IRSE /// News

Institution of Railway Signal Engineers

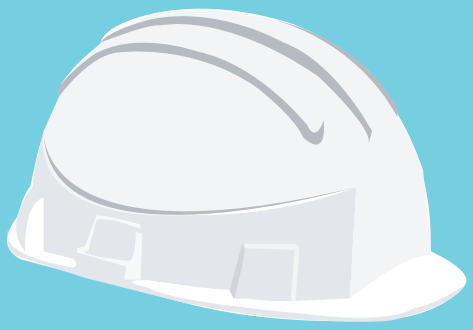
November 2019

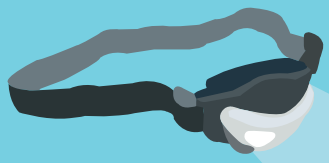
Delivering change
in traffic management

Formal methods
for ERTMS hybrid level 3

Wi-Fi 6
the next step?

Signalling Engineer





We've got all the gear and knowledge you need to make a kick start in your Signalling Engineer career. Signet Solutions offers a wide variety of courses to get you set up or to help you add to your existing skills. We've been providing training excellence since 1996 - that's over 8,000 delegates who have all benefitted from our courses so why not be next?
Call us today and we'll get you on the right track to success.

+44 (0)1332 343 585

enquiries@signet-solutions.com

www.**signet-solutions**.com

Signet Solutions

Raising the Standard in Development

IRSE
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.

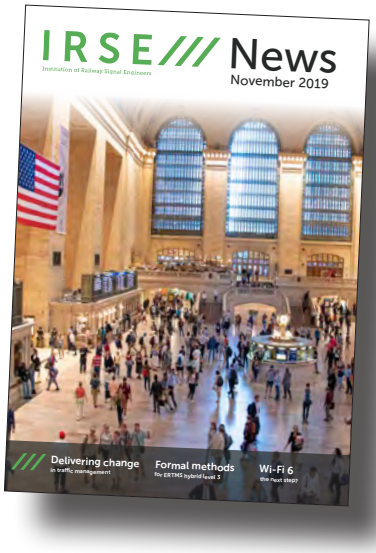
Embracing cultural differences, by having an appreciation for how people think, work and are motivated, is essential to integrate in diverse teams and to produce the best results from each individual for the project.

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



IRSE
Institution of Railway Signal Engineers

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 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.

"Digital control technologies are seen as a means of increasing capacity and improving performance"

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).

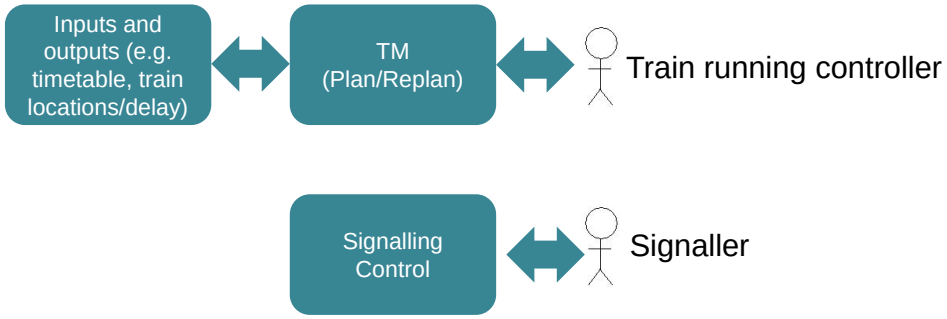


Figure 2 – Traffic Management – Interfaced.

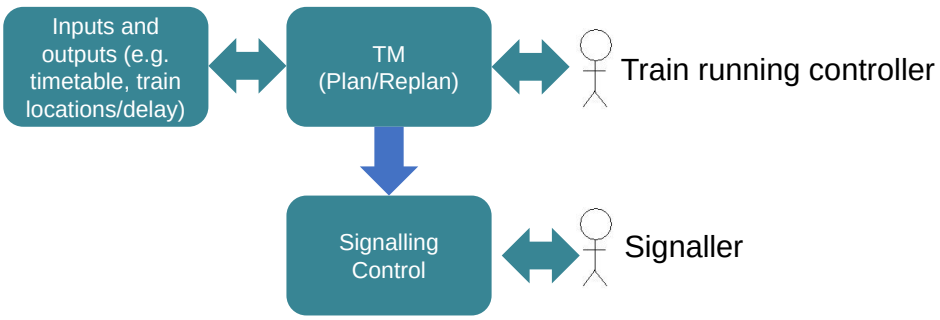


Figure 3 – Traffic Management – Integrated.

