IRSE News

Institution of Railway Signal Engineers

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Digital resilience
maturity matrix

Lessons learned
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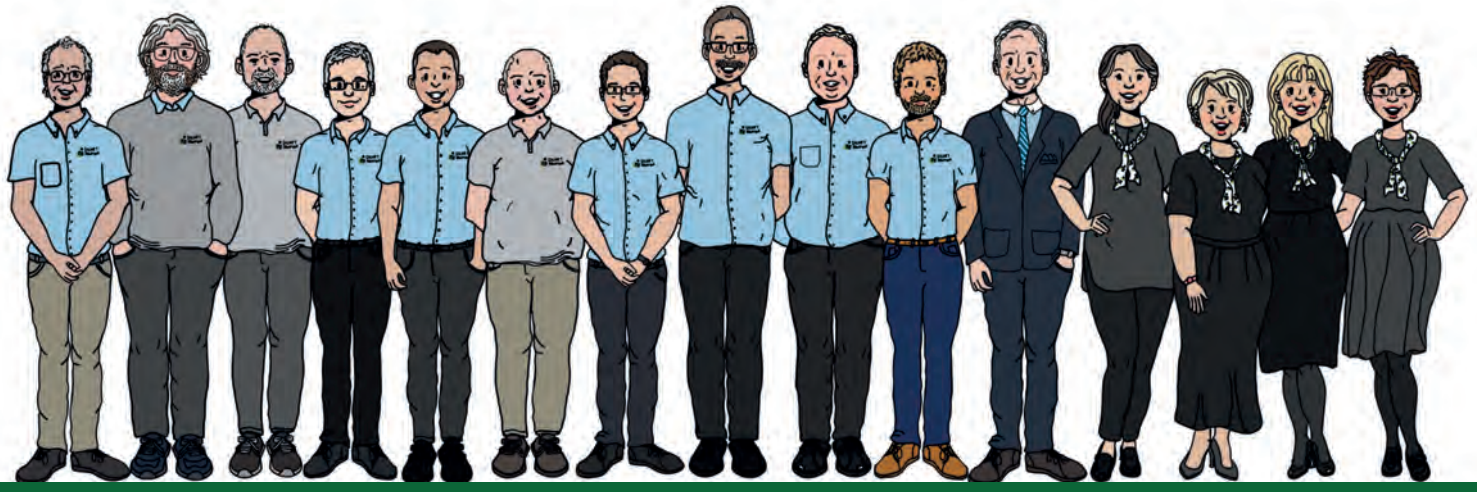
Compatibility
the return of Ruth

Staying Safe and Connected



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IRSE
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From the IRSE

Cleaning up our act

As hope of a new world post-Covid starts to grow, governments everywhere are considering how to kick-start struggling economies. A recurrent topic is decarbonisation and moving from fossil-fuelled transport to more sustainable solutions. We are privileged to work in an industry with strong 'green' credentials, moving large loads of people or goods over long distances in an efficient manner, often using zero-emission vehicles.

But technology, innovation and just thinking differently can allow us to play an even greater part in the move to driving out carbon. This applies throughout the lifecycle of railway systems, from construction, through operation, until upgrade or replacement.

When we build command, control, signalling and telecoms systems we have unthinkingly embedded carbon within them and relentlessly used scarce resources. We have poured concrete to act as foundations for signals and antenna masts, trackside location cases and buildings – indifferent to the vast amount of energy needed to create it. We have used steel to erect gantries, we have copper cables to carry power or data. That's changing and we can now use network connections to connect multiple systems over a single fibre optic cable, we can use less power more efficiently, or even generate it locally, and for many railways cab-signalling allows signals, and their supporting structures, to be removed entirely.

Our signalling, data transmission, train control and traffic management systems are all just at the start of their journey to drive decarbonisation. They can make decisions based on the energy consumed network-wide whilst still managing the safe and efficient movement of trains. We can advise drivers – or automatically driven trains – of the optimum speed at which to travel to avoid having to stop and restart unnecessarily, and to ensure right-time arrivals. We can conceivably manage timetables to use energy recovered from braking trains to accelerate departing ones.

Our profession is probably in the most dynamic and exciting phase since its inception in the mid 19th century. We all have a role to play in getting more people to travel on a cleaner, greener public transport system. We can design systems that embed less carbon and use less energy, we can manage trains across entire networks more efficiently, we can use fewer resources and provide greater societal gain. What an opportunity, let's take it.

Mark Glover
production manager, IRSE News

Cover story

BHP Rail Pilbara network, Goldsworthy Junction Australia. A trial by BHP of the Australian designed and manufactured Siemens Easy Access Folding Mast for potential use on its network.

One of many lowering structures in use throughout the world to avoid working at height. What other simple ideas can we introduce to reduce the safety risk to track side signalling and telecoms workers?

