed of technological development

Figure 1 highlights the main technological 'disruptive' development steps in railway signalling. Whilst it shows an upward trend, it illustrates the fact that these disruptive developments tend to follow each other at ever shorter intervals (the x-axis is not to scale!). Most importantly it shows that with an increased span of control and functionality made possible by technical advances, the complexity of the system increases. In addition, we are crossing the threshold into the world of open systems, based on commercial off the shelf (COTS) platforms.

This breaks the traditional railway control system paradigm of safety through engineering of complicated deterministic systems operating within a controlled and protected environment. Instead we are in a realm of highly complex systems in which hazards exist outside our control. Defending against cyber threats puts a new perspective on hazard management and reducing risk as low as reasonably practicable (ALARP). More than ever we need to design systems that are highly resilient and which, when they fail, do so softly (or gracefully), rather than abruptly and totally. In that context we must also address the need for better business continuity management and contingency management processes so that railways can continue to operate with minimal disruption of services.

Whilst railway command and control signalling hasn't seen the pace of obsolescence matching that of some other industries, increasingly rapid change brings major new challenges to our industry.
Photo Shutterstock/ Mykola Vakal.

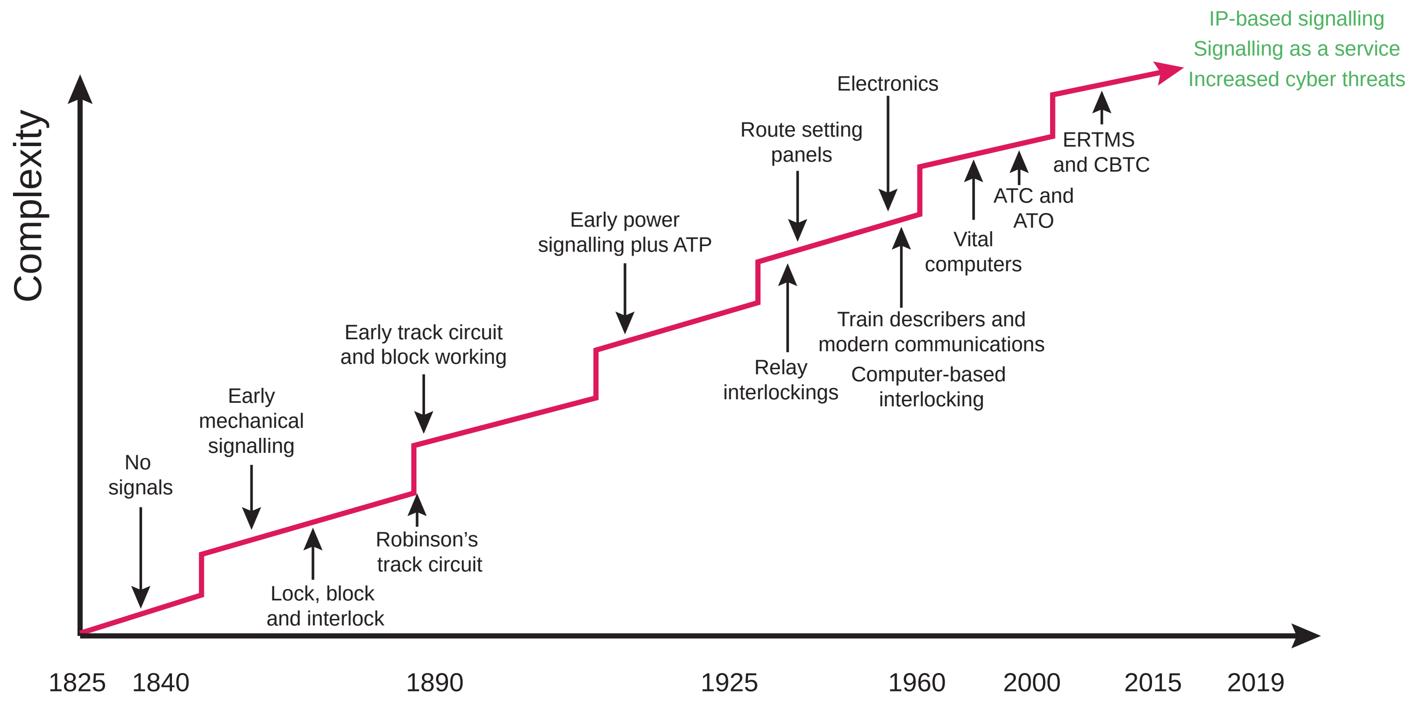


Figure 1 – Disruptions follow each other at ever shorter intervals.

Obsolescence

Obsolescence is usually thought of as technical systems becoming life expired, no longer maintainable or losing relevance for the required functions in their operating environment. It can also refer to processes that become out-dated or no longer fit for purpose (is this true of some of our assurance processes?). And it can apply to people – either when the skills to maintain old systems are in short supply, or when the workforce does not have (and cannot acquire) the knowledge and expertise required for new systems. Even a profession can become irrelevant and outmoded.

Technology obsolescence

Traditionally, railway Command Control and Signalling (CCS) systems have long lifecycles, in the order of 30-40 years and more. They use bespoke designs and are engineered to be fail-safe as well as highly reliable. National suppliers delivered systems for both larger European railways and smaller railways within their geographical area of business activity. They had the expertise to address the problem of component obsolescence by (re-)designing functional like-for-like replacements, thus keeping their systems operational for the railways they served.

The Dutch first generation Automatic Train Protection (ATP) system, known by its Dutch acronym ATB (Automatische TreinBeïnvloeding), is an example of such a system. First developed in the 1950s, it is still in use today – in some places in conjunction with first generation electronic interlockings that use microprocessor based bespoke platforms dating from the early 1980s.

Whilst in the past suppliers were sometimes able to source components to address problems of obsolescence (or even manufacture processors such as Intel's 80186 themselves), this is no longer the case. Increasingly, designs are based on COTS platforms and operating systems with their associated inherently shorter product and operating system lifecycles. The advent of Programmable Logic Controller (PLC) platforms for interlockings is the most recent and clear example of this trend.

At the same time CCS systems have become communications based, as demonstrated in a whole range of proprietary Communications Based Train Control (CBTC) systems in the mass-transit market, and by ERTMS as the standardised ATP/ATC (Automatic Train Control) platform mandated to be used across the member states of the European Union. In fact, ERTMS is becoming widely used by main line railways across the world, not just in Europe.

The fact that ERTMS is, or in all probability will soon become, the only available main line ATP/ATC system adds to its complexity because of the need for it to operate on a wide variety of railways. As the standardised and mandatory ATC system in Europe, its initial Functional Requirements Specification (FRS) inevitably became the sum of the specifications of all systems that preceded it (and more), to cater not only for current but also all future needs that could be envisaged at the time of its inception around 1990.

Not only are the specifications complex, but the ERTMS system architecture and the underlying technology are representative of the state of the art three decades ago. To take one example, the GSM-R communication backbone used for ETCS level 2 and upwards has already been announced as life expired many times already. Current predictions indicate 2030 as its end of life, and successor technologies have long been

"We need to design for failing softly, consider business continuity management and introduce contingency management concepts"

Obsolescence has been a fact of life for millennia, it is not just a sign of our increasingly complex lives. There are examples of systems that have either outlived their intended purpose, could not be maintained economically, or have been overtaken by new solutions in nearly every walk of life.
Photos Shutterstock/ MrNai/NYCRuss/ JoseRPizarro/M Barratt.

on the market. The predicted end of life of GSM-R is well before current ERTMS deployments are life-expired, and further ERTMS deployments, many of which are still in a (pre-) tender stage, are still being announced and are reliant on GSM-R. The Future Rail Mobile Communication System (FRCMS) project is studying successor technologies, but as yet no indication exists on how a new carrier could replace GSM-R whilst maintaining interoperability and backwards compatibility. This marks the first instance of the race against obsolescence becoming a mainstream issue.

Like for Like replacement

Traditionally, designing like-for-like replacements to replace outdated components or systems is a tried and trusted strategy within a given signalling eco-system. An eco-system in this context is a coherent set of technical subsystems, operating procedures and rulebooks, such as "North American main line railway signalling", of which the Dutch "NS-54 system" is a localised variation, geared more towards urban high frequency operations. Other such examples include the German, Swiss and Austrian family of signalling systems, and French main line signalling.

"Designing like for like replacements to replace outdated components or systems is a tried and trusted strategy"

The ERTMS architecture was based upon the Form Fit Function and Interface Specification (FFFIS) principle, using standardised and open interfaces between functional 'black' or 'grey' boxes that suppliers could build and compete with each other on price and/or quality. This would facilitate the provision of functional like-for-like replacements as technology became obsolete. The Euroradio interface between the ETCS application and the GSM-R communication air-interface introduced an abstraction layer from technologies that were beyond our control or could not be proven safe, such as GSM-R. The Euroradio concept was an early example of using encryption to secure a grey channel, aimed at easy replacement of the channel or the encryption when one or the other became obsolete or compromised. This design principle is now becoming a standard practice to protect operational technology platforms from cyber-threats.

The ensuing development of ERTMS holds another important lesson for obsolescence management. The use of FFFIS was promoted by the railways to avoid vendor lock-in (as well as minimising technology obsolescence risk), and this objective certainly did not contribute to its consistent and straightforward implementation in ERTMS. Thus, for instance, in the implementation of Euroradio and GSM-R the interfaces have become muddled and replacing one or the other with a successor technology may in practice prove to be more difficult than anticipated. Avoiding vendor lock-in and technology obsolescence are also central to the EULYNX project, which aims to provide standardised interfaces between functional blocks with differing rates of ageing and life expectancy. Managing the interfaces is still a key concern.

The obsolescence cycle speeds up

In 1986 the "first in class" electronic Interlocking in the Netherlands was commissioned in Hilversum for "supervised commercial operation". It was based on the SIMIS-B platform and by 1990 the first interlocking of a series of three was commissioned in Rotterdam. By then the SIMIS-C platform had replaced SIMIS-B and shortly after the commissioning of the Rotterdam interlocking the platform was upgraded to address the fact that the original memory boards were no longer manufactured or in stock. The Hilversum test interlocking was decommissioned in 1992. At the time of writing, the SIMIS-C installation in Arnhem is being replaced and Rotterdam will follow in the not-too-distant future. Meanwhile 2006 saw the introduction of a successor platform, SIMIS-W, for a trial in Deventer. Similar product lifecycle examples can be quoted for competing platforms such as the succession of electronic interlockings from various suppliers.

The first tell-tale of the race against obsolescence is that, even though in the case of SIMIS-C the originally specified design life of 30 years seems to have been met, the speed with which new platforms are replacing existing ones for both new projects and renewals is increasing, either because older ones can no longer be supplied or are no longer commercially attractive as platform lifecycles drop below 10 years.

Economic consequences

Shortening technology lifespans and reduced operational service lifetimes necessitate more frequent re-signalling. As the total amount

of money available for re-investment and replacement is unlikely to increase significantly, the pressure to reduce the cost/price of signalling systems and projects will grow. However, almost inevitably, the required development, type approval, engineering and construction costs will increase. As the cost of the hardware platforms itself is already low in comparison with the cost of project execution (including software development, verification, validation and certification), there is a strong incentive to move to transmission-based cloud systems. Not all railway lines are in dense conurbations with ample mobile coverage, and where the railways have to provide coverage themselves it is surprising how much cabling is required to connect the base stations and cell-towers, which adds considerably to project costs. Cabling is also required to provide power to point machines and similar actuators.

"If cycle times reduce and the amount of money does not increase, we need cheaper, more standardised, COTS systems and interfaces"

If cycle times continue to reduce and the available finance does not increase, we will need cheaper, more standardised, COTS systems and interfaces. Hence the importance of initiatives such as EULYNX (the European initiative to reduce the cost and installation time of signalling equipment).

Obsolescence of processes

Rail as an "over-compliant" discipline

It is interesting to consider the following quote from Sidney Dekker and Rene Almaberti:

"There are circumstances and industries where a set of cultures and structures develops, because any failure of the safety system can result in such a loss of public confidence that all operators are put at risk going forward. So processes and legislation develops to demonstrate compliance and assurance, rather than having a little bit of space to allow the necessary experimentation for the technology to adapt and evolve. This then locks the system into fixed practices, a spiral of ever-increasing paperwork, barriers to innovation, and a cultural reflex that anything outside the rules is by definition unsafe.

"A side effect is that when small unplanned events occur or non-compliant behaviour is necessary to keep the system working, this is pushed underground as it is unacceptable to talk about it. The management develops absolute trust in the assurance process that doesn't actually contribute to the safety of work. Finally, the mismatch between the system-as-designed and the system in the real world became too great, and some small trigger event or apparently insignificant non-compliance cascaded into catastrophe that nobody saw coming."

"We cannot be less compliant"

Anyone who has observed the genesis of railway practices for producing safety cases, originally based on FMEAs modelled on Military Standard MIL-STD 1629A via ORE A155 (predecessor standard to EN50129), then later using EN50126, EN50128 and EN50129 and the railway-sector specific implementation of IEC 65501, and eventually culminating in the Technical Specifications for Interoperability and the Common Safety Methods, will recognise the picture described in this quotation. Nowadays, the certification of the development of a new critical railway system, a new interlocking product, or even a new ERTMS baseline, takes years before the approval to place it on the market or entry into service is granted. Any significant subsequent proposed change (i.e. one that affects performance or safety of the system) invalidates the certification and thus the process has to be repeated.

Over-compliance or over-regulated?

We cannot, however, be less compliant in an effort to reduce the bureaucracy and cost of certification processes. There are clear examples in other industries of where attempts to speed up processes by cutting corners have led to disaster.

Boeing 737 MAX: The Lion Air and Ethiopian Airlines crashes of "4th Generation" Boeing 737 MAX jets with the loss of a total of 346 lives have raised very significant questions regarding the design, certification and introduction to service of this updated aircraft and the human factors associated with pilot training. For two nearly new aircraft to have crashed so quickly in succession and under such similar circumstances is extraordinary and it is hard to see Boeing's initial reaction as anything other than lacklustre. The IRSE's International Technical Committee (ITC) has explored the issues associated with these accidents, and their relevance to the rail industry, in an article in IRSE News 257 (July 2019) – "Human Factors and ethical considerations associated with automation".

Figure 2 – The 'Stint' vehicle, permission to use these vehicles has now been withdrawn in the Netherlands.
Photo Shutterstock/ DutchMen.

Stint: The Stint (Figure 2) is an electric cargo bike designed to transport young children between kindergartens and day-care centres. In essence it consists of a bathtub-shaped hold that can accommodate up to eight children. It is propelled by an electrical bicycle drive controlled by a person standing on a platform at the rear of the vehicle. Operation does not require any special license or permit. The vehicle itself was not roadworthy under Dutch legislation but in an attempt to promote innovation a derogation was granted and the vehicle was admitted as a "special type of moped", one of the arguments being that walking or using large numbers of automobiles is also not without its risks.

"These examples clearly illustrate the dangers of relaxing safety requirements"

On 20 September 2019 a Stint operated by a 32-year-old person became unstoppable as it approached an activated level crossing, drove through the barrier and in the ensuing crash with the approaching train four young children died, and the driver and a fifth child were seriously injured. Although the ongoing investigation has not established the cause of the inability of the driver to stop the vehicle, it appeared that the design of the traction control and brake system contained several unsafe failure modes and a number of unreported modifications had been made to the design. Consequently, the permission to operate these vehicles was withdrawn.

These examples clearly illustrate the dangers of relaxing safety requirements and the need to separate the duties and powers of the verifier/ validator and the safety authority. But we must also come to terms with the fact that no amount of paperwork and compliance demonstration can replace effective safety management. Furthermore, as technology develops and becomes more complicated the saying that "in this sector you are either independent, or competent, but the combination does not exist" applies even more. An independent safety assessor, or for that matter verifier or validator, will have to rely on the detailed knowledge and understanding of the technology, design and software code that only the supplier's specialists have and are able to maintain. The assessment can therefore only really cover the scrutiny of the supplier's due diligence, the assumptions underlying the design and the V&V efforts made by all parties involved in every step of the lifecycle. In particular, if these duties are devolved to different parties in different phases, such as design and implementation, installation commissioning and testing, it is all too easy and common to assume that a certain check is in the scope of another party, and this can extend to assessments if various phases in the lifecycle are covered by separate Independent Safety Assessors (ISAs).

Complexity catching up

Figure 1 shows that the complexity of CCS systems increases as technological advances enable us to increase the span of control of these systems, and to provide more and increasingly complex functions. The observed development lead times in the ERTMS system itself (from inception in 1989 to the introduction of baseline 3.6.0 in 2019, which almost makes it a commercially viable product) and the observed cost and planning overruns in ERTMS and other CCS projects that have been widely publicised, are evidence of the fact that our industry struggles with complexity.

We are shifting from controlled complicatedness to working with complexity

Again, it is useful to observe our profession through the eyes of outsiders, as they describe their perception of fail-safe design principles:

"Railways take an extreme version of a command and control strategy." ... "Passenger safety appears to be achieved by defining very clearly in advance what are the necessary prerequisites of safe operation and forbidding operation outside them. When the system moves outside this clearly defined safe envelope, the railway system stops, regroups and restarts only when the necessary operating conditions have been re-established."

(Hale and Heijer (Chapter 9 in Hollnagel, E, Woods, D, Leveson, N, Resilience Engineering. Great Britain: Ashgate, 2006).

This perception is reflected in the safety management standards and directives quoted earlier. They are predicated on a paradigm where a signalling system is seen as a very complicated, yet deterministic system, that can be understood, analysed and proven to be safe in its entirety. But still we struggle with software in our systems that can never be proven to be completely error free, or even tested in full, we have to resort to formal methods for specification and automated testing in an effort to "save the paradigm".

"In reality we now live in a world of complex systems"

However, with the advent of communication-based signalling and more generally the digital railway we have already opened up our closed world in which all outside influences were known, predictable and capable of being mitigated to an acceptable level if hazards resulted. Cybersecurity issues have forced us to face this new reality.

We now live in a world of complex systems where actors and their actions cannot be (completely) predicted, controlled or mitigated. Such systems are not deterministic but can operate in one or more seemingly stable system states that they move between, unlike the classic failsafe design paradigm characterised by the assumption of controlled complicatedness.

In the existing paradigm we assume that although signalling systems can be extremely complicated, they are a closed, walled-in system. The system is deterministic in nature and, at least in theory, one person can oversee and comprehend it in its entirety. How else would an Independent Safety Assessor be able to conclude on the basis of the evidence presented that the system is safe (enough), that all hazards are controlled to an ALARP level and that it is fit for its intended purpose?

In reality this was never true, as human operators introduce an element of unpredictability that we try to control with rigid and tightly controlled procedures – and indeed they are the very reason we need train control systems, to mitigate that hazard of human error.

"EMC and EMI problems are an example of such poorly understood and manageable external influences"

In addition, there is a limit to which we can control environmental influence and fail safely when we operate outside specified parameters, even if we can detect such excursions outside the controlled environment in time to initiate the fail-safe control mechanism. EMC and EMI problems are an example of such poorly understood and manageable external influences. We can also no longer claim that vandalism and sabotage or acts of terrorism do not need to be taken into account in our hazard and risk management. The effects of copper theft and wilful acts of vandalism are examples to the contrary.

Cybersecurity management issues

Cybersecurity management has been much debated in recent times and it requires a much broader perspective of the system under threat, its interfaces etc. (See Boss, John, "Signalling and Cyber Security: Closing the gaps that prevent comprehensive security solutions", IRSE ASPECT 2019). To illustrate its influence on our race against obsolescence, we now shift our focus from the obsolescence of components, systems and technology, to processes and methods.

Firstly, cyberthreats break the CSM model of hazard management whereby any hazard must be mitigated to an ALARP level – or at the very least it suggests that we need to redefine the ALARP criterion. There is consensus that cyber-attacks by actors described as "nation states" are supported by means, methods and resources that we cannot defend against (if we could, our society would be changed in ways that we would not accept). The consequence of this conviction is that where such hazards could lead to consequences associated with one or more casualties, many injured or large environmental impact, they would be classified as catastrophic, with a frequency of occurrence that must be deemed rare or occasional. This would constitute an intolerable or undesirable level of risk in a classic EN50126 and CSM Risk Assessment.

The second cause for rethinking our failsafe design paradigm and/or compliance culture stems from the responses often described for managing cyber threats. The security principles are based on layered defences and defence in depth. The description goes somewhat like this:

The question is not "if" but "when" a line of defence will be broken. When that happens, we retreat, recover and regroup behind another line of defence, quickly looking for an enhanced or diverse defence to close the breach and recover as soon as possible. This need for resilience and quick recovery is based on the fact that we are dealing with critical systems, and railways in most countries are deemed critical infrastructure, where continuity of service provision is essential. An often-quoted example is one where a critical encrypted transmission link is compromised, perhaps because the encryption itself was broken. We assume new or better encryption devices will be available and can replace the compromised ones relatively quickly.

In this design strategy we recognise the Euroradio approach to securing GSM-R communications, and indeed most modern architectures for cybersecure CCS systems. Leaving aside the somewhat improbable assumption that Euroradio could be replaced quickly by an improved version, or the applicability of such strategies to legacy CBI platforms or indeed current ERTMS trackside architectures, in almost all cases this would be classified as a "significant change" under the CSM directive. This would invalidate all existing safety cases and certificates, requiring another multi-year certification process, involving Notified Bodies (NoBo), Assessment Bodies (AsBo) Independent Safety Assessors (ISA), accredited laboratories and similar entities. Needless to say, this does not fit well with the concepts of resilience, nor with the need for business continuity of service provision. In conclusion, we must rethink our safety management paradigm and compliance culture before we as an industry and its practitioners become obsolete ourselves.

Complex systems

We must face the fact that we are no longer working in a paradigm of controlled complicatedness but in reality are dealing with

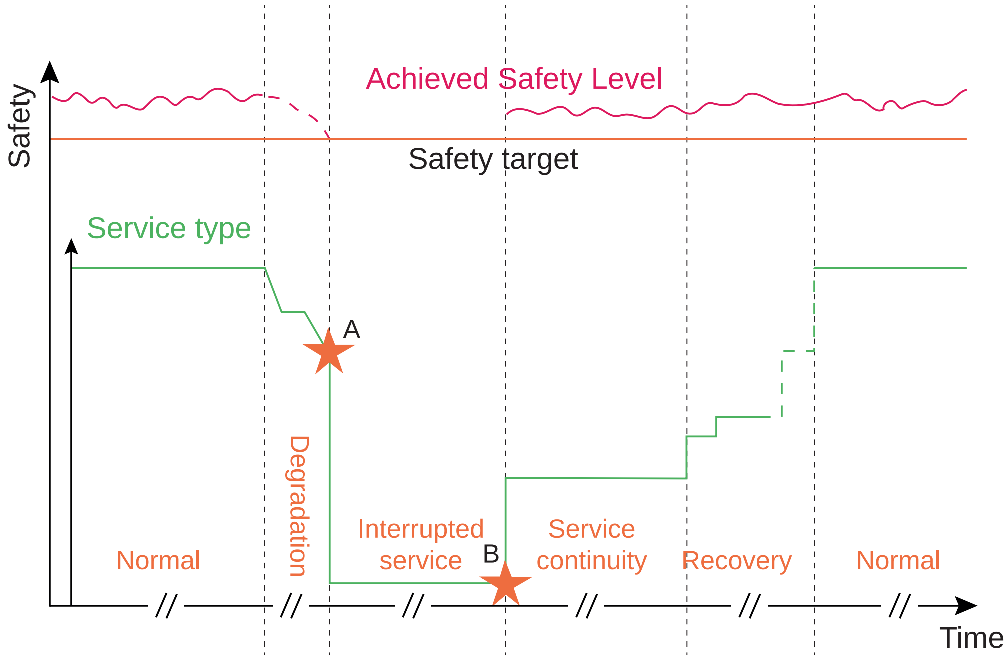


Figure 3 – Service types identified in EUROCONTROL guidelines for air navigation services.

"Even though we manage to make most of our systems fail safely most of the time, that really only maintains the safety of the operating railway no longer than a quarter of an hour at max"

complex systems. This class of systems, like the weather, the economy or ecology, is characterised by the fact that they are subject to uncontrollable outside influences and can have multiple stable system states between which they can transition. That does not have to imply the science of railway command and control systems engineering will start to resemble that of global climate change (the concepts of "management" or "engineering", unfortunately, not being applicable there). It does however force us to rethink the assumptions in our systems engineering and safety management, as indicated above.

Contingency management

Having discussed the race against obsolescence from the point of view of technological obsolescence and security management, the remaining aspect is one more directly applicable to our traditional type of safety management.

Failing safely or failing smoothly

Every signal engineer knows that even though we manage to make most of our systems fail safely most of the time, that really only maintains the safety of the operating railway for a maximum of about a quarter of an hour. In some locations, such as tunnels, it really is not safe to stop a train. But even if that consideration is left aside, passengers and road users become impatient quickly and will start to act on their own initiative. As an example, road users waiting at a failed level crossing (barriers closed) will start zigzagging around the barriers, or even lift them. Train drivers will be issued with verbal or written orders to proceed "on sight".

The fact that we provide override buttons in train control systems, that we distinguish between permissive and non-permissive signals etc. demonstrates that, to a degree, resilience engineering has always been part and parcel of our trade. The phrase "resilience engineering" has become fashionable enough to become the theme of an IRSE presidential year and an ASPECT conference.

Railways, and certainly mass-transit systems, have become "critical infrastructure" and therefore "continuity of service provision" is nowadays an explicit system requirement. How does this affect signal engineering?

Fail safe vs fail functional

We must learn to design systems that are better at failing in such a way as to remain at least partially functional or failing gradually and safely rather than abruptly and completely. We will need to consider degraded mode operations at the design stage. This is not necessarily a new observation; the ITC has produced a report on this subject, and projects such as "Compass" (Combined Positioning Alternative Signalling System) advocate using fallback systems that are allowed to use "lower-SIL" technologies. But it seems the requirement for contingency management has been overlooked.

Contingency management is a systems engineering approach developed in air traffic control management. It considers, analyses and prepares for safely managing interrupted, degraded and recovery modes of operation. Hazards which may result from, or have different risk levels in abnormal modes of operation, are included. In a sense, it extends the CSM approach for hazard management to contingency modes of operation.

In Guidance Notes published by Eurocontrol, the system operates as designed in normal service and the actual safety level is above an agreed safety target level. In Figure 3, "A" marks the moment where "something" happens, either in the form of a (technical) systems failure or perhaps a security incident in the technical domain (e.g. a cyber-attack) or as an act of sabotage or violence. In any case the safety of operation drops below the agreed threshold and service is interrupted, either by a technical fail-safe design measure activating or by an operator or authority decision.

In air traffic control this may involve processes to clear the skies, which could in railways equate to a decision to start reversing trains out of a long tunnel or direct them to a 'safe haven' where passengers can be detrained. It is assumed that after some time, at "B", the processes, systems or controls are in place to allow service to be resumed, provided that in this service continuity phase, the system achieves a safety level that meets or exceeds the safety target level. In one or more steps technical and/or operational systems are recovered and brought into service, until normal operations are resumed.

"The loss of situational awareness is equally hazardous on railways"

It is not difficult to spot the analogies with railway operations, such as written or verbal orders for the continuity phase, temporary speed restrictions, single line working, clipping and scotching points for recovery mode etc. In fact, we might argue that the rulebook is an implicit manual for railway contingency management. The difference, and perhaps the area in which our processes are becoming obsolete compared with air traffic control contingency management, is that there is a requirement for a pro-active analysis of all scenarios. It also requires explicit hazard management and the realisation that human factors must be considered, as drivers and operators may respond in different or unpredictable ways if situational awareness is lost or hampered in degraded and recovery modes of operation. Training and proficiency checks are required to support adherence to predefined scenarios to deal with contingencies if that is the control strategy of choice.

Recent accidents, such as that in Bad Aiblingen on 9 February 2016 (ITC Report 47 "How do we reduce the number of accidents involving human factors?" IRSE News issue 242) show that loss of situational awareness is equally hazardous on railways.

The need to analyse and practise contingency measures for degraded and recovery modes of operation was also encountered in the testing of the new rulebook in the Danish ERTMS programme, where it was found that users had difficulty in understanding, remembering and correctly executing the new rules.

Last but not least, it will require a type of safety management that uses the benefit of hindsight in accident and incident investigation to evaluate and learn. Such hindsight must not however assign blame or liability, if we want to protect safety practitioners and operators that may be found to have been simply wrong, but not negligent. Without such learning in a blame-free manner, failing safe (instead of failing functional or smoothly) will continue to be the solution of choice in system design and contingency management.

Conclusion

The rate of change in technology will not slow down and it is unlikely that vital infrastructure like rail will become less regulated in future. In order to stay in business, we will need to become better at managing projects in terms of budget and planning issues. This is outside the scope of this article but addressed to some extent in ITC paper "Why do signalling projects fail?" in IRSE News issue 244.

The learning point from this paper is that as an industry sector (and that includes the regulators and safety authorities) we need to become better at managing change, and develop improved processes that maintain the essence of the Common Safety Methods approach whilst avoiding the bureaucratic and cumbersome processes that seem to have become synonymous with Cenelec standards and interoperability certification. The real challenge is to maintain our high safety standards in ever more complex systems, faced with security threats and during contingencies.

Managing obsolescence nearly always involves understanding the humans impacted by changes in technology if safe and efficient service is to be maintained. *Photo Shutterstock/ Belish.*

Penetration of Artificial Intelligence in Indian Railways

Bharti Jain

The advancement of railway technologies is complimented by a growing population, which coincides with the evolution of digitisation. The use of online services through the internet allows the integration of everything data related to provide better services. Data is computable and predictable. This leads to the upcoming role of Artificial Intelligence (AI) in Indian Railways.

AI in Indian Railways

Indian Railways is the fourth-largest network in the world with a track length of over 70 000km and more than 20 000 passenger trains running per day. Managing all aspects – operation, maintenance, scheduling, repair, and monitoring – has always been a challenge for the Indian railways. This is due to the difficulty of integration of various systems such as signalling, telecoms, operations, rolling stock, electrical distribution, information technology, traffic management and the involvement of human factors.

One way to meet the demand is to enhance railway infrastructure. This has been the key feature of current projects such as the Konkan Railway double-track expansion and the introduction of 'bullet' trains along the Mumbai-Ahmedabad High Speed Corridor. But the question is "why overlook the potential increase in throughput, to meet the increasing demand, by the incorporation of AI, machine learning, and self-control systems?"

These systems are designed to improve the reliability of existing infrastructure and make up for the one-time heavy investment. This can reduce the need for human interference and provide the required level of safety whilst increasing operational speed. It should be possible to do more with hardware if we can make the software more efficient. This includes greater information sharing, lower latency, and smart algorithms. This is why many Original Equipment Manufacturers (OEM) and startups worldwide are now investigating the feasibility of services based on AI.

Feasibility of AI in Indian Railways

We should analyse whether the amount of data required for simulation and mathematical modelling is available. Let us consider various areas of interest separately for Indian railways.

- Operation – AI for any system requires a huge amount of linkable data. In Indian railways, the network already runs a supervisory control and data acquisition (SCADA) system, so a vast amount of operational data is available for modelling and training purposes.
- Infrastructure – Digitised versions of railway infrastructure should be readily available. The same argument can be made for train rake information and crew rosters.
- Tracks and rolling stock – The data for predictive maintenance of the tracks or trains may not be available in India. But the physics of these problems does not vary with geography. Therefore, data from other countries can be used to establish these models.
- Signalling and telecoms – The history of events may be obtained from the data loggers of the interlocking and other systems. This can help to schedule the movement of trains and manage machine-driven operations.

Although we have good availability of data, the key challenge is in developing a framework where researchers can start with several individual problems, and then integrate them effectively. Hierarchical or more generic architectures are effective in handling such issues. These could be used from an algorithmic standpoint. The need is to make the various systems talk to each other effectively. This is where expertise in software/hardware architectures and system integration is required. A typical integration scenario is shown in Figure 1.

Applications of AI in Indian Railways

There is a broad range of service spectrum which AI can address depending upon the level of efficiency and need. The feasibility of some of the primary requirements of railways which AI can provide is discussed below.

Train scheduling

For train scheduling, data will be required in the form of train identity numbers, their origins and destinations. Once such data is available, track resources for each train can be assigned for a fixed period. This will allow all trains to complete their journeys without conflicts.

All signalling rules assume that tracks at stations are normally occupied by at most one train at a time. This can be ensured by algorithms, simulation models, graphs, heuristics and control systems with the required degree of AI in Indian Railways.

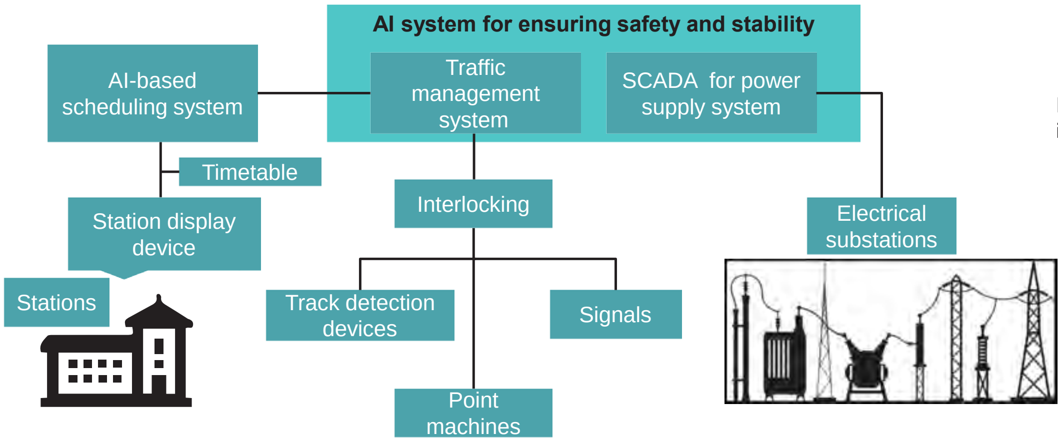


Figure 1 – Simplified example of integrating AI in a railway network.

The information which can be obtained from AI includes:

(i) Time duration from the first event to the last event,

(ii) The total or average running time of trains,

(iii) The priority-weighted running time of trains,

(iv) Robustness of the timetable to deviations, and combinations thereof.

This will ensure one of the following:

(i) track section between two stations is occupied by at most one train at a time (in absolute block signalling), or

(ii) piece of track between two signals is occupied by at most one train at a time (in automatic block signalling).

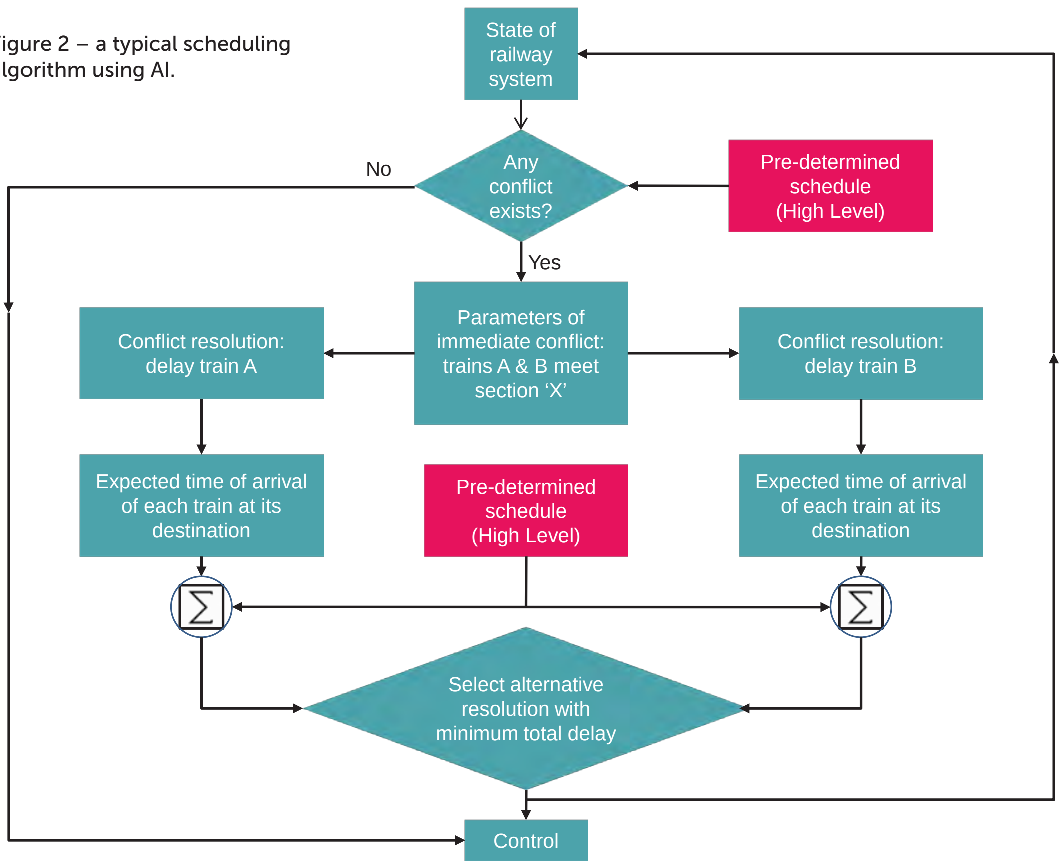
Currently, most railway networks do not use automated algorithms for this function. They instead rely on the training and experience of controllers (dispatchers) to take decisions. They cannot process a large amount of contextual information, neither can they meet the demand for short turnaround time for decision making. But the above-mentioned approach will generate high-level timetables and schedules of train movement. They will specify tracks to be occupied, the time required for switching tracks, and signalling requirements. The parameters of immediate conflict can be evaluated in real-time. Hence, instant scheduling decisions can be taken, generating microscopic schedules.

With AI, one can develop iterative optimisation approaches or graph-based models to compute low-level timetables with real-time decision support using heuristics as summed up in Figure 2. AI also offers a way of training algorithms to react to disturbances quickly and yet with near-optimal solutions.

Controlling the speed profiles of trains

An AI-based conflict resolution scheme should not only achieve hard signalling (signal aspects) but more optimum approaches such as train speed management. Both the energy consumption of the train and total delay depend on the speed profile used between stations. Using Reinforcement Learning (RL) or dynamic programming, energy-efficient speed profiles for

Figure 2 – a typical scheduling algorithm using AI.



single trains can be computed at the initial level. However, for broader applications in the country, the future possibility is the development of AI techniques that can:

(i) interact with human train operators without increasing their load,
(ii) be implemented by humans in the loop, and
(iii) detect obstacles on the tracks.