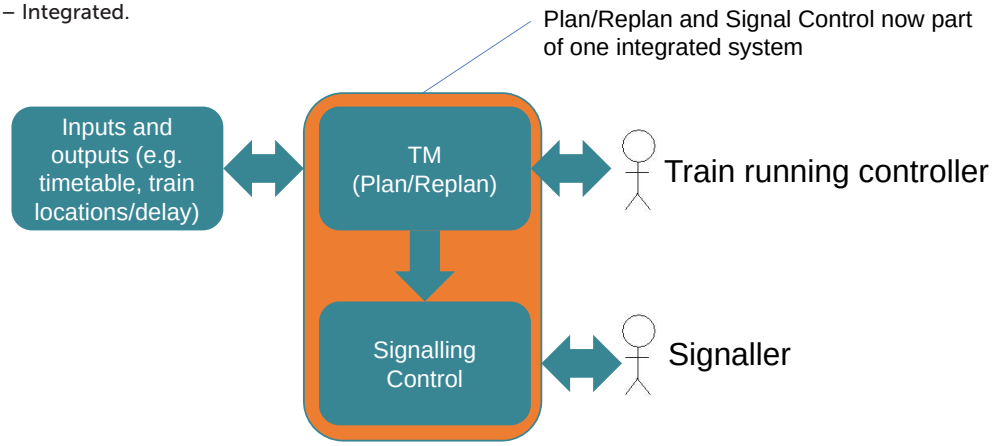
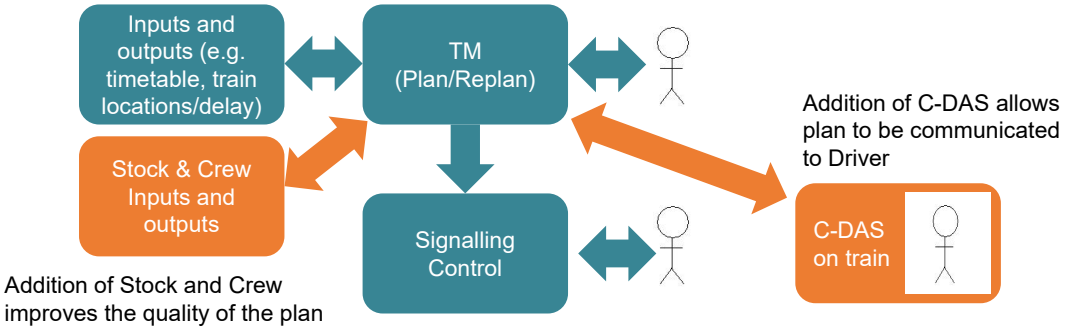


Figure 4 – Addition of Stock & Crew and Connected Driver Advisory System (C-DAS).



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).

"Management of data throughout the lifecycle of a TM development is vital"

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

"Business change was another area where the effort required was probably underestimated"

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.

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.