Photo Richard Flinders

IRSE
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Digital resilience maturity matrix for the railway sector


Alzbeta Helienek and Mathijs Arends

This, the fifth paper of the 2020-2021 presidential programme, was presented online on 20 January 2021.

Cyber security has become a critical part of delivering an efficient and safe railway, driven by ever more digitally connected systems and the evolving threat landscape. Much has been achieved over the last few years but even today the railway finds itself in various stages of cyber security awareness and readiness.

As an industry we range from having developed and integrated security assurance frameworks, allowing safe, secure R&D and project implementations through to no awareness at board level and lack of understanding of responsibility within engineering teams. Our proposed Digital Resilience Railway Maturity Matrix presents a method to categorise, recognise and support organisations with their roadmaps to integrate security into daily operations. It provides a powerful benchmarking tool in a competitive landscape, which in a race to become more effective has also become more vulnerable to today's technological changes.

"Maturity models are used in cyber security to estimate how advanced an organisation's current cybersecurity processes are"

Maturity models are used in cyber security to estimate how advanced an organisation's current cyber security processes are and can be used to provide a clear roadmap to improvement. Usually, these matrices define different domains and define maturity levels that describe how security activities in these domains should take form at the given maturity levels.

There are various maturity matrices in the cyber security field, ranging from the generic Cyber security Capability Maturity Model (C2M2) matrix to more domain specific models such as the Open Web Application Security Project – Software Assurance Maturity Model (OWASP SAMM).

While they are usually constructed on the same underlying principles; their specificity makes them useful in various situations. C2M2 was made with a focus on critical infrastructure but is applicable to most companies with a cyber security programme. While OWASP SAMM contains specific software development processes that most companies will not find to be very relevant, however the companies it does apply to can get a lot of mileage out of the described processes.

These more specific matrices have one very important purpose: translating generic instructions into domain or industry specific processes. Knowing that your company should have business continuity plans is a first step, but the realisation that a company should be able to keep its most vital connections running without IT support is another. A problem that we have observed is that translating classical cyber security matrices into railway specific processes can be quite difficult.

Related work

When developing the Digital Resilience Railway Maturity Matrix, we looked at various models. The OWASP SAMM model served as an inspiration in the level of specificity that it offers to users in its own specific domain. It defines three different maturity levels for different practices where "Each level within a security practice is characterised by a successively more sophisticated objective defined by specific activities, and more stringent success metrics than the previous level. Additionally, each security practice can be improved independently, though related activities can lead to optimisations" (**irse.info/ei5wx**).

The OWASP SAMM model is a great example of what we want to achieve in a completely different field. The scope of this model is a lot greater than what we are aiming for, but every software developer can identify where their organisation is on the matrix, and it provides a clear way to achieve higher maturity levels.

A more general model that is more applicable in the rail domain is the C2M2 model. The US Department of Energy (DOE) developed C2M2 from the Electricity Subsector Cyber security Capability Maturity Model (ES-C2M2) Version 1.0 by removing sector-specific references and terminology. Due to this model's origins in critical infrastructure, it is a good one to consider in the rail domain and its scope is organisation wide. This defines ten domains, and defines various objectives. Each objective then has three maturity levels. This model is specifically interesting for us since there is a domain specific and non-domain specific version available (**irse.info/79cay**).

"Developing a maturity model has been done before, so we built our model in line with what already exists"

The Control Objectives for Information and Related Technologies (COBIT) framework is useful for almost any company with an IT infrastructure and covers more than cyber security. It can be divided into five components, one of which is maturity. Moving up the maturity levels in this model means both an increase of scope and an increase of organisation, but the maturity levels do not explicitly tell what these levels should look like in practice. Although the COBIT framework is a very useful one, for our audience and purposes it is simply too broad.

The last framework we want to mention is the US National Institute of Standards and Technology (NIST) framework. This is an amazingly influential framework and almost every security professional must have heard of it. It is a security specific framework with an emphasis on critical infrastructure. It is not a maturity model in itself, but it is possible to assess an organisation's security maturity in complying with NIST using for example a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) review as defined in NIST 800-53. Such a review is large in scope and could be time consuming, which is something we are trying to avoid in our model. See **irse.info/cy2z4** and **irse.info/y35uf**.

Developing the matrix

The five levels

Developing a maturity model has been done before, so we built our model in line with what already exists. The approach of taking various domains and defining different maturity levels in those domains is common practice. When looking at what the different maturity levels mean there seems to be some variations, but it can usually be divided into either:

"For our model we decided to go with the combination of improvements in organisation and scope"

- Improvements in organisation (documentation, management formalisation).
- Improvements in scope (larger coverage, doing more and better tooling).
- A combination of improvements in organisation and scope.

For our model we decided to go with the combination of improvements in organisation and scope. Our maturity levels are characterised as follows:

Level 1

Is the first step on the cyber security journey. The railway organisation recognises the problem and is taking first steps toward dealing with this topic.