Delay prediction and reduction

One major role of AI is the prediction of train delays. This is an important consideration for the highly limited nature of railway networks. Currently, there is no mechanism in Indian Railways to take corrective actions for the delay in train timings. Such delays are caused due to train priorities, downstream conflicts with other trains, freight loads, and irregular stopping times. A human cannot process all of these factors simultaneously or come up with an optimal solution for the network as a whole.

Accurate delay predictions due to the incorporation of AI in Indian Railways would help dispatchers (controllers) in downstream portions of the network. It would also improve the passenger experience by providing early updates regarding their journeys. A system to predict delay time would learn from past train delay data, predict how long each delay will be, and use a cloud-based service to deliver updates.

An AI-driven approach is a 'sense-analyse-respond' system to predict and correct delays. The 'sense' part of the programme gathers data about the status of trains in the network. The 'analyse' part calculates the implications of each possible option. And the 'respond' part allots the computed track resources to each train based on physical capabilities and safety standards.

Asset management

Fool proof working of the signalling system is important for safe train operations. Railways completely depend on the health of signalling assets along with real-time information. Most of the delays happen due to the failure of signals. So far, Indian systems follow a manual maintenance system and find-and-fix methods. But the adoption of AI in Indian Railways can help predict failures by remote condition monitoring of the system well in advance.

This can be made possible by embedding smart sensors on critical rail components and taking the necessary preventive actions. Inputs are collected at fixed intervals and sent to a central location (such as operations control centre or OCC). As a result, any problems in the signalling system would be detected on a real-time basis. This is shown in Figure 3.

Trains equipped with smart sensors and Global Positioning System (GPS) transmit component-wise health status and location to the Asset Intelligence Centre (AIC). The AIC which maintains the digital database of all railway assets also collects inputs from the safe distance warning (SDW) system embedded in the track-side cameras about train/wagon defects and electronic damage notifications (also transmitted to the driver). Once such information is gathered and integrated, data analytics in the form of Reliability, Availability, Maintainability and Lifecycle Cost (RAM / LCC) diagrams are generated which calculates the cost overhead in maintaining the particular train component at a given time and conditions and also generates a digital Rulebook (Rulebook 4.0), which provides an easy access to the maintenance policies in the form of a structured data model for use by concerned operators and workshop staff in the future. The AI recommended decisions based on dynamic algorithms and policies as per the digital Rulebook are then encapsulated into a consolidated maintenance schedule inside the Digital Fleet Control Module and compared against the workshop capabilities to generate demand for material and labour. This demand is eventually fetched to the workshop digital interface in the form of digital order.

As of now, remote monitoring of some signalling is operational in a number of countries including the UK. The system there involves data transfer through a wireless medium (3G and 4G). The data based on these inputs is utilised with the help of AI for prescriptive big data analytics. This allows the detection of signalling asset defects, automated self-correction (through machine learning) and informed decisions. Indian Railways decided to trial this on two sections of Western Railway and South Western Railway at Ahmedabad-Vadodara and Bengaluru-Mysuru.

Intelligent signalling systems

These can be built by generating a 'digital twin' of a railway section. A digital twin is a simulation model of a real physical system and its operations. Multiple data sources continuously update the virtual replica and change its state to represent the effects on the physical counterpart.

A helicopter or a drone equipped with laser scanners and cameras can capture images of the whole section and simulate a fully mapped-out, three-dimensional digital model. Then a digital guide of all assets can be developed. This can include thousands of kilometres of track, signals, points, radio towers, stations, cable ducts, bridges, tunnels, and level crossings.

The benefits of such a model include:

i) Automation of design: A digital twin can help semi-automate the design with total precision, saving months of work. It eliminates the need to go onto the site and manually measure and estimate gradients, determine equipment requirements such as cable and connectors, locate infringements and track crossings. A 'digital twin' has been developed by Alstom for the busy UK West Coast Main Line (WCML) for the Pendolino train. The entire train fleet encompasses fifty-six trainsets along with five maintenance depots. The maintenance of such a complicated system with the required degree of prediction needs many aspects for consideration which would not happen without a digital twin .
ii) Scheduling: Daily operating requirements for the routes and timetables regarding the trains and capacities can be estimated.
iii) Maintenance: Frequency and parameters (such as time or mileage) for train inspection as well as the details of preventive and corrective maintenance for the depots can be determined.
iv) Asset safety and reliability: The digital model will indicate the instance of theft or the possible failure of any signalling equipment. This 'predict-and-prevent' model will save money, increase capacity, and eliminate any unplanned delay or service cancellation. The added cyber-security option can be used to deliver a secure online key management system for the trains to communicate securely with the wayside signalling system using encryption keys.

As shown in Figure 4, data from track and train is collected by smart sensors and cameras and acts as an input for digital twin modelling. Hence two parallel layers – physical and digital – are created on the network which communicate with each other through suitable interfaces. The digital model calculates the operation time and interval of the train which may be applied to the AI-based risk evaluation algorithms. The real/physical layer monitors and adapts to the changes in rules and regulations by the government and then sends the information to the digital

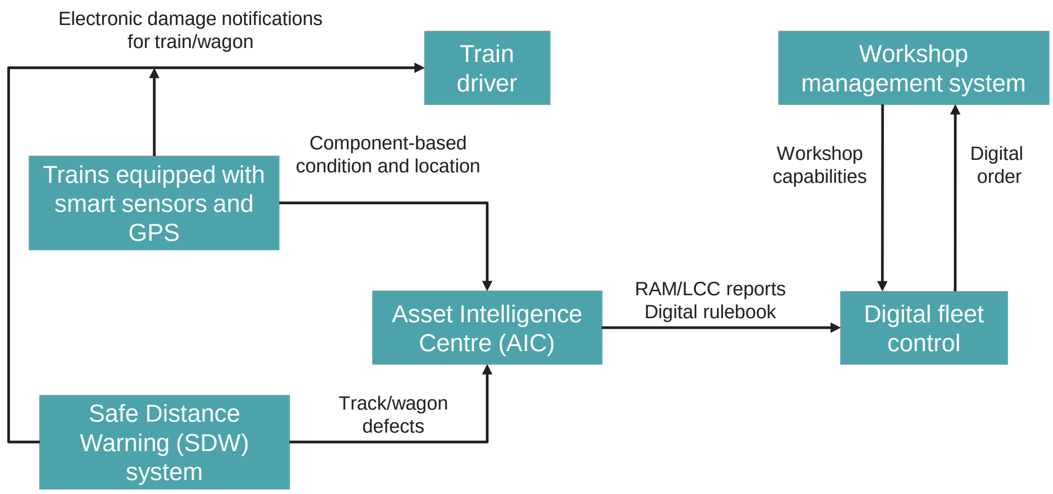


Figure 3 – An example asset management system overview.

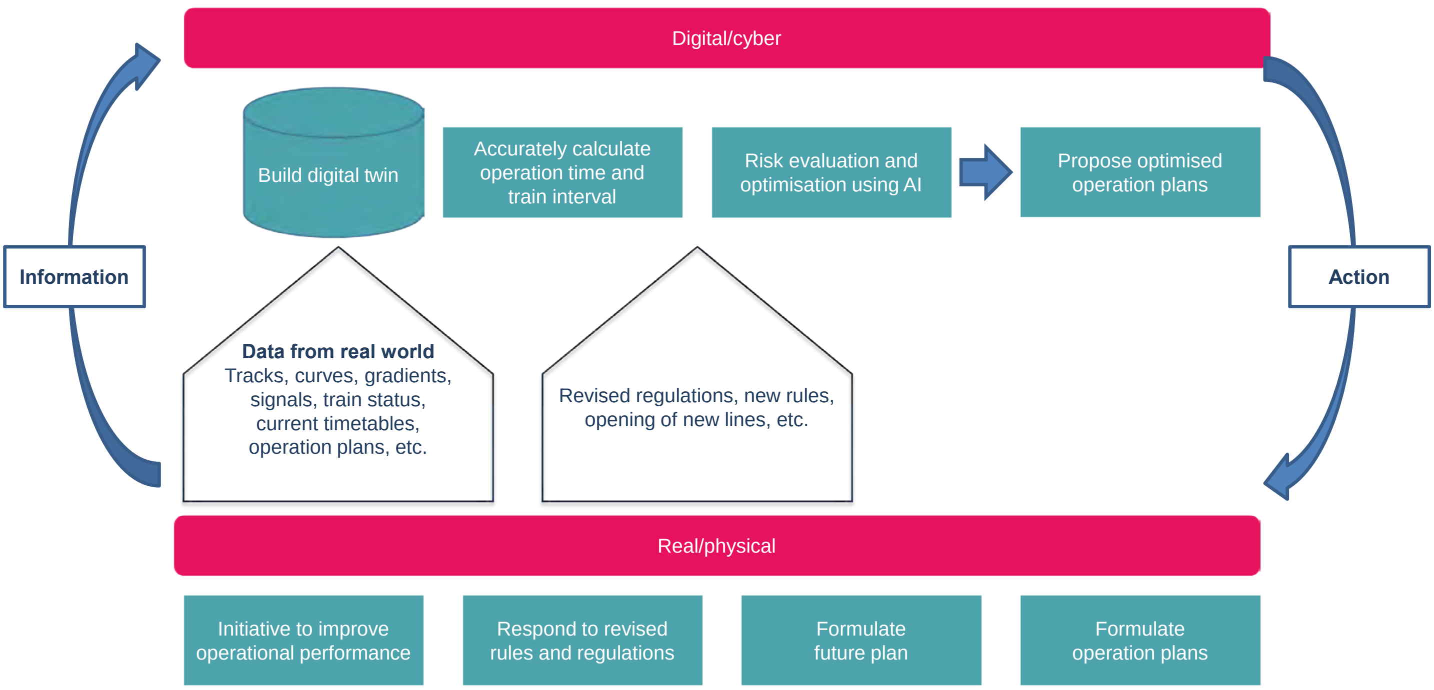


Figure 4 – Conceptual diagram of a digital twin.

layer which updates risk calculations whenever new information is received. Finally, on the basis of the collected information, the operation plans generated are tested on the digital model and proposed to the physical layer for encapsulation.

Ensuring public safety

The advisory roles in train positioning, acceleration, safe braking, and interlocking can eliminate the need for direct control by the driver. The first autonomous tram launched by Siemens in Potsdam, Germany in 2018 can avoid the threat of people walking in front of a moving vehicle. With the help of sensors, lasers, and cameras, any obstacle on the path can be detected. This helps in taking the split-second decisions bringing AI-assisted tram to an abrupt stop. It is still in the development phase, but it surely has a great deal to offer the wider autonomous vehicle market that is speeding up at a high rate.

To understand this approach, let us assume an Operation Control Centre (OCC) as shown in Figure 5 overleaf contains the central server for traffic monitoring and management of the entire railway section. The radio balise fitted on the track transmits the location and signal aspects to the train through on-board sensors and antenna. This information along with the train's health status is sent through an AI-based train monitoring module to the communication module. This module also collects track-based information such as track failure or an obstacle on the route from the trackside processor and sends it to the OCC. The OCC on the other hand also receives the risk analysis output from the probabilistic AI modules and feeds the cumulative information to the deterministic AI algorithms to generate a final decision. The outcome is conveyed to the train driver's screen and the result is an automatic instantaneous response in the form of acceleration, braking, closing or opening of doors, etc.

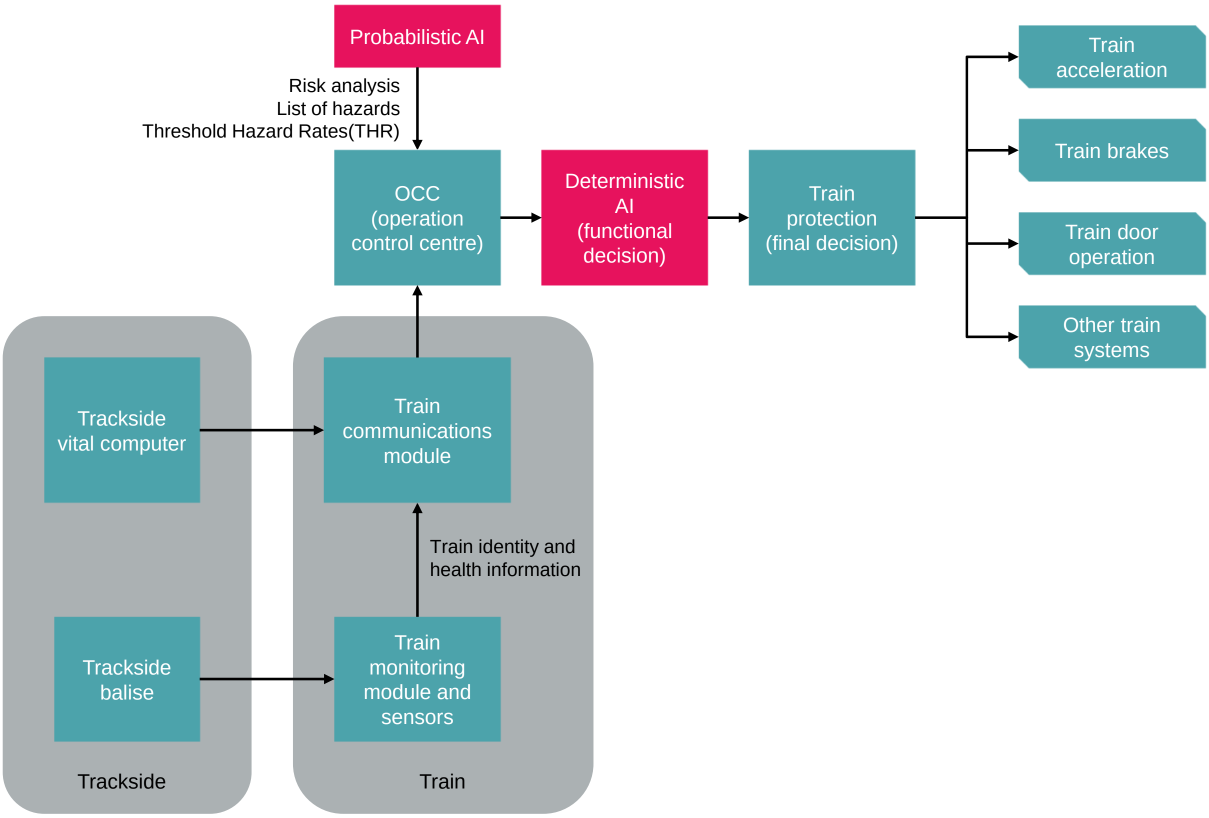


Figure 5 – A possible architecture for AI train control.

Other applications

Predictive maintenance

Smart detectors can be fitted to axle counters, track circuits, point machines, signals, and rolling stock so that any flaws can be detected. They can measure the peak load exerted by railway carriages as they pass over the tracks. As a function of time and location, the historical data is available in the form of track geometry and fluctuations underneath the carriages. The data is translated into defect measurements. Hence any developing faults are sensed well in advance. The remaining life of tracks and wheels is predicted almost accurately. If the modelling is good enough, maintenance can be carried out (automatically in case of Augmented Reality (AR)) before the faults become critical but not so frequently that the cost becomes prohibitive.

Predictive maintenance enables the operators to quickly react to the existing issues and failures. It also detects any potential failures before they happen. Hence the need for lengthy root cause identification is eliminated. This leads to reduced maintenance costs, less (or zero) failure rate, quick repair and increased customer satisfaction.

Crew management

Using linear programming and heuristics, an AI-driven adaptive approach can ensure that the operating personnel in a given railway section can adhere to the timetable or schedule by

i) Crew rostering – long-term distribution of personnel at various nodes of the network and

ii) Crew scheduling – a short-term planning problem.

The rules that apply to both can be complex combinations of capacity, crew preferences, rest periods, overnight stays, and other factors.

Data management

The rail industry, like any public system, uses many procedures. Such applications generate a vast amount of data that will only grow in the future and hence difficult to handle. Under such a scenario, cloud-based AI technology can allow railways to store and manage the collected data digitally, which will save costs and provide consistent accessibility.

Another merit of cloud technology is that it can easily be integrated and connected to other software. So, operators can immediately have organised information for fast decision making.

Biometrics

Biometric ticketing includes retina scans, voice verification, vein scans, facial recognition, and fingerprint scans. Infrared light-based cameras capture the length, texture, and shape of body parts in immense detail. The data may be used for ticketing and registration purposes. This would greatly improve the overcrowding of passengers at train stations and eliminate the need for ticket counters.

Currently, companies like Customer Clever and Bristol Robotics Laboratory of the UK are already developing this system. It cannot be tricked by photographs, can distinguish between identical twins, and can even recognise people wearing glasses. The system can already identify people while they are walking. This would allow stations to completely replace ticket gates.

Challenges

AI seems to be a powerful cutting-edge solution for almost all the areas of railway systems mentioned above. But the technology has a range of challenges to be faced during the planning stage.

Easy penetration

The techniques developed must be usable across all problem instances, without extensive retraining. A scheduling algorithm developed for one portion of the railway network must be usable in any other portion.

Variability

Not every problem instance (for example, a piece of the railway track) contains the same number of inputs and decisions. Many algorithms under the AI umbrella (for example, deep learning) handle only a fixed input-output size. Careful design can meet the discrepancy between raw methodology and domain constraints. But this requires time and effort.

Need for detailing

Black box approaches are acceptable for conceptual studies and testing. But they are not viable for safety-critical applications of the railway. Instead, machine learning approaches will be required in the form of decision trees or neural networks with small input-output sizes.

Adherence to operating rules, procedures, and constraints

Real-world systems and national rules need to source the data requirements for building any methodologies. They must allow for AI-based measurements and prevent errors in those calculations. It is necessary to meet the integration and connectivity requirements within the allowed limits of transmission latency.

Interoperability

With large sharing of data comes the need for closer collaboration. This includes operations, communications, and integration of data amongst different OEMs. Hence different AI-based solutions need to integrate into a cohesive framework.

Cost and complexity

The modification of existing systems to IT-based subsystems will require thoughtful planning and a huge cost.

Conclusion

Digital railway is a developing reality worldwide. It commits to providing advanced technology for both trains and track to deliver faster, more frequent services for passengers and businesses alike. Our economy can have a massive boost by the involvement of AI in Indian Railways. But this may take some time to be deployed in India since AI-based train systems are currently at the testing or development stage. The overhead in terms of cost, complexity and the high level of technical competence cannot be ignored.

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Back to basics: Interlocking Part 1

Francis How

This, the third in a series of articles on 'back to basics' themes, looks at the essentials of 'interlocking'. Interlocking is central to railway signalling, as it ensures that the components of a signalling system act together in a manner which is safe for the routing and movement of trains. Whole books could be written about the subject, and this article is no more than an introduction, intended for IRSE members new to the industry rather than those who are experienced in specifying, designing and testing signalling systems.

> "Interlocking does not check that everything is safe for the passage of a train"

This article focuses primarily on the technology used for interlocking. Next month there will be a further article, in which we will look at the functionality of an interlocking – what it actually does in practice.

What is interlocking?

If you ask a signal engineer about interlocking, they may well point to an equipment room full of relays, or a cabinet of computer equipment in a control centre, or perhaps even some complicated-looking arrangement of metalwork underneath a lever frame in a signal box. It is true that all these things are 'interlockings', but 'interlocking' is defined as a feature of a control system that makes the state of two functions mutually dependent. In the context of railway signalling, interlocking is used to keep trains safe from collision and derailment. The primary purposes of these interlocking features are to ensure that:

1. Before a train is given authority to move along a section of track from one signal to the next:
   - points are in the correct position (to avoid derailment),
   - there are no trains already on the track (to avoid collision), and
   - no conflicting train movements are already authorised (also to avoid collision).
2. When a train has been given authority to move:
   - points in the section of track are prevented from being moved, and
   - other trains are prevented from entering the same section of track.

   until the train has passed through the section of route.

There is more to interlocking than this, as we shall see, but this is the essence of what it is all about.

What does interlocking not do?

Interlocking does not check that **everything** is safe for the passage of a train. A section of railway track must be safe for the passage of trains in many other ways as well. For instance, the distance between the rails must be correct, the track-bed must be capable of supporting the weight of a train, and the train's cross-sectional dimensions (the dynamic envelope) must be compatible with the positioning of items such as platforms and bridges, so that the train will not hit them. These can also cause collision or derailment – but they are not generally the concern of the signal engineer. Railway engineers have other methods for ensuring the integrity of these other features upon which train safety depends.

Interlocking safety

Interlocking functions (such as moving a set of points or clearing a signal) must be executed only when it is safe to do so. Industrial control systems (of which railway signalling is an example) are designed to meet a specified 'safety integrity level' (SIL). There are five such levels, from 0 to 4, and the interlocking functions in a modern main line or metro railway signalling system must usually meet SIL 4 requirements – the highest level possible. This means the likelihood of an unsafe failure is incredibly small.

The underlying safety principle traditionally associated with railway signalling, and particularly with the interlocking, is known as the 'fail-safe' principle. This means that if an interlocking system develops a fault, it is designed so that it will fail in a manner which stops trains, by putting signals to danger. This fail-safe property is achieved in various ways, including the use of inherently fail-safe components, the design of the interlocking logic, and the system architecture.

It is important to note that 'fail-safe' does not mean that the signalling of trains is 100% safe. This is partly because in practice the occurrence of unsafe failures cannot be completely eliminated, and partly because if trains have been stopped by a (safe) failure of the signalling system, the movement of trains then depends largely upon the application of operational procedures, with the associated risk of human error.

Not all parts of a signalling system need to be ultra-safe. In modern systems the use of high integrity (SIL 4) design techniques is usually restricted to those parts of the system which are essential for safety – including the interlocking functionality. Other parts, such as the control panel or desk, are usually of a lower integrity (typically SIL 0 to SIL 2). You might wonder why we do not design all parts of the signalling system to achieve SIL 4 levels of safety. The answer is that designing systems to meet high levels of safety integrity is complex, time-consuming and expensive, and can lead to lower levels of reliability.

A little history…

When railways first appeared, they had no signalling in the form that we would recognise today. The concept of a signal box did not exist, signals were very rudimentary (originally just a man with a flag), and giving permission for a train to enter a section of track relied simply upon allowing sufficient time for the preceding train to have left the section – without any knowledge of whether in practice it had done so!

Not surprisingly, it didn't take long for accidents to demonstrate the need for safer ways of controlling the movement of trains. This article does not explore the evolution of railway signalling, but there were some key milestones in its development which are worth noting. One was the introduction of the electric telegraph, so that someone at one end of section of railway line could communicate with someone at the other end. This eliminated the need for 'time interval working' by enabling the person controlling entry to a section of line to receive positive confirmation when the whole of the preceding train had left the section and therefore the line was again 'clear'.

A second crucial development was the introduction of the signal box, to enable signals and points to be controlled from one place. Previously the setting up of a route for a train had relied upon people walking about on the track to move points and operate signals. Centralisation of these activities was not only more efficient and reduced the possibility of misunderstanding, it also facilitated the introduction of 'interlocking' – mechanical equipment in the signal box that helped to prevent mistakes being made by the signaller when moving points or operating signals. Even in the age of computerisation, it is remarkable to look back at how railway engineers of the 19th century invented mechanical logic systems that largely overcame the risk of human error when signalling trains.

So, the way was paved for the introduction of 'interlocking' according to a defined set of principles or rules – which for the most part still apply today, albeit they vary in some respects from railway to railway.

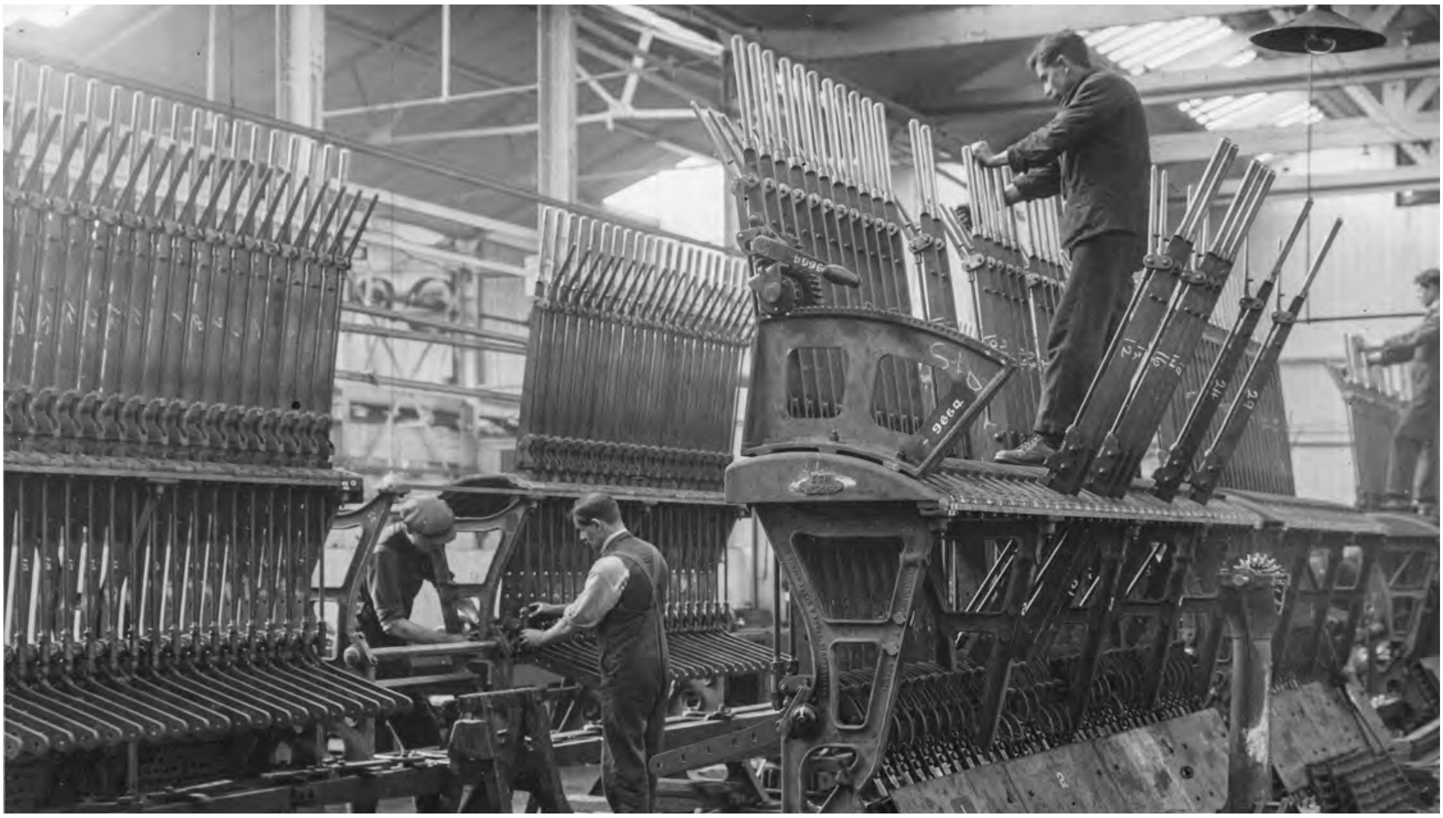


Figure 1 – The Chippenham, UK, factory of Westinghouse Brake & Saxby Signal Company in 1927. Some 60 years after the invention of the interlocking skilled teams were still assembling complex lever frames – some of which are still in use today.
Photo WB&S Archive/ Chippenham Museum & Heritage Centre.

Interlocking technologies

Mechanical interlocking

The earliest form of interlocking was purely mechanical. Signal boxes were usually two storey buildings, with the signaller working upstairs and the interlocking downstairs. To allow a train to move, the signaller would operate large levers, separate ones being provided for each set of points and for each signal. These levers were directly connected via mechanical rods and/or wires to the points and signals outside, and therefore could require considerable effort to move.

On the ground floor of the signal box, underneath the levers, was an arrangement of metal bars that were connected to the levers, with other bars at right-angles to the first. The physical interlocking of the two sets of bars prevented the signaller from moving a lever unless other levers were in the correct position. So, for instance, he could not move a signal lever to allow a train to move unless the relevant points levers were in the correct position.

Gradually engineers began to introduce simple electro-mechanical locking in combination with the mechanical locking, to prevent a lever from being moved unless its electric lock was energised. Energisation of the lock (via an electrical circuit) required other levers to be electrically proved to be in the correct position. Further conditions were progressively added to the lock circuits to improve safety, such as the requirement for relevant track circuits to be clear before a signal or set of points could be moved.

Safety features were also added to the block systems that controlled the movement of trains between neighbouring signal boxes, to prevent a signaller from sending a train from the area that he controlled to that of the next signal box unless it was safe to do so.

Mechanically interlocked signal boxes are still in use on railways in many parts of the world, well over 125 years since they were introduced.

How does mechanical interlocking work?

A flat metal bar (called a tappet) is attached to the end (tail) of each lever. All the tappets are held within a locking box, so that each one moves in one direction when the corresponding lever is pulled to its reverse position, and in the opposite direction when the lever is pushed back to its normal position.

To create a lock, a bevelled notch is cut in the side of a tappet, and a locking piece (sometimes called a nib) is cut to fit the notch. If a horizontal bar is placed in the locking box with one end connected to the locking piece, and the other end is connected to another locking piece, the movement of one lever is prevented or permitted according to whether a locking piece is held in a notch in the tappet, or is clear of (or free to move out of) the notch. The use of bevelled edges enables a tappet, when free to move, to force the locking piece out of the notch.

In Figure 2a below, when Lever 1 is pulled from normal to reverse, the tappet will move in the direction of the arrow. The positions of the tappets and locking pieces will then be as shown in Figure 2b, and Lever 4 is locked in the normal position. It cannot be moved because the second locking piece (connected to the first) has engaged in the notch in the tappet of Lever 4 and is not free to move out of it. Thus Lever 1 locks Lever 4. The converse is also true. If Lever 1 is normal and Lever 4 is reverse, Lever 4 locks Lever 1 normal, as shown in Figure 2c (this is called reciprocal locking and is an inherent feature of mechanical locking). Much more complicated locking arrangements can be created than the simple one shown, with levers being locked in both normal and reverse positions by multiple other levers, and with locking of one lever by another being conditional on the position of a third lever.

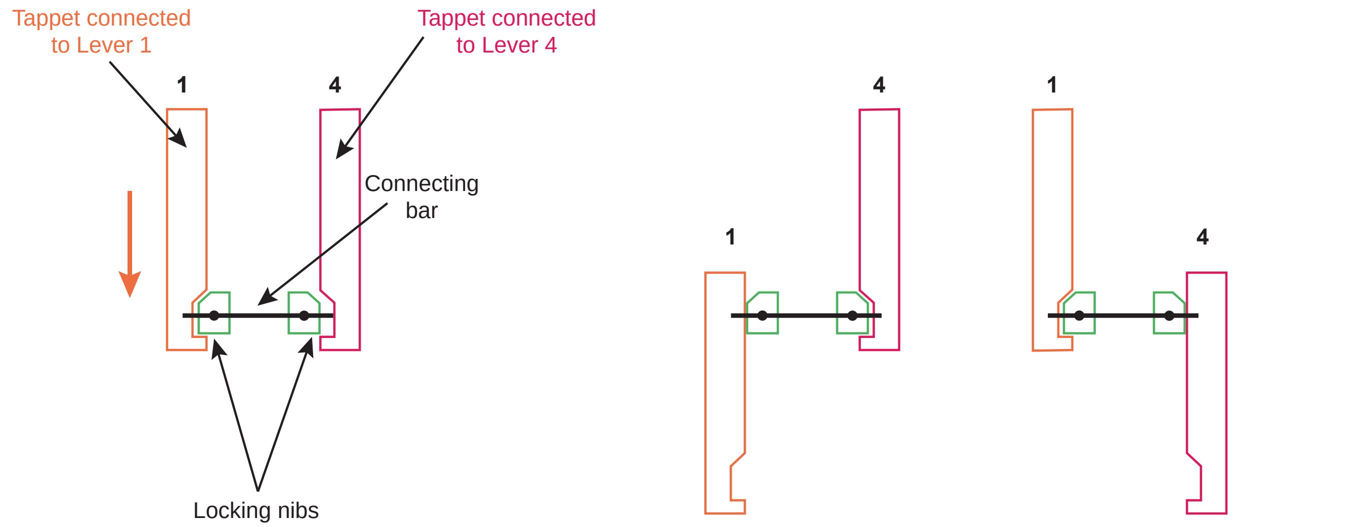


Figure 2a Figure 2b Figure 2c

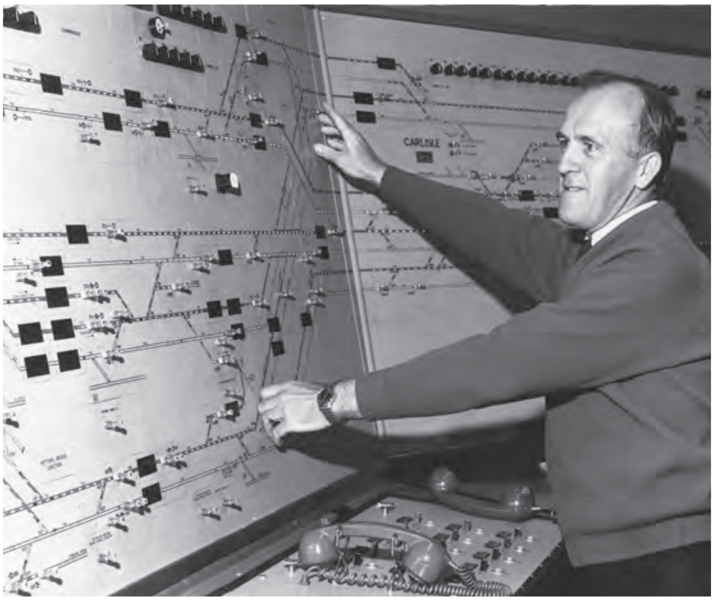


Figure 3 – The introduction of relay-based signalling allowed control centres to move to the use of complex panels. These UK examples are from Carlisle (left) and London Bridge (right) power signal boxes, commissioned in the 1970s.
Photos WB&S Archive/ Chippenham Museum & Heritage Centre.

Figure 4 – Different approaches to relay design. Below, the type N relay, bottom the type C.
Photos Siemens Mobility and E Dold & Söhne KG.

Electrical interlocking

The advantages of using electrical locking became even more evident when colour light signals and electric point machines began to be introduced. Mechanical locking could be entirely replaced by electric locking, and large levers were no longer necessary for operating points and signals, since no great physical effort was required by the signaller to switch an electric signal or point machine.

Early all-electric signal boxes used miniature mechanical levers on a desk, replicating in a more modern form the row of levers in mechanical boxes. This evolution led in time to the introduction of control panels, with switches and buttons on the panel being used to set whole routes from one signal to the next, without the signaller needing to set the points in the route individually.

The 'route setting' approach eventually became the preferred form of control. The role of the interlocking was crucial in this. Instead of being a passive system for determining whether it was safe to operate a set of points or a signal (as mechanical locking had been), it became an active system that interpreted and acted on requests received from the control panel. In simple form, the request to set a route from one signal to the next is set up by the signaller using switches and buttons on the control panel (which has a diagram of the track layout on it). The interlocking then moves the relevant points provided it is safe to do so, checks that the track is clear of other trains, and clears the entrance signal for the route.

Relays

The fundamental building block of the traditional route-setting interlocking is the relay. Before the relay interlocking gained prominence, relays had already been used for track circuits and for other simple circuits in mechanical and early electric signal boxes. These relays had generally been relatively large devices, often designed to sit on shelves. But as relay interlockings became more popular, relays were progressively made physically smaller, and were often designed to plug into bases to which all the wiring was connected, so making it easy to replace a faulty one as well as enabling hundreds or even thousands of them to be housed in a much smaller space. All the wiring and the relays and their bases were mounted on vertical racks, and a large interlocking might have dozens of such racks, all housed in a 'relay room'.

Not sure what a relay is?

A relay is an electromechanical switch, with an electromagnetic coil, an armature and various contacts. When the coil is energised, the armature moves and closes a number of contacts ('front' or 'normally open' contacts) and opens others ('back' or 'normally closed' contacts). These contacts are used in other circuits to create the logic conditions for operating other relays, powering point machines, illuminating the aspects of signals etc. When the coil is de-energised the armature returns to its original position, opening the front contacts and closing the back contacts.

Relay interlocking architecture and design

The architecture of relay interlockings varies from railway to railway (even within a single country), and from country to country. We are not going to explore all the variations here, but it is worth understanding a little about the basic design philosophies that characterise almost all relay interlockings.