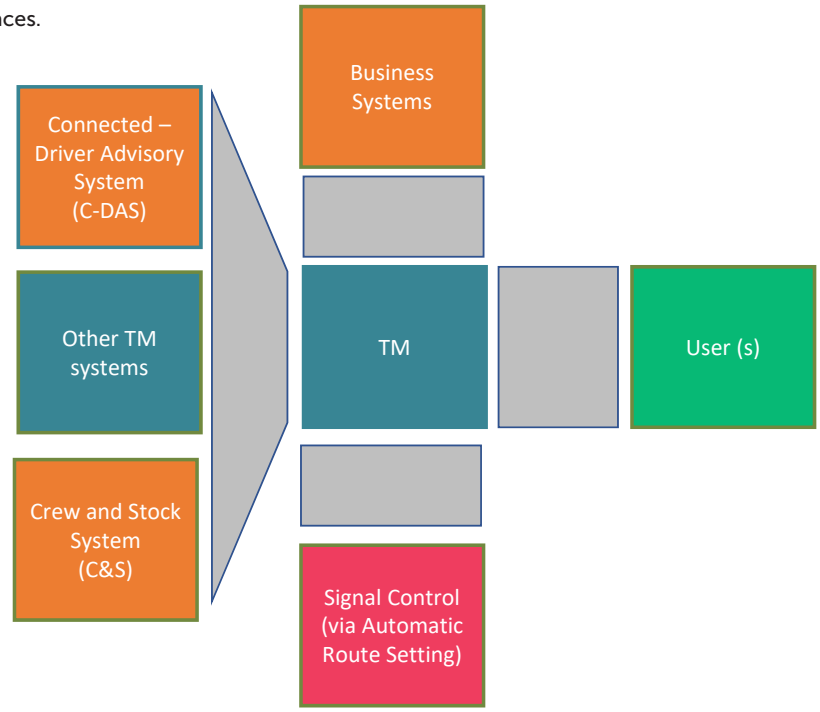
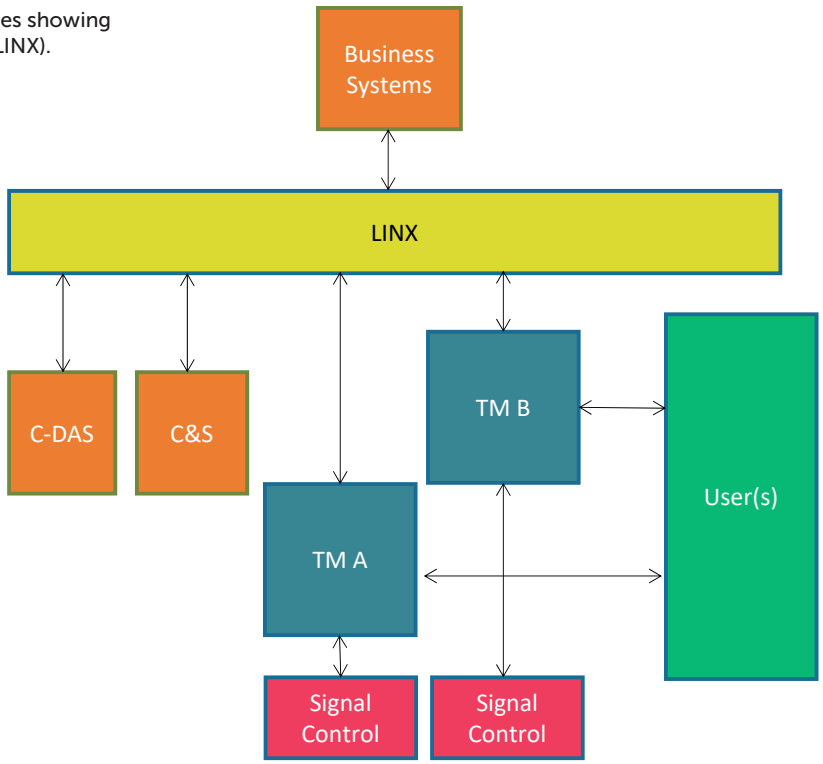


Figure 6 – Traffic management interfaces showing role of layered information exchange (LINX).



"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.