Level 2

Basic principles, controls and best practice are being rolled out in the most critical part of the organisation and their digital assets.

Level 3

There is a definitive strategy and roadmap showing how to achieve security maturity throughout the organisation. There are pockets of good practice and areas with a lack of security are guided by an organisational strategy and people feel responsible for securing the critical infrastructure.

Level 4

The organisation knows what is going on in their network, with their people and with their vendors. They have some good supporting tools to help in the quest of managing security and cyber risks. The organisation is prepared and can easily achieve compliance with the EC and UK Networks and Information Systems (NIS) NIS-D legislation and can produce evidence if requested.

Level 5

The organisation actively defends itself against cyber threats. Personnel and vendors are fully aware of their responsibility and contribution to securing the safety integrity and the business of the organisation as well as the whole railway eco-system.

The five dimensions

The dimensions we have developed are based on the experience of working with and analysing various railway and rolling stock organisations. Our purpose in developing this model was not to cover every aspect of a cyber security strategy, but rather focus on a handful of topics an organisation which operates or contributes to national critical infrastructure needs to tackle as a priority. Therefore, we decided on five dimensions that we think are most useful for rail/rolling stock companies, aligning with cyber security best practices, standards, and regulations.

People

People are an organisation's first line of defence and at the same time quite possibly their weakest defence. It is essential that every railway organisation takes its people with it on the journey to achieve higher cyber security maturity, as it is impossible to thrive in any other dimension without getting its people on-board.

Risk

How do you know what to do and do the things you do right? The answer is by managing risk – specifically cyber security risk. Railway organisations should be well equipped to deal with this dimension of the challenge, as the processes are not that different from safety risk and can be very well combined and integrated.

Maturity level / categories	People	Risk	Technical	Safety	Incident
1	A cyber security training and awareness program exists in your organisation.	Your organisation has conducted at least one cyber security threat and risk assessment and therefore knows which assets are critical for safety and which for business continuity.	The organisation's network separates their corporate IT from their safety critical network.	The people responsible in the organisation for safety and security structurally communicate. Security requirements are managed and linked to safety requirements.	There is a formal business continuity plan that describes how to keep trains running in case of a cyber incident The BCP is published and available to everyone in the organisation. We should still think about disaster recovery.
2	Cyber security awareness/ training is based on specific role needs.	A plan has been made to assess in detail the most important company digital infrastructure and most important suppliers.	The network is separated into different zones and conduits. An intrusion detection system can pick up unusual activity in the network.	Created at least one safety case where security issues have been considered and safety testing takes into account malicious actions. The V-lifecycle includes cyber security activities.	The most important lines can be kept operational manually during an incident. Processes in the BCP are included in training.
3	Cyber security trainings are incorporated into HR and can be evidenced.	Cyber risks are actively managed in a company risk management system.	The critical assets and network traffic are monitored and logged. Vulnerabilities are discovered with targeted scans.	Threat and vulnerability and hazard assessments contain at least one representative of both domains. The validation and verification process includes methods of security testing.	Backups are tested regularly. The business continuity plan includes processes for different durations, for example a week or a month. Tabletop crisis management exercises should be conducted at least yearly.
4	Cyber security is included in role descriptions based on your organisation's cyber security needs.	Cyber security risks are known across the whole network including legacy systems.	Security monitoring includes automatic rules and incident alerts that trigger defence response.	Safety and security engineering are integrated as described in CENELEC 50701. Security threats are linked to safety hazards.	Incidents can be contained in such a way that automated process not directly affected by the incident can still be used. The BCP is continuously improved and crisis management exercises are conducted yearly with key staff.
5	Cyber security is a natural part of everyone's job. Part of your organisation's DNA.	Dependencies and triggers for changes in cyber risks are embedded in the risk management process.	A security operation centre monitors, analysis and corrects incidents on digital assets.	Continuously changing security threats are dynamically linked to safety hazards. Safety and security activities are performed by a team with deep understanding of both domains.	There is a dedicated incident response team that will actively work to keep the railway operational during a cyber incident. Crisis management exercises are conducted with scenarios, simulations and multiple stakeholders.

One considerable difference though is that cyber risk changes constantly, as the attack surface, threats and exploitation of vulnerabilities change constantly. It is vital for a railway organisation to acknowledge that fact and build a continuous cyber risk management framework to be able to make the right decisions about technology, investments, and their infrastructure.

Technical countermeasures

Of course, we are talking about technical countermeasures as the digital threat grows with technology, connectivity, and digitalisation, so naturally the technical frontier needs to be looked at. We focused on the use of specific cyber security tools and methodology to complement the new technology being used in the railway sector.

Integration with safety

Railway signalling technology is safety critical. It is therefore natural that something like a digital threat that can compromise all the safety measures built in this industry over decades needs to be looked at and incorporated into the safety processes. In particular the tension between the safety and security culture needs to be addressed at this point and turned into a productive collaboration, where both sides are involved in the solution.