In the early days all relay interlockings were 'free wired'. With this approach, each circuit, whatever its purpose or function, was individually designed and wired, usually in accordance with a set of templated (standard) circuits. In time an alternative approach emerged, whereby manufacturers provided a range of factory-wired, pre-tested sets of relays known as 'geographical' units. Each type of unit was designed to provide the standard interlocking functions required for a specific combination of signals, points and train detection sections. By connecting the appropriate units together (usually with plug-coupled cables) to mimic the actual layout of the track and signalling, the required route-setting functionality could be

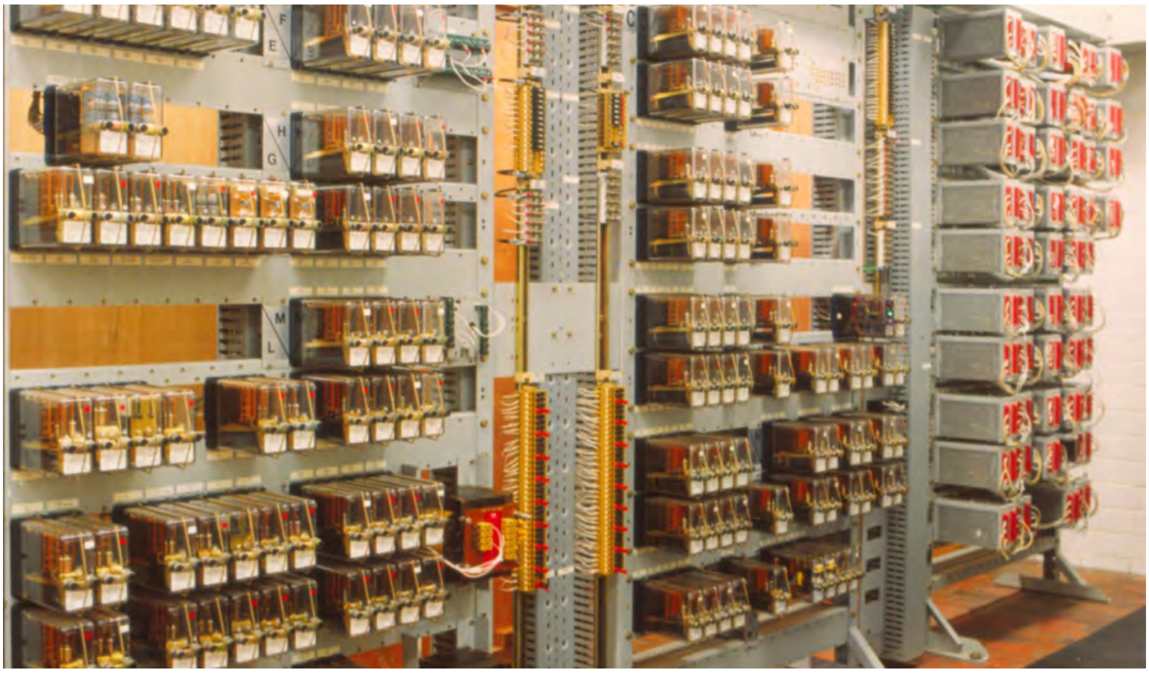


Figure 5 – Route relay interlockings have been very successful in a huge range of applications world-wide. In this example from the original Singapore MRT scheme the interlocking is interfaced to coded track circuits allowing a high performance automatic train protection and automatic train operation system to be implemented. *Photo WB&S Archive/ Chippenham Museum & Heritage Centre.*

built up relatively easily. There are advantages and disadvantages with both approaches, including cost, flexibility, speed of design and testing.

Secondly, the relay interlocking circuits (both free-wired and geographical types) vary in form according to the type of relay used. There are, broadly speaking, two generic types of relay used for all interlockings. One type is inherently 'fail-safe', meaning that if the coil is de-energised, the front contacts will always open, and it is virtually impossible for a failure to occur whereby front and back contacts are in the 'closed' position at the same time. The use of non-welding materials for the contacts makes it impossible for a contact to weld in the closed position. This type of relay is known generically as type N in UIC standard 736i. The best-known family of signalling relays in this category is probably the BR930 series, the development of which, incidentally, involved the IRSE. There are at least 200 variations of this same basic relay, with different operating characteristics (slow to energise, slow to de-energise etc), different numbers and types of contacts, and different operating voltages.

"A route relay interlocking is, in effect, a hard-wired parallel processing logic machine."

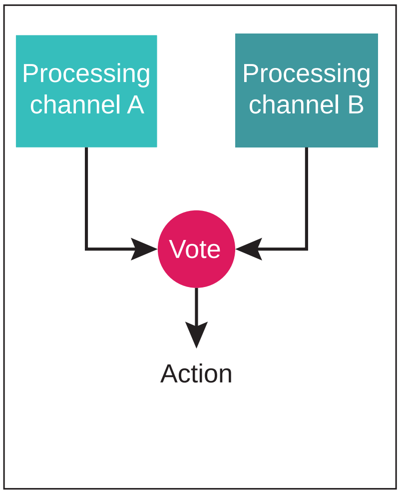
The other generic type of relay used in some interlocking systems is known as type C in UIC standard 736i. It is not guaranteed to behave in the inherently fail-safe manner described above. Specifically, it is possible for a contact to weld so that it remains closed when it should be open although, as with a type N relay, the mechanical design prevents any front and back contacts being closed at the same time, even if welding occurs (a feature known as 'forcibly guided' contacts). Such relays have the advantage of being considerably less expensive and smaller. But in order for the interlocking as a whole to behave in a fail-safe manner, the circuits are more complicated as a consequence of using additional contacts to prove that relays have de-energised correctly, and because of the need to check that the circuits are operating in the correct sequence with the passage of the trains. By contrast, the dependable fail-safe nature of the type N relay makes it generally unnecessary to include this additional complexity.

In all interlockings the circuits are designed to exploit the safety characteristics of the relays. Usually this is done by requiring a relay to be energised to allow a less restrictive state (e.g. to allow a signal to show a proceed aspect, or to allow a set of points to move). If the relay or the power supply fails, or there is a disconnection in the circuit, the relay de-energises, so causing the signalling equipment to revert to a safer state.

Computer-based interlockings (CBI)

With the development of electronic logic gates in the form of integrated circuits, and subsequently with the emergence of the microprocessor and programmable logic controllers (PLCs), it was a natural step to see how this technology could be applied to interlockings. Early experimental installations were implemented in the 1960s and 1970s, but it was in the mid-1980s that the electronic software-based interlocking first became a reality. One of the best known of these was SSI – the 'Solid State Interlocking', developed in the UK.

The use of software-driven electronic logic presented a whole new set of challenges for system designers. A route relay interlocking is, in effect, a hard-wired parallel processing logic machine. If it goes wrong it could initiate unsafe actions, but the potential failure modes and their causes are well-understood and, by good design practice and by testing it to make sure the locking conforms to the application rules, the probability of an unsafe failure is very low. A computer-based interlocking (CBI), which makes use of microprocessors, is another matter entirely, however. Microprocessors comprise hardware and embedded software, and these are not designed to meet the high integrity safety requirements



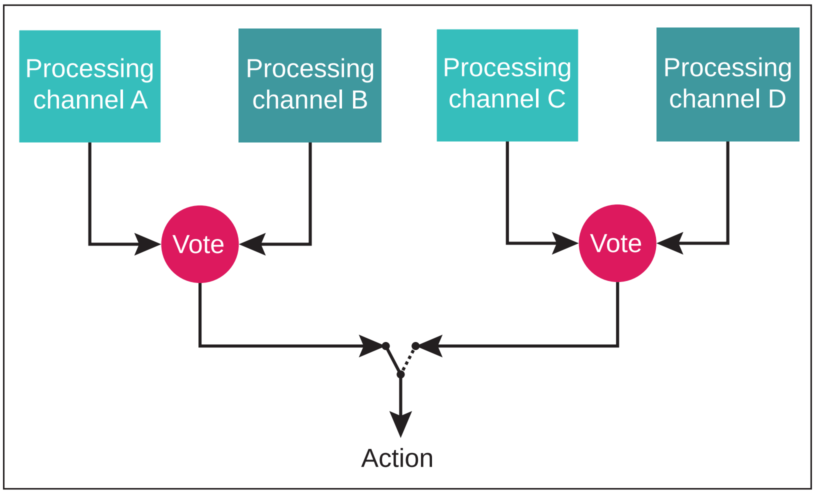
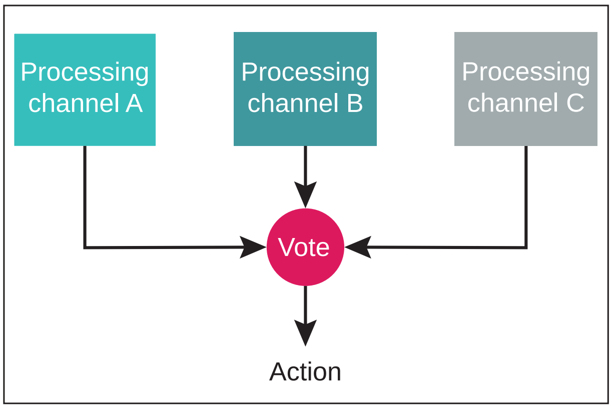


Figure 6 – Achieving safety and availability in interlocking systems typically involves the adoption of one of the architectures shown here.

Above left, 'two out of two' requires both processing channels to determine a course of action which will only be carried out if both agree. If either fails then the system shuts down to a safe state.

Above right, duplicating two sets of 'two out of two' and switching between the two pairs increases system availability.

Right, 'two out of three' uses three processing channels. At least two channels must agree on an action before it is taken, but failure of a single channel will not lead to a shut down.



"Failure modes of microprocessor-based systems are much more complex and unpredictable than in relay logic."

necessary for an interlocking. Failure modes of microprocessor-based systems are much more complex and unpredictable than in relay logic, and their causes can be difficult to trace. These causes include electrical interference, unstable supply voltages, poor programming (leading to memory stack overflows, race conditions, deadlock, etc), derived requirement errors and manufacturing defects.

The architecture of the software-based interlocking must be designed so that the overall level of safety is at least as safe as the best relay interlocking, despite the relatively low integrity of the component parts and the complexity of their failure modes. The basic approach is to have two separate processing channels in the interlocking, each one executing the route requests from the control panel (or desk/VDU) in accordance with the signalling principles and application rules for the particular track and signalling layout. This is known as a 'two out of two' (2oo2) configuration. In the event of a difference in the outputs from the channels (indicating an error has occurred), the system shuts itself down and a safe state is enforced. In most systems lineside signals return to danger (stop) and points cannot be moved.

In practice, achieving a safe shutdown is not quite as simple as it might at first appear. Firstly, the part of the system that compares the outputs of the two channels and shuts the interlocking down in the event of a difference must be highly dependable. A simple electronic comparator that is monitoring the two outputs is not sufficient. Secondly, there is the problem of common mode failure. Since both channels are executing the same task, there could be processor problems or programming errors which would affect both channels in the same way. In such circumstances there would be no disagreement between the outputs presented to the comparator, and the system would consequently not shut down.

There are various solutions to these problems, of course, and different system manufacturers adopt different approaches. These may involve:

- using different hardware and/or software for the two channels to reduce the likelihood of common mode failure (often called 'diversity').
- more complex cross-checking of internal states, inputs and outputs between the two channels in order to detect faults.
- more than one mechanism by which a shutdown can be enforced (and employing special hardware for the purpose).

These mechanisms are not without their difficulties. For instance, a lack of synchronisation (differences in timing) of processing in the two channels can cause the two channel outputs to be different for short periods of time, even though each channel is behaving correctly. These short-term differences may be interpreted by any cross-checking as an error and cause a shutdown, creating a serious threat to reliability.

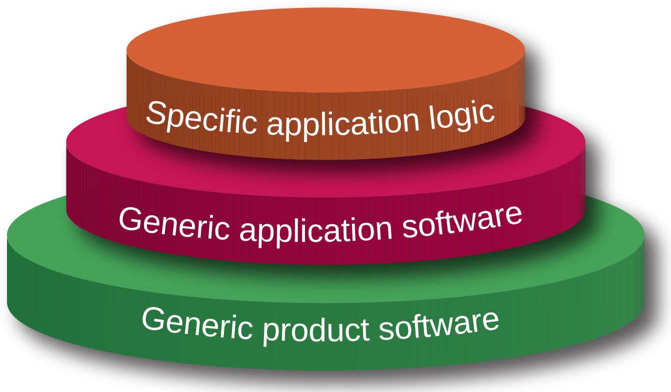


Figure 7 – Most computer-based interlockings split their software and configuration into a number of layers, enabling the same basic hardware to be used in many different applications.

"The safety of the railway is critically dependent not only upon the core interlocking product but also upon the correctness of the specific application data/logic"

Reliability of CBIs

The reliability of computer-based interlockings is almost as important as their intrinsic safety. A fault in a relay interlocking (such as a failure of a relay) may cause a small number of routes to be inoperable, but it is very unlikely to render the whole interlocking unusable and thus stop all trains. But a computer-based interlocking that detects a processing fault may shut itself down completely, stopping all trains in the area of control. Most modern CBIs therefore have built-in redundancy to improve reliability.

One approach is to have three processing channels in the interlocking, instead of two. If one channel disagrees with the other two, a majority voting system shuts it down and the interlocking continues operating with the two remaining channels. This configuration is known as 'Two out of Three' ('2oo3') and was popular in early CBIs when computers were expensive, because it used less hardware than the alternative arrangement described below. There is a marginal safety disbenefit in this arrangement, because very rarely it could be that one channel is correct and the other two are in error. In addition, if the same software is used in all three channels then common mode failure remains a risk and producing three diverse sets of code and/or hardware to avoid such failures would be very expensive and create an even greater risk of timing issues. However, the other safeguards built into the systems makes these issues extremely unlikely in practice.

Alternatively, some interlockings have a complete duplication of the two channels (i.e., two sets, each comprising two channels) – a configuration known as 'Duplicated Two out of Two' (2X2oo2). If one set identifies a disagreement between its channels, it is shut down and the other set (which is in effect a 'hot standby') continues to operate the railway. This tends to be a more popular arrangement in modern interlockings, as it is easier to implement than 2oo3 and the cost of the additional hardware is not such a big issue as it used to be. The set of hardware and software that is acting as the hot standby must have all the same inputs and be kept in complete synchronism with the controlling set otherwise the changeover will not be seamless and some form of initialisation process will be required.

Configuring CBIs

All interlockings must be configured for the particular track and signalling layout required – a task generally performed by a signal design engineer. In the case of computer-based interlockings, he or she has to produce configuration logic (program code and/or data) – a process commonly known as 'data preparation'.

The concepts of 'free-wired' and 'geographical' relay interlockings have their equivalents in computer-based interlockings, each with their advantages and disadvantages. Both make use of the duplication and redundancy techniques described above to achieve required levels of safety and reliability.

The free-wired equivalent typically uses general purpose safety PLCs which are configured for each specific railway layout. A notation known as 'Ladder Logic' is frequently used to configure the system, although it is also possible to use fundamental Boolean logic or more sophisticated PLC programming languages. Ladder logic resembles a conventional circuit diagram that has switches, relay coils and contacts, and other electrical elements such as counters, latches and timers. It is therefore intuitively easy to produce by someone familiar with relay circuits.

The equivalent of a geographical relay interlocking uses a more conventional form of microprocessor-based computer. The core system (the 'generic product') is customised by incorporating standard software modules which define how basic track and signalling elements operate in accordance with the signalling principles for the railway on which it is to be used. This hardware and software package is the signalling manufacturer's interlocking country/client-specific product (known as the 'generic application'). The signal design engineer then produces application data which defines how the country/client-specific software modules are configured to represent the particular track and signalling layout (known as the 'specific application'). The data format is usually proprietary to each manufacturer's system.

In both types of interlocking, the safety of the railway is critically dependent not only upon the core interlocking product but also upon the correctness of the specific application data/logic, which is why so much effort goes into checking and testing it.

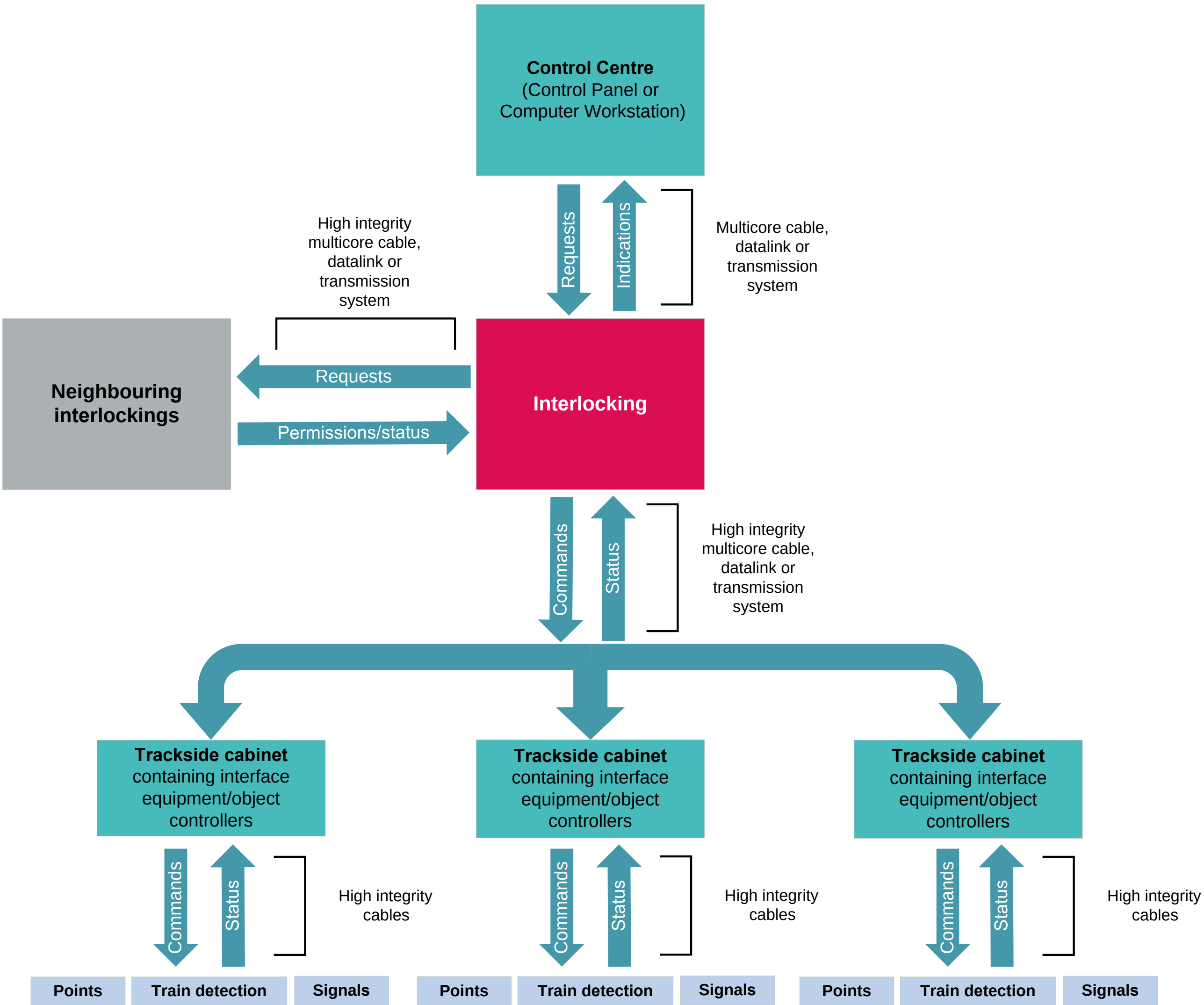


Figure 8 – The interlocking forms the 'safety layer' of a railway signalling system, receiving information from and relaying status to a control centre, communicating with adjacent interlockings, and controlling trackside objects.

Nowadays a large proportion of the data and logic for computer-based interlockings can be generated automatically from the signalling scheme specifications. Signal design engineers can therefore concentrate their skills on the special or unusual interlocking elements of a signalling scheme which cannot be designed automatically. Simulation and automated testing can also reduce the amount of manual verification and validation required. Because interlockings primarily implement a set of logical rules they are particularly well suited to testing and validation using formal methods and automation. Most of the major interlocking suppliers have now adopted these methods in some form and as a result the number of errors found by more conventional testing, particularly in the field, has reduced very significantly.

The interfaces between an interlocking and other sub-systems

In a modern signalling system, an interlocking interfaces with a number of other sub-systems. The three most important interfaces are with the trackside equipment, with the control panel (or computer workstation), and with other neighbouring interlockings. There are of course other interfaces, but we are not attempting here to describe the architecture of a complete signalling system, so they are not explored in this article.

Interlocking to control panel/desk interface

The signaller controls the movement of trains either by use of a control panel or by using a control desk and workstation. A panel is equipped with a representation of the track layout, on which are buttons and switches for setting routes etc, and indications to show him or her information including what routes are set, the positions of trains and the aspects of signals. In the case of a control desk and workstation, the signaller has the same information presented to him/her on screen and sets routes etc by use of a keyboard and mouse.

The interface with the interlocking is therefore two-way, with route requests being sent from the control panel/desk to the interlocking and information from the interlocking being sent to the control panel/workstation. There is usually some sort of interface sub-system (either relays or software-based) between the two.

A typical control panel/desk will communicate with several interlockings, as the geographical area covered by the control panel/desk is often larger than that covered by a single interlocking. Where all the interlockings are housed in the same building as the control panel/desk, the communication with the interlockings is achieved either by multi-core cables or by a data

Figure 9 – The use of computer-based interlocking, and increasingly the use of network communications, allows modern control systems to be implemented, as in this example from Hong Kong MTR. The interlocking continues to ensure that the signalling rules are enforced to assure safety, but the non-vital control system above allows the railway to be operated optimally. *Photo Francis How.*

"Just as with relay interlockings, the integrity of the communication link is vital for safe operation"

communications bus. If some of the interlockings are in buildings some distance from the control centre, then some form of remote control and indication system (using, for instance, time-division multiplexing) is often used to connect interlockings to the control centre to reduce the amount of cabling required.

It is important to note that all these communication links are not safety-critical (i.e. they do not have to be SIL 4). The interlocking ensures the safety of train movements even if there is a fault or failure in the communications links or interface sub-systems. That said, the interfaces and communications links must be as reliable as possible, both for normal working and in degraded mode situations. In both cases, the control panel or workstation is presenting the signaller with information about the railway, upon which he or she makes decisions regarding the movement of trains.

Many modern signalling systems include Automatic Route Setting (ARS), a sub-system which automatically sets routes ahead of each train based on the timetable and, where conflicts arise (eg because of late running), on a set of rules for prioritisation of train movements. This relieves the signallers of much of their routine work. So far as the interlocking is concerned, however, it receives and acts on ARS route-setting requests in the same way as if the requests had come from the signaller and the control panel/workstation.

Interlocking to trackside equipment interface

In the case of a relay interlocking, in most systems the items of trackside equipment (signals, points, track circuits etc) are connected to the interlocking by multi-core cables, with a dedicated pair of cores for each circuit. The cables are generally specified and constructed to meet railway requirements, both in terms of resilience to the trackside environment, and in terms of the integrity and separation of each core. This is necessary because they are carrying safety critical circuits for operating the signals, moving points, indicating the occupancy or otherwise of a track circuit to the interlocking etc. The interlocking depends upon the integrity of these circuits in order to function safely.

In the case of computer-based interlockings, the items of trackside equipment are normally (but not always) connected to nearby object controllers which provide the power for the equipment, pass the interlocking commands to the equipment and receive equipment status information for sending back to the interlocking. The object controllers are connected to the trackside equipment by high integrity cables as described above, and to the interlocking via a communications datalink. Just as with relay interlockings, the integrity of the communication link is vital for the safe operation of the interlocking. The object controllers therefore generally have a 2oo2 configuration to ensure safety, and the datalink uses highly secure coding techniques to prevent (or detect) corruption of the transmitted data. In some manufacturers' systems the communications protocol is proprietary to their product, but increasing use is now being made of IP addressing techniques. Manufacturers still use their own safety and applications protocols, although the European EULYNX project is promoting open standards for interfaces, to reduce signalling life cycle costs.

Interlocking to interlocking interface

Interlockings must be able to interface with neighbouring interlockings, because almost inevitably at the geographical boundaries there will be routes that have their entrance signal in the area controlled by one interlocking and their exit signal in the area controlled by another. The route setting process is initiated by the interlocking responsible for the entrance signal, but requires action by, and information from, the other interlocking in order for the complete route to be declared 'set', before the entrance signal is allowed to clear.

It is common practice, so far as possible, to arrange the geographical boundaries of interlockings to occur on sections of plain line, where the interlocking arrangements for each cross-boundary route are very straightforward. However, this is not always possible, particularly in places such as complex station areas where more than one interlocking is required. In the case of relay interlockings, the interface generally takes the form of high integrity multi-core cables to link circuits in the two equipment buildings – the same sort of cables as are used to connect the relay interlockings with their items of trackside equipment.

In the case of computer-based interlockings, a high integrity datalink is used for the interface (bearing in mind that the two interlockings may well be in physically adjacent cabinets in an equipment room rather than in separate buildings). However, the interfacing arrangements tend to be more complex than in the case of relay interlockings. The two sets of software have to act together and perform 'handshakes' with each other in order to set, lock and release routes.

The future of interlocking

At the beginning of this article we said that 'interlocking' is the mutual dependency between signalling functions (moving points, clearing signals etc). We have seen how these interlocked functions are made real by use of some sort of 'logic machine', whether mechanical, electrical or computerised, which signal engineers call an interlocking. In a modern signalling system we might expect to see a relay interlocking or a suite of computer interlockings housed in a building or in a cabinet trackside, connected to trackside equipment, the control panel/desk and screen, and to other interlockings by cables and data transmission systems. But the concept of a physically discrete interlocking is starting to change.

"The concept of a physically discrete interlocking is starting to change"

Various examples come to mind. Firstly, in the case of ERTMS Levels 2 and 3, there is a second vital element in the system, namely the Radio Block Centre (RBC), which links trains with the interlocking, sending information about movement authorities, permissible speeds etc and receiving information about the train speed and location. Like the interlocking, the RBC must be of the highest safety integrity. System suppliers are starting to combine these two functions on the same computer platform, and in the world of metros, a number of systems already combine the functions of interlocking and track-train messaging within the same system.

A second possibility, and one that is already being explored, is to use cloud technology for interlocking. This has various advantages, including cost, flexibility and, potentially, resilience. It also comes with challenges, not the least of which is maintaining cyber-security (and therefore safety as well as reliability).

Thirdly, we may see a move towards distributed interlocking functionality. In recent years the trend has been to place computer-based interlockings together in a single location (often co-located with the control centre). In time this may change, with some interlocking functions shared between the train-borne and trackside systems. Indeed, it could be argued that this is already happening to a limited extent with CBTC and ERTMS.

Even more radically, the train may play a key role in initiating the setting of the route ahead and in determining its own safe movement authority, making use of train-to-train communications to do so. A more train-centric architecture will be adopted, with the trains being 'smart' rather than simply responding to movement authorities issued by trackside infrastructure systems. Again, suppliers are already starting to make some of this a reality. This may well lead in time to some of the traditional principles of signalling being challenged, such as making the distance between following trains dependent upon their relative speeds rather than always assuming the train ahead is stationary.

Closing remarks

This article has provided an introduction to the technologies used for railway interlocking. Next month we will look at the functionality of an interlocking.

If you want to know more, some of the IRSE textbooks cover the subject in greater detail. For many signal engineers the specification and design of interlockings is at the heart of their careers. It requires knowledge, experience and expertise – and it is vital to the safety of the railway. But if you are new to the industry, don't let that deter you. Instead, take every opportunity to learn from those who have the experience and knowledge.

About the author ...

Francis has been a long-time member of the IRSE. First with British Rail/Railtrack, Atkins, as the technical director of the Railway Industry Association and chief executive of the IRSE. He was an IRSE exam Thorrowgood scholar and served on Council for many years and was president of the Institution 2012-2013. He is widely respected for his professionalism and technical knowledge and played a vital role in drawing younger members into the running of the Institution and has encouraged and helped them develop their capabilities in both their professional and IRSE roles. He has given quiet encouragement and encouraged self-confidence in many of the rising engineers in the control and communications industry.

Industry news

For more news visit the IRSE Knowledge Base at irse.info/news.

Main line and freight

Major investment in Germany

Germany: A €86bn (£73bn, $95bn) LuFV III railway operating and financing agreement running to 2030 has been agreed by the German government. The ten-year agreement provides for maintenance and renewal of the national rail network, an annual average of €8.6bn/year (£7.3bn, $9.5bn) which is 54% more than in the previous five-year plan period. The government will contribute €62bn (£52bn, $68bn), and DB €24bn (£20bn, $26bn) from its own resources.

The work will include the renewal of around 2000km of track and 2000 turnouts each year, and the modernisation of 2000 bridges over the ten years, along with digital interlockings and ETCS. Managing director Axel Schuppe said DB wants to see better co-ordination across the rail sector, accelerated planning processes, and more efforts to minimise the impact of engineering work on train operations. He also emphasised that performance measures should be carefully designed to avoid "perverse incentives".

Longest ETCS L2 line

Saudi Arabia: The North South Railway project is the world's longest route to adopt ETCS L2 to date. The 2400km passenger and freight rail line runs from the capital city Riyadh, in the northwest of the country, to Al Haditha near the border with Jordan.

The industrial line is 1362km from Al Jalamid (phosphate mines) in the north to Al Zabirah (bauxite mines) and will run eastwards to the export facilities at Ras Al Khair. Trains will run at the speed of 100km/h (empty) and 80km/h (loaded). The 1314km passenger line runs at 200km/h from Riyadh to Al Quorayyat. Thales ETCS is being employed and the route will run through provinces where half of the Saudi population lives. The project is expected to help Saudi Arabia become the second largest exporter of minerals in the world.

Beira Alta Line upgrade

Portugal: A tender has been published for the modernisation of the Pampilhosa-Santa Comba Dão section of the Beira Alta Line. The contract will also include a new line and viaduct to connect with the North Line as part of the Mealhada Agreement project. This will be a 3.2km electrified line north of Pampilhosa station between the Lisbon-Porto main line and the Beira Alta Line, along with the construction of a 1.2km viaduct.

The work includes 34km of track renewals, enhancements at Mortágua station to allow 750m-long trains to pass and new platforms with improved accessibility, and upgrading signalling and telecommunications. The contract also includes the removal of level crossings as well as work on ten tunnels and eight bridges.

The modernisation of the Beira Alta Line, which forms part of the TEN-T network and is part of Rail Freight Corridor 4, is expected to save more than 120 million tonnes of CO_2 by 2046, increasing the number of trains operating on the line by 20% and the amount of freight transport by 26% per year. The European Union is co-financing 85% of cost through the Connecting Europe Facility (CEF) programme.

Swedish ERTMS revised roll-out programme

Sweden: Infrastructure manager Trafikverket has announced the programme for installation of ETCS Level 2 in Sweden has been extended by two years. Following a joint assessment and discussions with train operators the programme has been revised, providing more time to phase out older rolling stock and retrofit the fleets with ETCS onboard equipment. The work will still start in 2023, with completion put back by two years to 2029. Trafikverket say this will have no impact on the overall cost.

"We have an ongoing dialogue with stakeholders in the rail industry and we have taken note of their input", said Trafikverket's project manager Patrik Assarsjö. "We also need to coordinate the programme with other ongoing infrastructure projects, and create an extra buffer for implementation. ERTMS is a large and complex project that will continue for several years, and we need to relate to what the reality actually looks like. The new schedule gives the industry even better conditions for a smooth roll-out."

Hungarian ETCS

Hungary: Thales has been awarded a contract by the Hungarian National Infrastructure Development Company (NIF) for the ETCS on 110km railway section from Szajol to Debrecen, which connects the country's largest cities of Budapest and Debrecen.

The electrified double-track line covers eight stations and will be provided with ETCS Level 2 from Szajol to Ebes and ETCS Level 1 from Ebes to Debrecen. The project includes necessary interfaces to the existing signalling system, configuration and data preparation, as well as safety and approval requirements.

Sarajevo resignalling

Bosnia: AŽD Praha has been awarded a €1.2m (£1m, $1.32m) contract by the Railway Federation of Bosnia & Herzegovina (ŽFBH) to modernise signalling equipment in the Miljacka junction area west of Sarajevo, and the Stup freight facility.

The project includes the design and installation of the companies type ESA 44-BH electronic interlocking, which will be controlled from Blažuj station, along with the supply of LED signals, point machines and axle counters.

Haramain high speed ETCS maintenance

Saudi Arabia: A seven-year contract has been awarded to Xrail Group for the maintenance of the ETCS Level 2 on the Haramain high speed line, acting as subcontractor to Siemens Mobility. The contract will provide 24/7 support from six maintenance centres situated along the 453km route. Haramain high-speed railway is also known as the Western railway or Mecca-Medina high-speed railway.

Maintenance of Madrid to Málaga high speed line

Spain: Thales has been awarded a €68.8m (£58m, $75m) contract by Infrastructure manager ADIF to continue to maintain signalling and traffic control systems on the Madrid-Sevilla and Córdoba-Málaga high speed lines for a further two years. This is in addition to contracts covering signalling and train control systems on more than 2200km of the Spanish high-speed network.

Thales has been responsible for signalling on the 470km Madrid-Sevilla line since it opened in 1992, along with the 21km La Sagra-Toledo branch added in 2005 and Córdoba-Málaga in 2007.

Vinkovci-Vukovar contract signed

Croatia: A contract for resignalling, electrification, level crossing upgrading and station modernisation on the Vinkovci-Vukovar line has been signed by HŽ Infra, Comsa SA and Comsa Instalaciones y Sistemas Industriales SA in Vukovar on 20 December.

The 18.7km line connects the Zagreb – Vinkovci corridor with the River Daube port of Vukovar. As well as supporting freight traffic, the modernisation will raise the maximum speed of passenger services to 120km/h, significantly shortening journey times. The 516m kuna (£59m, €69m, $77m) project is being 85% co-financed through the EU.

Bender RS4 approval

UK: Network Rail has approved Bender UK's RS4 Rail Signalling Power Protection system which delivers increased sensitivity for first earth fault location and enables compliance with Network Rail's insulation monitoring and fault location requirements.

The new RS4 delivers multiple-tier smart cable insulation monitoring. RS4 Tier 3 has increased sensitivity for improved feeder first fault location from the 20kΩ pre-warning level to 100KΩ or higher, depending on system capacitance. The improved Bender RS system offers a holistic picture of cable health, along with a data set that meets the requirements of NR/L2/SIGELP/27725.

City railways and light rail

New York CBTC

USA: A $246m (£189m, €224m) contract has been awarded to LK Comstock & Co to install Siemens Mobility CBTC for the 8th Avenue subway corridor. The contract covers the local and express tracks between 59th St/Columbus Circle in Manhattan and High Street in Brooklyn, and includes some of the busiest station complexes on the network, including Columbus Circle, the Port Authority Bus Terminal, Penn Station and West 4th Street.

The CBTC will interface with C and E lines under the Queens Boulevard signal modernisation project, which will mean that all of Line E will be using CBTC. The scope includes interlockings at 30th and 42nd streets, power supplies, zone controllers, cables, fire suppression, HVAC, lighting and equipment housings.

The project will be New York City Transit's first to use axle counters instead of track circuits, which is expected to reduce delays and maintenance costs.

Lisbon CBTC

Portugal: Metropolitano de Lisboa in Lisbon have appointed a consortium of Siemens Mobility Unipessoal and Stadler Valencia contracts worth €114m (£97m, $125m)to provide CBTC signalling equipment and 14 three-car metro trainsets on the Blue, Yellow, and Green lines in the city. The contract includes maintenance for three years, with a two-year extension after acceptance of the equipment.

The investment programme is intended to sustain the strong growth across the network, which saw a 9% year-on-year increase in ridership in 2018-19.

Light rail and tram growth in Europe

Europe: Tram and light rail systems are available in 392 cities around the world, with 204 over half located in Europe. In 2019, the International Association for Public Transport (UITP) provided a worldwide landscape of light rail and tram (LRT) systems and reported the annual LRT ridership is circa 15 million passengers. UITP has now published "Light Rail and Tram: The European Outlook. Statistics Brief", which breaks down LRT ridership and growth across Europe. See irse.info/5nug6.

UITP says LRT has seen a steady increase since 2000, with 108 new cities opening their first line – with 70 in Europe. Germany and Central Europe made up half of all patronage – with the rest split between South Eastern Europe, France, Poland, the Benelux countries (Belgium, The Netherlands and Luxembourg), Western Mediterranean, Nordic/Baltic and the British Isles.

Between 2015 and 2018, LRT infrastructure in Europe grew by 3.9%, with ridership growing by 9% to 10 422 million passengers in 2018. So, demand growth is 50% higher than supply growth. Ridership evolution varies according to regions – from 17.5% in the British Isles, to 1.5% in Poland. The busiest LRT network in Europe is in Budapest, Hungary, with 411 million passengers. The longest LRT network in Europe is in Berlin, at 193km.

With ongoing pressure to reduce congestion, tackle air quality in cities and reduce greenhouse gas emission contributing to climate change, UITP say LRT will continue to obtain support of decision-makers and the travelling public in Europe; as it is clean, silent and space-efficient.

Driverless metro in Turkey

Turkey: The European Bank for Reconstruction & Development is to provide a loan to finance the €755m (£638m, $831m) Üçyol-Buca driverless metro line serving the southeast of Izmir. The line will run for 13.5km, serving 11 underground stations, with an interchange with the city's existing metro line at Üçyol and with Izban suburban services at Şirinyer. There will also be a 6km link between the main line and the depot and workshop site.

Glasgow Metro project approval

UK: The first stage of Glasgow's proposed metro network has received approval from Glasgow City and Renfrewshire councils, with the scheme to connect Paisley Gilmour Street station to the city's airport and the Advanced Manufacturing Innovation District Scotland (AMIDS).

Glasgow City Council leader, Ms Susan Aitken, said the next step is to plan to connect the first spur into a wider southwest corridor to reach destinations such as the Queen Elizabeth Hospital, Braehead, and Renfrew, the largest town in Scotland without a rail connection.

A feasibility study is expected to conclude this year to allow the project to be considered in the government's second Strategic Transport Projects Review in early 2021, which will identify nationally significant projects which Transport Scotland and the government will commit to deliver during the next 20 years.

Hamburg automated driverless metro

Germany: Funding has been confirmed by the city's government in the form of a grant for the first driverless metro line in Hamburg to the operator Hamburger Hochbahn. Construction of line U5, designated U5 Ost, is expected to commence at the end of 2021, subject to completion of planning, with the opening date still to be confirmed.

South Wales Metro Control Centre

UK: Transport for Wales has commenced building work on £100m (€118m, $130m) metro depot at Taff's Well. The new depot will include a maintenance facility for new metro vehicles (tram-trains) with a control centre to overseeing metro operations, including signalling.

The South Wales metro project has been part-funded by the European Regional

Development Fund through Welsh Government. Located on the Garth Works Industrial Estate the new depot will become the base for approximately 400 train crew, 35 train maintenance staff and 52 control centre staff.

First autonomous tram tested in Poland

Poland: The countries first autonomous tram has made its trial ride in the city of Kraków, running 3.4km without a driver. In a trial the Newag Nevelo tram departed from the "National Museum" stop ("Muzeum Narodowe" in Polish) and arrived at the final destination – the "Quiet Corner" tram terminus ("Cichy Kącik" in Polish), with a return journey.

During its trial, the tram carried passengers including journalists. The three-car Nevelo tram, also known as type 126N, was developed and assembled by Polish rolling stock manufacturer Newag. During the test technicians monitored the performance of the system which operated the vehicle. This was developed and installed by Newag, assisted by others including the Cracow University of Technology, Rail Vehicles Institute 'Tabor' and CYBID and MEDCOM.

The system is based on satellite navigation and allows the vehicle to perform automatically including departure, stopping, emergency braking after the obstacle detection, and door closing.