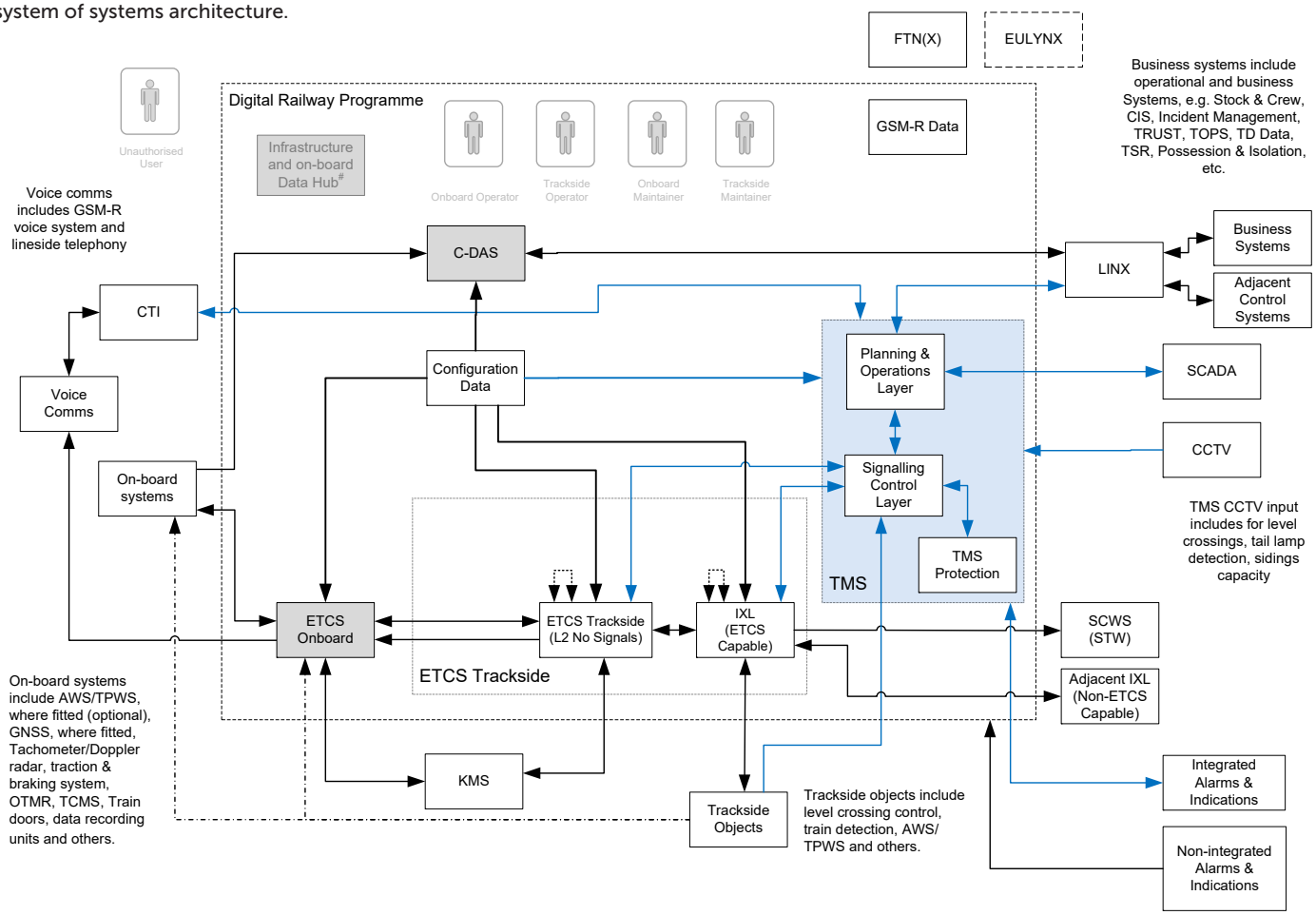
Network Rail has not yet experienced a full TM asset lifecycle, so there will be learning on maintenance and mid-life changes to the system (for example where the underlying railway is changing as well as the traditional obsolescence issues with electronic systems). Additionally, industry structure changes could offer opportunities and challenges around the systems, who uses them and the ease of future integration with crew, stock and C-DAS systems.