"We developed this as a tool for railway executives, safety engineers and any cyber-security interested party to get a quick overview of their situation regarding cyber security"

Incident management

One of the most famous quotes in cyber security is "it is not a question of if, but only when we will be attacked", which we wanted to be reflected in the maturity matrix to promote awareness in an often-underdeveloped dimension. The big difficulty with cyber attacks is that they are constantly changing and evolving, and it is an illusion to believe systems will stay protected against everything and anything. This is especially the case with safety driven industry and large infrastructure which demand a certain stability, adaptations in behaviour, culture, and technology which cannot be achieved overnight. Therefore, it is safe to assume a number of breaches and attacks will hit railway companies, infrastructure managers and railway suppliers. But in a national critical infrastructure it is not only vital for safety and business continuity to be able to react in a crisis and 'keep the lights on', but it is also required by law – in Europe by the national adaptation of NIS-D.

How to use the maturity matrix

We developed this matrix as a tool for railway executives, safety engineers and any cyber security interested party within a railway undertaking to get to a quick overview of their situation regarding cyber security. It should be viewed as 25 simple questions that can be answered by yes or no. Dependent on how many questions an organisation can answer with yes, the higher the maturity level they reach.

It distinguishes itself from a threat and risk assessment conducted by a cyber security professional in terms of both the effort required and detail considered. The maturity matrix does not replace a professionally conducted assessment but gives a quick overview of the railway organisation's cyber position.

It clearly has the potential to be used as an industry wide benchmarking system once enough railway undertakings have asked themselves the 25 questions and have decided to share their maturity results either in full or in part.

The matrix should therefore be seen as a checklist for companies. Experience in supporting railway companies on their journey dealing with this "new" topic of cyber security has shown that knowledge and excellence are quickly developed in one or two dimensions, but sometimes other dimensions are forgotten or underdeveloped, so this gives a company the chance to check what has been overlooked.

Updating and future development

The next crucial part in developing the matrix is testing and validating it with railway organisations. Evidence in usability and relatability will help to improve and develop the maturity matrix, so it fulfils the purpose being understood and used by you, dear railway readers. We hope that this will encourage you to use this matrix, try it out and give feedback.

As in all cyber security processes the objective is to improve with every iteration.

About the authors ...

Alzbeta 'Betty' Helienek is a principal consultant at Ricardo Rail. Betty has 25 years' experience working in the railway and cyber security industry and specialises in combining the two to help solve the challenges safety critical systems face when confronted with cyber-attacks. She is a certified cyber security expert for industrial automation and control systems and developer of products and professional services.

In 2013, Betty introduced cyber security at Research Platform of the European Commission, which has since grown to be the working group for the upcoming CENELEC standard in cyber security for railways. She is also an advisory group member of the UK Cyber Security Council Formation Project.

Betty is currently delivering cyber security consulting for the railway and automotive industry and is co-founder of C4SAM, a European cyber security start-up. She recently joined the International Society of Automation's Smart Manufacturing and Industrial Internet of Things (IIoT) cyber security technical committee to look for solutions, best practices and possibly write a new standard for the IIoT.

Supporting author Mathijs Arends is a Dutch rail IT and data consultant with a focus on cyber security. He is a newcomer in the rail industry and has a background in software engineering for aviation support systems. With broad technical skills in embedded environments in combination with a passion for cyber security he tries to make the railways more secure. Currently he is focusing on cyber security in the rail sector for Ricardo Rail, with a specific interest in autonomous train operation, and supply chain management.

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Lessons learned from the Singapore re-signalling project

L Y Lam

When originally constructed, the Singapore metro lines used a range of microprocessor based train control and supervision techniques to connect the rapidly developing city state. Technology, and demand, moved on and by 2012 it was time to upgrade. The photo shows the main line and depot entrance at Bishan in the late 1980s. *Photo Westinghouse archive.*

The North-South and East-West Lines (NSEWL) are the first two metro railway lines built in Singapore. The first section of North-South Line (NSL) from Yio Chu Kang station to Toa Payoh station was put into service in November 1987, the other sections on NSL and East-West Line (EWL) were progressively opened and completed in 1990 with two interchange stations at City Hall station and Raffles Place station.

Further extension of these two lines took place in 1990s with another interchange station at Jurong East station. Having operated for over twenty years, there were equipment obsolescence and reliability issues on the NSEWL's signalling system and it was also difficult to find replacement parts. The Land Transport Authority (LTA) decided to replace the signalling system with a new generation system and the contract was awarded in February 2012. The new signalling system was put into service on NSL on 28 of May 2017 and then followed by EWL exactly one year later. During the first two years of the service, there were quite a number of issues due to software and hardware failures. This paper discusses some of the issues that resulted in train service delays.