Hannover tram collision detection

Germany: Hannover operator Üstra has awarded Kiepe Electric a contract to equip 50 light rail vehicles (LRV) with Bosch Engineering collision detection systems. Following a trial with a TW3000 vehicle, an additional 50 LRVs are to be retrofitted.

Radar and camera sensors continuously monitor the distance between the LRV and objects ahead, as well as the speed of the LRV. If a collision is predicted, a warning is conveyed to the driver with the brakes activated if the driver fails to intervene in time. The autonomous braking can be overridden by the driver, to either brake harder or release the brakes.

Upgrade of Beijing Airport people mover

China: A consortium of CRRC Puzhen Bombardier Transportation Systems and Bombardier NUG Signalling Solutions Co has been awarded a contract to upgrade the automated people mover at Beijing Capital International Airport.

The upgrading of 18 existing Bombardier Innovia APM 100 cars and the supply of an additional nine APM 300 cars, along with Bombardier's Mitrac train control and management system is included within the 215m Yuan (£24m, €28m, $31m) contract. The existing signalling will be upgraded from Bombardier's Cityflo 550 to Cityflo 650.

Government and markets

ORR market study into railway signalling

UK: The Office of Rail and Road (ORR) rail regulator has opened a market study looking into the supply of rail signalling systems in Britain. Signalling accounted for over £4bn (€4.7bn, $5.2bn) of Network Rail's spend over the five-year period between 2014 and 2019. This spend is forecast to remain significant into the future and include costs for the planned roll-out of new digital technology on to the network.

The ORR intends to focus on the level of competition for the delivery of significant signalling projects. They want to look at the strength of competition for tenders, and, whether there are any barriers to innovation or new entrants entering with new technology solutions. In particular, the ORR will examine whether there is fair and commercially reasonable access to interlocking technology, and other aspects of the installed railway infrastructure base, which are necessary to deliver complex signalling projects in Britain.

The market study builds on ORR's recent work in the signalling market, notably engagement with the European Commission about the proposed merger of Siemens/Alstom, which was blocked in February 2019. Another important reason for looking at this market now is to ensure that any competition issues in the supply chain do not slow down or drive up the cost of the roll-out of ETCS, said the ORR.

Communication and radio

Mobile connectivity on UK rail must improve

UK: The National Infrastructure Commission warns that progress on mobile connectivity on rail in the UK has stalled since the government accepted the findings of the Commission's 2016 Connected Future report. The new report calls for clear ministerial leadership to avoid further delays.

The Commission found that a lack of leadership, frequent ministerial changes, and split departmental responsibilities have halted any initial momentum in steps to improve passengers' access to mobile services. In contrast, road users have benefited from 'clear, continuous progress' on connectivity, with UK motorways now offering near universal coverage for voice and data calls and good progress elsewhere across the roads network.

The Commission's research found no evidence of an overall plan exists for rail connectivity. Combined with the cancellation or de-prioritisation of initiatives. It found the lack of progress is largely down to difficulties accessing Network Rail land, the cost of installation and associated potential risks, and a failure of leadership. The Commission's original recommendations on roads – endorsed by government – stated that the necessary infrastructure for an open and accessible mobile telecom and backhaul network that is fit for the future, must be in place by 2025 at the latest, and that steps must be taken to achieve this objective.

Private LTE/4G network for drone control

Japan: Sendai City and Nokia have conducted a test flight of a drone controlled via a private LTE network. The test looked at the potential use of drones during disasters to help in prevention and mitigation efforts.

Sendai City is the centre of Tohoku Region, Japan, to the northeast of Tokyo on Honshu Island. The coastal areas were devastated by the tsunami caused by the Great East Japan Earthquake in 2011. In the verification test, it was assumed that a major tsunami warning would be issued in the coastal area.

Nokia deployed a private LTE network using their 'plug-and-play' digital automation cloud technology. Using speakers, HD cameras and thermal cameras mounted on the drones, recorded and real-time voice messages were delivered, together with aerial monitoring using HD and thermal camera video streaming. Such systems may be interest to railways for infrastructure and incident management

Growth in cyber-security market

USA: A report by MarketsandMarkets Analysis (**www.marketsandmarkets.com**) of USA says the world railway cyber-security market was estimated to be worth $6bn (£4.6bn, €5.5bn) in 2019 and is predicted grow at 9.8% per year to reach $12.6bn (£9.6bn, €11.5bn) by 2027.

Europe is predicted to lead the railway cyber-security market due to the increasing focus on safety and security, along with government initiatives related to cyber-security. Asia Pacific is estimated to be the fastest growing market for cyber-security, growing at 11.5% per annum.

Private LTE networks

Finland: Nokia said they signed 40 new customers for private LTE networks in the three months to the end of 2019, so they now have contracts for private LTE networks with 130 customers. These include recent contracts with Deutsche Bahn for a 5G-based network for automated rail operations, and with Sendai City in Japan for private wireless connected drones.

Nokia has also partnered with Microsoft to bundle private LTE and IoT for operators and enterprises. UK based BT has already signed to resell the package, offered as a managed service.

Nokia also signed 15 commercial 5G contracts in the period, including launches with O2 in the UK, Zain in Saudi Arabia, Sprint in the US (in various cities), and Vodafone in New Zealand.

People

Women in rail

UK. Despite 81% of women in Britain never considering the rail industry as a career path, women working in rail insist it's a career worth thinking about. A recent survey identified that only 16% of the total UK rail workforce are women, within even less in engineering demonstrating a dramatic gender gap and an urgent need for diversity in a traditionally male-orientated profession. Another survey, conducted by the Rail Delivery Group, found that 81% of women in Britain have never considered the rail industry as a career path despite the varied roles available.

As part of a 'Next Move' initiative by Community Rail Lancashire, female pupils from a number of schools in north west England were recently given the opportunity to talk to female figureheads in the rail industry. Some of the pupils had never even travelled by train before. The initiative, in partnership with Manchester United Foundation, promoted rail as a rewarding profession for females by giving students the chance to hear from a number of female railway employees, which included Claire Beranek, route asset manager signalling and IRSE member.

"When I first joined the railway in 1990, it was very different to how it is today, said Claire. "I was working with the men on the track and there were no female toilets, so I had to ask permission to go to the men's toilet and check there were no men in there before I used them. "30 years on, it's very different now, but at that time it was a bit strange having a woman doing engineering." Visit irse.info/p21yz for the full report.

Education

China trains Afghan railway engineers

Afghanistan: China recently hosted staff from the Afghan Ministry of Transport for training in railway management, signalling and operations. This included a visit to a high-speed rail training centre.

The Afghanistan Railway Authority AfRA confirmed the engineers acquired a wealth of technical skills during the visit, which they would pass on to other Afghan staff to help support the country's railway plans. This follows visits to other countries including Iran and Tajikistan for technical training.

Arup work experience week

UK. During June and July Arup are holding an Engineering Awareness Week (EAW) at a number of locations for 14 to 17-year-old students. The objective is to give students insight into the day-to-day life of engineers.

Over the course of a week, students work in groups to plan for a major event taking place in their local city. They take on a range of projects and solve problems, created to develop their understanding of a variety of engineering careers. Over 200 young people have participated in the programme since 2010.

Full details and how to apply for one of the weeks in Manchester, Leeds or Sheffield can be found at irse.info/yc947.

Innovation, research and big data

CSA Catapult to deliver energy-efficient intelligent rail system

UK: Compound Semiconductor Applications (CSA) Catapult is collaborating with a consortium of organisations to deliver an IoT sensing capability for intelligent railway monitoring. The consortium, which also includes AP Sensing, Pyreos and Lightricity, is tasked to develop a low-cost, multi-sensor system which explores new areas of railway monitoring including human trespassing, vandalism, fire, track temperature changes, soil saturation and pollution levels.

The project will offer Network Rail, and other rail infrastructure operators, a cost-effective and energy-efficient way of collecting data to enhance a predict-and-prevent maintenance strategy, through the fitting of sensors in track areas previously inaccessible due to lack of power, connectivity or prohibitive costs. The sensor system will leverage existing trackside fibre optic cables using AP Sensing's Distributed Acoustic/Vibration Sensing (DAS/DVS) system which 'listens' over a 70km range by detecting changes in light transmission caused by the acoustic disturbances on fibre cables.

The DAS/DVS will be augmented through combining the technologies of the consortium partners. CSA Catapult will integrate all the intelligent and self-sustaining sensor nodes in order to transmit sensor data through the cable network. The sensor nodes are designed to interact with the pyroelectric infrared sensors provided by Pyreos, that detect fire, temperature changes, motion and graffiti activities. The entire system will harvest energy from Lightricity's ultra-efficient solar cells, meaning that every part of the architecture is powered by renewable energy.

Field trials of the system will begin in 2020 at Network Rails Rail Innovation and Development Centre in Melton Mowbray, with the objective of providing condition knowledge that allows rail infrastructure operators to detect problems like fire and trespass, whilst enhancing line safety and security management to previously unfeasible levels.

Co-operation for rail research, innovation and development

UK: Network Rail and Strukton Rail have signed a Memorandum of Understanding to cooperate and develop asset management, intelligent infrastructure and advanced data analytics. Both companies have ambitions to improve the availability and sustainability of the railway infrastructure they maintain.

It was determined that a joint approach to the development and deployment of agreed capabilities would benefit both parties and will help the rail sector move forward. The MoU covers a coordinated strategy for rail research and development activity, including demonstrations in order to drive innovation in the railway industry forward.

With thanks and acknowledgements to the following news sources: Railway Gazette International, Rail Media, Metro Report International, International Railway Journal, Global Rail Review, SmartRail, Shift2Rail, Railway-Technology and TelecomTV News.

News from the IRSE

Blane Judd, Chief Executive

IRSE Subscriptions Renewal

We will shortly be getting in touch with all members to renew IRSE subscriptions. Accurate email, postal address and telephone contact details are essential for us to deliver the best service possible to our members. Please check your details are correct online **irse.info/k59og** (requires login) or by emailing **membership@irse.org**, call the London office or write to us. Now is also the time to tell us about any changes to your subscription, such as whether you wish to become an e-member and not receive IRSE News by post, or if you have retired recently.

Blane's World

It was a pleasure to meet so many section committee members at the former National College for High Speed Rail in Birmingham UK (now known as the Advanced Transport & Infrastructure National College) recently. A report of the wide-ranging discussions can be found on page 32.

I attended a Professional Engineering committee meeting on behalf of the IRSE. The IRSE is often asked about the challenges faced in running an institution where 50% of the membership is based outside of the UK. Most recently this was brought up by those working in Australia who have CEng registration through IRSE but are struggling to gain recognition through Engineers Australia. The Engineering Council and several of the smaller PEIs have agreed to work with us to help try to resolve what amounts to a misunderstanding by Engineers Australia of the License that IRSE holds for CEng, IEng and EngTech registration.

This year's IRSE Annual Dinner on Friday 24 April at the Landmark hotel London is sponsored by Siemens Mobility Limited. The guest of honour will be Paul Seller, managing director of Ricardo Rail and the charity for the evening's fundraising effort is The Samaritans. The AGM will be held the day before the dinner this year and I hope as many members as possible will be there to hear our new president, Daniel Woodland give his inaugural presidential address.

Professional development

Results of the 2019 exam

We are pleased to announce the results of the 2019 IRSE Professional Exam modules and to congratulate all those listed, especially those who have now achieved the IRSE Professional Exam. Currently there are seven exam modules and to gain the exam candidates are required to achieve a 'pass' or higher in Module 1 and three other modules.

Thank you to all those who have supported candidates through their studies by organising study groups, acting as sponsors, and running the exam forum. Thanks also to the exam facilitators and invigilators for organising the venues, running the exam day and collating and returning the papers, and of course to the examiners for the considerable amount time involved with setting and marking the papers. Without your time the IRSE Professional Exam would not be the success it is.

For more information about the IRSE Professional Exam, including details about the changes to structure of the exam, please go to our website irse.info/irseexam. If you are planning to take the exam in 2020 please ensure you apply before the 30 April.

The modules referred to in the tables are as follows: Module 1 Safety of Railway Signalling and Communications (compulsory); Module 2 Signalling the Layout; Module 3 Signalling Principles; Module 4 Communications Principles; Module 5 Signalling and Control Equipment, Applications Engineering; Module 6 Communication Applications; Module 7 Systems Management and Engineering. In the tables P signifies a pass, C a credit and D a distinction.

The table below shows the results for modules taken in 2019 which now means that those listed have now completed the IRSE Exam by achieving a 'pass' or higher in at least four modules:

Name	M1	M2	M3	M4	M5	M6	M7
Victoria Aviomoh	P						P
Annafee Azad		C					P
Michael Bastow				P			C
Andrew Belson	P						P
Lee Edwards			P		P		
Adrian Farish		C	P				
Boris Gabai		C	P				
Paul Hobden			C				C
Ryan Hutchinson	C						C
Shahir Iqbal	C						
Greg Larkin	C				P		
Shui Fung Lau	P						

Name	M1	M2	M3	M4	M5	M6	M7
Mary-Ann Lew		P	P				
Andrew Love			C	C		P	
Mark Neilan	P						
Yatin Pathak					P		
Aaron Sawyer	P	C	P				P
Arvinder Singh	C						
Dhanya Srivathsan	D						P
Rob Taylor-Rose			P				P
Philip Tully	C						
Sean Wallace			P				
John Whyte	C						

The table below shows those who have successfully passed modules in 2019 but have not yet achieved passes in the required four modules to complete the IRSE Exam:

Name	M1	M2	M3	M4	M5	M6	M7
Martin Allen		P	P				
Mohammed Baporia	P						
Anthony Berridge	C						
Neil Blakeley	P						
James Bradley	P						
Emily Bramble	D						
Jonathan Calderwood	P						
Arjun Chauhan			P				
Sruthi Chityala		P					
Pankaj Chopra	P						
Bjorn Christensen							P
Wai Sing Chung		C					
Jill Cooper		P					
Aidan Courts		P					
Phil Dakin							P
James Darlington		C					
Shane Dowling		P					
Jonathan Farrell	D						
Zhang Feng	P						
Nilushi Fernando		P					
Thomas Flynn		P	P				
Joseph Francis		C					
Sean Gorman	D						
Kieron Hadlington Needs		P	P				
Stephen Hatton	P						
Ka Man Ho			P				
Mohamed Navis Hussain					P		
Kauser Ismailjee		P	P				
Andrew Jacob		P					
Clare Jameson					P		
Elliot Jordan		P	P				
Craig Kerrigan	P						
Michael Kingston	C	P					
Harshvardhan Kodam		P	P				
Pavan Kumar Kokkonda			P		P		

Name	M1	M2	M3	M4	M5	M6	M7
Praveen Kumar	P		P				
Dabi Lanlyan		P					
Billy Law			P				
Andrew Laz	P						
Kin Cheong Li		C					
Yin Ming Li		D					
Jason Lim			P				
Ying Lung Lau		P					
Hey Man Joshua Ma		P	P				
Graeme Marquis	P						
Aaron McConville							P
Kevin McGuinness							P
Rory Mitchell	C	P			P		
Philip Morgan		P					
Alan Morrison			P				
Mfundi Moyo		P					
Michael Murphy					P		
Gabor Nemeth		C					
Toby Parker	C						
Ravi Kiran Pesaramilli		P					
Andrew Plumb		C					
Hiu Chun Pun		P					
Matt Pylyp	P				P		
Suhanya Saenthan						P	
Andrea Scaricabarozzi		C					
Ming Tak Shum		P					
Vivich Silapasoonthorn	P						
David Snelling			P				
Prabhath Vakkantham		P					
Susannah Walker			C				
Mark Williamson						P	
Lap Hang Wong							P
Richard Wright	C				P		
Hai Tao Wu	P						P
Lau Ching Yin		C	P				

Quick links

Our website, for information about the Institution and all its activities worldwide.

Our sections, IRSE activities taking place near you.

Membership, everything you need to know about being a member.

Our examination, the ultimate railway signalling, communication and control qualification.

Licensing, our unique scheme to help you demonstrate your competence.

The IRSE Knowledge Base, an invaluable source of information about our industry.

Use your mobile phone in camera mode to read the QR codes above and go straight to information relevant to you.

Our sections

UK and Ireland networking event

Report by Paul Darlington

On Friday 31 January representatives of the UK and Ireland sections met with Blane Judd – chief executive, Judith Ward – director of operations and Polly Whyte – head of membership and registrations, for an IRSE sections networking event at the National College for Advanced Transport & Infrastructure in Birmingham.

Unfortunately, the York and Plymouth sections were unable to attend, but all other UK and Ireland sections were represented, including the Younger Members and Minor Railways sections. The objective of the day was to explore synergies and to discuss the challenges of running a section, and to share best practice in organising and running events/technical visits.

Blane opened the day by explaining the "IRSE Beyond 2020 Vision". This was very well received by the sections, and it set the scene for a very collaborative and useful day. The IRSE Beyond 2020 Vision can be seen on our website. The sections and HQ team then broke out in small groups to discuss the challenges in running a section and to identify best practice. The conclusions were then fed back to the overall group. It quickly became evident that the challenges are similar in most sections. Getting new committed committee members was one issue, and it was discussed that volunteer members should not be always be expected to join a section committee. There may be members who would happily assist sections, say to mentor and talk to new members and guests at section events, without formally joining the committee.

Most of the sections indicated they would like the ability to enter their event details onto the new website as before. It was explained that this was not practical at present but remains an objective for both UK and non-UK sections. The ability to filter events by section is however being progressed. Other collaborative methods of communications were discussed, such as a section bulletin board on the website. The sections requested central co-ordination of events, to avoid double booking with each other and with HQ events. Other good ideas discussed were having standby presentations available in case of speakers being absent, collaborative events with other institutions, and holding events at educational locations. The Midland and North Western section immediately took action with this idea and made enquires to hold their next Birmingham event at the National College for Advanced Transport & Infrastructure.

The managing editor of IRSE News explained the production process and timescales for IRSE News, and that section event notices and reports are always welcomed, especially small items to help larger papers start on a new page. He also provided tips on how to write articles and that the editorial team are always available to assist any writers.

Other topics discussed during the day were maximising collaboration opportunities, developing recruitment strategies, improving the engagement of section members and implementing section committee succession planning. Social events and networking dinners were identified as positive initiatives the sections organise, and events and visits involving local projects were always well attended. During the day the sections were given a tour of the impressive facilities at the college, which includes a Class 373 TGV electric multiple unit train Eurostar as a demonstration facility and an ETCS driver training system.

Ian Allison, right, presenting Blane with the Minor Railways Section's cheque to celebrate their tenth year. Behind them is the college's retired Eurostar train, 'Brumstar'.

Section members joined some of the HQ team in visiting the facilities at the college.

Plenty of hard work also went on at the networking event.

Blane presented Nick Rodney of the college with a plaque to thank him for his assistance on the day.

In celebration of ten years of the section, the Minor Railways Section presented a cheque for £1000 to the IRSE HQ team, for the bursary account and to assist other engineers to receive support from the Institution in order to attend events outside their own country.

All the sections thought it was an excellent day and recommended it is repeated for other committee section members to attend, and ways are considered to hold similar events in other parts of the world.

Midland & North Western Section

50th Anniversary

Report by Paul Darlington

IRSE
Institution of Railway Signal Engineers
MIDLAND & NORTH WESTERN SECTION

The Midland and North Western Section held its very first event on 4 February 1970 in Crewe, England. To mark and celebrate the occasion the section held an anniversary dinner in Crewe exactly 50 years to the day. All members of the Midland & North West Section past and present and guests were invited, with the menu a classic 1970s selection of prawn cocktail, chicken dinner and Black Forest Gateau. Unlike in 1970, a vegetarian alternative was also available.

The section committee were delighted to welcome past committee members, speakers, a number of past and future presidents and Colin Porter, a former chief executive of the institution to the dinner. Among the guests was past president Peter Stanley who was one of the very first committee members in 1970. Current chair Paul Darlington and committee member Peter Halliwell summarised the last 50 years highlighting key moments and mentioning a number of members who had filled a number of roles on more than one occasion over the years, including secretary, treasurer and committee chair. It was reflected that the section had delivered in the order of 400 events, both technical and social over the years to inform, debate and develop members of the institution.

A selection of section memorabilia had been assembled for display. These included the very first paper "Signalling for High Speed Trains" by J Tyler, chief S&T engineer British Railways Board. This was very far sighted, as 50 years later signalling for High Speed 2 (the UK's proposed new high speed link) through Crewe may soon be the subject of another paper. In the 1970 paper the author concluded that lineside signals were adequate for speeds up to 125mph, but higher speeds would need a form of in-cab signalling and that one day such technology could lead to automatic trains. 50 years later this is indeed the case for some railways. So, the section looks forward to a paper soon that may predict what train control and communications may be like in another 50 years' time. This will be on display at the 100-year dinner celebration on 4 February 2070.

Ties and badges to celebrate the anniversary are available at any section event or by emailing **clive.williams@networkrail.co.uk**.

London & South East Section

Delivering better timetables

Report by Clive Kessell

The London & SE section of the IRSE received a presentation on delivering better timetables, by Kris Alexander, the programmes & support services director, capacity planning within Network Rail.

There is a need to create more capacity on the UK rail network. Clever signalling systems to allow closer headways, longer trains with longer platforms, and more infrastructure are all part of this objective. However, increasing capacity is one thing, developing a timetable to fit all the extra trains in with minimisation of potential conflict points is something else.

Some basic statistics

The relationship between timetabling and signalling is crucial. Network Rail provides paths for 23 500 trains per day carrying 4.8 million passengers covering 900 000 of track miles, passing >1.5 million signals (hopefully at green) with 220 000 station stops. The plan is for all trains to arrive at the advertised minute. At timetable change time, some 10 000 changes are typically made. Weekend travel has experienced a 16% increase in the last 18 months. The current timetable performance is around 94% trains arriving within a minute of right time, with some services much worse. Incidents represent the biggest risk for achieving right time arrivals and the timetable has to encompass freight and non-franchised operations.

A 'good timetable' might be judged by the following:

- Most trains arriving right time.
- Regular timetabled or clock face departure
- Easy recovery from any disruption.
- services are provided that create economic growth and maximise utilisation of assets, primarily crew and rolling stock.

Timetable compilation process and constraints

It takes a long time to assemble a timetable and involves consultation with a multitude of interested parties. The current system of development takes:

- Commence consultation on TPRs (Train Planning Rules) and EAS (Engineering Access Statements) – 64 weeks out.
- Issue Notice of Change – 55 weeks out.
- TPRs and EASs published – 44 weeks out.
- Train Operator bids scheduled – 40 weeks out.
- Network Rail offer LTP (Long Term Plan) to Train Operators – 26 weeks out.
- Train Operators make bid for a STP (Short Term Plan) – 18 weeks out.
- Network Rail offers a STP – 14 weeks out.
- Information sent to Traveller Publications – 12 weeks out.
- Timetable implemented – week 0.

This looks complicated and time consuming. It can be adversarial and at best is inefficient. Much of the process is carried out manually.

Challenges

Five areas of improvements have been identified to ease the amount of human effort involved and to create a more robust timetable.

Challenge 1 is to automate the production of the timetable and to take account of line speeds, signalling diagrams, stock diagrams, TRUST (train reporting using system TOPS) and TPR (Train Planning Rules), all of which exist as separate data systems but without effective linkage. A typical example would be validating the data for a junction.

Challenge 2 is to unify the TPR and associated values. Currently there are no industry wide agreed rules and as an example it takes 15 documents to timetable a train from Southampton to Trafford Park. Included within this work will be the inclusion of timing allowances for minimum headways, plus measures to minimise the propagation of delays when they occur to other services.

Challenge 3 is to improve timetable performance modelling. This is a data hungry process which requires considerable manual intervention with much of the data being uncontrolled and inaccessible. Timetable modelling is not well aligned with other industry planning processes and is not properly understood by the train companies. It does not have a complete suite of tools and the industry has let go much of the skill set that existed ten years ago. Building back expertise is part of the challenge.

Challenge 4 relates to digital railway technologies, where a project is underway to define a new set of timetable requirements. These will include 1) timings to have an accuracy down to one second, 2) increasing the number of timing points across the railway, 3) ensuring that timetable planning rules are commensurate with the introduction of ETCS, 4) having a common infrastructure model across the industry, 5) creating a zero-defect timetable.

Challenge 5 relates to improving timetable planning data to enable improved analysis and optioneering. The current Sectional Appendix is unstructured and is not digitised with the result that elements may be wrong. Signal control tables have to be manually transferred into the timetabling process in the production of Station Simplifiers issued to station staff. Elements such as signalling plans, track layout variations and electrification work all impact on timetable production but few engineers recognise this fact and even if they do, how to input the element of change is not understood.

The improvement programme

A significant advancement in timetable production is urgently needed and £100m has been allocated. The main requirements are:

- Produce a Timetable Technical Strategy. Already in development, this involves a complex drawing together of all factors (around 50) into a single integrated data system. This major task may take ten years to complete.
- Produce a method for determining the effect of engineering work. Known as an Access Planning Programme, this will be vital to improve the knowledge and impact of engineering work and associated timetable disruption. Cost is estimated at £13.5m.
- Continue the work of producing an Integrated Train Planning System (iTPS). Initially introduced in 2010, it has proved very valuable in automating conflict detection situations and has produced machine generated planning values. £16m is allocated to introduce upgraded versions and to enhance the capability. An example will be assessing the impact of long trains stopping at short platforms.
- Produce a Timetable Performance Modelling Programme to better understand the impact of proposed changes and including a machine reading capability that will be capable of alignment with train schedule, crew and stock modelling inputs. Cost is estimated at £18.7m.
- Create a Timetable Data Improvement Programme costed at £8m. The aim is the extraction of more value from the data so this can be shared with stakeholders both within the rail industry and externally to the travel trade market and social media.

Other interfaces

Since this talk was delivered to a signal engineering audience, it was perhaps inevitable that a plea was made for the engineering data to be modified from its present unstructured forms into a single consumable format. Such data can impact on timetable performance but when timings become critical to the second, knowing everything about the signalling can be very important. The timetablers need to know about speed limits, gradients, tunnel bores, curvature, signal overlaps, signal control panel operation, even interlocking types, all of which should have a common data format that can be easily accessed

Two critical emerging interfaces are Traffic Management Systems (TMS) and Automatic Route Setting (ARS). TMS should ideally be provided with a perfect timetable but this is still a long way off. When first considered back in 2014, it was thought to be quick win through purchasing proven systems in use on other railways, where advantages were being realised in optimising real time train pathing decisions if disruption were to occur.

It has proved difficult to implement the trial systems at Cardiff and Romford. The Luminate product in use on the Great Western route proven to be the most beneficial so far, but it has taken a lot of work to get to the present position. On the Thameslink central core, the Hitachi TMS system is uploaded with timetable data each day so that it can constantly review train movements against the planned operation. Timetable conflicts and late running will be detected with revised trip and dwell times then calculated and offered to the signallers as an optimised pathing plan to keep disruption to a minimum. However, for this to be fully effective, the timetable data for almost the entire Thameslink area has to be entered in order for constant monitoring of real time running to be achieved.

Similarly, with ARS, whilst this has been available in basic form since the 1980s, the decision-making data has only been used in a localised area without the bigger picture of events being considered. Clearly if more accurate timetabling and train running is to be achieved, ARS and timetable data will need to be fully integrated.

Final thoughts and a postscript

A recent press briefing by Andrew Haines (chief executive of Network Rail) touched on timetabling challenges. Under the franchise system, train operators are virtually compelled to run more trains with better performance and at lower cost. This presents many difficulties of running a service when things go wrong. The May 2018 timetable was a classic example with both train operators Northern and Thameslink introducing huge timetable changes which could not be delivered. People have blamed the timetable for the ensuing chaos, but it was more the unpreparedness of the train companies to operate the resultant train service that caused the problems. A shortage of rolling stock, the lack of train crew and the rate at which they could be trained were major factors. Thameslink recovered quite well and within two months had a revised workable timetable in place. It has since been upgraded again and now offers a brilliant cross London service that has contributed to many new journey opportunities. For Northern, the misery has continued with the result that the franchise has now been terminated and effectively nationalised and put under government control. Some experienced operators saw these emerging problems and Network Rail was asked to delay the introduction, but this was not credible with only ten weeks left before introduction.

It is now likely that big timetable changes will need to be planned over a longer period, possibly up to two years out. Examples where things have gone better were the 2008 West Coast Main Line change and the recent introduction of the new Great Western timetable to take advantage of the Class 800 fleet introduction.

Recent government announcements about possible re-openings have included the Ashington-Blyth line in Northumberland which will use a section of the East Coast Main Linenorth of Newcastle where paths are already at a premium. As a general observation, the scarcity value of the last remaining path on any route may need to be reflected in the price paid. Equally, if more trains are to be operated over a route, it could mean enforced changes to the stopping patterns and run times of existing train services. This is already happening to some routes on the ex-Southern Region lines where services are now timetabled for longer journey times than in years past, in recognition that getting through pinch points cannot be guaranteed without additional recovery time.

One piece of advice is that when new trains and/or infrastructure are introduced, bed the service in on the existing timetable before attempting to change the service pattern with a new timetable. Trying to do it all at once will court disaster.

So, an eye opening subject where the relationship between engineers and timetablers is becoming ever more critical. One can only hope that the industry as a whole will be up for the challenge

Midland & North Western Section and Minor Railways Section

Technical visit to Unipart Dorman

Report by Paul Darlington

On Wednesday 22 January 20 members of the MNW section and MRS enjoyed an interesting and informative technical visit to Unipart Dorman in Southport, England, a supplier of LED signals to the UK, Middle East, Australasia and North America. During the visit we learned of the history and development of LED signals together with presentations from other Unipart Rail companies.

The company has a long history of creative and innovative engineering. It was founded in Salford England as Dorman Smith in 1874. In 1878 collaboration with Siemens Brothers & Company Limited provided the world's first ever electric floodlights for a football match, which took place on 14 October at Bramall Lane in Sheffield. Other notable engineering 'firsts' were explosion proof lighting for the Woolwich Arsenal in 1901 and switchgear for the RMS Titanic and RMS Olympic transatlantic liners in 1910. During the 1939 -1945 Second World War the company were involved with the manufacture of electrical switchgear for Radar and ASDIC (Allied Submarine Detection Investigation Committee) also known as Sonar, and in 1955 introduced the concept of modular electrical circuit breakers and modular switchboards.

1966 commenced the company's involvement with transport safety and the introduction of the UK's first electric road lamp as an alternative to the traditional paraffin lamp. In 1985 the Mk1 portable tail lamp was developed, which is believed to be the world's first use of LED technology for rail. LEDs were first used for signalling in 2000 with the introduction of the level crossing barrier boom light. This eliminated filament failures due to shock and vibration, and was followed in 2001 with the first LED lineside signal with a GPL (ground position light) signal.

In 2003 a main line colour light LED signal was introduced for the West Coast modernisation project and as confidence in LED technology grew other signals were developed. Today LED railway signals are the main market for the company, although they still provide some LED road traffic management products, such as Conelites and vehicle activated signs for roads. Over 100 000 LED modules in a wide variety of railway signals and indicators have now been supplied to improve both reliability and readability.

In 2002 the company became part of Unipart Rail; a division of the Unipart Group which is partially employee-owned and one of the largest privately owned companies in the UK, and also incorporates innovative companies such as Park Signalling, Instrumentel, Samuel James and Westcode. This provides Unipart Dorman access to extensive resources when required, while retaining the flexibility and focus of a smaller company. They are also able to support other companies in the rail division and for example when Park Signalling developed a replacement block signal token machine, the shape and form of an existing machine's front face was needed. A prototype was produced from a solid billet using the company's CNC (computer numerical control) machine. This reduced the lead time for a first off inspection item.

The iLS (integrated lightweight signal) system was introduced in 2008. This used improved optics fitted in a GRP head on a fold down post. iLS also delivered cost savings, reduced size structures, eliminates working height risk and is virtually maintenance free.

Factory tour

The sections were split into smaller groups for a tour of the impressive modern factory to see LED signals being developed and manufactured. Quality control arrangements were impressive and explained in detail throughout the tour.

We observed the 90 plus staff assembling signals and learned that 20% of the workforce have been with the company for more than 25 years – some with over 40-year service. Staff retention of this sort is unusual in UK manufacturing. On average over 120 000 parts are consumed per week with batch traceability and tracking from component to sub-assembly through to complete signals using a frequently audited logcard system. We were told of the plans and investment for a new digital manufacturing capability, which will include barcode tracking of items throughout the factory and live stock updates via Wi-Fi integrated into the MRP (material requirements planning) system.

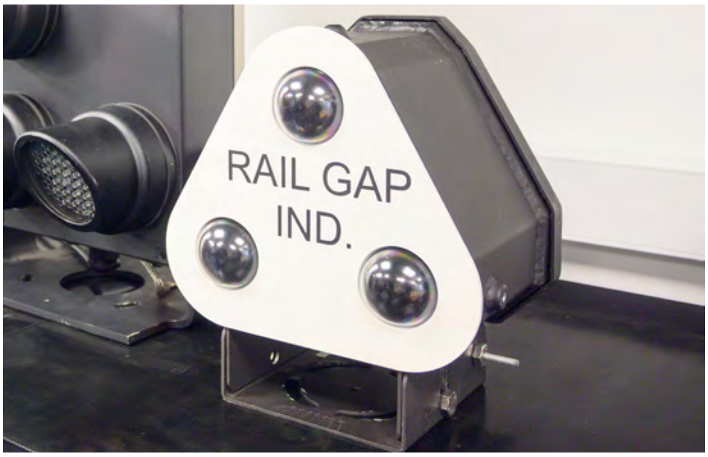
To enable a creative, innovative and continuous improvement approach a quality framework known as "The Unipart Way" is employed. This enables continuous improvement to be part of everyone's 'day job'. It is a philosophy of working, underpinned by a set of tools and techniques that enables the understanding of customers' real and perceived needs and to deliver their expectations. This is achieved through a system that combines process improvement with the effective engagement and development of people. By engaging people, the framework unlocks knowledge and creativity to develop new ideas and supports the development of a continuous improvement culture.


Instrumentel Ltd presented on a number of topics to members during the day.


Park Signalling demonstrate their IP communication link Digital Block Controller (DiBloC).


The impressive manufacturing area, designed to maximise efficiencies through process flow.


The end product, LED signal units ready for despatch.



4LM is a project to upgrade the signalling systems of four of London Underground's lines. One example of the new LED signals for this work is the Rail Gap Indicator.

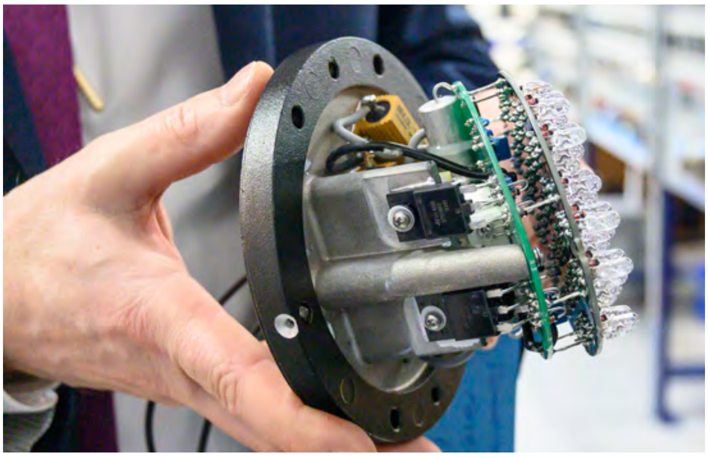

North American LED modules have been produced to convert signals from filament bulb and first-generation LED to modern LED standards.

The continuous improvement system is designed to engage everyone within the organisation. It motivates people and equips them with the skills to diagnose problems and create innovative solutions. The objective is for a culture where a 'can do' attitude and a 'will do' commitment are infectious.

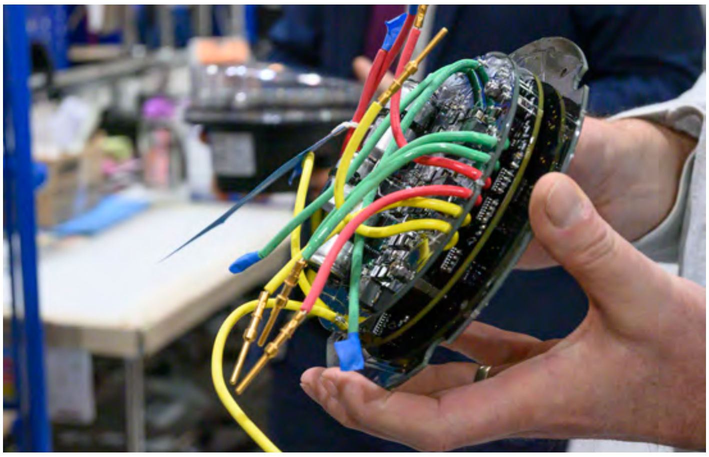
We saw LED signs and signals which have been developed for other infrastructure managers. Following the overturning of a tram at Sandilands junction, Croydon, on 9 November 2016, an LED sign to increase driver awareness of the 20km/h zones was developed in just nine weeks from the customer enquiry. This was based on the company's highway vehicle activated sign range.

4LM is a project to upgrade the signalling systems of four of London Underground's busiest lines: Circle, District, Hammersmith & City and Metropolitan to deliver more capacity and increase train frequency to every three minutes at peak times. A new range of LED signals to comply with the Underground's requirements has been developed.

For North America a wayside signal to enable the upgrade of signals across America and Canada from filament bulb and first-generation LED to modern LED standards and capability was also demonstrated. The objective is to again save costs with maintenance and increase safety with better readability.

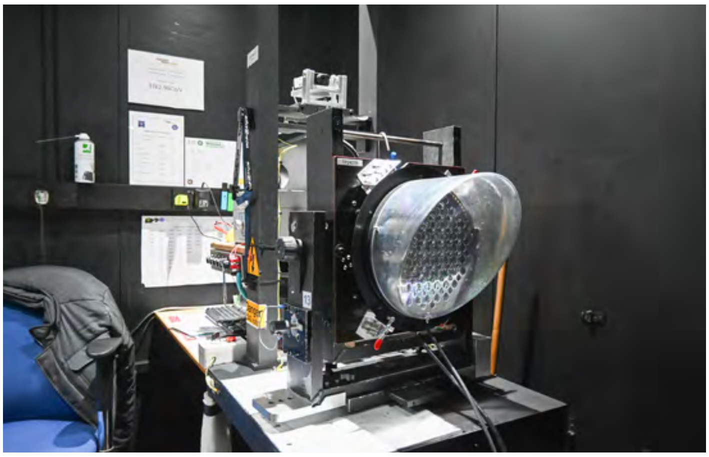


Internal architecture of the single colour signal lamp module first used in 2001.