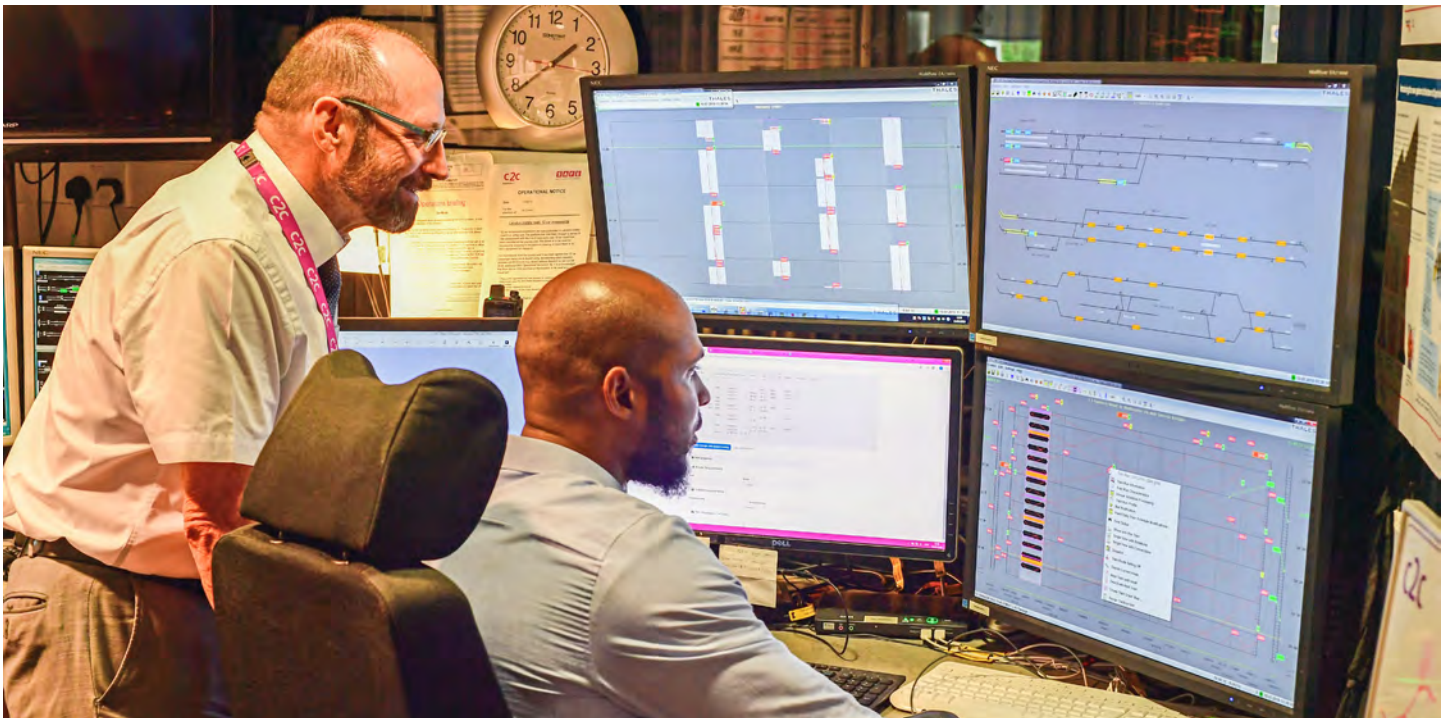
Integrated TM is the assumed default in Digital Railway's System of Systems architecture (see Figure 7), but has yet to be fully implemented in the UK (progress was made towards a working concept in the Anglia early deployment programme). There are business and functional drivers that could lead to a 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.

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"

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.

"TM implementations are not just technology projects, but business change programmes"

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.

References

[1] George Clark, IRSE president 2019/20, Presidential address, IRSE AGM, April 2019.

[2] Ian Prosser, director of railway safety, ORR & HM chief inspector of railways, Section 1 of ORR Annual Report of Health And Safety Performance on Britain's Railways, July 2019.

[3] Josef Doppelbauer, executive director, European Union Agency for Railways, paper on Command and Control 4.0, IRSE 2018/19 Presidential Paper, June 2018.

About the author ...

Andy Bourne is a senior technical director at ARCADIS and the rail discipline lead for railway systems and digital railway. He works across the railway industry to help infrastructure owners, operators and suppliers make a success of CBTC, Digital Railway and other complex rail system projects. Andy previously worked for Transport for London and was involved in the delivery of major line upgrades for London Underground Four Lines Modernisation, Northern Line Upgrade and Jubilee Line Upgrade.

IRSE
Institution of Railway Signal Engineers

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).

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 one of the world's most valued and widely used technologies"

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 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.

"The objective of Wi-Fi 6 is to provide full indoor coverage into every space within a building with the same high data rate.

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"

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.

"4G LTE is able to do all that railways require"

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.

Keeping it snappy with irse.info ...

Our link shortener, irse.info, has been in use since February 2017. In that time we have created over 300 links, which have been used by readers more than 10 000 times so far!

What does it do?

Throughout IRSE News we use irse.info links to point to online resources within our articles and news items.

irse.info is a link shortening system hosted by the IRSE, which allows us to replace long internet links with very short ones, usually something like irse.info/exam.

If you 'click' on the link in the online version of the magazine, you'll be taken straight to that resource.

If you type the shortened link into your browser (not a search engine like Google, but your Internet Explorer, Edge, Firefox, Chrome or Safari browser address bar) you'll be taken straight to the link.

Why do we use it?

We use this to make articles easier to read, to make finding online content easier to find, and to make managing the links more efficient.

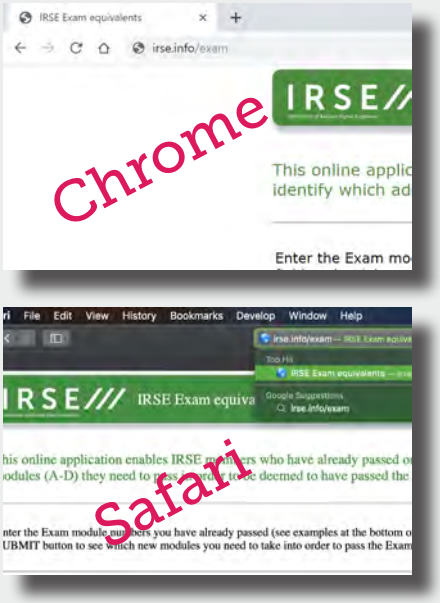
Not only can we see which are the most popular links, which helps us to bring the best possible service to our members, but we are able to change the links when necessary – for example links like **irse.info/nearyou** and irse.info/exam still work even though moving to the new website has changed the exact location of the information on the internet.