Background

The NSEWL resignalling project aimed to replace the fixed block automatic train control signalling system on both lines with a Communication-Based Train Control (CBTC) system. At the time of planning for this replacement project, there was another project to extend the EWL from Joo Koon station to Tuas Link and these two projects were taken into consideration by the Land Transport Authority. Tenders for the EWL Tuas West Extension (TWE) project and the resignalling project were invited at the same time and were subsequently awarded to the same

The Singapore MRT network showing the Tuas West extension on the west and proof of concept area on the east of the island.
Image Singapore Land Transport Authority.

contractor in February 2012. The rail map above shows all the railway lines in Singapore and the connection between the NSEWL and TWE. The NSL is coloured red, EWL (including TWE) is coloured green.

The scope of the resignalling project comprises the replacement of the legacy relay-based interlocking system, automatic train protection system (ATP), automatic train operation system (ATO) and automatic train supervision system (ATS) with a moving block CBTC system and a computer-based interlocking (CBI) system. It does not include replacement of trackside safety protection devices, track circuits and point machines. The new signalling system comes with a fallback control system through an emergency control PC at station level allowing trains to be operated at line of sight 'restricted manual' control mode at a maximum speed of 18km/h.

Project implementation

The NSL serves a number of highly populated districts, city centre and central business district area with the highest ridership among all the railway lines in Singapore. The signalling replacement works started with NSL first, followed by EWL. TWE contract started on the same day as the resignalling contract and the work on these two projects progressed in parallel.

As TWE is an extension of the EWL and completed before the resignalling of the existing EWL, it had to be interfaced with the legacy signalling system before EWL was commissioned for full CBTC operation. To achieve this, the switchover between the legacy signalling system and CBTC took place at Pioneer station, one station before the end of EWL, to allow dual-fitted trains to switchover from the fixed-block system to the CBTC system and vice versa.

Proof of concept

For this project, different migration strategies were adopted for different phases of the project. A proof-of-concept (PoC) stage was included in the early phase of the project. This provided a testing ground to demonstrate the design, installation, implementation methodologies, operational concept and migration principles at various migration phases. The PoC took place on the Changi Airport Line. This line branches off from the main EWL located at the east end of the EWL as shown in the trackplan above.

The PoC area consists of three stations separated in two zones and one reception track leading to Changi Depot. It was fully equipped with all the key trackside equipment allowing various phases of migration to CBTC and cut-over methodologies to be demonstrated and tested out. The demonstration included cross zone operation, shadow mode operation for CBTC system reliability data collection while a train is running on the legacy signalling system, CBTC system operation, legacy and CBTC system over and back implementation, mixed mode system operation and switchover to model TWE and EWL operation

The proof of concept area covered the line from Tanah Merah through Expo (seen here) to Changi Airport. *Photo Shutterstock/ Markus Mainka.*

with CBTC operating on the extension line and legacy system on EWL, depot train initialisation and launching, system remote control from the operation control centre, fallback mode operation and interfaces with other system-wide systems as well as electromagnetic compatibility.

North-South Line implementation

The NSEWL and TWE consist of 58 stations, with approximately 100km length of track and 198 trains. It is divided into 18 zones and provided with one ATS for the control of the entire CBTC system on NSEWL together with TWE. In each zone, there is a Zone Controller System which consists of a Movement Authority Unit (MAU) and a CBI.

CBTC system deployment started off on NSL. It covered the entire NSL, Bishan Depot and a test track in the depot, 27 stations, 76 trains and 10 locomotives. In order to collect more CBTC system operational data to gauge the system reliability growth, shadow mode running was put into operation as the CBTC system was progressively commissioned zone by zone while the dual fitted trains were running in the legacy signalling system. Under this mode of operation, the legacy signalling system had full control of signals, routes and protection devices and trains were running based on the legacy fixed block speed code system. The CBTC system only collected the CBTC system data through train underframe carried antennae, detectors and Wi-Fi radio for train positioning verification and message integrity and radio roaming transmission monitoring. During this period of time the CBTC system was only running in shadow mode and there was no switching between legacy system and CBTC system while the train was running on CBTC equipped zones.

"It is understood that the transition to a complex-software based system would entail certain issues during the initial system operational stage"

Major incidents and service interruptions

It is understood that the transition to a complex-software based system would entail certain issues during the initial system operational stage. This was no exception for the NSEWL resignalling project, and subsequent investigations indicated that the root causes of these defects were due to some common software errors.

Loss of radio communication

There was a Wi-Fi radio transmission failure on NSL. The wayside radio units (WRU) started to fail inside Bishan depot (BSD). It propagated to the adjoining stations on the main running line. All trains running in both directions on the main running line next to BSD experienced loss of communications between train borne and wayside signalling systems. Without continuous radio communication, all trains were unable to proceed in automatic mode and needed to proceed in restricted manual mode to the next station.