Significantly reduced real estate taken up by the new tri-colour wayside module.

Extensive soak testing in all extremes of temperature contributes to reliability.



In-house light output testing facility to confirm every module meets the correct optical standard.

It was also comforting to learn of further initiatives and future developments to improve LED signals, given that the full roll out of ETCS will take many decades to achieve. Having in-house design, development testing and manufacture allows quicker reaction to industry needs and reduces lead time for new or improved products. Cost reduction measures, design and reliability improvements can be trialled without paying third party test house costs, although type approval tests of final production types are carried out independently. Sustainability and lower power signals are the next big challenge, and plans include the possibility for 24V lamp proving systems with a power requirement of 1.5W. Several members were impressed with the range of innovations that Unipart Rail are working on across both Infrastructure and traction & rolling stock.

Other demonstrations

Unipart Rail had arranged demonstrations throughout the day from Park Signalling and Instrumental Ltd along with a virtual reality experience. These included Digital Block Controller (DiBloC) to allow a section of single line railway to be controlled with token working, but without the need for dedicated railway end to end cabling or on-board equipment, as it is designed to communicate through IP based private telecom networks. Having the same operational and key features as traditional electric key token machines is a main requirement, along with retaining the shape and form of the existing machine front face. Product trials are expected shortly.

Instrumental Ltd presented their condition based supply chain (CBSC) a concept for the seamless management of real-time data and information of an asset, combined with multiple data sources. The objective is to bring together several existing and emerging technologies and capabilities into a complete digital eco-system. Condition based monitoring (CBM) sensors are one source of data but other useful information can be used to help monitor and predict the need for replacement parts. For example, CBM data can be combined with historical demand patterns, defect, warranty and repairable reports and vehicle maintenance schedules. Improving the effectiveness of the supply chain in rail can have a large impact on reducing cost and carbon, while increasing capacity and customer satisfaction.

Other initiatives presented included the development for next generation UK train protection and warning system (TPWS). This will include changes to the in-cab TPWS panel to provide information on the occurrence of an advanced warning system (AWS), overspeed sensor (OSS) and signal passed at danger (SPAD) interventions. Other enhancements include in-built data monitoring and recording, connection to on-train data recorder, and to eliminate an inadvertent over-ride (reset and continue).

A train-borne system to monitor track circuits to acquire preventative fault data was also presented. Sensors have been fitted to a track recording coach for trials in the Swansea area, which included monitoring of TI21, Reed and DC track circuits. 2000GB of raw data has been collected and it has been concluded that the data is useable and is already providing condition information of track circuits.

The sections would like to thank Unipart Dorman for a most interesting day and look forward to returning sometime to hear of other innovative and creative developments for the signalling industry.

Younger Members Section

Section relaunch

Keith Upton

The Younger Members section is re-launching in 2020 and we need your help.

Who are the Younger Members?

We are members of the institution, of any grade, under the age of 35. However, we are also those less experienced members (nominally fewer than ten years in the industry) over the age of 35 who have recently entered the railway signalling and telecommunications, train control, traffic management and allied professions.

Our events and activities are tailored for those members. Nonetheless, the wisdom and encouragement of more experienced members is an important aspect of our events. We always welcome those members who don't necessarily fit into the Younger Member bracket too.

The role of the Younger Members Section is to ensure that the activities of the Institution are relevant and valuable to the professional development of current younger and less experienced members.

By:

- Supporting the initiatives of the Institution, based upon our knowledge of the needs of the Younger Members.
- Proactively encouraging the Institution to ensure the needs of their local Younger Members are met through representation within their events and organisations.
- Providing a focus within the Institution for the co-ordination of Younger Members' events, activities and communications.
- Promoting the benefits the Institution offers to Younger Members.
- Capturing and understanding the issues and topics relevant to Younger Members, so they may be raised within the institution and wider industry.
- Addressing these issues through Younger Members events and communications.
- Supporting multi-institution initiatives for the benefit of Younger Members across the industry.
- Organising specific events aimed at Younger Members and promoting relevant events from other IRSE sections and other institutions.
- Encouraging and supporting members undertaking the IRSE professional exam.
- Advocating use of the IRSE self-service mentoring scheme.

In the past we have organised:

- Multiple annual study days for the IRSE exams.
- Annual seminars with talks and technical visits for Younger Members (previous events have been in London, Swindon, Glasgow, Newcastle, Birmingham and elsewhere).
- Many technical visits including to the Northern Line Extension project, Aldwych Station, the North Pole Depot, Reading Train Care Depot and many more.
- International trips to Madrid, Lisbon, Munich.

We would like to relaunch the Younger Members Section in 2020 and would like your help. We want to know what you

The Younger Members' Section gets involved in a wide range of interesting, and fun, events, such as the 21st century Professional Institution event held in 2017.

The Younger Members' Section arranges visits, seminars, study groups and other meetings during the course of each year. These have included in recent years (clockwise from top left): Technical visit to Birmingham power signal box. A technical visit in Newcastle. Systems thinking exercise at the annual seminar. Attendees at an Exam Study Day Event. Attendees at the annual seminar in Birmingham.

would like from the Younger Members Section, so we have created a survey to understand the needs and wants of Younger Members. Please fill it in at **irse.info/fqrld** by 21 May 2020.

We want you to get involved in developing and growing the Younger Members Section by joining the committee. We have the following roles available:

- Chairperson.
- General secretary.
- Treasurer.
- Publicity secretary.
- Voting member (responsible for Exam Study Days).
- Voting member (responsible for the Mentoring Scheme).
- Voting member (General).

Joining the committee is a fantastic chance to ensure that the IRSE is relevant to Younger Members but is also a great development opportunity (i.e. good evidence for professional registration). You won't be alone as there is a lot of experience within the IRSE who can help you as you develop into your role. However, we also want you to take ownership of your role and arrange events and activities that you can be responsible for. These are great networking opportunities and a chance to meet people from different companies, with different experiences and membership levels of the IRSE (plus other institutions).

Note the Younger Members Section is open to anyone around the world, and we are always looking to promote international activities for Younger Members. So please fill in the survey and get involved wherever you are in the world.

Dates are already in the diary for 2020 (and details of further events will be available in due course):

- Telecommunications Day:
  4 April 2020 – Central London, UK.
- Exam Preparation Weekend, Modules 2, 3 & 5:
  25-26 April 2020 – Derby, UK.
- Safety and Systems Engineering Day:
  13 June 2020 – Birmingham, UK.

Your letters

Trustworthy satellites?

Re: "Using Global Navigation Satellite System (GNSS) in safety critical rail applications – Bernhard Stamm IRSE News 263". In 1859 a solar flare bombarded the earth with electro-magnetic radiation powerful enough to disable most telegraph systems. Since then, a number of less powerful ones have been strong enough to interfere with terrestrial electrical systems. Satellite specialists are reconciled to the probability that fairly soon a satellite collision will cause a chain reaction which will disable a significant number of satellites. With these two threats, we propose becoming more dependent on satellites, even for vital functions.

J R Batts

Ed – Other problems with GNSS for critical railway use are that infrastructure managers will have not have any influence in the supply of the service. If GNSS operators choose to disable their satellites then other countries may not be able to afford their own systems. GNSS will also not work in tunnels, sub surface railways or deep cuttings. What do you think of the use of GNSS for safety critical rail applications? Let us know by emailing editor@irsenews.co.uk.

Council elections

We have received some complimentary positive comments on this year's Council elections. "only took me a few minutes to vote" "really easy and did mine this morning on the bus" were some of the comments received. It certainly looks like there is going to be a much higher turnout voting-wise than other years. Within two days of the voting opening, 12% of corporate members had voted whereas historically 22% of corporate members in total have voted.

Others missed the postal voting system and not being able to see and compare the candidate's statement side by side. Next year we will look to publish the statements in IRSE News.

Thank you to all members who took the time to return your ballot form in this year's elections to make it a record year for the number of votes received by post and on-line. The results will be announced at the annual general meeting on Thursday 23 April to be held at the IET Savoy Place London from 17.30.

Paul Darlington
managing editor IRSE News

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at irsenews@irse.org.

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Membership changes

Current Membership: 5151

Elections

We have great pleasure in welcoming the following members newly elected to the Institution:

Fellow

Richard Mifsud, JMD Railtech, Australia

Member

Anne Borremans, Alstom, Belgium
Vui Ken Chung, MRCB George Kent, Malaysia
Brian Church, NRL, UK
Gordon Crawford, Arc Rail, UK
Hong Huang, CASCO Signal, China
Robert Kerry, Omada Rail Systems, Australia
Seng Cheng Lee, Systra, Singapore
Wellington Mapindu, Qatar Rail, Qatar
Muhammad Nadeem, Transport for London, UK
Andrew Rowlands, Babcock, UK
Ralf Wennrich, Siemens Mobility, Germany

Associate Member

Nicklas Barck-Holst, Bombardier, Thailand
Paven Bhatti, Alstom, UK
Ross Bryan, Eurotunnel, UK
Scott Cao, Kelly Services, Hong Kong
Tsun Yin Chu, Thales, Hong Kong
Christopher Clark, Volker Rail, UK
Benjamin Clarke, Network Rail, UK
Paul Comper, Eurotunnel, UK
Philip Drew, Translink, UK
David Dubois, Northern Ireland Railways, UK
Andrew Grimason, Northern Ireland Railways, UK
Jonathan Kelly, Translink, UK
Gregory Martin, Network Rail, UK
Crispen Mashingaidze, Huawei, South Africa
Thomas May, Eurotunnel, UK
Patrick McCann, Northern Ireland Railways, UK
Alexander Oshijo, Network Rail, UK
Chou Tek Sam Ti, MTR Macau, Macau
Carl Saunders, Network Rail, UK
Daniel Scourfield, Network Rail, UK
Liyang Song, Land Transport Authority, Singapore
Michael Toal, Translink, UK
Wai Kei Tou, MTR Macau, Macau
Kai Chuen Tsang, Thales, Hong Kong
John Woods, Northern Ireland Railways, UK
Tsz Ho Yeung, Thales, Hong Kong

Accredited Technician

Aneek Banerjee, TVM Signalling and Transportation, India
Rory Baxter, Network Rail, UK
Peter Briton, Dept of Planning, Transport & Infrastructure, Australia
David Gardner, Dept of Planning, Transport & Infrastructure, Australia
Tom Matwiejczyk, Network Rail, UK
Kenny Reith, Northern Ireland Railways, UK

Professional registrations

Congratulations to the members listed below who have achieved final stage registration at the following levels:

EngTech

David Haynes, Balfour Beatty Rail, UK
Matthew Mitchell, Siemens Mobility, UK
Craig Sowter, Network Rail, UK
Kate Wallace, London Underground, UK

CEng

Paul Robilliard, BWB Consulting, UK
Daniel Timmins, Ove Arup, UK

Promotions

Member to Fellow

Claire Beranek, Network Rail, UK
Christopher Miller, Omada Rail Systems, Australia

Associate Member to Member

Vishwanath Garg, Serco, UAE

Affiliate to Member

Zhixin Cui, Sydney Trains, Australia
Richard Flaherty, Atkins, UK
Robert Paterson, WSP, UK

Accredited Technician to Associate Member

Elliott Bonnet, Bam Nuttall, UK

Affiliate to Accredited Technician

Christian Simpson, Coyle Personnel, UK

New Affiliate Members

Nagaraju Anumula, Keolis Hyderabad MRT, India
Sivabalan Bala, Synetics Smart Solution, Malaysia
Paul Billson, Network Rail, UK
Martin Bimmermann, Siemens Mobility, Germany
Hamzah Brown, Arup, Australia
Revanth BS, SNC-Lavalin Atkins, India
Raul Carlos, HDR, USA
Siva Chidambaram, Malaysia
Hui Qi Evonne Chng, Land Transport Authority, Singapore
Agnes Darazsi, Irish Rail, Ireland
Luke Darling, Irish Rail, Ireland
Santosh Dharphal, SNC-Lavalin Atkins, India
Kenneth Dolan, Irish Rail, Ireland
Fabio Escandon, Siemens Mobility, Germany
Stephen Finch, UK
Tristan Ford, SNC-Lavalin, Canada
Philip Guerreiro, Alstom, UK
Nagesh Gunuguntla, Capital Metro, Saudi Arabia
Joseph Hall, WSP, UK
Peter Hindle, LP Railsystems, Malaysia
Tanzim Hussain, Arup, UK
Sunil Jassal, Arup, UK
Pankaj Jha, City Diamond Contracting, UAE
Eylem Korkmaz, Siemens Mobility, Germany
Mukadder Kuemet, Siemens Mobility, Germany
Vishal Kumar, Dedicated Freight Corridor Corporation, India
Rohan Kurane, Alstom, India
Michael Marriott, Public Transport Authority of Western Australia
John Mitchell, Barony Global Serices, UK
Delphine Ng, PYB Consultants, Australia
Hannah Nugent, Transport for London, UK
Jonathan Paley, Siemens Mobility, UK
Azim Patel, Saudi Railway Company, Saudi Arabia
Mohd Abid Pauzi, MRTC, Malaysia
John Plowman, Churnet Valley Railway, UK
Robert Rain, Siemens Mobility, UK
Anirut Smitinundana, Xenix Electech, Thailand
James Stanley, Alstom, UK
Derek Tinney, SWGR, UK
Kwun Ho Michael Tong, Laing O'Rourke, Australia
Ze Xian Yeo, East Japan Railway Company, Japan
Rui Zou, SNC-Lavalin, Canada

Resignations: Franciscus Van Dommelen, Netherlands.

IRSE News

Institution of Railway Signal Engineers

March 2020

Driverless trains on freight and main lines

Accessibility are we doing enough?

Train protection in Argentina

IRSE ///
Institution of Railway Signal Engineers

Issue 264
March 2020

In this issue

Feature articles

News and opinion

From the IRSE

From our Sections

'Whole system' safety

In many of the pieces I have written for IRSE news over the years I have emphasised the need for the 'whole system' to be considered in any safety assessment. Nowhere is that principle more important than when software is involved.

The tragic loss of two Boeing 737 Max aircraft, resulting in 346 deaths and the global grounding of the type has resulted in the Manoeuvring Characteristics Augmentation System (MCAS) becoming quite famous (or maybe infamous). Much of the reporting talks about the MCAS software needing to be changed; but I have seen nothing to suggest that the original software did anything it was not designed to do. The failure was very much one of the total system, involving problems with each of the three elements that any safe system needs to get right; informed competent people, good processes and well-designed equipment.

In rail we have seen several recent incidents emphasising the same principle. In this issue you will find an article by Ian Mitchell on the RAIB's recently published report into the loss of safety critical signalling data on the Cambrian Coast ERTMS pilot installation. Four trains did not receive temporary speed restriction data because a single point of failure in the software had not been detected; worse, the system was telling the signaller all was well. The safety documentation had been based on another project where changes had (albeit accidentally) mitigated the problem. On the Hong Kong Metro the March 2019 collision during testing involved a novel configuration of three computers (rather than the design's usual two) intended to deliver high availability. Changes in the additional warm-standby computer to avoid common mode failures with the main channels led to protection being incorrectly configured.

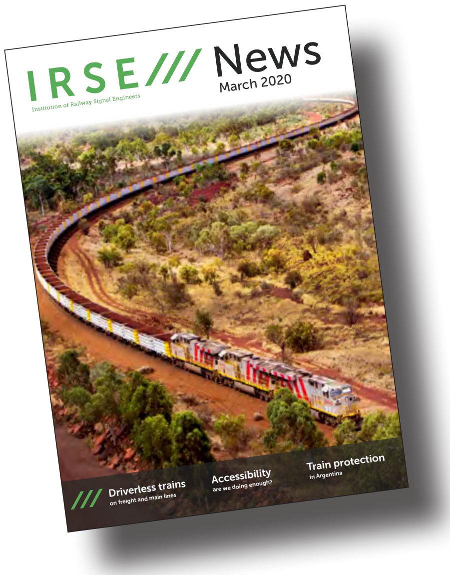
To me the key message from all these is, that when it comes to software, version control must be rigorous and assessment must include the actual versions used and the true and total system environment; and that includes all interfacing and underlying sub-systems. Change anything and the impact on all needs to be re-assessed. Expensive? Yes, but experience shows that the alternative is worse.

Rod Muttram, IRSE Council member

Cover story

Connected and autonomous vehicles (CAVs) have the potential to profoundly change transport, for rail, road and sea and even in the air. We are on edge of profound changes in the way people and goods move around by the introduction of CAVs with many exciting and potentially transformational opportunities ahead.

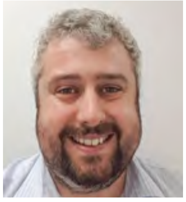
In some countries rail is ahead of road with CAVs and this month's front cover shows a loaded ore train in fairly typical Pilbara landscape, a large, dry, thinly populated region in the north of Western Australia. The railway runs parallel to the line of a creek through this area, explaining the number of reasonable size trees, sustained with underground water, in contrast to the hillside where the vegetation is quite sparse.



Mining railways have unique challenges, but also represent an opportunity for automation and realising the benefits it can bring to rail.

Photo © Rio Tinto.

Should we forget the driver?



Noel Burton

This paper was originally presented to an Australasian Section technical meeting in Wellington, New Zealand in 2019.

One of the key advantages that rail transportation has over its road-based competitors is that of driver efficiency. Typically, a train will need fewer drivers to get from A to B for a given load (be it humans or freight) compared to the number of road vehicles required to transport the same load. However, there is an emerging risk that this significant rail-vs-road advantage is about to be eroded. Huge amounts of R&D spending have been invested globally over the last 5-10 years in the pursuit of self-driving cars and lorries. Will this become a serious threat to rail's competitiveness?

Currently nobody has yet cracked the full self-driving problem for road vehicles but given the number of companies who have bet vast sums of their money that it is possible, it would be arguably unwise to assume their goal will not be reached in at least the medium term. This paper looks at some of the problems still facing our tarmac-based competition and whether these same issues also apply to rail if we (the rail industry) were to try and proceed to driverless trains across most rail operations in a similar timeframe.

Ultimately this paper asks the question: are we proceeding fast enough to a future where most trains can be operated without a driver?

There has been unprecedented investment into the development of driverless road vehicles by both new and established players in the automotive business. A report by the Brookings Institution [1] stated that a conservative estimate of the investment into autonomous driving related companies was at least $80bn (USD) between 2014 and 2017 alone. Although no fully self-driving cars or lorries are currently for sale, there are plenty of expectations, predictions and maybe some hyperbole predicting their imminent arrival.

I have been wondering if this massive push towards a driverless future from the road transport industry is something we in the rail industry need to be concerned about? Signalling suppliers and their engineers have been inventing solutions for driverless metros for years now and we are recently seeing the introduction of Automatic Train Operation (ATO) technology on more main line applications, although normally still with a driver. But are we guilty of making too many

A KiwiRail freight train using New Zealand's 85% renewably generated electricity, moving a load that would take 30+ trucks (each with a driver) if transported by road. Will autonomous and electric vehicles threaten these competitive advantages? *Photo Michael Kilgour.*

SAE level	SAE Level 0	SAE Level 1	SAE Level 2	SAE Level 3	SAE Level 4	SAE Level 5
Category	Driver support and assistance features			Automated driving features		
Example features	Lane departure warning	Adaptive cruise control	Adaptive cruise control with lane centering	Traffic jam autopilot	Local driverless taxi	Driverless, can go anywhere

Figure 1 – The Society of Automotive Engineers (SAE) defines six levels of driving automation for road transport, summarised in this table. *Image produced from SAE standard J3016.*

excuses on why full driverless operation is not viable for all rail operations, while the competition are aiming to produce driverless cars and lorries that can use any road?

My employer (Siemens) supplies many of the products and systems that will be required to compete against automation on the roads, as do other railway signalling suppliers. This paper however represents my views and opinions only and is intended purely as a stimulus for the industry to consider this issue more closely, rather than a case study of the current technology of one supplier in particular.

What is the competition up to?

Ready "next year"

For a few years now, rarely a week goes by without a news story or Twitter pronouncement that self-driving cars will be hitting the roads "next year". How realistic is this claim? On the one hand it is easy to dismiss automation prophets such as Tesla's CEO Elon Musk, who has a track record underestimating the time to market for his products. On the other hand however, he also has a very impressive record of eventually achieving success in endeavours that many 'experts' pronounce as impossible, whether it be to prove that electric cars can be both desirable and viable or to create reusable rocket boosters that land vertically. As such, it is probably foolish to totally dismiss his and others' predictions about the imminent arrival of self-driving cars. Rather this technology should probably be assumed to be inevitable albeit in a slightly more conservative timeframe.

"It is probably foolish to dismiss predictions about the imminent arrival of self-driving cars"

It is my opinion that people who have been bullish about the likely timeframe to reach full self-driving capability for road vehicles have assumed that their development would be relatively linear. It is indeed true that we have seen rapid development in this space, to the extent that it is now relatively normal for non-premium cars to come with impressive adaptive cruise control (signalling translation: ETCS Level 3 with moving block!) and lane keep assist systems, while more expensive cars are now coming with advanced autopilot systems that can do even more but still need constant human supervision.

Maybe not so easy?

It is one thing to make an autopilot system that can operate 99% reliably on a road with clear and standardised markings. However, it becomes exponentially harder to make one that will never need human intervention and can cope with non-complete information, such as missing/non-standard road marking or an unusual situation such as disturbed cones at a road work site.

The automotive industry has realised that there will not be a jump straight to full self-driving and as such have developed a range of 'levels' to describe the stages of automation as technology development progresses (see Figure 1). Current commercially available systems are somewhere between Level 2 and 3, which make driving more relaxing, but the real commercial benefits come with Level 4 and 5 where the driver is not needed at all.

Aside from the sheer technological complexity of the problem, there are also other hurdles for autonomous road vehicle developers to overcome. Insurance and ethics are obviously problems that need to be solved. Who wants to be the software engineer who writes a solution for road equivalent of the classic "runaway trolley problem" thought experiment (see Figure 2 overleaf), especially when it is no longer a thought experiment? Even if you have found a software engineer brave enough to play God (note: signal engineers have been doing this for years when considering competing flank protection risks in swinging overlap design!), you then need to convince the insurance companies and road authorities/regulators to allow your logically morally correct software into the wild.

Relative safety

Another phenomenon the developers of self-driving technology may not have fully understood yet is the general public's expectations with regards to safety when they are no longer in control of their transport vehicles. I believe the likes of Elon Musk when they make claims such as their Autopilot being statistically safer than the average human driver in the same situations. Musk is confident that once Tesla's Autopilot is proven to be 200% safer than a human driver, that most

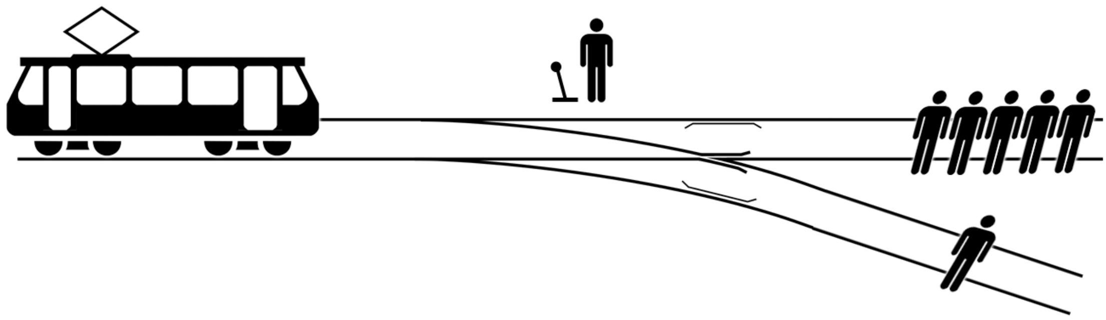


Figure 2 – The runaway trolley thought experiment. An out of control trolley/tram is heading towards five people working on the straight-ahead track. You can't stop the trolley, but you can pull the point lever such that the trolley will only hit one person on the other leg of the turnout. Do you pull the lever? *Image Wikipedia/ McGeddon, CC BY-SA 4.0.*

people will trust autopilot implicitly [2]. But the history of the rail and aerospace industries has shown that despite these modes of travel being many orders of magnitude safer than driving, the public will still not tolerate accidents when they do happen, regardless of how rarely.

I suspect that autonomous car companies are about to discover that the public's appetite for risk when they are not in control of 'the controls' is much different from when they have a steering wheel and the belief that they can 'save the day' if required. Even if they are statistically in a much safer place when the computer is in control. That said, I suspect that autonomous cars and lorries may not need to meet quite the same levels of safety as we are used to in the signalling industry and as such we shouldn't assume their pace of development will be as slow or cautious as we typically see for safety systems in the rail industry.

"Autonomous cars and trucks may not need to meet the same levels of safety as we are used to in the signalling industry"

Advanced technologies

Artificial Intelligence (AI) is being used to overcome some of these problems. It has become clear that AI machine learning is probably the only viable way to make a self-driving car able to cope with the almost infinite range of subtly different scenarios that it may encounter when outside a controlled environment. AI is also good at developing/learning its own solutions to moral dilemma problems that the vehicle may be presented with, such as having to make a split-second decision on which people to harm when there isn't a no-harm answer. Although this technology is in theory extremely powerful it is still not proven commercially in such a complex application, so there is still some way to go, especially in such a safety critical application.

Who has the harder problem to solve?

So, it seems clear that the road vehicle industry still has some considerable hurdles to clear before self-driving can become commercially available. But there are also undoubtedly strong incentives for them to try to reach their goal as quickly as possible.

Looking at rail on the other hand, I would argue that we have an easier problem to solve when it comes to automation. Delivery of the following two functions largely dictates how difficult automation is for a particular application, be it road, rail or air:

1. Ensuring safety; and
2. Coping with complex environments and unpredictable scenarios.

Rail and road have approached the safety challenge in very different ways. Aside from reactionary safety technologies such as air bags and anti-lock brakes, which are normally only used once an accident is imminent, road vehicle development has been focused more on adding driver automation aids to make the driver's job easier. These include aids such as 'cruise control' and 'lane keep assist'. These systems rely on the driver to provide the 'fail safe' component if these aids start to do something unsafe or are unable to cope with the situation they face. In contrast, railways have predominantly added fail-safe safety systems to try and prevent human operators (both drivers and signallers) from being able to perform potentially dangerous actions, before the situation can occur. This has been prioritised in rail over the last century before looking at ways of automating the driving or signalling of the trains in the last few decades. This approach for rail is reasonable because of the severe consequences of a rail accident given the higher energies and (likely) higher number of people involved.

This historical focus on safety for the rail industry gives us a real advantage when it comes to automation. In Tony Howker's seminal 1988 paper, "Have We Forgotten the Driver?" (which I admit I plagiarised for the derivative title of this paper!), Tony encouraged the industry to invest in Automatic Train Protection (ATP) systems to assist the driver and increase safety. Three decades later, it is good to see that compared to 1988 many more railways now have, or are moving to, a form of comprehensive ATP, such as the European Train Control System (ETCS). Most ATP systems are engineered to safety-critical, fail-safe standards and as such provide an envelope in which the train can be driven as desired by the driver, with (in theory) no chance of a mistake resulting in an accident.

Where ATP has been deployed it has normally been at a substantial cost to the infrastructure and rolling stock owners. Normally this cost is justified on the safety benefits alone but having an ATP system that provides a guaranteed safety envelope means that one of the hardest challenges for deploying ATO (be it with or without a driver) has already been solved on many lines.

The second challenge for automation is dealing with all possible scenarios and environments. Whereas cars operate in a mainly two-dimensional environment, railways are predominately in a one-dimensional environment. Not only does everything happen along a pre-defined 'track',

Figure 3 – Railway Grades of Automation, the railway equivalent of Figure 1. *Image based on chart from Shift2Rail website.*

Grade of automation	Train operation	Setting the train in motion	Driving and stopping the train	Opening and closing the doors	Operation in the event of disruption
1	ATP with a driver	Driver	Driver	Driver	Driver
2	ATP and ATO with a driver	Driver / Automatic	Automatic	Driver	Driver
3	Driverless	Automatic	Automatic	Automatic / Attendant	Attendant
4	Unattended	Automatic	Automatic	Automatic	Automatic

> "The second challenge for automation is dealing with all possible scenarios and environments"

but the environment is also strictly controlled, especially in terms of other 'traffic'. Unlike rail, a big challenge for autonomous cars is dealing with other cars and road users in the same road space and predicting what they will do. Thanks to the wonders of the railway block system and interlocking, this is something that an ATO system never has to worry about as it is taken care of by the ATP and the interlocking.

There are of course other environmental and scenario factors that autonomous trains will have to contend with, for example, degraded system modes, weather and trespassers. However, the fact that it is relatively easy to come up with a list of all the possible scenarios that rail vehicles have to cope with compared to the almost infinite unpredictable scenarios that road vehicles may face, again indicates that rail has a much easier problem to solve. (Imagine Elon Musk's relief if he woke up tomorrow to discover a world where all cars were already fitted with a standard system that meant they could never crash into each other, and all his autopilot R&D team had to do was write software that turned the steering wheel left or right correctly at each junction to follow the sat nav!)

Rail also has one other huge advantage; the ability in nearly all scenarios to stop the train in the event of system failure or uncertainty (i.e. fail-safe) and degrade to a fallback mode of operation or wait for rescue. There are far more scenarios where it is not safe to just stop a car in the middle of a busy road due to its computer not being sure. If a driverless autonomous car/lorry has stopped due to a system failure or because it does not have enough information to proceed (i.e. broken sensor) who will rescue it?

> "The railway industry has also developed a scale for describing the different levels of automation"

Autonomous trains

Trains with ATO functionality are not a new development. London Underground's Victoria Line was the first to be fitted with a driver supervised ATO back in 1967. Other systems followed and became more advanced, such as London's Dockland's Light Railway driverless (but attended) light metro that opened in the 1980s.

Grade of Automation

Like the Society of Automotive Engineers (SAE) 'Levels of Driving Automation', the rail industry has also developed a scale for describing the different grades of automation. The IEC 62290-1 standard, summarised in Figure 3, shows the four Grades of Automation (GoA) for rail operations. The original Victoria Line ATO system would be classed as GoA 2. The Docklands Light Railway is GoA 3, as there is still an attendant on the train who is needed to manually drive the train in some failure modes but doesn't normally sit in a driver's cab.

Metro and suburban

In recent years metro systems with GoA4 level are becoming more common. The new North-West metro in Sydney is the Australasian region's first example of such a system.

Dedicated metro systems have been the most likely to see GoA 3 and GoA 4 systems introduced for the following reasons:

- They are self-contained lines with no interfaces to other railways. As such they can tightly control the environment and normally only have one type of rolling stock to automate. This has enabled bespoke driverless signalling systems to be developed to match the requirements of each line.
- As these railways are typically new builds and will contain only 15-30 stations, provision of complex systems to further control the environment, such as platform screen doors, can be incorporated in the design from new.
- Very unlikely to have at-grade level crossings and also generally they have other very good protection measures against trespassers, such as being in tunnels or on raised viaducts.

- Require high numbers of services meaning that the number of drivers that would be required is very high, helping to bolster business case for automation.
- Very aggressive headway targets that can only repeatably be met and recovered after minor disruptions through the use of predictable automated driving. As such if all trains are to be operated in a GoA 2 mode for most times, why not go to higher grades if possible?

"We are also seeing an encouraging trend of specification of GoA 2 ATO for some main line projects"

We are also seeing an encouraging increasing trend of GoA 2 ATO being specified for some main line resignalling projects that are now being tendered. As mentioned previously, once you have a comprehensive ATP system such as ETCS, GoA 2 ATO becomes a relatively simple add-on and provides significant benefits in terms of predictable/optimised driver behaviour and energy saving when running on or ahead of timetable.

We have already seen such applications go live. The application of ETCS Level 2 + ATO on London's Thameslink is a good example of a GoA 2 system on main line operations. Recent work by the European Shift2Rail research project on such main line ATO systems has resulted in standards for such L2+ATO being developed, that we will see being deployed over the next few years. Shift2Rail are now undertaking research projects on what is required for GoA 3/GoA 4 operation for main line rail operations.

Freight and long-distance passenger

It is not just passenger rail that has been moving in this direction either. Probably the most well-known ATO implementation on a freight railway has been Rio Tinto's recent commissioning of their AutoHaul™ system for their 1700km network of iron ore railway in Western Australia's Pilbara region. This system allows them to run their 2.4km long, 28 000 tonne trains in a fully GoA 4 operation without drivers on the trains. As this railway is not in a tightly controlled environment like an underground metro, the system also includes some other features such as laser obstacle detection for level crossings, CCTV cameras on the front of each train and collision detection systems. [3]

A number of freight and passenger operators in Europe (such as DB Cargo in Germany) are also actively investigating and promoting the idea of ATO for their services. They believe this will be needed to remain competitive with automated lorries in the future. [4]

What are the advantages?

Automating the driving of trains brings several advantages including:

- The ability to deliver services based on real-time demand rather than to a timetable that is constrained by fixed staff rosters and predictions of customer demand.
- Enables staff to focus on customer assistance and dealing with emergency situations rather than on repetitive tasks that are ideal for automation.
- Improved performance. Removing variability between human drivers allows driving profiles to be optimised and predictable. This allows contingency time to be cut from timetables and trains to be guaranteed to use 100% of their available performance for service recovery when needed.
- Energy savings through smart driving algorithms which maximise coasting when running at or ahead of timetable.
- Lower operating costs for intensively used systems.
- Can make operations at fringe times (i.e. very early in morning and late at night) commercially viable and thus helps the overall usefulness of the system as public transport for all trips not just commuting. A similar argument also applies for freight trains in terms of commercially being able to operate shorter freight trains more often without additional staff costs.

Driverless trains are nothing new for mass transit lines, but driverless main line and heavy haul trains are showing real promise in terms of increasing capacity and reducing energy usage. *Photo Shutterstock/ Atul Singh Rawat.*

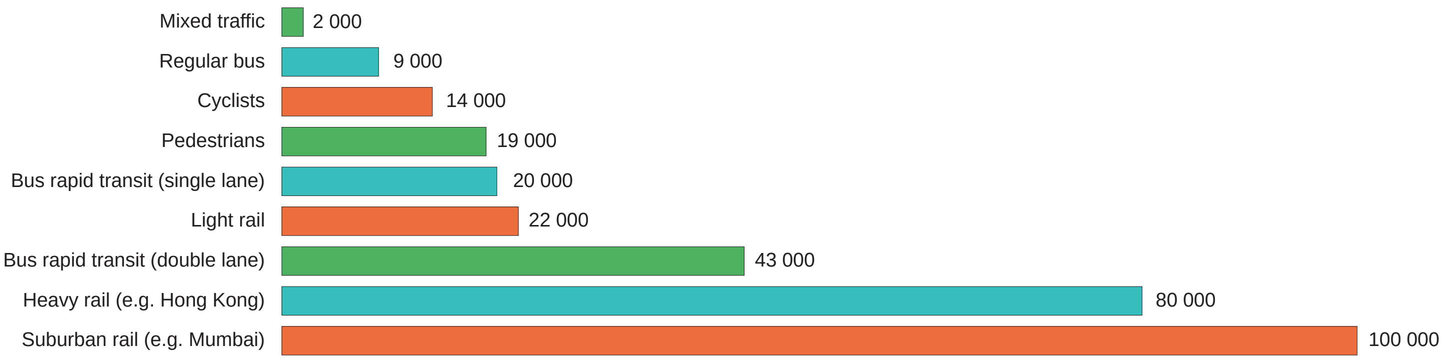


Figure 4 – data from the Asian Development Bank shows the relative capacities in people per hour of one 3.5m wide lane for different transport modes.

Disadvantages?

There will be some things that automation will never be well suited to and these need to be recognised as we move to an automated future. As discussed for road vehicles, computers are not good at dealing with unexpected situations or incomplete information. Although the environment in a rail corridor will nearly always be more predictable and standardised than the average road, situations will occur that the system designers may not have planned for; a car falling from an overbridge and blocking the tracks for example. Having a safety-critical trained human driver on each train obviously also has huge advantages in degraded mode situations and dealing with emergency situations or when ATO equipment fails. The challenge for engineers is how to develop additional functionality into our ATO systems to mitigate these disadvantages or allow remote operators to assist as required.

Are autonomous road vehicles really a threat to rail?

Urban

The ridesharing/taxi company Uber is investing approximately $500m USD per year [5] into R&D for autonomous vehicle technology. It is clear to see what their incentive is, with the potential to remove one of their biggest costs – human drivers. However, it is widely accepted that such ridesharing services alone can never be the backbone of a viable transportation system for the majority of people in a city environment.

Quite frankly as Figure 4 demonstrates, single occupant vehicles (as a driverless Uber would be) just cannot provide anywhere near the occupant density of rail. Therefore, they would quickly clog the streets long before they could make the need for a metro rail line obsolete, no matter how automated they are.

It could be argued that automation of metro and to some extent suburban passenger rail is not needed for the survival of rail, as rail already has so many other advantages over road-based transport in urban environments. Rather automation is just another tool to help further improve rail's advantage and enable cities to get further capacity and performance from their existing rail assets.

Regional/freight

Although most self-driving news stories are focused on technology for private cars and autonomous taxis, arguably the area of the road transportation where self-driving has the biggest potential impact for rail is with autonomous freight trucking.

I would argue there are several reasons why it is likely that the trucking industry will be the first to embrace full self-driving technology on a large scale before any other large-scale commercial application of this technology on the roads:

- As we have seen one of the key problems for self-driving cars is dealing with the almost infinite different type of road layouts that a vehicle might have to interact with. However,

In a sector driven by brand names, UBER has become a well-known organisation, and is investing heavily in a future without drivers. *Photo Shutterstock/ Mike Dotta.*

for major hub-to-hub trucking operations, which is what rail is competing with, the routes for lorries are more likely to be set and known. They often involve most of the journey being on motorway or other main routes. As such these routes will be easier to get sign off for self-driving lorries as the vehicle's performance can be tested and validated over these routes, rather than needing to be certified for generic operation on any road.