If you have trouble accessing the system email IRSE News at editor@irsenews.co.uk and we'll be happy to help.

Why don't we use shorteners like bit.ly or tinyurl?

Simply so that we still 'own' the information and can keep it up to date, with full access to all the information we need to keep control of the system. We are able to maintain the system ourselves and ensure that it does what our members need.

Type the irse.info/... link into the address area at the top of your browser and press 'return'.



IRSE
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.

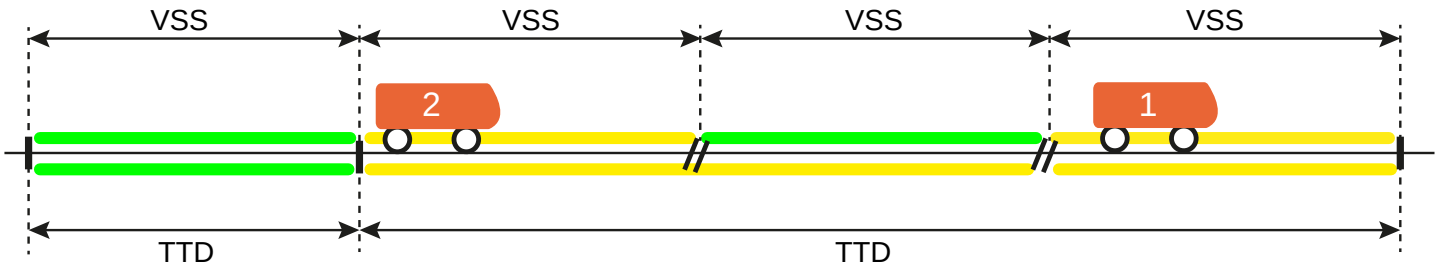


Figure 1 – The principle of ETCS Hybrid Level 3 is to divide trackside train detection sections into several virtual sub sections, increasing capacity.

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.

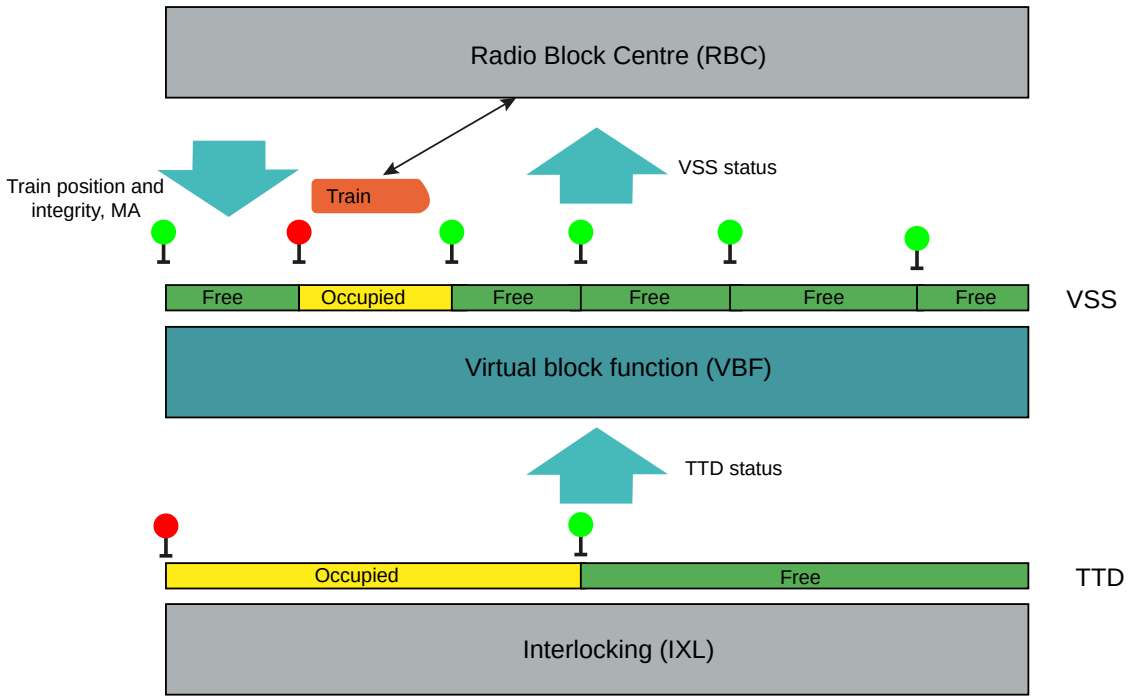


Figure 2 – The role of the Virtual Block Function (VBF).