It was noticed from the Network Management System that WRU failed one after another starting from BSD and extended to the main running line. Further analysis indicated that the WRU failure occurred in the direction of movement of one particular train. This train was immediately withdrawn back to depot for further investigation. All the affected WRU were then reset to resume normal train operation after this rogue train had returned to the depot far end siding.

The root cause of the WRU failure was due to a specific scenario of unexpected data corruption that resulted in data structures being shifted in memory. This resulted in unexpected values in the data structure leading to a constant software loop which can be called a halt. The software was updated to handle unexpected

data corruption by doing more defensive coding. This then results in better error handling and allows the units to continue functioning even after a data corruption. As a lesson learned, it is always good practice to do defensive coding with operations-friendly recovery, to handle unexpected scenarios.

"It is always good practice to do defensive coding with operations-friendly recovery, to handle unexpected scenarios"

Verification of input from other systems

Due to a fault detected in the active central ATS server, the system switched over to the hot standby server. This led to a "ghost train" being created at the zone border. The train associated with this ghost train icon had passed the zone border into the adjacent zone. The ghost train icon was just an icon with no train associated with it so it would not move. The traffic controller tried to resume train service after server switchover and did not notice it was a ghost train icon and routed this ghost train to the adjacent zone. As the actual train was already in the adjacent zone, the adjacent zone MAU used the real train's position to do route check in/check out for verification. As the position did not match it brought the MAU to a halt.

The MAU is a SIL4 system and will halt the system if an unsafe condition is detected. But to reject a route call from ATS due to invalid parameters and raise an alarm does not violate any signalling principles. Not setting a route would not cause any unsafe conditions for train movements within the zone. So there was no need to halt the system because of an invalid input from ATS and the system in the adjacent zone. Halting the system resulted in all trains inside the zone operating in restricted manual mode and operators having to countermand the signals within the zone to maintain minimum train service.

The system is designed with fault detection but not necessarily in a manner that benefits the operator as in some cases the unit instead of rejecting an invalid route call will halt the processing. In any system when the input is not as expected the system can halt or reject the data and continue operation as long as SIL 4 is maintained and this is a tradeoff analysis that needs to be considered. In the context of this problem, each zone has its own MAU and CBI, both are designed to SIL 4. The signalling status from CBI in the same zone must be reliable and any information from other systems or adjacent zone must be screened and verified before it is used and processed by the system. It should always assume inputs from other modules and systems may contain errors. The system should not just detect these errors as in this case but it should handle it without halting so as to not significantly impact operations.

System capacity and response time

The NSEWL is one of the biggest systems delivered by the contractor, in terms of track length, number of stations and number of trains. The ATS design was baselined from previous projects which were relatively smaller compared with the NSEWL re-signalling project. The ATS throughput analysis carried out by the system designer was simply to expand it to the number of trains/workstations required by the system. Another aspect is the added new functionalities for the NSEWL project. The bigger system and new functionalities resulted in significant increase in the ATS system data processing and volume of information transmission between various functional systems within the CBTC system. The amount of data the ATS server has to send to the workstations depends on how many updates required, number of moving trains, commands issued, timetable size, etc. In this ATS system the central server continuously updates all operational status to all workstations installed at stations along the running line, central operation control centre, backup operation control centre and maintenance

Resignalling a system of this complexity brought many challenges, including fitting new transponder antennas to existing rolling stock.

centres. This update also includes system overview, live train moving information status and system playback data, timetable and fault logs of various systems.

The replacement CBTC system provides automatic bi-directional and shuttle train operation. A bi-directional area is an area in which two trains can oppose each other and become deadlocked. In this CBTC ATS system, route setting is dynamic. Routes can be set from any point on the line to any other point on the line. A route does not necessarily need to start from a signal to another signal (signal to signal route). This design approach does not allow route locking of this nature to be carried out at interlocking level and must be carried out in a system which has full knowledge of all train movements in the system irrespective of timetable train movements or manual route commanded by operator.

The ATS system provides deadlock prevention mechanisms for turnback areas, bi-directional areas, and terminus areas. When a manual route is commanded by the operator the bi-directional handling trigger refreshes for all trains. This generates a large amount of data and causes internal queue overflow. This slows down the response to commands issued by ATS and by operators, in particular for those critical commands which are supposed to be executed at the earliest possible time.

The problem was resolved by only processing the bi-directional handling refresh trigger for the train concerned, increasing the queue size and data compression for telegram transmission and increasing the network throughput.

The assumption that using exactly the same software will work may not always be valid without detailed evaluation of the requirements and assessment of the scale of application.

"High volume data transfer should only be sent to those workstations that require it to operate and control the system in normal day to day operation"

The system capacity, the response time performance, the minimum and maximum arrival rates for each input, the communication path, bandwidth and the rate output produced need to be evaluated and size the system provision as appropriate right at the beginning of the project. High volume data transfer should only be sent to those workstations that require it to operate and control the system in normal day to day operation. For other workstations this information should only be made available on demand basis to reduce unnecessary data transfer through the network and reduce the processing load of the central servers.