- The trucking industry is notorious for operating on very tight margins and always focused on any possible cost savings. Therefore, they are likely to be early adopters if/when the technology is proven as viable.
- Lorries currently have a large disadvantage compared to rail on trunk routes due to the high number of drivers needed to move the same amount of goods as a single freight train (at least 40 lorries per train, often many more depending on the railway).
- Lorry operators have to comply with strict rules around driver hours, meaning trips over a certain length cannot be completed without a driver change.
- Another reason for shifting freight from road to rail in the past has been to reduce the harm done by road traffic accidents. However, with a move to autonomous driving it is very likely lorries will become safer on our roads. For example, the risks associated with driver fatigue will be completely removed.
- Rail currently offers huge benefits in terms of reduced CO_2 per tonne due to the efficiency of the steel wheel on steel rail compared to trucking. However, as well as automation, the other current trend in road transportation is one towards electrification. With a fleet of electric lorries, charged with New Zealand's approximately 85% renewably-generated electricity this no longer becomes a no-brainer in rail's favour, especially if rail is still using diesel locomotives.

"There is a strong argument for focusing more effort on automating medium and long-distance freight and passenger operations"

Given the reasons listed above, there is a strong argument for focusing more effort on automating medium and long-distance freight and passenger operations, as it is possible this is where the real competition to rail's competitiveness will come from.

Could we be moving faster?

All of this leads us to the question of whether, as an industry, we are moving fast enough so as not to be caught out if/when driverless road vehicles arrive en masse? There is definitely a noticeable trend for new dedicated metro lines to be delivered with GoA 4 from opening, which is encouraging. However, as we have seen, in some ways this is one of the easiest types of railway to automate as the environment tends to be very carefully controlled.

Our excuses

As railway signalling engineers, we have a long and proud history of treating change and new technologies with a fair degree of scepticism and

caution. This approach is of course justified when dealing with safety critical systems and systems that have very high availability requirements. However, as previously discussed when it comes to ATO, in rail we have an advantage that we are building upon a failsafe safety layer in the form of the ATP system. This makes the task of engineering the ATO much easier than for road vehicles. But not so fast - we also have plenty of other arguments as to why this is all just too hard for railways outside of the controlled environment of self-contained metros. What about level crossings? What about trespassers? What about landslips? What about failure modes when the ATP cannot offer fully supervised protection?

Generally, the established belief has been that GoA 4 normally requires a highly segregated rail corridor, so it is not something that is typically considered outside of metro type environments. The expenses of full grade separation, fencing, security and platform screen doors etc. was never going to be economical on larger railways with many more kilometres of rail corridor to control that a typical metro.

"Rio Tinto has proved that driverless trains can exist outside the city environment"

Although Rio Tinto has proved that driverless trains can exist outside the city environment, their application is relatively unique, with most of the railway travelling through a desert type environment, with very few people in it and a huge development budget that just isn't available to most railways.

What about home-brew GoA 4?

As mentioned earlier, research projects such as Shift2Rail GoA 3/GoA 4 are attempting to create standards for driverless main line operation. These projects still have years to run and afterwards the standards/solutions proposed will need to be adopted by suppliers and turned into products. The evolution timeline of the existing Level 1 and

Rio Tinto Zinc's Autohaul operation has dispelled many myths about what is possible with driverless operation.
Photo Rio Tinto.

Level 2 ETCS standards provide a likely indication of how long it will take for these solutions to gestate and become mainstream.

So should railways wait until a standardised solution is available, or should more railways be following in the footsteps of Rio Tino with an AutoHaul™ like solution of their own creation (with suitable technology partners)?

Arguably railways and suppliers already have access to all the technology needed to make driverless trains a possibility for normal heavy rail operations. The problem is not so much one of expensive product development but more of integrating together various systems and technologies that are already available to create a self-driving solution.

"ETCS Level 2 with GoA 2 solutions are effectively available 'off the shelf' now"

ETCS Level 2 with GoA 2 ATO solutions are effectively available 'off the shelf' now. This as a foundation building block will deliver a system with a comprehensive ATP system that will automatically drive the train after the driver starts the ATO as long as a full supervision movement authority is given (and continues to be extended) by the ETCS system. However, GoA 2systems still need a driver, some of the driver's key responsibilities would be:

- Start of mission activities and enabling ATO, dealing with failure mode scenarios and permissive (on sight) movement authorities.
- Look out for obstructions on the track ahead and at level crossings.
- Monitor the train for faults.
- And many others such as managing safe station stops for passenger trains.

Let us look at some of these sample tasks and consider if solutions already exist that would allow us to automate these tasks?

Start of mission and driving in permissive modes

For start of mission, some ETCS Level 2 solutions now allow trains to start directly in Full Supervision if their position is known, and the interlocking/Radio Block Centre can prove that there cannot be another train between them and the next clear train detection section. Thus, to automate or remote control the pressing of the ATO start buttons via a remote radio link from a controlling Traffic Management System or by a remote operator would be an easy task.

More challenging are scenarios where interaction with the ETCS Driver Machine Interface (DMI) is required, such as entering train data and dealing with situations where the ATP system cannot guarantee that the track ahead is clear. For such situations a high definition camera on the front of the train, remote control of the train's throttle and brakes and remote access to ETCS DMI would allow a remote operator to take over control in these scenarios. The system would need to be designed such that a small pool of qualified drivers is located in a central control room and alerted when a train needs manual intervention like this. Remote control of locomotive controls (normally for yard shunting applications) is not new technology. The integration of remote desktop technology into supplier's DMI solutions is also theoretically possible without requiring a complete redesign of their ETCS onboard solutions. Of course, there would be serious cybersecurity threats to be mitigated, but with cloud based interlockings now being available it is clear that solutions for secure safety critical communications via the internet are available and possible. The imminent rollout of 5G technology will also see a step-change in the bandwidths available for such low latency/high quality video feeds that will be required for such applications.

Obstruction detection

Railway corridors are generally fenced in most countries and it is illegal for members of the public to trespass on the rail corridor. Numerous education campaigns and signage are provided to inform the public that tracks are for trains. This is different from the roads where in most cases it is quite legitimate for pedestrians and cyclists to share the same space that autonomous cars will need to operate in. In the tragic event that a train and a car or human collide in the rail corridor, it is normally the case that the train is relatively unharmed. Even in the event that a driver does spot an obstruction ahead, there is often not the time or distance to stop before a collision. As such it could be argued that the task of obstruction detection does not need to be treated with the same level of safety criticality as some other aspects of railway automation.

With advances in computing power and more recently AI, the science of video analytics for CCTV systems has progressed greatly in recent years. Commercial off the shelf solutions are now available that can identify and track humans within a fenced area of view (e.g. the rail corridor) while being taught to ignore other objects such as animals and other trains so as to avoid false positives. [6] Such a system integrated with normal and infra-red cameras could be linked to the train's horn (and brakes for serious obstructions that don't move). With regards to proving the performance for such a system, a trial system could be fitted to a couple of trains. The horn activations by the video analytic system could be monitored over a few months and compared against the number of times the human driver identified risks and sounded the horn. If a statistical analysis demonstrated that the CCTV system identified more valid risks than a human, it is hard to argue why a system any better or more advanced would be required.

Other tools are also available to supplement such train-based obstacle detection. These include LIDAR (light detection and ranging) detection systems for proving level crossings are clear before trains can pass over them and fibre optic Distributed Acoustic Sensing systems. Such systems can use existing trackside fibre cables to listen to the sound signatures of rail corridor intruders and could be automatically linked to apply a temporary speed restriction in the area until a human operator can review video footage to confirm the line is clear again.

Fault monitoring

The driver is clearly also responsible for monitoring the myriad of systems on a modern train and taking action if faults occur. However, there is also a current industry trend to provide remote diagnostics combined with big data analysis to provide predictive maintenance solutions for trains. As these systems develop, not only will they allow this real-time fault monitoring to be done remotely for nearly all systems on the trains but they should also be able to predict faults so they can be fixed before they become a problem.

Integration

Certainly, providing all of these subsystems and integrating them, along with the modifications needed to the ETCS DMI software are not going to be cheap, but these are problems that would only need millions of dollars to solve, not billions. Again, this proves that automating rail surely is an order of magnitude easier than the equivalent problem for the road transportation industry.

Of course, this is not an exhaustive list of the additional tasks and responsibilities of a human driver. All of these tasks would need to be carefully analysed by any railway wishing to undertake full automation to make sure all scenarios are considered, and an appropriate solution is engineered to handle each situation that could occur.

Conclusion

It was never the intention of this paper to provide any answers. Rather my aim was to raise some important questions for our industry on whether driverless road vehicles present a risk and if so, are we moving quickly enough to compete against what might be coming? If this paper fosters further discussion on this topic then it has achieved its goal.

The paper has not attempted to evaluate the business cases for automating nearly all trains, this is clearly an important step that would need to be undertaken before investing our own $80bn(!) into the race to be first to be truly driverless. The benefits, especially around being able to provide passenger and freight services on demand and shorter more frequent trains without additional crewing costs are clear to see.

The good news is that the railway industry has been developing driverless technology for many decades already. Reaching full driverless for all/most rail operations is also a problem that is probably orders of magnitude easier to solve than for the equivalent solution on the roads. We are also now seeing GoA 4 solutions arrive for both metro and freight operations, albeit the latter not on a large non-bespoke, affordable scale yet. Money is being invested into research and standardising GoA 3/4 solutions that could be applied on a more generic basis. I hope I have also sown the idea that building a GoA 4 system doesn't need some kind of technological silver bullet but is maybe something that many railways could investigate developing themselves, with the help of willing suppliers and a bit of clever integration.

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What do you think?

Is automation the only way forward? Will it encourage modal shift away from road-based forms of transport? Are the environmental benefits such that we should prioritise this? Do we already have the technology we need? Or indeed is this not relevant, and should we continue to employ skilled humans to operate trains?

We'd love to hear what you think and share it with IRSE members world-wide, email **editor@irsenews.co.uk**.

About the author …

Noel has been working in the railway signalling industry for nearly 20 years. Noel has previously worked in the UK and Australia but has spent his last ten years in New Zealand. He has been involved in numerous areas of the industry including R&D of SIL4 products, signalling design, signalling testing, systems integration, project engineering and project management. He currently holds the position of engineering manager, Siemens Mobility, NZ where he manages the technical delivery of all Siemens Mobility signalling projects in the country.

Future integrated railway think tank: Accessibility

Francis How

"How can we make rail travel more user-friendly, easy to undertake, and more attractive to people who would not normally contemplate using rail as part of their end-to-end journey?"

This was the key question posed at a workshop of people from various parts of the GB rail industry (and a few from outside it) in November 2019, organised jointly by the IRSE, WSP, the Rail Delivery Group (RDG) and KPMG. It was the first of a series of open discussions aimed at identifying and developing ways in which rail travel can be made a more practicable and attractive option in Britain.

We think that an accessible railway is one which is:

- Easy to use, even for those who travel infrequently.
- Consistently good in providing an excellent travel experience.
- Integrated with other travel modes to facilitate the end-to-end journey, and
- Focused on meeting the personal journey needs of travellers.

In this article we provide more detail on what we think these characteristics mean in practical terms, we present a vision for the accessible railway, and we offer some suggestions as to how the railways in Britain can become more accessible. The report may also have some relevance for railways in other countries.

The workshops

The workshops are being organised by a team drawn from WSP, IRSE, RDG and KPMG. We have come together to stimulate debate and action in four key areas of rail's performance:

- Accessibility: How do we make rail travel user-friendly, easy to undertake and an enjoyable experience for all passengers? Note that this is quite deliberately a very broad definition of "accessibility" and is not just about providing access for people with restricted mobility.
- Dependability: How can we make rail travel more reliable, so that a disrupted journey is a very rare event?
- Affordability: How can we make the railway more viable in economic terms (for government and service providers), and be more affordable and offer better value for money for passengers?
- Sustainability: How can we provide the same or better level of service whilst reducing adverse environmental impacts?

We are tackling these themes through four workshops, focusing predominantly on passenger travel. Because the growth of freight on our railways is just as important, we are also intending to run at least one workshop that will focus exclusively on the freight perspective.

Our objective is to stimulate discussion about "what good looks like" in the four areas listed above. In particular, we are looking for ways in which information and data can be used more imaginatively and effectively in order to improve the profile and performance of railways as perceived by passengers and, most importantly, those who are "not yet passengers" – by which we mean those people who for whatever reason never use rail as a mode of transport.

Our deliberations are all undertaken in the context of the "end to end journey", which of course almost always includes other modes of transport in addition to rail. Even if the rail element of a complete journey was faultless, people might still find a journey involving rail unattractive or impracticable for a variety of reasons, including the connectivity between modes. Hence exploring how rail and other transport modes integrate effectively is a key part of our thinking.

After each workshop we will produce a report, of which this is the first. We are also considering other actions that will help to raise awareness of the opportunities for improvement, develop the ideas in more depth and, we hope, support implementation. Rather than just being a "talking shop", we want to encourage and work with rail operators, innovators and others to deliver practicable and worthwhile improvements.

We are very conscious that other organisations and groups within the rail industry are also exploring similar themes and issues. We are keen to work with them, recognising that no single group has a monopoly on good ideas. We do believe, however, that the independent and open nature of our workshops allows us to bring some alternative and useful perspectives, as well as giving a voice to those who might not otherwise be involved in tackling these issues.

Whilst rail travel is normal for many, there are others who would never contemplate using railways as part of their end-to-end journey. The think tank considered this issue and proposed ways in which rail travel could be made more practicable and attractive in Britain. *Photo Shutterstock/ Rostislav Glinsky.*

Finally, we acknowledge that, at the time of writing, the Williams Rail Review has not been published. The Williams Review was established to recommend the most appropriate organisational and commercial framework to support the delivery of the UK government's vision for the main line railway in Great Britain. Led by independent chair Keith Williams, the Rail Review's recommendations will be implemented from 2020. It has the potential to significantly impact how the national railway in Britain is governed, organised and delivered. This is to be welcomed, but it will of course take considerable time for the changes to be fully implemented, and even longer for passengers to see tangible improvements. In the meantime, there is a pressing need to tackle the challenges of accessibility, dependability, affordability and sustainability. In this context we should make clear that our thinking is intended to cover not only end-to-end journeys that make use of the national rail network, but also London Underground and other geographically specific railways.

Context

Britain's national rail network is an integral part of the country's transport ecosystem. In all 17 billion tonne-kilometres of freight were transported and 1.71 billion passenger journeys were made on the network in 2018.

Demand for rail services in Britain has more than doubled over the last 20 years, increasing faster than for any other transport mode. Despite this growth, rail still accounts for only ~9% of freight tonne kilometres and ~8% of passenger kilometres. Rail travel is also skewed; around 70% of all national rail network passenger journeys are made in London and the South-East (where ~27% of the population live); and people with higher incomes make substantially more rail trips than the rest of the population.

The environmental and health impacts of road vehicles, increasing congestion (on road as well as rail) and ever-rising customer expectations create a pressing need for rail to work more closely with other transport modes and thereby compete more effectively with the "car only" journey.

Investigations and surveys by the Rail Delivery Group, Transport for London and Transport Focus have consistently identified that rail passengers have a number of prime expectations, relating to:

- Punctuality and reliability.
- Cleanliness of train (inside).
- Help and information from staff as well as systems (particularly when a journey is disrupted).
- Over-crowding and getting a seat.
- Frequency of services.
- Safety and security.
- Travelling with luggage, bicycles, pushchairs, wheelchairs.
- Seat comfort.
- Duration of journey.
- Handling of complaints.
- Affordability and perceived value for money.

Priorities vary somewhat depending upon the type of traveller (commuter, business, leisure), but in all cases satisfying their expectations is critical for a passenger to be able to say they found their journey experience enjoyable and stress-free. Disappointingly, the surveys find that, in most of these categories, expectations are not sufficiently well met.

Significantly, in the context of accessibility (as defined in this report), the surveys do not tell us much about end-to-end journeys (surveys tend to focus predominantly on the rail portion of a journey) or why many people never travel by train at all.

Accessibility: the challenges

Our workshop identified various important issues that relate to the "accessibility" of the railway as perceived by passengers and those who do not use railways. We have grouped them together into six themes:

Travel mindset

Many people never travel by train. The railway is an alien environment for them - to the extent that when considering how to make a journey, the idea of using the train may not even occur to them. Jumping in the car is regarded as more convenient, being door to door with no modal changes. It involves less planning, is less expensive (or is perceived to be so), guarantees them a seat in a personalised environment, carries their luggage as well, and comes with a Satnav to guide them all the way from start to finish.

How can an end-to-end journey which includes a rail element compete more effectively with the apparent advantages of the car? Just as importantly, how can the industry raise awareness that in many cases there is a viable alternative to the car, and that travelling by rail is not necessarily disadvantageous (for example total cost of using a car, environmental impact, opportunity for working on the train)?

Trust in rail

For people who rarely (or never) travel by train, there is a lack of trust and confidence that if they make a journey involving a train, it will turn out as they planned, and be enjoyable and stress-free. This lack of trust is likely to be shaped by various factors, including the complexity of planning their end-to-end journey and their lack of familiarity with using the railway. Their low expectations may also be shaped by what they hear in the news about dissatisfaction with railways, the complexity of buying the right ticket, and fears of disruption to travel at weekends (when occasional travellers are most likely to make use of rail). Trust may also be undermined by previous bad experiences, which always stay in the mind longer than any number of good journeys. Bad experiences also undermine the confidence of regular rail passengers as well, of course – see "service quality" later.

How can the rail industry raise awareness of the possibility and practicability of travelling by train for part of a journey? How can we make an individual's end-to-end journey planning process one which builds confidence in rail travel, rather than undermining it? What can we do to understand better why people don't travel by train when they could?

Journey information

End-to-end journey information is not always as good as it could be, both for journey planning purposes and during the journey. Information is sometimes unclear, incomplete or contradictory, which creates uncertainty. Travellers may have to consult multiple sources of information to create a complete travel plan. People want to know whether they are likely to find a parking space at the station (and perhaps whether there will be an electric vehicle charging point available). They want better information for finding their way around stations, and for connections and modal changes that form part of their journey.

When their rail journey is disrupted, they need help and advice to be readily available, rather than having to work hard to find out what their options are and how it will affect their journey time. At their destination station they want readily available information about how to complete their journey; a map showing where the station is in relation to the town or immediate environs; directions for finding the taxi rank, the right bus, tram or metro (and the departure times); and where to find their friend, family member or business colleague who has come to collect them from the station.

How can the railway work with other transport modes and with innovators to create accurate, complete and personalised information for end-to-end journeys? How can this be made available not only to users of the internet and phone apps, but also those who are not "digital natives"? How can we equip on-train and station staff with sufficient information that they can readily and adequately respond to myriad questions from travellers?

Making the railway accessible affects every part of the experience of travelling by train, and every system that underpins network operation. That experience includes everything from planning travel to leaving the destination station. *Image Shutterstock/ Buchan.*

Interaction with railway staff is an underpinning element of customer experience, and directly affects decisions to travel by rail. That does however mean that station and train staff need continuous and accurate access to reliable information. *Photo Shutterstock/ TanaR.*

Ease of use

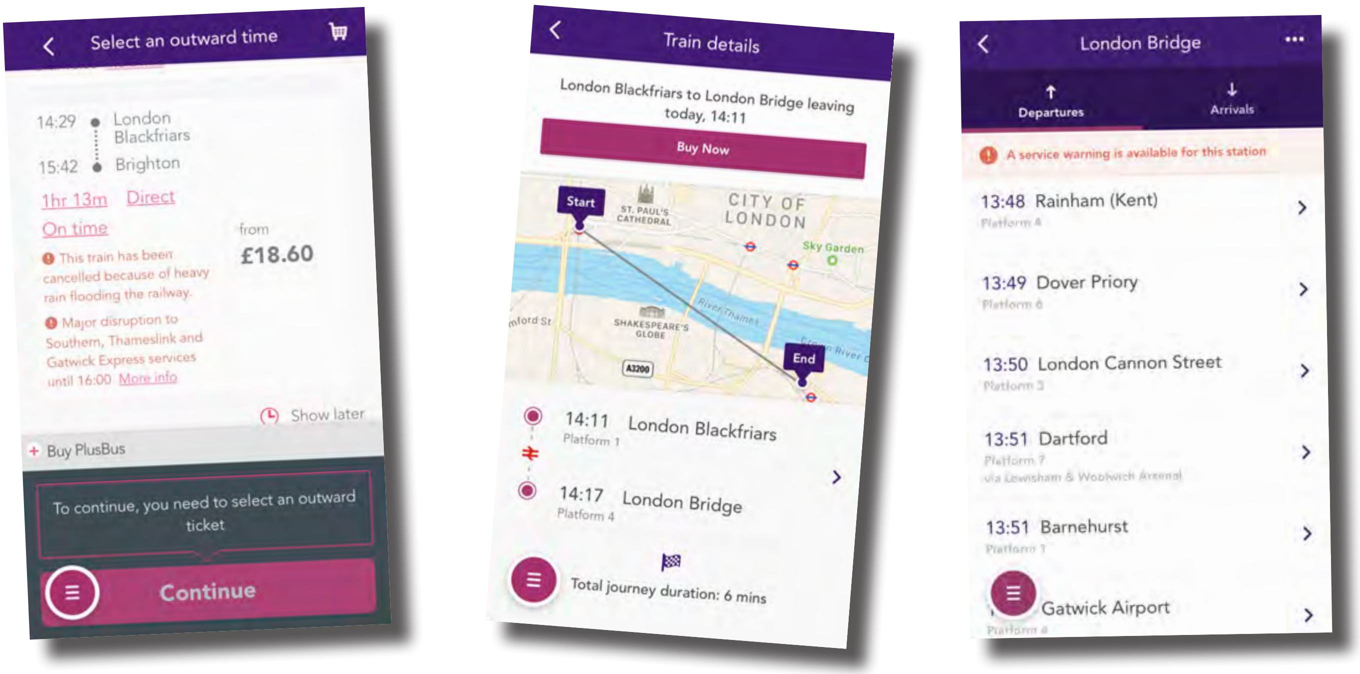
For commuters and other regular users of a particular train service, navigating the railway is not generally a major challenge. They know how to purchase the right ticket, and the restrictions on its use. They know the station layout, the platform numbering, where the lifts, escalators and stairs are. They know what shops and other facilities are at the station, should they wish to use them. They don't travel at weekends, so they aren't particularly concerned about the impact of engineering work. They know how information is presented on the platform display screens and what it means for them. They know the formation of their train, and where to stand on the platform to get the best chance of finding a seat. They don't have a suitcase, buggy or bicycle so finding storage space isn't an issue. They know how to get to the taxi rank when they arrive at their destination station. They have an unconscious mental model of the whole of their journey and how to navigate their way through it.

By contrast, infrequent rail travellers do not have this wealth of background information, and they must discover it for themselves afresh every time they make a journey. To the extent that they have a mental model of their journey, it is at best incomplete, and they may not be clear about how to fill in the gaps in their knowledge. At worst, they don't know what they don't know, and their journey is a series of trials and errors. All this creates stress and can take the pleasure out of travelling.

How can the people who design our stations, trains and the timetable, and who daily operate the railway, put themselves in the shoes of the infrequent traveller? How can this perspective be used to make the railway much more user-friendly and easily navigable for everyone? How can we make it more attractive for people to make a spontaneous decision to travel by train, requiring less planning? What can be done to reduce the impact of engineering work, to make weekend travel as straightforward and practicable as on weekdays? Do we need better strategies for addressing issues such as level access to platforms and trains, rather than introducing such improvements on an adhoc basis as and when opportunities arise? Can we provide better facilities for taking bicycles and luggage on trains? How can we make it possible for people to travel without the need for a pre-purchased ticket (physical or electronic) to get through the barriers? TfL does this already with credit and debit cards of course. Could we eventually do away with station gates/barriers completely?

Service quality

People who use railways often encounter annoying failings in the delivery of the service, and these may affect future decisions about whether to travel by train. They find that their train has been cancelled; there is a late change to the platform from which their train is scheduled to depart; they can't find someone on the station to help them; on the train, the seat reservation system isn't working; there is no buffet or at-seat trolley service when the train was advertised as having one – and passengers only discover this after they have boarded the train; toilets are locked out of use or are unhygienic/dirty; the train clearly hasn't been cleaned inside or out for some time; it isn't possible to find a vacant seat on a long journey; the onboard Wi-Fi isn't working and I need it for business purposes; belatedly I discover my train isn't going to call at my change or destination station because of "earlier disruption"; there was a garbled public address announcement at the station about delays affecting the next leg of my journey, but I couldn't understand it, it wasn't repeated and the station staff didn't seem to know about it either. The list is lengthy, and it only takes one of these events to occur for their travel experience to be regarded unsatisfactory and to stick in the mind long after the journey is completed.



Smartphone apps are increasingly sophisticated and functional and offer one way of sharing accurate information with those that need it. *Images from Thameslink app, IOS version.*

How can the rail industry raise its game and pay unremitting attention to getting the details of the passenger experience right every single day, so that instead of one in ten journeys having an unsatisfactory element, it is one in a hundred or better? How can the industry focus more effort on pleasing its customers, rather than regarding success only in terms of trains running (more or less) to time?

Enhancements and integration

For many people, of course, rail is not a practicable travel choice because to get to a station they need to travel by car, and once in the car they might as well complete the journey using it. Public transport is simply not sufficiently extensive in some parts of the country to make a difference to people's travel options. But it is increasingly clear that the car cannot continue to be such a dominant transport mode, even taking into account the beneficial aspects of electric vehicles and autonomous driving. Land take, resource utilisation, environmental and health impacts are pressurising us to consider afresh the alternatives. Rail cannot meet all transport needs, but it can be a greater part of the solution than is currently the case.

What options exist for extending the rail network and for introducing more stations on existing routes to serve more communities and towns? Where are the needs and opportunities for new bus services to link communities (including new housing developments) with railway stations? How can these be provided in an economically sustainable way, and at a sufficiently frequent service level that they provide a viable travel option? What other incentives need to be put in place to encourage people to use such services, rather than continue to use their cars? Where does the frequency of rail services need to be increased, either to cope with additional demand, or to encourage more rail travel? What partnerships need to be put in place to ensure that rail and bus services together provide an effective integrated transport offering? Is there a place for loyalty schemes and more flexible purchasing options, to encourage people to use integrated public transport networks?

A vision for a more accessible railway

Taking account of the issues raised above, we think that an accessible railway is one which:

1. Promotes its services in order to raise awareness of rail travel as an option, and advertises the cost, environmental, speed and other advantages of rail travel compared with the car.
2. Provides prominent and clear information about how to use the railway, and online tools and other forms of easy-to-understand information to enable people to plan and make their end-to-end journeys, aimed particularly at helping the non-regular rail user to feel confident about making their journey.
3. Equips its front-line personnel with a rich source of easy-to-access, accurate and timely information, and the skills, to be able to respond promptly and accurately to passengers' questions.
4. Offers an easy-to-understand fares structure, with incentives to encourage people to make greater use of rail; and makes it very easy for a traveller to decide to travel by train without planning ahead (including the option for "pay as you go" using debit/credit cards when passing through station barriers).
5. Pays unremitting attention to getting the details of the passenger experience right, day after day, so that less than one in a hundred rail journeys is regarded as unsatisfactory or disappointing.
6. Encourages and makes it easy for people with special needs to travel by rail (those with luggage, buggies, wheelchairs and bicycles, as well as people with restricted mobility).

7. Grows its service provision to give more people and communities a realistic choice of using rail as part of their journey; and works closely with other transport modes, local authorities and other organisations to integrate rail and other modes into attractive end-to-end journey offerings.
8. Adopts systematic, well thought-out strategies to improve accessibility, based on a strong understanding of the expectations and needs of its passengers, particularly those who use trains infrequently.

Some opportunities for improving accessibility

So far, we have explored a wide range of issues that are relevant to the accessibility of rail travel. We said at the outset, however, that our focus is on ways in which the better use of data and information can improve accessibility. Here are some of our ideas which make use of data and information:

a) Provide railway planners and controllers with better information about customer travel habits and experiences, to enable them to make more empathetic user-centric decisions.

b) Create a one-stop end to end journey planner in partnership with other transport undertakings; must be suitable for the infrequent traveller; aim to eliminate the need to use multiple apps or sources of information.

c) Provide a “Satnav” for the rail element of a journey, to help people do things like navigating around stations (“Street view” for stations?), finding a seat on their train easily, informing them about the progress of their train, connecting with other transport modes.

d) Make sure onward transport information is available and prominently displayed at stations.

e) Make station and on-train staff more visible, trained and equipped with systems to answer every question (they need to have more information to hand than a passenger can get on their mobile).

f) Systematically seek the views of infrequent (and “not yet”) rail travellers and use this to improve the accessibility and attractiveness of rail.

g) Develop and use information systems to routinely collect data about defects affecting the quality of service, and link these with the rail personnel who are best placed to remedy them. Make it easy for people to report problems. Monitor defect duration times to improve responsiveness.

h) Use end-to-end journey data from users to refine the service offering and connectivity between modes (offering things like end-to-end planning systems and tickets facilitates this).

i) Make more data available for innovators to use for journey applications and research. This is also a prominent feature of the GB Rail Sector Deal that was published in December 2018. The Rail Sector Deal is a partnership of the GB rail industry and UK government to transform the rail sector by increasing the use of digital technology, boosting productivity, improving the travel experience of those who use our railways, and building the skills of the UK workforce.

j) Review signage and information provision at stations to focus on the needs of the infrequent traveller. Seek the input of people who use railways infrequently.

And here are some ideas that are wider in scope, not necessarily related to data and information:

k) Reconsider the balance between weekend and weekday engineering work, so that the infrequent traveller does not face the

Accessibility doesn’t only apply in our cities. Transport poverty is a very real issue in some rural areas where frequent train services are not available, and there are limited alternatives. Windermere, shown here, benefits from more frequent services than other country lines. *Photo Shutterstock/ Kamira.*

challenge of a disjointed rail service. Routinely undertake impact and options analysis of planned engineering work to minimise the impact on travellers.

l) Make it easier for SMEs and innovators to work with rail companies; get involved in strategic thinking and action (not just solving specific problems); and make commercial returns from their contributions.

m) Simplify fares structures; offer end-to-end journey purchasing (single "ticket" for whole journey, not just the rail element).

n) Change the industry mindset to consider the end-to-end journey (not just the rail element), aiming to deliver better connectivity (rail with other modes as well as rail with rail), easier physical accessibility, improved wayfinding through stations, etc.

o) Work closely with other transport modes to improve connectivity at stations.

p) Learn from other enterprises which focus on delivering a personal experience – including the likes of Amazon which responds to customer behaviour ("Customers who bought this also looked at/purchased…").

What next? A call to action

At the UK's 2019 National Rail Conference Andrew Haines, chief executive of Network Rail, made an impassioned call to the rail industry to embrace the recommendations of the forthcoming Williams Rail Review. There will be, he said, no excuse for not acting on them.

We agree with this, and we think that just as importantly the whole rail industry (not just the national rail network) needs to grasp the challenge of making our railways more accessible and attractive to its users – the infrequent traveller as well as regular passengers.

We believe this report should be regarded as a call to action. Different companies will doubtless wish to engage in different ways, with their own priorities for improvements. But we suggest that some of the most important opportunities include:

- More SME/innovator engagement with rail operators to address the opportunities.
- Conduct research into why some people rarely/never use rail.
- Develop and use systems for routinely collecting information about, and promptly resolving, deficiencies in the quality of service that passengers experience.
- Provide better information at major stations about transferring to other modes of transport.
- Develop a Satnav for rail travellers.

Some of these will require a collective approach, rather than action by individual companies.

We are very willing and keen to contribute to these and other improvements to rail's accessibility. We also hope to develop further our thinking around some of the ideas in this report, to assist the operators and owners of Britain's railways.

Participants in the workshop were drawn from

- Rail Delivery Group
- IRSE
- WSP
- KPMG
- RSSB
- Department for Transport
- Transport for London
- Hitachi
- Leadership Champions
- University of Birmingham
- University of Leeds
- HS1
- IEEE
- Xerox

For more information

For more information about this article, and about forthcoming workshops, please contact Blane Judd (IRSE CEO) via hq@irse.org.

What do you think?

Do you agree that more needs to be done to attract people who never normally use railways? Perhaps you think this would create major additional capacity problems on parts of the railway that are already over-crowded?

Is there a particular contribution that train control and communications engineers can make to improving the accessibility of railways?

Do you have personal experience of some of the issues described?

Do the solutions and recommendations in the article seem sensible to you? What have we forgotten? Have you already implemented solutions that go some way to making the railway more accessible?

If you don't live in Great Britain, can you relate to the challenges described in your country? If rail accessibility has been improved where you live, how was this done?

Please let us know what you think – we would very much like to hear from you. Email editor@irsenews.co.uk.

About the author …

Francis has been a long-time member of the IRSE, first with British Rail/Railtrack, Atkins, as the technical director of the Railway Industry Association and chief executive of the IRSE. He was an IRSE exam Thorrowgood scholar and served on Council for many years and was president of the Institution 2012-2013.

He is widely respected for his professionalism and technical knowledge and played a vital role in drawing younger members into the running of the Institution and has encouraged and helped them develop their capabilities in both their professional and IRSE roles. He has given quiet encouragement and help build self-confidence in many of the rising engineers in the control and communications industry.

The life of an IRSE assessing agency manager

Pam Martin

I didn't set out to be an IRSE assessing agency manager. My original connection to the railway was through my husband, who was an S&T engineer in London, but also did IRSE assessments. I was working at local colleges delivering childcare and play work qualifications part-time, whilst bringing up our children. So, my husband and I were working in very different fields but related by the fact that we were both assessors and internal verifiers.

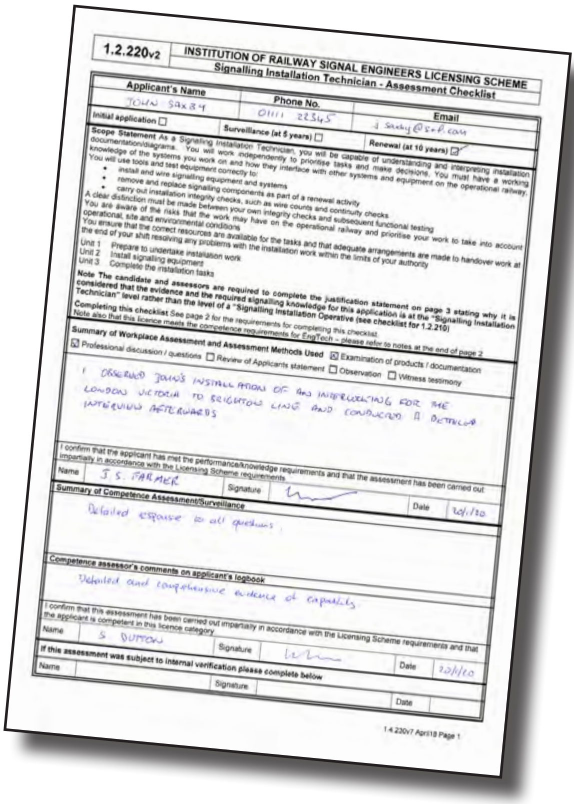
Our paths met professionally when we moved to Wales and he started a new job as an assessing agency manager. He had some new trainee assessors doing their A1 qualification and they hadn't been given the correct guidance. He asked me to come in as a one off and help them to get on the right track. I can't say I was initially enthralled by the idea as I had just left a college where I'd had to sort out a difficult situation, where a previous tutor had led candidates down the wrong path. However, as husband and wife, we are a team, therefore I agreed to go in and help him. This was when "PM Training and Assessing" was born.

Over the next few years I continued to deliver assessor training, but also expanded into internal verifier and trainer qualifications too. I was still mainly working for Carillion but also built up a few other clients.

Eventually things moved on and we reached a turning point in our business. We decided we would pool our skills and start doing IRSE Licensing. I would provide the management and non-technical skills and he would provide the technical know-how. We both had a clear understanding of qualifications and quality assurance which had been built up over the years, so we understood the importance of doing assessments to the standards set and how to try and achieve a quality provision.

The start of our agency

As with any new business it was a slow start, but it soon became apparent that the larger companies did not want to provide IRSE assessments for contractors, even though the IRSE required them to be open to doing assessments outside their company. We then started getting requests from contractors and their agencies. In this way our IRSE agency developed. As well as providing licencing to contractors, we now also provide help to the larger companies who are not able to resource their



1.2.220v2 INSTITUTION OF RAILWAY SIGNAL ENGINEERS LICENSING SCHEME
Signalling Installation Technician - Assessment Checklist

Applicant's Name	Phone No.	Email
JOHN SAXBY	01111 22345	J.Saxby@S+P.com
Initial application ☐	Surveillance (at 5 years) ☐	Renewal (at 10 years) ☑

Scope Statement As a Signalling Installation Technician, you will be capable of understanding and interpreting installation documentation/diagrams. You will work independently to prioritise tasks and make decisions. You must have a working knowledge of the systems you work on and how they interface with other systems and equipment on the operational railway. You will use tools and test equipment correctly to:

- install and wire signalling equipment and systems
- remove and replace signalling components as part of a renewal activity
- carry out installation integrity checks, such as wire counts and continuity checks

A clear distinction must be made between your own integrity checks and subsequent functional testing
You are aware of the risks that the work may have on the operational railway and prioritise your work to take into account operational, site and environmental conditions
You ensure that the correct resources are available for the tasks and that adequate arrangements are made to handover work at the end of your shift resolving any problems with the installation work within the limits of your authority

Unit 1 Prepare to undertake installation work
Unit 2 Install signalling equipment
Unit 3 Complete the installation tasks

Note The candidate and assessors are required to complete the justification statement on page 3 stating why it is considered that the evidence and the required signalling knowledge for this application is at the "Signalling Installation Technician" level rather than the level of a "Signalling Installation Operative (see checklist for 1.2.210)

Completing this checklist See page 2 for the requirements for completing this checklist.
Note also that this licence meets the competence requirements for EngTech – please refer to notes at the end of page 2

Summary of Workplace Assessment and Assessment Methods Used
☒ Professional discussion / questions ☐ Review of Applicants statement ☒ Examination of products / documentation ☐ Observation ☐ Witness testimony

I OBSERVED JOHN'S INSTALLATION OF AN INTERLOCKING FOR THE LONDON VICTORIA TO BRIGHTON LINE AND CONDUCTED A DETAILED INTERVIEW AFTERWARDS

I confirm that the applicant has met the performance/knowledge requirements and that the assessment has been carried out impartially in accordance with the Licensing Scheme requirements

Name	J.S. FARMER	Signature		Date	20/1/20

Summary of Competence Assessment/Surveillance

Detailed response to all questions.