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.

References

[1] Principles Hybrid ERTMS/ETCS Level 3, Ref 16E042, Version 1C, EEIG User Group. **irse.info/kb5q6**.

[2] Case study Hybrid Level 3 with formal methods, International ABZ Conference ASM, 2018.

[3] Using a Formal B Model at Runtime in a Demonstration of the ETCS Hybrid Level 3 Concept with Real Trains, University Düsseldorf, Thales, Published in ABZ 2018.

[4] Modelling and Analysing ERTMS Hybrid Level 3 with the mCRL2 toolset, Maarten Bartholomeus, Bas Luttik and Tim Willemse, Formal Methods for Industrial Critical Systems, FMICS 2018.

[5] ATO/ERTMS Level 3 test at the ETCS National Integration facility. Video by Maarten Bartholomeus, July 2018. **irse.info/g492d**.

[6] Demonstration der ETCS Level 3 Technologie im Living Lab der DB Netz, Video by DB, September 2018. **irse.info/ugzy8,** with English subtitles **irse.info/ce4it**.

About the authors ...

Maarten Bartholomeus is ERTMS signalling expert, Prorail BV, Netherlands.

Bas Luttik is assistant professor, Department of Mathematics and Computer Science, Eindhoven University of Technology, Netherlands.

Tim Willemse is associate professor, Department of Mathematics and Computer Science, Eindhoven University of Technology, Netherlands.

Dominik Hansen is system architect, Thales Transportation, Germany.

Michael Leuschel is professor, Department of Computer Science, University of Düsseldorf, Germany.

Paul Hendriks is manager signalling, ProRail BV, Netherlands.

IRSE
Institution of Railway Signal Engineers

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.

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

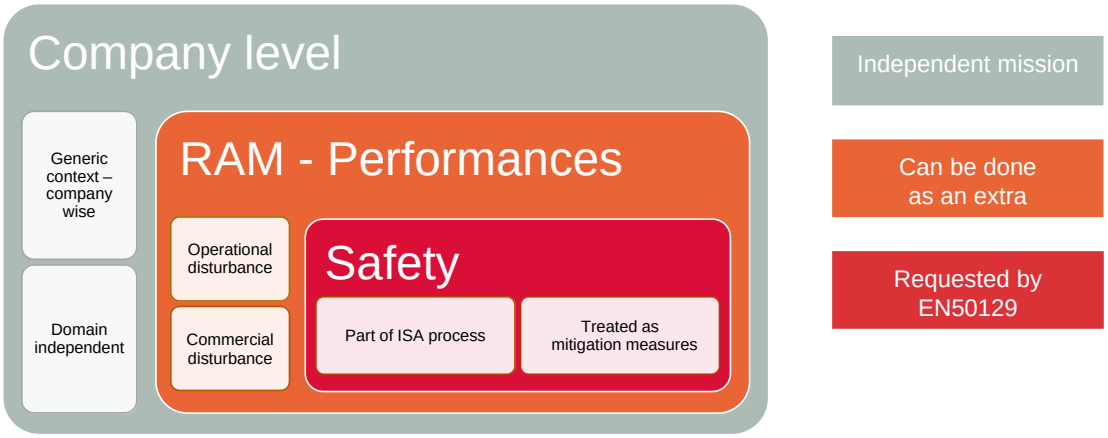


Figure 1 – The different aspects that can be related to cybersecurity.