Door synchronisation at terminal stations

For the NSEWL project, each train is equipped with two Vehicle On Board Computers (VOBCs), one at each end of the train and which are connected to provide head-tail redundancy. There is a requirement to switch the VOBC over at terminals or when a train reverses. After switch-over the newly taking over VOBC should retain all the ATO/ATP/interface control status and data.

It is an operational requirement in Singapore that there is always a train crew in the train cab while it is on the main running line. At terminals, train crew step-back takes place in order to meet the short turnback headway requirement.

Under automatic mode of train operation, a train arrives at the terminal station with train door and platform screen door open control in automatic mode and door close control in manual mode to facilitate train crew control of train door operation before departure. The replacement train crew enters the tail end of train cab and leaves the cab door open to prevent the train from moving off automatically after dwell expired and train saloon doors and platform screen doors are closed. VOBC switchover takes place about 18

seconds before the dwell expires. Shortly before the dwell expires, the front end train crew closes train doors and platform screen doors using the manual button on the cab console after passenger exchange and leaves the cab and closes the cab door manually. As there is no synchronisation between the two VOBCs on board the train the newly active VOBC detects there is a discrepancy in train door and platform screen door, because the cab door of the newly occupied cab is open. It issues a door open command to synchronise both train door and platform screen door. Then all the platform screen doors are open. To close the platform screen doors the train operator needs to operate a manual switch located at the headwall at the platform.

Although this does not pose a safety risk, there is a need to address this synchronisation problem, by updating the passive VOBC on the door command status before switchover takes place. The passive VOBC will memorise the last door command and this becomes the default door command until the train departs from the station. Alternatively, removing the requirement of VOBC switchover at terminals and change-end locations will avoid the issue of VOBC synchronisation from happening unless it so happens that the active VOBC fails at these locations. Separating the cab door and saloon door control and detection is another way to get around this door synchronisation problem.

The issue here is the understanding of operational requirements at terminal stations.

Watchdog switchover triggering control

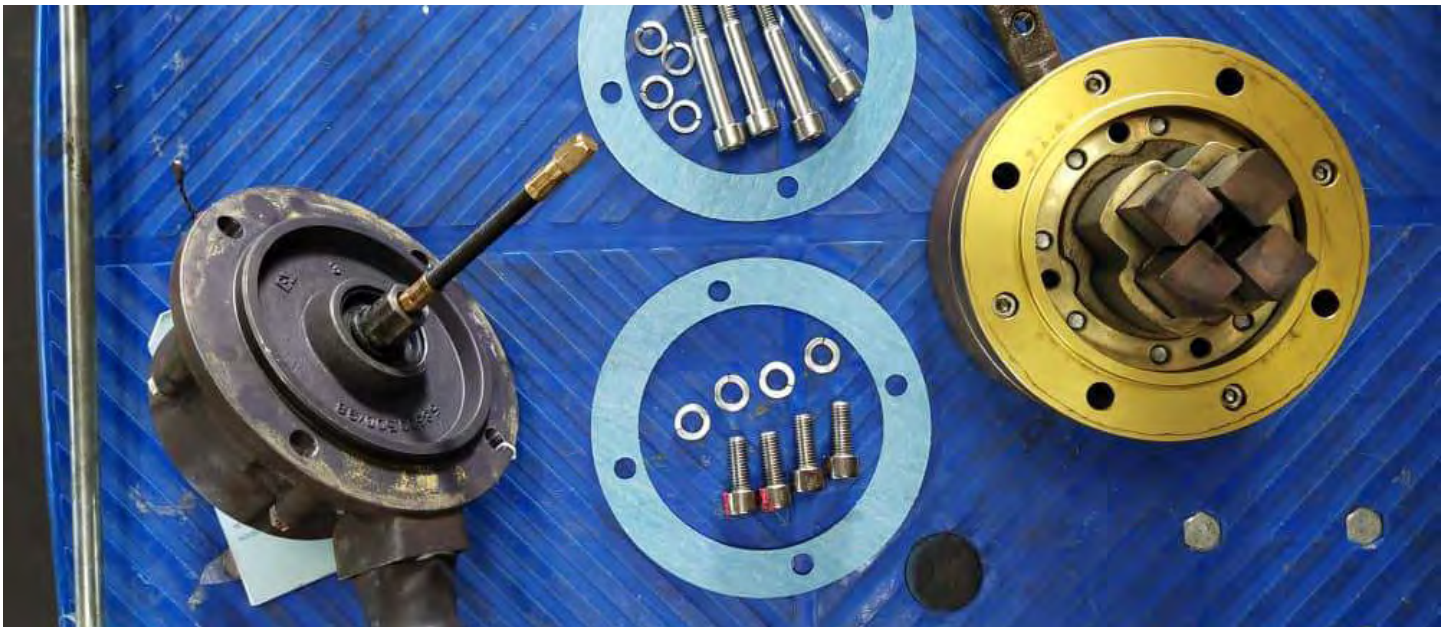
A complete zone went down due to the watchdog monitoring the healthy status of the CBI communication module being unable to detect an intermittent failure of the module, hence it could not trigger the restart of the module and switchover to the passive module.