Competence assessor's comments on applicant's logbook

Detailed and comprehensive evidence of capability

I confirm that this assessment has been carried out impartially in accordance with the Licensing Scheme requirements and that the applicant is competent in this licence category

Name	S. DUTTON	Signature		Date	20/1/20

If this assessment was subject to internal verification please complete below

Name		Signature		Date	

1.4.220v7 April18 Page 1

IRSE requirements in house. I've been encouraged by the way the assessing agency managers from the large companies are keen to work collaboratively with us. This gives the candidates a positive experience of the process.

So, what does my job involve?

Well, looking after the assessors is first and foremost. They are the people who are front line with the candidates, and they need to understand the importance of their role and implement it to the standards we expect of them. We do this by having meetings throughout the summer. I travel around so I can meet up with the assessors in different parts of the UK. Each year there are usually different aspects of assessing that we need to address to make sure everyone is working to the same standard. This year I went through the different ways in which we can use technology to help make the assessments more authentic or make the paperwork easier to deal with. One thing they didn't all realise was you can dictate your comments on to the checklist from most modern computers and tablets. Those of you who had done your own IRSE licences will know that over the years the amount of detail the IRSE requires has increased, so showing them how to dictate was of particular interest to those who are dyslexic or do one finger typing. The meetings also give the assessors the chance to meet up with each other and discuss assessments, as often the issues are the same for everyone.

Another part of looking after the assessors is to make sure they are all up to date with their approvals. Both workplace and competence assessors need to be reapproved every five years, so we use spreadsheets to track when they are running out. For competence assessors this means they have to have an interview with the IRSE every five years to show they are still competent to assess their categories. We also have to observe them regularly to make sure they are carrying out assessments appropriately. We do this by using spreadsheets to track who needs to be updated.

I also need to make sure that the assessors stay up to date with new standards and procedures the IRSE distributes. For example, this month the engineering manager standards are being reviewed so I have forwarded the proposed new standards to the assessors so they can have their input into what should or shouldn't be included in the revised standards.

When it comes to candidates, we need to ensure every candidate has a fair assessment. We therefore try and ensure that each candidate is going for the right category for the work they do. One of the challenges that we have had in the past couple of years is with the installer categories. The categories have changed from one installer category to two different levels of installer. We don't want to set anyone up to fail so we try our best to ensure that the candidate is going for the right category. Sometimes this is simple, but other times I arrange for them to talk to an installer assessor who can help them decide which is the right category for them. The candidates need to have the appropriate experience for them to go for a category.

As candidates only do their assessments every five years, a lot can change in that time, so we try and provide as much help and support as practical. The main way in which candidates struggle is understanding the criteria and writing their personal statements. The candidates who do the practical categories struggle the most, as many of them have difficulties with reading and writing such as dyslexia. We send out examples so they can see what kind of things the IRSE is looking for. Candidates also need to have an up-to-date IRSE log book. To help them with this I have provided an online presentation with videos about how to fill in each page.

In order to try and make the assessment as smooth as possible we put them in direct contact with their assessors so they can make arrangements for their assessment. This is particularly important for assessments where observation is mandatory.

Once the assessment has been completed and the assessor has written up the paperwork, it is all sent to the office. This year we have mandated that our assessors send in their paperwork electronically. This means we are reducing the amount of paper and ink that is being used. This is important to us as we have signed up to the Welsh Government's Green Growth Pledge. If everything is in place, then our office admin sends it to one of our Internal Verifiers (IQAs) to sample the assessment. If everything is in order, then my deputy sends the assessment to the IRSE. We do this electronically too so that nothing gets lost in the post. When there are problems or issues this is where I get involved, if I haven't been already, and we try and work out a solution to whatever problem has arisen.

Very occasionally we have candidates who appeal against their assessment decision. Interestingly we have never had a candidate appeal against a decision where they have been found competent. We take every care to try and make sure that candidates are going for appropriate assessments. However sometimes candidates can be found 'not yet competent' by assessors. Although it is a very rare occurrence for a candidate to appeal, we take it very seriously and I have to ensure that we follow our set down procedures. This ensures that both the candidate and the assessor have a fair hearing to put their point of view. It is never a nice situation but usually it can be resolved when a common sense approach is taken by everyone involved.

Another challenge is when we do assessments for candidates who are based abroad. The IRSE Licensing Scheme is recognised in many countries around the world and it can often be interesting and challenging getting the candidates the opportunity to do assessments. We do have some assessors who are based abroad but their location and competencies don't always match with the candidate's requirements. For some assessments we can use video conferencing for the assessment. There are rules on how these should be carried out and I need to make sure the assessor is following these rules. Sometimes, where practical assessments need to be carried out, assessors will go to the candidate to observe them. We have done this for candidates in Taiwan and Dubai in the past.

In order to keep the Assessing Agencies up to date the IRSE invites us to yearly meetings. At these they go through how things have gone in the past year and the new updates they are planning for the upcoming year. Once I get back to the office, I brief this to my assessors to make sure they have current information.

Our other annual event is our IRSE audit. Every year the IRSE auditors visit to make sure that we are implementing the scheme in the way they would like. In the weeks leading up to the audit we take the opportunity to make sure our policies and procedures are up to date and we have 'crossed all the Ts and dotted all the Is'. The audit itself is done over a day, and as we are a large agency, we have two auditors visit us. This year we had a new lead auditor who didn't know us, which was interesting as we needed to explain from scratch the way that we work, and a fresh pair of eyes see things from a different point of view. The audit is an opportunity for us to make sure that we are doing the best job we can. We are constantly looking at ways in which we can improve.

In summary

I must admit that sometimes I have been frustrated with the scheme. I would like to be able to put more help and support in for candidates, but time and resources mean that I have to be a realist and I can only do my best for both the candidates and assessors. I have a fantastic team of assessors who are committed to making sure that candidates are assessed to the right level. My staff in the office keep me sane and are a lovely team to work with.

The scheme itself is invaluable as we have a workforce that moves, not only around the UK, but around the world. It provides a benchmark for all signalling engineers and the different disciplines within, which I have not seen replicated in other areas. We are all working towards making every railway a safe railway, both for passengers and for the staff who work on it. I keep this at the forefront of my mind when implementing the IRSE scheme.

What do you think?

What's your experience of life as an IRSE license assessing agency manager, assessor, verifier or candidate? Does Pam's experience reflect what's happened to you? Perhaps you have some top tips to share? We'd love to hear from you, email us at editor@irsenews.co.uk.

Learn more about IRSE licensing at our website

Argentinian train protection system

Lázaro Javier Sartori and Matias Rocha

In 2016 the Argentine rail network began a process of signalling systems modernisation for the Metropolitan Area of Buenos Aires (AMBA) with the aim of raising the operational and safety standards.

The first stage of this process, with short-term objectives, is the implementation of an Automatic Train Stop system (ATS) which is being installed in the rolling stock and on the infrastructure linked to the existing signalling systems.

The ATS is being implemented on the eight railway lines that make up the network in the Metropolitan Area of Buenos Aires, an area that includes the Autonomous City of Buenos Aires (Argentina Capital City) and its conurbation over the Province of Buenos Aires, where more than 400 million passengers are transported annually.

The eight lines are: Belgrano Norte Railway, Belgrano Sur Railway, Roca Railway, Mitre Railway, San Martin Railway, Sarmiento Railway, Urquisa Railway and the "Tren de la Costa".

Of the aforementioned lines, only the Roca Railway had partially implemented an ATS system since the 1980s, provided by the Japanese company Nippon Signal. In 2015, following modernisation of the trains of that line, new ATS on-board equipment was installed by the same provider. In terms of AMBA this line represented only 10% of the network with any ATS protection.

It has been now been decided to expand this ATS system, not only to complete the Roca Railway, but to extend it to the remaining seven lines in order to provide 100% protection of the AMBA rail network. This choice is based on successful experience over more than 30 years, the need for interoperability and technological uniformity between the lines, the extensive knowledge and familiarity of the driving and maintenance personnel with the system and above all the flexibility which the system offers to constant changes in the layout of the network infrastructure.

This system, as its name suggests, automatically activates the brakes of a train in potentially dangerous situations, such as the passing of signals at danger or for overspeed. When a potentially hazardous situation is detected, the system activates the service brake, emergency brake or traction inhibit signal to the rolling stock as necessary.

The Nippon Signal ATS system consists of two subsystems: the wayside equipment (installed on track) and the on-board equipment. The first one is interfaced with the signalling system and the second one, installed on the rolling stock, is interfaced with the braking and traction control system. The interaction between the two subsystems equipment takes place through pre-established frequencies.

The wayside equipment is linked with every signal, and consists of a coil in the track composed of a circuit of the LC (inductor-capacitor) type that resonates at pre-established frequencies to convey the appropriate signal to the rolling stock. A relay and capacitor box is interfaced with the interlocking of each signal. Each aspect of the signal activates the relays, and the contacts of these will select various capacitors thus modifying the frequency of the coil on track, and therefore changing the information transmitted to the on-board equipment.

The on-board equipment is made up of an on-board control unit (OBCU) that compares the speed of the rolling stock obtained by two pulse generators versus the speed assigned by the wayside coil. The OBCU detects the wayside code through an on-board coil and, if the last wayside reading set a lower speed than the actual trains speed, the OBCU will send the brake application signal to the rolling stock braking system. The signal will be either be emergency brake, service brake, or traction inhibit depending on the level of overspeed. In addition, the driver has a display and operational console.

The current stage of implementation of the ATS system consists of installing the on-board equipment on 280 trains, which are composed of EMU (Electric Multiple Unit) powered by third rail or catenary, DMU (Diesel Multiple Unit) and locomotives (road switcher and double cab). The rolling stock in Argentina has three types of gauge: 1000mm, 1435mm and 1676mm.

More than 1500 signals will have wayside equipment installed. In Argentina, and specifically in the AMBA, there are two types

Photos of the equipment as installed. Clockwise from top left. Coil antenna mounted to underside of train. Pulse generator on axle end. Trackside coil with cover mounted adjacent to a signal. Operation box for the driver. Close up view of the control unit. Drivers' display.

of signalling system. Those with mechanical interlockings dating from the beginning of the last century, and of British origin, and those using electrical interlockings based on railway relays of European, North American and Japanese origin, installed between 1960 and 1985.

The mechanical interlockings had semaphore signals actuated by metal wires, so conversion from mechanical to electrical signals had to be carried out first, using illuminated signals and railway relays. This provides a suitable interface with the relay box and capacitors of the ATS.

The advantage of introducing this protection system is to provide automatic backup to braking that is currently dependent on the human factor. This minimises the risk of collisions between trains by stopping them when they pass a signal at danger, and ensures that maximum speeds are respected.

As previously detailed, this is the first stage of a modernisation process for the signalling systems in Argentina and specifically Buenos Aires, which raises the safety standards in the railway operation in the short term.

The current reality in Argentina, merits a second stage with total modernisation of the signalling systems of the eight lines of the AMBA, using modern interlockings which incorporate Automatic Train Protection (ATP) technology.

The implementation of an ATP system does not mean dismantling the ATS from Nippon Signal, which may be kept as a backup system in case the future ATP system is out of service, and to provide a basic protection system for the entry of freight trains into the AMBA.

Cambrian ERTMS loss of temporary speed restrictions

Ian Mitchell

On the morning of 20 October 2017, four trains travelled over the Cambrian Coast railway in the UK while temporary speed restriction (TSR) data was not being sent to the trains by the ERTMS/ETCS Level 2 signalling system. The TSR data was not uploaded during an automated signalling computer restart the previous evening, but a display screen used by the signaller to verify the uploading of TSRs incorrectly showed the restrictions as being loaded for transmission to trains. The fault was only recognised when a train driver realised he had passed over a level crossing at excessive speed because a TSR that applied on the approach to the crossing was not displayed on his driver machine interface (DMI) and he reported this to the control centre.

No accident resulted, but this was clearly a significant wrong side failure of the first ERTMS/ETCS application in the UK and the Rail Accident Investigation Branch (RAIB) decided to launch a full investigation. It turned out to be one of the most complex investigations undertaken by RAIB since its inception and it was over two years before the full report was published on 19 December 2019. The release of the report was accompanied by a public statement from the chief inspector of rail accidents in which he challenges the industry to ensure its safety assurance process for high integrity software-based systems will prevent similar occurrences when 'Digital Railway' systems are applied on a larger scale in future. The full report can be read at irse.info/f8hoq.

How are TSRs managed in the Cambrian ERTMS system?

The Cambrian lines from Shrewsbury to Aberystwyth and Pwllheli were chosen as the pilot scheme for application of ERTMS/ETCS Level 2 to a mixed traffic railway in the UK. The contract was awarded to Ansaldo STS (now Hitachi STS) who supplied both the trackside subsystem, comprising control centre, interlocking, radio block centre (RBC), axle counters and balises, and the on-board subsystem installed in a fleet of Class 158 passenger trains and Class 97 locomotives. The system was fully commissioned in March 2011 and has operated successfully since then.

With conventional trackside signalling in the UK, permissible speeds, including TSRs, are indicated to train drivers by trackside signs and there is no automatic supervision of train speed. With ERTMS/ETCS cab signalling, TSRs are taken into account in the definition of a speed profile, which is sent by the RBC in the control centre to each train as part of its movement authority. The permissible speed is then displayed to the driver on the cab DMI, and the onboard system will intervene to apply the brakes if the train is running too fast. This is clearly a safety improvement, but it requires the RBC to have an accurate record of the current TSRs on the route.

Whereas most of the data used by the RBC is 'static' and can be configured as fixed geographic data as part of the signalling design and data preparation process, there needs to be a mechanism for a TSR to be created by operations or maintenance staff when a requirement arises, and then stored securely in the system until it is no longer required. The ERTMS/ETCS standards do not define how this is to be achieved, as it is not relevant to interoperability between track and train, but to achieve the safety target for the overall system the process needs to be at a quality level commensurate with the highest safety integrity level defined in CENELEC standards, i.e. SIL 4.

The solution adopted by Ansaldo STS (which is similar to that adopted by other ETCS suppliers) is shown in Figure 1. When a TSR is required, the necessary data is entered by a signaller through a computer server known as GEST (Poste de Gestion des Signalisations Temporaires). The GEST terminal allows the boundaries of TSRs to be defined in terms of kilometres along the route and displays them on a scaled schematic track diagram. The GEST server translates this data into the ETCS position reference system used by the RBC (a reference to the nearest balise installed on the track and the distance in metres from that balise), and forwards the processed data to be stored in the RBC memory. The GEST server also stores the data, in both formats, in an SQL (standard query language) database on hard drives of both master and backup computers (the GEST is a duplicated system).

The RBC is a SIL 4 system and so once the correct restriction data is stored in its memory, the safety target will be achieved, but as the process for applying or removing a TSR is susceptible to human error in the initial data entry or processing errors in GEST (which is a SIL 2 system), a verification process is

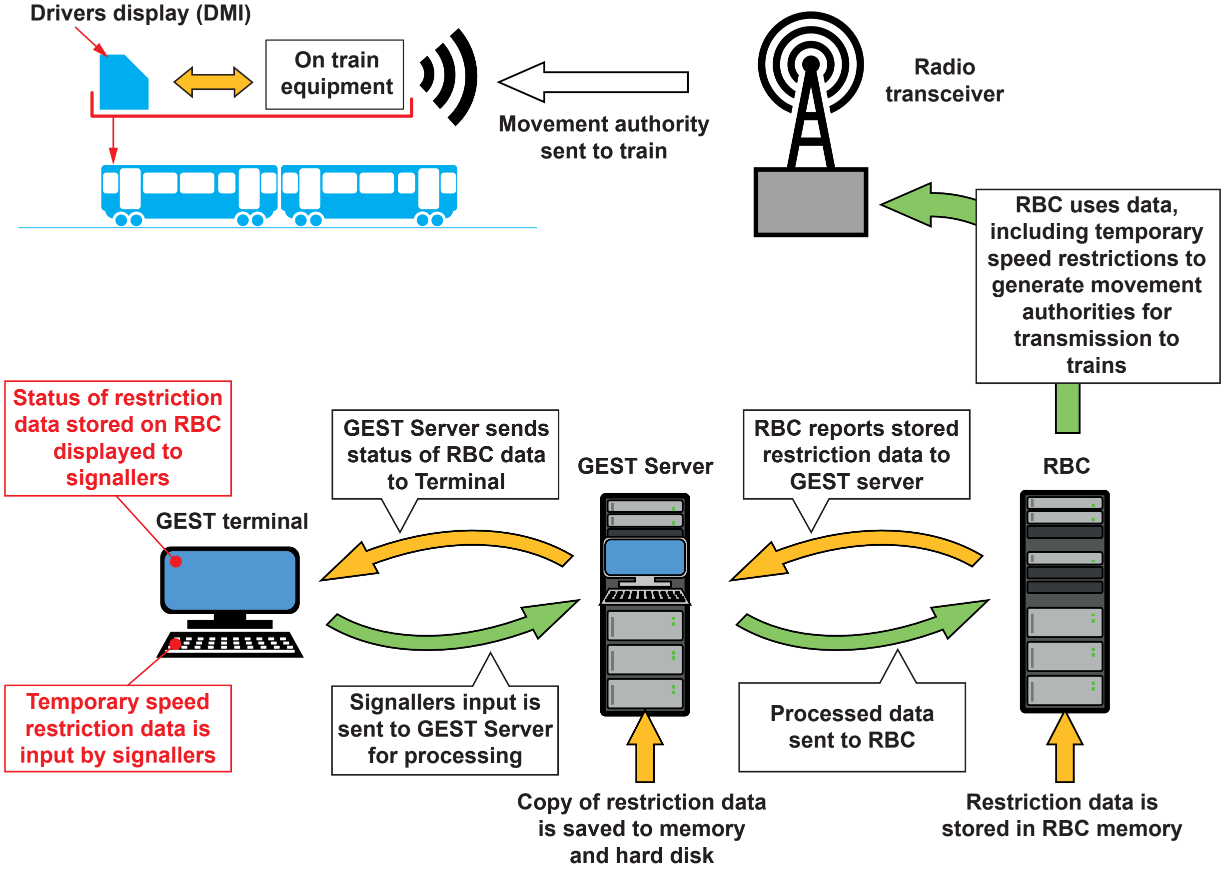


Figure 1 – Simplified arrangement of GEST and signalling control system interface.
Diagram, RAIB report Figure 6.

necessary to confirm the intended data has been stored correctly in the RBC. The RBC continuously sends status reports, including TSR data, to GEST, which then compares these with its own record of the TSRs, and displays the information on the signallers terminal highlighting any discrepancy. This then allows a second person in the control centre to verify that the TSR data has been correctly entered and stored within the system. This combination of human and computer checks is considered to be 'commensurate with SIL 4' so the overall process meets the safety target.

If the RBC loses its record of TSRs for any reason, it will request the data from GEST, and the verification process must be undertaken before any movement authorities can be issued. Signallers are required to check temporary speed restrictions have been loaded correctly on to the RBC by comparing the displayed restrictions on the GEST terminal to a printed copy of the imposed restrictions kept alongside the GEST terminal, before clicking an icon on the GEST terminal screen to unlock the RBC to resume the train service.

What went wrong?

Just after 23:00 hrs on 19 October 2017, and near the end of passenger service, an automated software reset occurred in the RBC. This automatic reset, known as a 'rollover', was triggered when equipment on board a train requested part of a movement authority it had previously released for use by another train. The RBC software was written to trigger a rollover as a safe response when movement authority conflicts, and other exceptional events, are detected. During a rollover, the RBC memory of TSRs is not preserved, and has to be refreshed from the record of TSRs stored in the GEST.

At that time, internally triggered software rollovers were occurring between 10 and 12 times each year, and the signalling staff at the control centre followed their established processes for returning to normal service, including the check of TSRs on the GEST terminal. The TSR data appeared to be correct and so they unlocked the RBC to allow normal operations to recommence.

There had in fact been a failure of one of the software processes (the 'Operation thread') within the GEST, which resulted not only in a failure to send TSR data to the RBC, but also the freezing of the display of TSR information on the GEST terminal. There was nothing on the GEST terminal to indicate that a failure had occurred, and the display was reporting the TSRs that were correctly stored in the RBC before the rollover. This misled the signallers into unlocking the RBC when it did not have a correct record of TSRs. The discrepancy was only revealed the following morning via the train driver report.

The reason for the failure was not at all obvious to the signallers and maintenance staff, but they were eventually able to restore normal operation after manual restarts of the RBC and GEST servers. Unfortunately this process resulted in a loss of some historic data recorded in the system which would have been useful in the subsequent investigation. Network Rail then put in place a process for additional verification of TSRs following a rollover, using information recorded on a data logger that is independent of the GEST. Since then Hitachi STS has implemented RBC software updates that have reduced the frequency of 'rollover' events, including eliminating the specific cause of the event in October 2017.

To support the RAIB investigation, Hitachi STS assembled a laboratory replica of the Cambrian system. Using this they were able to reproduce the incident and deduce that failure of the Operations thread was the cause. The initiating event for this is believed to be a corruption of the SQL database, but how this occurred and why remains unknown.

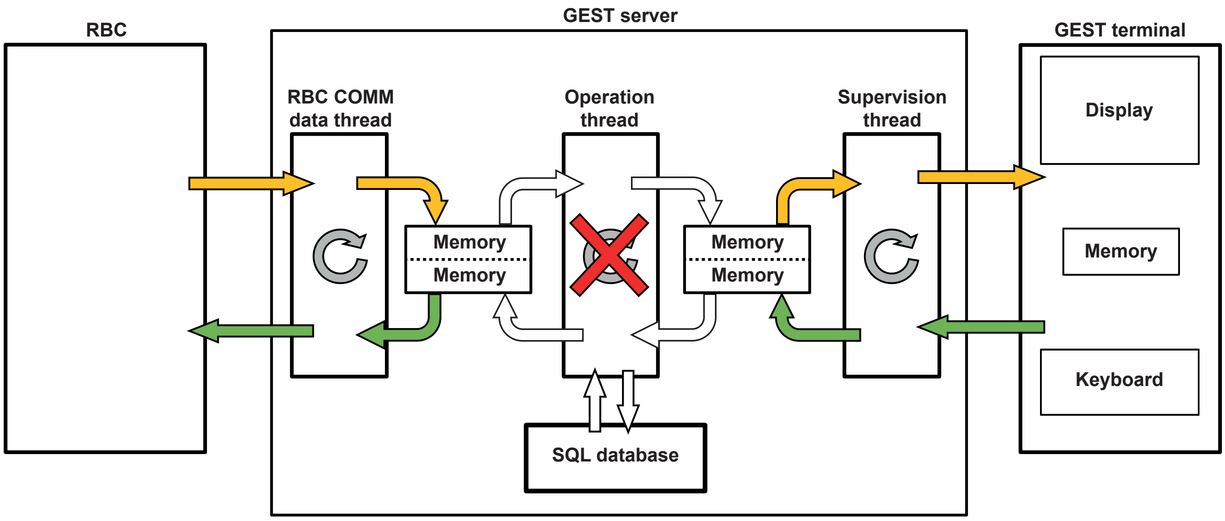


Figure 2 – Information flow between RBC and GEST broken due to stopped operation thread. *Diagram, RAIB report Figure C4*.

How could this have been prevented?

With hindsight it is clear the software architecture within the GEST server resulted in a single point of failure that invalidated the process that had been devised for verification of TSRs. Had the potential for the single failure of the Operation thread to undermine the system safety integrity been understood, it would have been possible to specify a mitigation such as diverse paths for uploading restrictions to the RBC and sending RBC feedback to the GEST terminal, or a warning when displayed data on the terminal could be invalid.

The RAIB report looks in some detail at the system assurance process for the Cambrian project to try and pick out why this issue was missed. The hazard relating to incorrect storage of TSRs was correctly identified at the overall system level and a safety requirement for GEST was specified as follows:

"The data displayed on GEST workstation shall always be consistent with the ones recorded in GEST servers and with the ones received from RBC, in order to guaranty [sic] the relevancy of these data."

What seems to have been missing was an analysis at the subsystem level looking at the software architecture within the GEST, to ensure this requirement was not invalidated by unrevealed single points of failure. As GEST is based on a commercial software and hardware platform and is "only SIL 2" it was subject to a less rigorous analysis than the safety critical SIL 4 components such as the RBC, interlocking and onboard ETCS subsystems, and received less scrutiny by the independent safety assessors and system review panels. Specifically, there was no generic product safety case produced for GEST and the safety justification relied on work being undertaken for a project in France which was delayed and commissioned after the Cambrian.

The RAIB report also identifies a missed opportunity for risk reduction by storing TSRs in non-volatile memory within the SIL 4 RBC so they are preserved during a rollover event. After the Cambrian line was commissioned, Ansaldo STS provided this capability for the RBC used in the LGV Est project in France, but this was not retro-fitted to the Cambrian RBC.

What has the RAIB recommended?

The RAIB has made five recommendations as a result of its investigation. Two of them relate specifically to the Cambrian ERTMS installation, but the other three are very generically applicable to high integrity software-based systems.

1. Network Rail, in consultation with RSSB and the wider rail industry and drawing on existing processes where appropriate, should develop and implement a mandatory safety assurance procedure (and associated guidance) for its client role on projects involving installation and modification of high integrity software-based systems.
2. Hitachi STS should take account of the findings of this report in a review, and where necessary improvement, of its current safety management processes for the design, design verification, design validation, and retention of records for high integrity software-based systems.
3. Network Rail, in consultation with RSSB and the wider railway industry, should review and, where necessary, improve the capture and dissemination of safety learning available through the reporting and systematic investigation of complex software-based system failures.
4. Network Rail, in conjunction with Hitachi STS, should implement a procedure to ensure the capture and retention of data which could prove useful for investigating any future safety related failure of ERTMS on the Cambrian lines.
5. Hitachi STS should provide a technical solution meeting the intended safety integrity level (SIL) 4 to ensure that the radio block centre (RBC) on the Cambrian lines contains correct temporary speed restriction information when restored to service after a rollover.

(This is only a summary of the recommendations – please see the RAIB report for the full text).

Reflection on the lessons learned...

Throughout the history of signal engineering, reports of accident investigations have made a major contribution to the progressive refinement of the technology and improvements in railway safety. The latest RAIB reports are a worthy continuation to this tradition – with a significant difference that in many cases today we are lucky enough to be learning from 'near misses' instead of accidents with loss of life.

The article above is a very concise summary of this particular RAIB report, and I would recommend a full reading as an essential element of continuous professional development for all IRSE members – like all RAIB reports, it is freely available to download from the UK government web site. However, as we are often reminded (thanks to Judith Ward for the CPD articles in IRSE News), reflecting on what you have learned needs to be the key outcome of any professional development activity, and I would like to end by sharing my own reflections from reading the report and writing this article.

Simon French, chief inspector of rail accidents said:

"The pilot installation of the European Rail Traffic Management System (ERTMS) on the Cambrian lines has provided valuable experience for engineers and operators of how this system might perform when it is extended to other parts of the national network in the UK. Much of this experience has been positive, but there have been some incidents which have led to disruption to services and some, including the events covered by this investigation, which were potentially dangerous.

"The lessons that have come out of this investigation are important ones for the railway industry. It is fundamental that the process of digital design is robust enough to ensure that software-based systems are of the necessary integrity. In this case, the people operating the railway did not know that there was anything amiss. Digital railways need to detect when they have failed and report this to those who need to know – in this case the signallers.

"The safety of a digital system can be difficult to assess. A system is often made up of a number of 'black boxes' which perform particular tasks. It can be hard to know how each of these boxes really works or to fully understand their potential failure modes – particularly when the box has been bought 'off-the-shelf' or imported from another application entirely. Once our black boxes have been plugged together, do we really know how they will interact with each other, and with the human operator? Digital systems don't often breakdown – safety critical failures tend to be related to the way they are designed or the way that design has been translated into a working system.

"So, assessing the safety of digital systems is often seen as 'tricky' or 'too difficult'. That doesn't mean that we shouldn't try to master the problem. Existing industry guidance helps us by breaking the problem down into distinct steps: specification; definition of requirements; design, checking and testing; and validation against the original specification and requirements.

"How does the industry know whether it has got this process of safety assurance right? Is it fit for purpose as we move into the digital age? We are recommending that the industry comes together to develop a safety assurance procedure for its role as a client for high integrity software-based systems. This will involve learning from other industries and co-operation between many different bodies. The railway industry must not shrink from the challenges that this will present, as it will be vital for establishing and maintaining public confidence in the digital railway of the future."

My first reflection may be controversial, but I have a concern that Recommendation 1 in the report and the chief inspector's public statement put too much emphasis on the need for Network Rail to develop a new mandatory safety assurance procedure. We already have a process for safety assurance defined in the Common Safety Method, CENELEC standards and RSSB Guidance, and I would prefer the emphasis to be on how the existing standards should be practically applied, particularly at the interface between systems engineering and software development, rather than on writing another standard.

On the other hand, I would strongly support the intent behind Recommendation 3, relating to the capture and dissemination of safety learning for software-based system failures. Where an issue has arisen within an individual supplier's 'black box', commercial attitudes to intellectual property are a potential obstacle to openness, but this should not be allowed to be a barrier to the sharing of generic problems and solutions. The concept of 'share with pain' briefings between signalling project teams in Network Rail and its conventional signalling suppliers has become accepted, and hopefully this mind-set can be adopted in the world of software-based systems. The IRSE has a valuable role to play in this area –see for example the article 'Delivering CBTC in Hong Kong' in the January 2020 IRSE News, which described two software related incidents which disrupted operations on the Hong Kong metro network.

So, with this in mind, my lessons learned from this incident are:

Where a safety process requires an operator to check information on a computer screen, 'liveness' of the information displayed is crucial. This applies to many of the functions of operator interfaces to signalling systems. Display of a constantly updating clock or a 'rotating baton' can provide re-assurance the screen has not frozen, but it is crucial that this takes account of all the elements in the software chain from the information source to the user interface.

The safety case for an 'intermediate SIL' system must take account of failure modes of the software architecture. In a SIL 4 system, the highest level of safety assurance is provided by multi-channel processing systems in which any failure is detected by a divergence between the channels. For less critical systems, single channel processing is the norm, so there needs to be greater reliance on self testing and exception management within the software architecture to ensure that failures are revealed.

Good communication between safety engineers and software developers is essential. Safety analysis and software development are usually undertaken in different teams, by staff with very different cultures and mindsets. The specification of safety requirements is a crucial interface, but there is always a danger of different interpretations, especially where non-functional attributes are attached to a requirement (e.g. the words 'shall always' in the example above).

'Fit and forget' is never ALARP for a software-based system. When a complex system achieves a successful commissioning, there is always commercial pressure for both supplier and client to end the project. In practice some sort of ongoing support is always required, and this should take account of developments that could allow safety improvements. In this case, when non-volatile storage of TSRs in the RBC became an option, it should have been recognised that the solution on the Cambrian was no longer reducing risk 'as low as reasonably practical'.

What do you think?

What is your take on lessons learned from this incident? Do you have ideas on how the IRSE can contribute to the capture and dissemination of safety learning for complex modern systems? Could you write an article for IRSE News summarising an accident investigation from your part of the world? Your feedback and ideas are welcome, email us at **editor@irsenews.co.uk**.

Automation of mining railways

Prepared by Tony Godber
on behalf of the IRSE International Technical Committee

For new construction and major re-equipping of urban mass transit railways, automatic operation has become the most popular mode of operation. Depending on the environment, this can range from unmanned or driverless operation (GoA 4 – no driver on the train) to some form of attended operation with staff present, who may have limited operational tasks, including driving the train in exceptional or emergency situations.

Applying unmanned automatic operation to mining railways has now been successfully demonstrated, but there are many differences (some obvious, and some not so obvious) compared to operating a rapid transit or metro system. While the core principles of controlling and supervising an automated rail system are similar, these differences must be addressed when considering automation.

Assumptions

In this paper, a number of assumptions are made about the nature of a mining railway. A mining railway infrastructure is a self-contained route or network. While some ancillary traffic may be carried, the conveyance of minerals from a mine to a port or a processing facility is the reason for the railway's existence and the predominant traffic. All mineral trains are unit trains. Remarshalling en-route is not required and trains are only divided or reformed infrequently to facilitate servicing, loading or unloading. Vehicle mass, train mass and axle loads are high. This permits efficient transport of a bulk product. This generally requires the use of high-powered diesel-electric or electric locomotives and most loading and unloading is automated.

Typical characteristics of a mining railway

In its simplest form, a mining railway will operate from a mine to a port. Loaded trains operate in one direction and empty trains in the opposite direction. Most of the following characteristics will therefore apply:

- Long trains – typically 1-3km.
- High axle loads for loaded trains (and therefore a major difference in train mass between empty and loaded trains).
- High overall power but low power to weight ratio – track profile provides for "easy" gradients against loaded trains (typically well under 1%).
- Depending on train mass and length it may be necessary to use distributed power to limit longitudinal forces within the train.
- Many mining railways operate in remote areas of low population. Thus, the rail corridor is often not secured against natural intruders (animals) or unauthorised access.
- Unlike automated metros, road level crossings may still be present.
- Much equipment is operated close to the limits of its design (wheels, brakes, suspension, draw gear, bearings).
- Most control system intelligence and processing power is concentrated at the control centre and on locomotives – rolling stock is mostly "dumb". Therefore, monitoring the health of vehicles is predominantly performed from the infrastructure.
- Due to the high consequences (asset loss/damage and production loss) of derailments and major failures, significant real time asset monitoring is conducted (e.g. wheels, bearings, dragging equipment, rock fall, flood, broken rails).
- While high density operation may require dual track, the network is likely to include large portions of single track with passing loops.
- Maintenance demand for access to track is much higher than for passenger railways. This will encompass inspection, repair and renewal. Conversely, maintenance opportunities do not arise to the same regular patterns as passenger railways – so maintenance and production have to be planned in a more integrated manner. Alignment of major works with maintenance of the non-rail upstream and downstream production (e.g. mines/ports) is desirable.
- Both technical and procedural processes for maintenance access to track should minimise time to mobilise and demobilise and maximise available work time. Signalling should minimise need to operate in degraded modes (e.g. by including full bidirectional signalling on dual track sections).

Reassignment of tasks for automation

When considering the automation of a mining railway, all tasks associated with the railway's operation must be considered. They may be automated, eliminated, modified, re-assigned

A loaded ore train in fairly typical Pilbara landscape. Mining railways have unique challenges, but also represent an opportunity for automation and realising the benefits it can bring.
Photo © Rio Tinto.

or remain unchanged. It is therefore important to understand fully what all existing systems and people currently do, and the functioning of the interfaces between them.

Redesign for automation will then need to ensure all tasks are correctly assigned and resourced, as well as meeting RAMS (Reliability, Availability, Maintainability and Safety) requirements.

Basic automated operation

Operating functions for an automated mining railway will broadly remain the same as a conventional railway. However, many human inputs will be replaced by system inputs. Required functions will include a means of controlling, supervising and monitoring the rail network, together with controlling the passage of each train to ensure safe separation (a signalling system). A train protection system to guard against exceeding permitted speed, limits of authority and unintended movement with driving each train within its safe operating parameters will also be required. Monitoring the health of each train, with appropriate interventions if needed will contribute to efficiency.

Controlling the network

A control centre, similar to that for a conventional railway is still needed. However, this will undertake some monitoring functions previously performed by drivers. Delivering the required data from trains and infrastructure in a timely manner is critical to this task.

Various models for task assignment within the control centre are possible and will depend on the individual operator's operating model. This includes a person responsible for everything that happens within a defined territory (trains and infrastructure, including maintenance activity), and individuals to manage trains and infrastructure separately, together with managing normal operations and exceptions (faults/incidents) separately.

Signalling system

The signalling system need not be significantly different to that of a conventional railway. It is important that movement authority updates can be received by the train promptly, for example when monitoring of train or infrastructure indicates a critical fault that requires the train to be stopped. Long stretches of track without communications to the train will probably not be tolerable. Thus, intermittent transmission (such as provided by ETCS level 1) may not be acceptable.

Train detection must be continuous over all territory to be automated but can be track based or train based. If a train-based train detection system is to be used, this must include confirmation of train length and train integrity to an appropriate safety integrity level (SIL). As mineral train configurations and systems are very different to passenger trains, there is currently no technology that is directly transferable. Electronically controlled braking systems (if used) will employ a trainline and an end of train marker. There is potential for these to contribute to the train integrity function, but there is no ready-made product currently available. Determining the position (and any uncertainty) of the rear of the train would generally need to be to SIL 4, but with standard length trains and an effective means of checking that the train is continuous from front to rear, there may be an opportunity to simplify requirements. If impacts on capacity can be tolerated, a default maximum train length could be assumed.

An existing railway may have discrete interlocking systems in the field at many sites. However, automation usually requires a centralised system to manage movement authorities for all trains (e.g. the Radio Block Centre in an ETCS level 2 system). This creates an opportunity to centralise interlocking functions alongside the movement authority server(s) or even integrate them into a single system. However, field interlocking systems can be retained, provided that a high integrity data transmission system regularly updates field data to the movement authority servers.

To provide for manned operation when needed, movement authority information must be displayed in the locomotive when in any manual mode.

Train protection

With an automated railway, comprehensive automatic train protection (ATP) is essential. This must protect against exceeding permitted speed (including all temporary speed restrictions as well as train and infrastructure limits), exceeding limit of movement authority and unintended movement or rollaway.

With long and heavy trains, it is desirable that any ATP intervention brings the train to a complete stop before recovery to normal operation. Drawgear forces within the train can be large and complex, therefore it is undesirable to recover from an ATP intervention on the move.

While the ATP system may utilise the same brake interfaces that are used for normal train driving, these are usually designed for efficiency and speed of operation, rather than to specific safety integrity targets. Therefore, a high integrity or fail-safe brake interface (e.g. a brake valve held closed by the ATP system that directly exhausts the train brake pipe) is highly desirable as the last resort for bringing a train to a stand.

Directly exhausting the air brake from the leading locomotive inherently has a longer delay in application than a trainline based system such as electronically controlled pneumatic brakes (ECP). This more conservative braking curve may have some capacity implications.