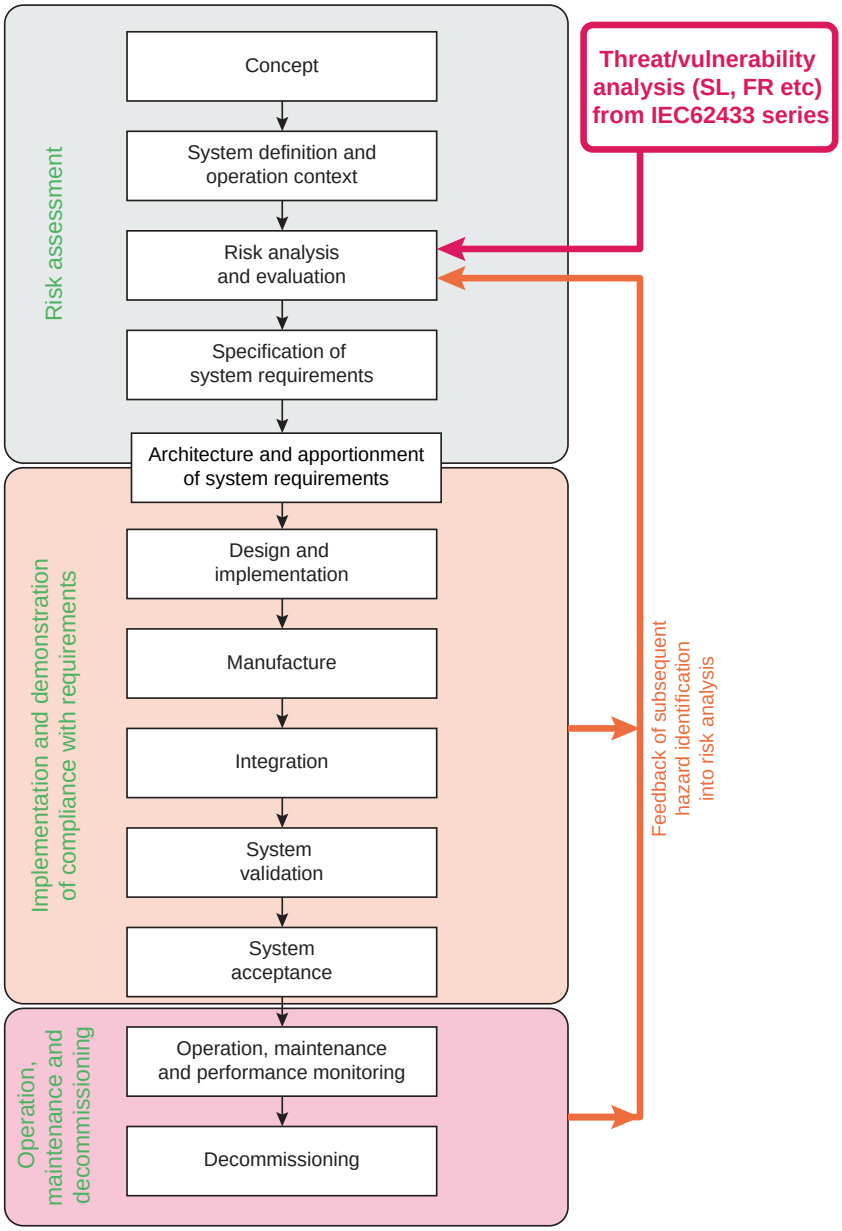


Figure 2 – A simplified view of the system lifecycle from EN50129, showing the point at which cyber security requirements should be included and the feedback loop from hazard identification to risk analysis/evaluation.

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.

IRSE /// Institution of Railway Signal Engineers

London Office

IRSE, 4th Floor, 1 Birdcage Walk, Westminster, London, SW1H 9JJ, United Kingdom

Enquiries – Membership or of a general nature

Tel: +44 (0)20 7808 1180
Fax: +44 (0)20 7808 1196 e-mail: hq@irse.org

Licensing

Tel: +44 (0)20 7808 1191 e-mail: licensing@irse.org

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.

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.

Networking Fawley style. *Photo Judith Ward.*

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

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.

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 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, right, enjoying his retirement with friends in 2004.

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**.

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.

Printed by Herald Graphics, Reading, UK
www.heraldgraphics.co.uk

Planting trees to catch carbon · Planting trees to catch carbon ·
9444263
Printed on Carbon Captured paper

IRSE
Institution of Railway Signal Engineers

London Office

IRSE, 4th Floor, 1 Birdcage Walk, Westminster, London, SW1H 9JJ, United Kingdom

Enquiries – Membership or of a general nature

Tel: +44 (0)20 7808 1180
Fax: +44 (0)20 7808 1196 e-mail: hq@irse.org

Licensing

Tel: +44 (0)20 7808 1191 e-mail: licensing@irse.org

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