As with passenger trains, only the leading "cab" needs to have an operational ATP system. Power and brake settings for locomotives operating in multiple will be controlled by the trainline connection between directly coupled locomotives and the distributed power control system for any remote locomotive sets.

Driving the train

A system to replicate the driver's actions to drive the train is the primary additional system required for automatic operation. Unlike passenger trains, which may have traction motors evenly distributed along the train, heavy mineral trains will have high powered locomotives at the head of the train and perhaps mid-train and rear locomotives as well.

Drawgear forces for traction and dynamic braking are high and can change rapidly with gradient changes and transition between power and braking. The automated driving system must therefore be designed to contain the longitudinal forces within safe limits. Failure to do so can lead to derailment and/or drawgear damage and divided trains.

There are driver advisory systems (DAS) on the market. However, some of these may be unsuitable for development for unattended train operation. They may be focused on optimising fuel economy or achieving a specific arrival time, rather than managing longitudinal forces in the train. Nevertheless, these objectives may still be important factors for a mining railway. Because they are designed to assist rather than replace a driver, they may not adequately cover the initial and final stages of starting from rest and stopping, or other exceptional circumstances.

The automated driving system will need to know the detailed topography of the rail network. This will either need to be held in a database on board the train or dynamically updated as the train travels. In either case, there must also be a process for updating the data and maintaining its overall integrity when infrastructure changes are made.

Monitoring the train

While a driver's main task is driving a train, it is also important to monitor the health of the locomotives and braking system. Therefore, all information that the driver normally has access to in the cab must be gathered and transmitted to the control centre. This is a significant part of the overall system; most locomotives will not be designed to provide this comprehensive level of remote monitoring.

While the trains may be unattended in normal operation, there will usually be a need for field personnel to attend a train if a fault or alarm cannot be dealt with remotely. The number and location of field personnel will be determined by the response time expectation if a train has to be stopped.

There are various situations that could require a train to be stopped. This may occur through an ATP intervention to address overspeed, movement authority protection or unintended movement, another safety system intervention to protect the train, or controller intervention to stop an individual train or all trains in an area immediately or at specified locations.

Selection of the stopping location may also need to consider safe access to the track for personnel to board the locomotive(s) or to inspect the train.

Telecommunications

Systems commonly used on passenger railways often have their mandated or preferred telecommunications technologies (e.g. GSM-R for ERTMS and LTE/Wi-Fi derivatives for CBTC). These are generally implemented in an urban environment where suitable supporting infrastructure (high capacity digital transmission, equipment buildings, power supplies, towers) are readily accessible. In remote areas with little urban infrastructure, even some public mobile telephone services have large areas with no service.

Generally wireless systems for communication to the trains will need to operate at lower frequencies (e.g. VHF or UHF bands) to maximise coverage from each radio base station.

As with all communications technology these days, cyber security is a major consideration. Precautions will not differ from those of conventional railways, but the consequences of a security breach may be very different to those of a passenger railway. For example, while the deliberate and malicious derailment or collision of passenger trains may put large numbers of lives at risk, the major concerns for unmanned freight trains would be the value of the assets and the disruption to production.

Other considerations

Track maintenance activities

While authorising and providing protection for maintenance activities on track will follow the same principles as a conventional railway operation, obviously there must not be any

Road crossings pose a particular challenge for automated railways. In this Pilbara example, the white box in the right hand corner is one of the two obstruction detection scanners. On the far side is the mast with CCTV camera and crossing illumination.
Photo © Tony Godber.

reliance on a driver sounding the train horn on the approach to work groups. If it is necessary for work to be carried out on 'live' tracks and such an audible warning is still considered desirable, alternative systems must be provided to initiate it at the required location when the train approaches a work site.

Level crossings

If level crossings are fully enclosed and interlocked with signals, no special provisions should be necessary for unmanned trains other than to comply with any existing requirements for sounding the train horn.

However, for efficiency of operation, automatic crossings may predominate in areas of low population. Using predictor technology can provide consistency of warning times and minimise delay to road traffic.

For automatic crossings, additional detection is desirable to detect vehicles, road users or other obstacles that are present within the crossing boundaries (i.e. stopped on the crossing) when the crossing is not activated. The detection system must be able to filter out normal vehicle and pedestrian activity. Vehicles and persons intruding into the crossing boundaries after the crossing has been activated by a train must also be detected and the detection system must filter out train movements.

While it may not be possible to stop a train short of the crossing if an intrusion occurs, the speed of impact from a train will be reduced and an appropriate response initiated.

Real time video monitoring of each crossing will enable controllers to assess alarms (and override them when appropriate) as well as providing evidence to assist incident investigations.

Actual train movements can be used to confirm continuing correct operation of the obstacle detection system.

Collision detection

Where the rail corridor boundary is not secured, collision detection on the leading locomotive is desirable. Combined with the collection of forward-facing images, a collision alarm can be checked to determine whether it is desirable to inspect the train for damage.

Infrastructure monitoring

Drivers can be a very useful presence to report extreme weather conditions (e.g. flooding), bush fires and trespassers. On the driverless railway, field personnel along the rail corridor will need to perform these activities instead.

Track irregularities may often be reported initially by drivers on a conventional railway. On the driverless railway, the frequency of track monitoring may need to be re-assessed.

Interfaces to manned operation

Automated systems are excellent for repetitive tasks such as main line driving of trains or low speed loading. However, they cannot be expected to deal with every eventuality. The system will need to be designed with the following circumstances in mind.

Setting up and starting an automated journey

As well as the technical requirements, the infrastructure at terminal locations must also be designed for safe access. After setup is complete, staff must be able to leave the locomotive safely and confirm that they are clear of the train. Commencement of journey can then be initiated from the control room.

Needing to board an automated train to deal with a defect or incident

There must be a means of securing the train and indicating that it is safe to access it, and of resetting for automated operation once the problem is resolved and staff are clear, and at the end of an automated journey, permitting a driver to safely board and revert to manned operation.

Fault response and Grade of Automation

Automation does not eliminate all staff. Personnel are still required to attend to faults and incidents and in some cases they may need to drive the train manually. Unless the number of response personnel is significantly less than the drivers displaced then some form of attended automatic operation (GoA 2 or 3) may be a better option as this keeps the response personnel on the trains. It therefore follows that there is a certain minimum capacity of a railway at which full driverless operation becomes viable.

Other benefits

While automation is usually viewed as a means of improving capacity or productivity and reducing variability, there are other benefits of particular relevance in a mining railway environment, such as eliminating the need to change train crews at remote locations. As well as the unproductive time involved in getting drivers to and from changeover points, the time and fuel consumed in stopping and restarting heavy trains are saved and risks associated with driving road vehicles are also reduced. In addition, the skills required to drive heavy freight trains may take several months to acquire to an acceptable level and years to perfect. With automation, the lead time required to train new drivers to take account of growth and staff turnover is no longer a constraint on capacity.

Conclusion

Overall, the core systems for operating a mining railway automatically do not differ markedly from passenger railways. However, the type of trains and the environment demand significantly different treatment in certain aspects.

None of these issues are insurmountable and we now have a working example of successful implementation in Rio Tinto's AutoHaul® project in the Pilbara region of Western Australia.

This paper does not claim to be an exhaustive summary of all possible issues, nor does it try to predict the future direction of the technologies already in use, or guess what additional technologies may be added. But it seems reasonable to expect that other mining operations will consider automation for their future rail operations, and in doing so they will need to take into account the issues addressed in this paper.

About the author …

Tony is principal signalling and operations in Rio Tinto Iron Ore's rail technology and studies department. He is based in Dampier, Western Australia. His current role focuses on technology development and strategy for the Rio Tinto Pilbara rail network.

Tony's career spans over 45 years in the signalling industry, commencing as a graduate with British Rail in the UK. He undertook a range of consultancy work with Transmark, as a senior consultant and British Rail Research as their standards engineer. He moved to Hamersley Iron, now part of Rio Tinto, to support the introduction of its Integrated Control Signalling System (ICSS) with in-cab signalling and ATP on their in-house iron ore rail network. He has since worked in engineering, operations and maintenance roles for Rio Tinto.

Industry news

Main line and freight

Network Rail signalling contracts

UK: Network Rail has awarded five major signalling framework contracts – worth an estimated £2.4bn (€2.8bn, $3.1bn) over Control Period 6 (2019-2024), and up to £3.6bn (€4.2bn , $4.6bn) including options to extend for the first two years of Control Period 7 (2024-2026). The frameworks are split into five geographical areas.

- Southern region and Eastern region – Alstom.
- Scotland region and North West & Central region – Siemens Mobility.
- Wales & Western region – A joint venture between Hitachi Rail STS UK and Linbrooke Services.

The major signalling contracts sit alongside contracts awarded last year for telecoms and minor signalling frameworks. This will now allow signalling and telecoms works of all size and complexity to be carried out by original equipment suppliers, system integrators and small/medium signalling and telecoms contractors.

The telecoms and minor signalling frameworks consist of contracts, to 34 suppliers, to deliver design services, worth an estimated £400m (€468m, $521m) for Control Period 6 (2019-2024) and up to £640m (€749, $833m) including options to extend the contracts into Control Period 7 (2024-2029).

The Design Services Framework (DSF) consists of four multi-discipline frameworks and 78 single-discipline frameworks. The details of the suppliers and contracts can be found at **irse.info/6ez7y**. The framework contracts went live on 1 January 2020.

The contracts are in addition to the six framework contracts announced in April 2019 to deliver signalling and telecoms, worth an estimated £750m for Control Period 6 (2019-2024). See **irse.info/mn39k**.

Canadian National meets US PTC deadline

USA: Canadian National CN says that it has met the federal requirement to roll out Positive Train Control on 35 of its US subdivisions, 13 months ahead of the December 2020 deadline. This now provides interoperability with Amtrak, CSX, NS, BNSF, CP and WSOR, and CN expects full interoperability with all tenant railways by 31 December 2020.

Portuguese signalling contract award

Portugal: Infraestruturas de Portugal, a state-owned company who manages the Portuguese rail and road infrastructure, has awarded a contract to Thales Portugal and Portuguese electric utility company SISINT for control-command systems. The project is part of Portugal's 2020 rail plan, which aims to increase rail safety. The new systems are also expected to enhance road safety with the integration and automation of level crossings.

The contract worth more than €40m (£34m, $45m) includes the design and maintenance of the system in the Caíde-Marco section of Douro Line, Aveiro-Vilar Formoso Railway Link in the Atlantic Corridor and Évora-Elvas-Caia section on the Sines/Elvas Rail Link. The scope includes installation and maintenance of ETCS and signalling systems on different sections of the National Railway Network (RFN).

Ireland's five-year programme rail investment

Ireland: The transport minister has announced a new €1bn (£855m, $1.1bn), five-year programme of investment in rail infrastructure for Iarnród Éireann. This is an increase of 40% on the previous investment programme, and will be used for track relaying, signalling improvements and safety related initiatives.

The budget is through the Infrastructure Manager Multi-Annual Contract, or IMMAC, provided by the minister for transport Shane Ross and national rail operator Iarnród Éireann. The funding will cover 2020 to 2024.

The network currently extends to approximately 2400km of operational track, 4440 bridges, 1,100 point ends, 970 level crossings, 144 stations, over 3300 cuttings and embankments, 372 platforms and 13 tunnels. The network includes main line, Dublin suburban and commuter passenger routes, together with freight-only routes.

The IMMAC investment programme is separate to funding provided for other rail related projects such as the recently approved National Train Control Centre and the expansion of the Greater Dublin Area Commuter Rail Fleet.

China opens world's first automated high-speed line

China: The 174km Beijing North-Zhangjiakou line opened on 30 December 2019 and claims to be the world's first automated high-speed railway. The line has eight stations including Badaling Great Wall and Xiahuayuan North, where the 52.2km Chongli high-speed line branches off to serve the Olympic Village in Prince Edward City.

The journey time between the two cities will be cut from 3h 7min to 47 minutes with a maximum speed of 350km/h. The Chongli branch has a top speed of 250km/h with a Beijing-Prince Edward City journey time of 53 minutes. The route will operate 36 round trips per day on the two new lines plus six daily round trips in peak hours. China now has the longest high-speed railway network in the world, with a total of 32 200km high speed lines.

Train collision at Neville Hill

UK: At about 21:40 hrs on Wednesday 13 November 2019, an empty passenger train approaching the maintenance depot at Neville Hill in Leeds, caught up and collided with the rear of another empty passenger train moving into the depot on the same track. The low speed movement of trains close together is permitted by the signalling system at this location. The leading train was travelling at around 5mph (8km/h) and the colliding train at around 14mph (22km/h). No one was injured in the accident.

The colliding train was a nine-coach class 800 train, part of the Intercity Express Programme (IEP). Its front end suffered significant damage during the collision. The leading train was a High Speed Train (HST) set comprising nine coaches and a class 43 locomotive at each end. The trailing class 43 locomotive on this train also suffered significant damage.

As a result of the collision, the trailing bogie of the second and third coaches and the trailing axle of the fourth coach on the class 800 train derailed to the right in the direction of travel. The investigation will consider: the actions, training and competence of the staff involved, the design and validation of the class 800 train – including cab ergonomics, its crashworthiness performance and its resistance to derailment in collision scenarios, and any underlying factors.

The investigation by the UK Rail Accident Investigation Branch is independent of any investigation by the railway industry and the Office of Rail and Road; the UK safety regulator.

Hitachi Rail STS LGV+ Paris-Lyon project

France: Hitachi Rail STS is to modernise the SNCF Réseau LGV+ Paris-Lyon route, via a €129m (£109m, $144m) contract. The project covers 634km, including 550km of high-speed rail with 80km of connections.

Around 240 trains run the Paris-Lyon high-speed daily, making it one of the busiest high-speed lines in Europe. The upgrade will provide an additional one to three trains during peak hours and improve reliability.

Hitachi Rail STS will be responsible for providing its Computer-Based Interlocking technology (CBI) with France's bespoke automatic train protection (ATP) system and make equipment compatible with ERTMS standards. Routes connecting Paris to Strasbourg, Bordeaux and Rennes will use the upgraded equipment.

Plum Railway returns

Czech Republic: Regular passenger services have returned to the "Plum Railway" in the Ústí nad Labem region after AŽD Praha restoreed services on the Litoměřice horní nádraží – line U10.

Trains had been withdrawn in 2007 due to the poor condition of the infrastructure along the 38km line. The railway was purchased by AŽD in 2016 for use as a testbed for its signalling systems. The company has restored the line to operational condition at a cost of around KC100m (£3m, €4m, $4m), repairing the earthworks, drainage and renewing the track with new signalling to increase the line speed to 100km/h.

In co-operation with the Ústí region, AŽD initially began operating a weekend tourist service from Lovosice to Most but has now been awarded a contract to reinstate daily services. The company is operating 11 trains each way between Litoměřice and Most, serving 14 intermediate stops, plus another seven short workings between Litoměřice and Třebívlice. A spokesperson said that the abandoned line has been transformed into one of the most modern regional railways in Europe in less than three years.

AŽD equipped the branch with its StationSWing ESA-44 electronic interlockings, TrainSWing RBA-10 Radio Block Centre and GSM-R, providing ETCS Level 2 to Baseline 3 standards, with the signalling allowing for testing of ATO over ETCS to the latest UNISIG and Shift2Rail specifications. AŽD expects to begin trials with autonomous trains during 2020 and up to GoA 4 without drivers.

Other signalling systems installed for demonstration purposes on the Čížkovice – Obrnice section include the company's GateSwing PZZ-J level crossings with electronic controls, LED warning lights and telescopic barriers made from aluminium or composite materials. AŽD is also trialling its prototype FieldSWing SNA-100 signals for speeds above 160km/h, various types of point machines and an optic fibre sensing system to detect rail breaks. Selected level crossings will be equipped with a transmitter communicating with road vehicles in line with the emerging C-Roads specifications.

AŽD has also been testing the use of drones for remote monitoring and the detection of failures, including the visual identification of defects and rail breaks and say that subject to legislative approval, the technology is now ready for commercial use.

Dutch ATO testing

Netherlands: The first trials of Automatic Train Operation (ATO) took place on the Hanzelijn between Lelystad and Zwolle in the Netherlands using a modified New Generation Sprinter (SNG) EMU in late 2019.

While the intention is for the ATO system to operate the train, a train driver will supervise the automatic operation and intervene if required, as the first trials are planned without passengers on board.

The Dutch rail network is operating almost at full capacity and traffic is still increasing, so automatic operation is planned to help to increase capacity with shorter headways between trains and allowing more trains.

Dutch infrastructure manager Prorail and freight operator Rotterdam Rail Feeding have already conducted ATO tests at Grade of Automation (GoA) Level 2 on the Betuweroute freight-only line, using a type V100 diesel locomotive equipped with ETCS Level 2. Arriva Nederland, in cooperation with Prorail, carried out ATO tests in the northeast of the country on the Groningen-Roodeschool line.

Vectron Locomotive ETCS Baseline 3 approval

Germany: Federal Railway Authority (EBA) has approved the Vectron locomotive for operating in Germany with ETCS Baseline 3. Approval for Sweden has already been received with approval in additional countries to follow.

Compared to ETCS Baseline 2, which is currently used in most countries, ETCS Baseline 3 has many new features, including a universal braking curve model. This will simplify the deployment of an ETCS on-board equipment throughout Europe.

City railways and light rail

Beijing – world's longest metro

China: Beijing metro has opened two extensions to make the total network length 699.3km with 405 stations, including 62 interchanges. It is now the world's largest metro network.

Operated by eight-car Type B trainsets, the eastern extension of Line 7 now runs 16.6km from Jiaohuachang to Huazhuang and Huanqiu Dujiaqu, with nine additional stations and serves the Universal Studios Resort. The last two stations are also served by the Batong Line, which has been extended 4.5km south from Tuqiao to Huanqiu Dujiaqu.

Taoyuan Airport rail link

Taiwan: Siemens Mobility has received a contract for the delivery of signalling and communications systems to Taoyuan Airport rail link in Taiwan.

Alongside its fellow members, ST Engineering and BES Engineering Corporation, the consortium will supply systems to service two new stations at terminal three of Taoyuan Airport. The consortium is responsible for the signalling system including CBTC with ATO. The signalling system will be installed in two stations and 20 trains, with a provision for installing the system in a third station.

The first station will be commissioned in 2022 and the second in June 2024. ST Engineering will provide smart rail electronics solutions such as SCADA, platform screen doors, a maintenance management system and integrated communication system. BES Engineering will provide the power system.

Last year, the city of Taoyuan awarded a metro rail contract to a consortium of Siemens Mobility, Hyundai Rotem and BES Engineering. Siemens Mobility is responsible for delivering its Trainguard MT CBTC system, traction drives for the trains and the direct-current (DC) traction power supply.

CBTC for BART

USA: Hitachi Rail STS USA has been awarded a $798m(£613m, €717m) contract to provide CBTC on the San Francisco Bay Area's BART metro, along with improvements to passenger connectivity. CBTC is one of a number of elements of the $3.5bn (£2.7bn, €3.2bn) Transbay Corridor Core Capacity Project, which also includes more carriages, a maintenance facility and new substations. In addition, Hitachi Rail has been awarded contracts worth $82m (£63m, €74m) to supply CBTC for the Silicon Valley Extension.

BART are also working with Mobilitie to improve mobile phone connectivity and provide seamless Wi-fi at stations within four years and on trains within five years. This will enable mobile ticketing and personalised information services along with Bluetooth technology supporting indoor navigation at stations. Connectivity will also be provided in the Muni light rail network's Sunset, Twin Peaks and the Central tunnels within two years, and fibre optic cables will be installed on the network to generate additional revenue.

Communication and radio

Teleco contracts for 5G

Europe: Telenor has chosen Sweden's Ericsson as the provider for its 5G telecoms network in Norway, and to gradually remove China's Huawei from its network after a decade of collaboration with 4G. The United States has recommended that NATO allies such as Norway exclude Huawei from 5G contracts for security reasons. Norwegian security services also made similar warnings. The use of Huawei network components in Norway will be phased out over a 4-5 year modernisation period.

However, in Germany Telefonica Deutschland has chosen Nokia of Finland and Huawei to build its 5G network, even though Germany has yet to finalise security rules on equipment suppliers. Huawei, in addition to Nokia, will provide equipment specifically for the radio access network. Telefonica emphasised its commitment to ensuring its 5G network won't jeopardise security. So, as well as not relying on a single vendor, the contracts with Nokia and Huawei are subject to the successful safety certification of the companies and their products.

Germany is tightening up security regulations for telecoms operators. Among the proposals included in a consultation are a requirement for telcos to obtain proof of their suppliers' trustworthiness, and to avoid relying on a single vendor.

DB fibre optic network for third party use

Germany: Deutsche Bahn (DB) has opened its 18 500km railway fibre optic network for use by third-parties. DB established DB Broadband as a subsidiary to manage the sale in 2019 with the network now offering municipalities and businesses access to rail fibre optic connectivity.

DB Broadband also manages DB's wayside property which is also available for use for telecoms infrastructure such as 4G and 5G radio masts and to support the expansion of mobile coverage along rail routes and for neighbours.

First train operator to trial onboard 5G Wi-Fi

UK: Virgin Trains commenced 5G trial connectivity on the West Coast Main Line in late 2019. Working alongside McLaren Applied and Vodafone super-fast on-board broadband has been tested, which will offer customers in the future Wi-Fi connections that are up to ten times faster than current 4G based systems.

The first tests took place in November 2019 between London Euston and Birmingham New Street, and London Euston and Manchester Piccadilly. Testing continued from 8 December when the West Coast Main line franchise switched over to become Avanti West Coast.

Nokia 5G Hamburg S-Bahn trial

Europe: In Germany DB Netz and Nokia are to trial the first "standalone 5G system for automated rail operation", say Nokia, and in France SNCF and Nokia are to develop a 5G laboratory to prepare for the switch from GSM-R to the Future Railway Mobile Communication System (FRMCS) in the mid-2020s.

FRMCS will be designed for 5G, which offers reliable, high-speed, low-latency performance and much greater capacity than 2G GSM-R to improve existing telecommunications services and allow the development of new rail applications. SNCF and Nokia will evaluate FRMCS applications in the both the laboratory and in the field.

In partnership with Siemens the DB Netz trials will form part of DB's programme to automate part of the Hamburg S-Bahn.

The €60m (£51m, $67m) project aims to have four trains operating automatically on a 23km section of Route 21 between Berliner Tor, Bergedorf and Aumühle by October 2021. This is ready for when the city hosts the World Congress for Intelligent Transport Systems.

Trains will operate unattended for around 1000m when entering and leaving a siding near Bergedorf station and a driver would be retained for the rest of the journey but would only intervene in the event of a problem.

TfL communication assets to be managed by telent

UK: telent Technology Services Ltd has been reselected by Transport for London (TfL) to manage a wide range of communication assets, including public address speakers, CCTV cameras, customer help points and information displays.

The seven-year contract combines maintenance services, system design and upgrade works to TfL's communications systems, including all London Underground stations, depots and operational buildings, TfL office buildings, bus stations, river piers, cycle hire stations and the London Transport museum. The scope includes the management of security and access control systems, across TfL's estate, including more than 270 underground stations, depots and 80 bus stations and stands.

Ofcom Wi-Fi 6GHz consultation

UK: The UK telecoms regulator Ofcom has launched a consultation on a proposal to provide an extra 500MHz for Wi-Fi use in the 6GHz range, as well as make the 5GHz band easier to use. The proposal is to free up 5925-6425MHz for low-power indoor and very low-power outdoor use, as well as changing the rules on 5725-5850MHz. See irse.info/svkfe.

The proposal leads the way with spectrum policy in Europe and would align the UK with the USA. The US Federal Communications Commission has indicated the lower part of the 6GHz band will be for Wi-Fi, which leaves the upper part of the band potentially free for 5G.

With thanks and acknowledgements to the following news sources: Railway Gazette International, Rail Media, Metro Report International, International Railway Journal, Global Rail Review, SmartRail, Shift2Rail, Railway Technology and TelecomTV News.

News from the IRSE

Blane Judd, Chief Executive

Blanes's World

Council has approved the new strategy for IRSE, covering the institution from 2020 to 2025. At the core of this "beyond a 2020 vision" is the delivery of safe global railways, with a focus on new strategic aims – engage, grow, network and assure. I am looking forward to seeing how we develop these themes over the coming months and years to establish the Institution among decision-makers and opinion-formers as a trusted advisor and valued contributor wherever the IRSE has an impact.

For full details see the strategy section of the IRSE website **irse.info/strategy**.

January started with a meeting with the immediate past president Markus Montigel to agree a way forward with the Knowledge, Skills and Abilities work he is lead on for the Institution. This important work feeds directly into the development section of our new strategy and will see us providing a searchable collation of the wealth of expertise that exists in the Institution. More on this as it develops.

IRSE president, George Clark and I were once again hosted by the Dutch section where we met with senior leaders in Pro-rail to progress discussions on how the IRSE can help to develop a broader group of competent members who can work on ERTMS in a global context. The E&PD committee has agreed to take this on as a project for the future.

I am continuing to work with the Rail Delivery Group, WSP and KPMG on our new Think Tank series. If you haven't already visited the website about this first session have a look at **irse.org/Thinktank** and read about it on page 11 of this issue of IRSE News.

Council matters

We are in the middle of elections for Council. A large number of nominations for new members has been received so it's now up to members to use their votes to decide who the new Council members for 2020 should be. Civica Election Services (formerly Electoral Reform Services) is assisting to engage with as many corporate members as possible to participate in this year's council elections. Historically, only approximately 20% of our corporate members vote. In keeping with our policy to reduce paper wherever possible and offer a faster, digital alternative, you can either return your ballot paper by post or vote online via the IRSE website.

At the December meeting, Council was pleased to hear reports from six of our local sections as well as the International Technical Committee and the Younger Members' Committee - all showing what a range of activities our sections provide and the wealth of knowledge in our membership.

Well done

Congratulations to all those who have passed module(s) of October 2019's IRSE professional exam and thank you to the volunteers who have supported all the candidates. Full results will be published in IRSE News in due course. This year's exam will be held on 3 October 2020 and will be the last opportunity to sit Modules 1-7, and the first opportunity to sit Module A (fundamentals of railway control engineering). Please keep an eye on the IRSE website **irse.info/irseexam** for more information about applying.

Merit Award for Tom

Tom Spronk, a founding member of the Dutch section and vice- chairman of the ASPECT 2019 committee, was presented with a Merit Award at January's presidential lecture in Utrecht. The award recognises Tom's ongoing commitment to IRSE Nederland and the outstanding organisation skills and financial management which contributed to the success of Aspect 2019.

Another ITC committee member and stalwart of the Dutch section, Wim Coenraad delivered his fascinating paper on 'Delivering Change – the race against obsolescence' (available to watch free of charge to members in the publications section of our website **irse.info/webcasts**). President George Clark ended the event on a high note by making the well-deserved presentation to Tom who served the full, maximum eight year term as a board member of IRSE Nederland local section, devoting a vast amount of his spare time to the section despite being very busy on international signalling projects. Merit awards are bestowed by the IRSE Council following the recommendation of a section or individual.

IRSE head of licensing – vacancy

Due to unforeseen circumstances we are re-advertising the role of head of licensing. For a full job description see **irse.info/5dx8o**. We welcome applications from members with previous experience of licensing.

Midland & North Western Section

IRSE Institution of Railway Signal Engineers MIDLAND & NORTH WESTERN SECTION

Signalling and telecoms structures and foundations

Report by Paul Darlington

January's talk for the section was slightly different to a normal presentation as it focused on the civil engineering requirements for signalling and telecoms structures. Paul Mansell, general manager of Haywood & Jackson, gave an interesting talk about his personal experiences from the past 25 years on the structures and foundations required for S&T assets, and the everyday challenges faced in planning large and small installations.

Paul explained the experience gained with innovation in foundations with the use of helical pile techniques, and the part he played in development of the onsite strategies for the choice of foundation type, delivery and erection of such structures. He also covered how life extension requirements for signalling structures are driving further innovation in maintaining structure foundations until the introduction of ETCS.

The traditional way of providing a foundation for a signal base, a location platform or telecoms mast, was to dig a large hole, assemble a pre-made shutter, lower it into the excavation and fill with many tonnes of wet concrete. Once cured the structure could be erected. All this activity would take several days/nights and possibly multiple track possessions, not to mention temporary access and logistics for concrete delivery.

A step change was the introduction of helical pile foundations. With this method a series of helical piles are installed by twisting them into the ground, just like a corkscrew is twisted into a cork in a bottle. As the shaft of each pile disappears below the surface, additional extension segments can be connected with bolted couplers and screwed into the ground - ultimately resulting in a single pile which can extend many metres into the ground. For S&T structures a depth of only a few metres is normally required. Typically, a small number of piles are installed to support a metal base for the structure.

In many cases, the steel pile itself is enough to meet the load requirements. However, for even more robust deep foundation systems, concrete (also known as grout) can be incorporated if required. In a grouted column, concrete is continuously poured down the sides of the pile. This technique produces a reinforced pillar that will withstand the most extreme compressive, uplift, and lateral forces.

Paul explained his involvement in the trials and the training involved with introducing the technique into S&T, with one early construction being a large steel cantilever structure for WH29BR signal at Camden. This was safely completed in two three-hour possessions. A paper explaining the technique first appeared in IRSE News issue 99 in November 2009 and

Structures installation has to take place in all weather conditions. Who says most S&T work takes place in warm equipment rooms?

Gantry P2 at Tapton, near Chesterfield, being moved to site. A case of true 'road and rail' movement.

was further recognised with the award of the 2004 HSBC Rail Engineering Excellence of the Year. On August bank holiday 2006 Paul received a call at 6am on the Sunday to say a road rail machine had hit and totally demolished TT35 signal at Clay Cross north of Derby.

The force of the impact had totally sheared off the signal from its base. Paul quickly assembled a team, provided a temporary base and re-erected the large structure ready for service by 13.50 on the Monday. The solution was designed, procured and installed using helical piles in 31hrs 50 minutes.

Access and delivery,

Access to sites in some cases can be quite a challenge. With Gantry P2 on the Tapton project near Chesterfield, the original "Plan A" was to install a temporary road parallel to the track and site, erect the crane and install from a site near the track. However, a large amount of rain fell which washed the road into the adjoining field, leaving the access unavailable for lorry and crane. 'Plan B' was required, using the track and a rail-road vehicle to deliver the structure to site. The crane 'hopped' the track and travelled over a missing section of the formation to site before the rails and sleepers were installed.

Paul had also been involved with the national Network Rail GSM-R project, where the rapid deployment base (RDB) design introduced by the project had dramatically improved the ability to deliver the thousands of sites required. With the RDB design a small number of precast concrete blocks were installed to support a steel platform. The equipment building for the GSM-R base station sat on the platform with the GSM-R mast bolted to the platform. Again, this design could be deployed in a few hours, rather than weeks of digging large holes and pouring tonnes of wet concrete, all requiring disruptive possessions.

Signalling life extension

With the extensive time and resource required to deploy full ETCS across the national network there will be a requirement to keep some conventional signalling well beyond its normal resignalling lifetime. Haywood & Jackson has invested time and resources to understand the life extension requirement for S&T structures and the issues which will need addressing. These will include corrosion of the signal structure, hand-rails, mesh protection, floors of the structure, ladders and hoops, and location case platforms. This could result in the structure being unsafe to climb and compromise maintenance and increase business risk.

Over time signal posts can be subject to degradation through ground conditions and water ingress at the base of the post, causing a capillary action with moisture creeping up the inside and oxidising the metal. This will cause the metal to thin. Should there be any type of holes drilled in the post water ingress can also causing thinning. Paul explained that his team has the ability to non-destructively test any areas of concern and provide an assessment of the degradation 'life span' implications.

Many signal foundations were installed in accordance with the signalling installation handbook (circa late 80s through the early 90s). These were generally provided with no formal ground investigation and a standard 950mm square top shuttered or pre cast base provided. Many of these bases are now suffering from subsidence, with the signals or locations starting to lean. Helical piles can be used to stabilise the base and allow the structure to be made vertical, all of which are designed for a minimum of 25 years, and which can be deployed cost effectively in a few hours.

In collaboration with Unipart Dorman the company has also designed a series of bases to cover most of the situations encountered in new signalling schemes or life extensions, with the product range going by the name of "signal in a box". The system again uses handheld installed helical piles.

The company has other products available for S&T structures including steel and GRP location case platforms. The MNW Section may arrange a technical visit to the factory of Haywood & Jackson in Northwich later in the year and if any members are interested in a visit to the factory please let the MNW Section know.

We're looking for a volunteer advertising sales manager to join the IRSE team

The IRSE is looking for someone to join the volunteers who support the Institution, fulfilling the role of advertising sales manager. The successful applicant will be responsible for the sale of advertisement space both in IRSE News and at various IRSE events held around the world.

You will be able to identify potential clients and offer them advertising proposals by initiating discussions through calls, emails, and scheduled meetings, along with identifying new approach/techniques to maintain advertising sales for the IRSE. The role will maintain contact with clients to provide them advice as well as offering new advertising services and opportunities.

You will review media placements to ensure they are in accordance with clients' needs and preference, with any necessary adjustment or feedback relayed to the responsible designer.

Applicants will ideally have experience in business administration, advertising or marketing in the railway signalling and telecommunication industry, along with a good range of contacts around the world.

If you believe you have the experience to assist the IRSE in this role please contact Blane Judd at hq@irse.org.

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at irsenews@irse.org.

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Membership changes

Current Membership: 5067

Elections

We have great pleasure in welcoming the following members newly elected to the Institution:

Fellow

Matthew Perkin, Canadian Pacific, Canada
Pavel Popov, Joint Stock Co R&D Institute, Russian Federation

Member

Lihui An, Bombardier, Australia
Siddheshwar Andhale, Thales, Qatar
Junfeng Cui, CRSC, China
Ke Cui, CASCO, China
Gang Liu, CRSCD, China
Pavan Kumar Gudavalleti, Manak Bhawan, India
Xiaohui Huang, CRSCD, China
Dani Indrianto, Metro Trains Melbourne, Australia
Ming Jiang, CRSCD, China
Gavin Jones, Colas, UK
Ming Nin Kan, Alstom, Hong Kong
Robert Kay, Network Rail, UK
Bin Liang, CRSCD, China
Vasu Ponala, Hitachi, India
Jack Schneider, SBB, Switzerland
James Thomson, DB Engineering & Consulting, Israel
Yaju Wang, Bombardier, Australia
Joon Hau Wee, Syarikat Pembenaan Yeoh Tiong Lay, Malaysia
Binghao Wu, CRSC, China
Mingchun Yang, CRSCD, China
Izham Zainal Abidin, Mass Rapid Transit Corporation, Malaysia

Associate Member

Michael Adeyele, Network Rail, UK
Eilidh Bell, Siemens Mobility, Australia
Syedali Buhari, Rio Tinto, Australia
Andrew Dent, Avon Valley Railway, UK
Herre Kamsma, Sweci Bederkabd, Netherlands
Allard Katstra, Arcadis, Netherlands
King Wo Leung, Thales, Hong Kong
Ahsan Mohammad, Thales, UK
Jyotheeswara O, SNC Lavalin Atkins, India
Stanley Pinheiro, Rail Vikas Nigram, India
Ali Raza, Sydney Trains, Australia
Mohammed Umair, Siemens Mobility, UK

Professional registrations

Congratulations to the members listed below who have achieved final stage registration at the following levels:

EngTech

Jodi Hurcombe, Amey, UK
Kristian Lee, Amey, UK

CEng

Kyu Sang Choi, Louis Berger Consulting, India
Eduardo Olleta Balduz, SNC Lavalin Atkins, UK

Past lives

It is with great regret that we have to report that the following member has passed away: Brian Foster.

Promotions

Member to Fellow

Paulus Hendriks, ProRail, Netherlands
DK Sinha, Kochi Metro Rail, India

Associate Member to Member

Mario Czornyj, Omada Rail, Australia

Accredited Technician to Member

Nicholas Franklin, FTR Engineering, UK

Affiliate to Member

Patrick Kwan, MTRC, Hong Kong
Thomas Stankowski, Transport for London, UK

Affiliate to Associate Member

Kelvin Liu, John Holland Group, Australia

New Affiliate Members

Kamran Ahmed, Huadong Engineering, Saudi Arabia
Haifa Al Ali, UAE
Roel Aldenkamp, Thales, Netherlands
Mohammad Baig, Pakistan Railways, Pakistan
Helmi Razy Bin Mohd Rosli, Akka Technologies, Saudi Arabia
Bharath Bolla, SNC Lavalin Atkins, India
Jerry Britton, Unipart, UK
Daniel Brown, Network Rail, UK
Bruce Crowe, Network Rail, UK
Rudy Desplan, UK
Suahil Ermus Lopez, AEGIS, UK
Ryan Essington, LTK Engineering, USA
Matthew Harding, Australian Rail Track Corporation, Australia
Aaron Healy, Irish Rail, Ireland
Michael Herries, Transport for London, UK
Niranjan Kalidass, SNC Lavalin Atkins, India
Abhilash Kallakuri, SNC Lavalin Atkins, India
Akash Kankanala, SNC Lavalin Atkins, India
Chandan Kumar, Rail Vikas Nigam, India
Kumar J Pawan, SNC Lavalin Atkins, India
Krishnendu Manna, India
Venkata Marra, UAE
Crispen Mashingaidze, Huawei, South Africa
Andre McKenzie, Long Island Railroad, USA
Sam Mitchell, Network Rail, UK
Rabiul Mithu, SMEC, Bangladesh
Bhaktvatsal Naithani, Alstom, Singapore
Sayan Nandy, University College London, UK
Terry Ngan, Network Rail, UK
Ruchitha Pottala, SNC Lavalin Atkins, India
Hanumesh Pujar, SNC Lavalin Atkins, India
Karthik Raja, SNC Lavalin Atkins, India
Lorna Richardson, Alstom, UK
Saumya Shekhar, SNC Lavalin Atkins, India
Jamil Solangi, WSP, Saudi Arabia
Chaitra T A, SNC Lavalin Atkins, India
Spoorthi T P, SNC Lavalin Atkins, India
Sridhar Thirumalasetti, WSP, India
Andrew Thomson, Self-employed, UK
Graham Whiting, South Devon Railway, UK
Li Xie, MTRC, Hong Kong
Kai On Yip, Thales, Hong Kong

Resignations: Adrian Buchanan.

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