Due to intermittent failure of the communication module, the MAU in the zone only received intermittent messages from the CBI. Because the messages received were intermittent and incomplete, all messages were rejected. As there was no update from CBI on trackside equipment status MAU closed all tracks within the zone.

Because of this failure, the active communication module could not update the trackside equipment status to the passive module. Failure of synchronisation between the active and passive communication modules led to the passive communication module trying to take over control. However, it was unable to take over as it detected that an active communication module was still running when it initiated the taking over process, so it restarted itself.

The root cause of the failure was due to a hard disk failure. It caused an application to pause while it attempted to read from/write to hard disk. The pause of this particular application software led to software in the watchdog to malfunction and freeze. Apart from the software reset, the watchdog was also provided with a hardware reset. However, this intermittent failure occurred periodically at a time interval less than the hardware reset time of 30 seconds. No switchover could take place until the active communication module failed.

The watchdog design for the CBI communication module includes both hardware and software resets. It is rare to have them both failing to detect the failure of the communication module to communicate with peer module and MAU. It leads to a new look at the architecture and algorithm of the watchdog on the software side. For safety system communication, message integrity, timeliness and sequence compare are normally included. The same approach is adopted to improve the integrity of the watchdog architecture and algorithm. Timestamps are provided to ensure the freshness of the messages exchanged between the watchdog of both active and passive communication modules and to ensure there is no missing cycle between messages. This prevents any short, intermittent failure from remaining undetected.



An example of innovation necessary during the resignalling was the mounting of new tachogenerator speed sensors on an axle used for traction current return.

Singapore LTA's ATS is a complex, service critical system.

"The ATS is a service critical system. Even when input variables/ parameters may be invalid, the system reaction should be considered to not inconvenience operation"

Input parameter verification

A train leaving the EWL main line returned to depot with one VOBC active and the other VOBC passive. The EWL ATS kept an image of the train VOBC configuration of the train. Due to a fibre optic cable failure in the depot, the train could not communicate with the depot ATS. During maintenance work VOBC was switched over. Because the train had never communicated with the depot ATS while the train was inside the depot, its image in EWL ATS was not updated and remained as in its original configuration before it left the main line earlier.

When the train was went back into service, it established communication with EWL ATS at the reception track. It reported a different configuration because of the VOBC switchover had taken place while the train was in the depot. This led to EWL ATS to have two active VOBC registered for this train, one in memory and one during train launching when communication between the train and the ATS was established at the depot reception track. This led to the ATS failure. The watchdog timer was then activated and re-started the ATS and switchover to the passive ATS server.

The ATS is a service critical system. Even when input variables/parameters may be invalid, the system reaction should be considered to not inconvenience operation. The ATS should only halt under extreme conditions where if the execution continued it would cause more operational problems than the halt. However, in some cases a halt is a better design principle if the backup unit can be activated seamlessly.

Data storm

NSL was put into full CBTC revenue service on 28 May 2017, while at the same time installation work was in progress on the EWL. Exactly one month after NSL commenced CBTC service, shortly after the beginning of the evening peak the Network Management System (NMS) showed that all WRU on NSL went down. It was later identified that there was a data storm on the data communication backbone network.

One day before the data storm incident, the WRU ring from Buona Vista station (BNV) and Redhill station (RDH) was brought online with its link to the backbone in BNV disconnected. On the day of the incident, the contractor's engineer uploaded the latest radio software and initialised the network in BNV. The coupling switches at BNV and RDH were running different versions of software. The old version had an issue with the coupling protocol which always activates the link. The new version had properly working coupling protocol and was provided with a function that would not activate when detecting the presence of its peer. However, at the time of incident the new version did not detect the presence of a peer that was running an old version of software. As per configuration it activated itself automatically. The engineer did not know there was incompatibility between the old version and the newly uploaded software version and connected the link together. He then uploaded the remaining part of the ring with the new software at RDH. When the redundant coupling port was connected in BNV, it caused both coupling ports to activate and create a loop in the network. This caused a data storm on the data communication backbone network serving both NSL and EWL until the links connecting the lines together were isolated.

NSL was originally designed with one depot at Bishan. Due to line extension, Bishan Depot does not have the capacity to hold all the trains required for NSL service. Some of the trains are stabled in Ulu Pandan Depot (UPD) on EWL. The ATS and data network of NSL and EWL was then designed to operate as one monolithic system for ease of train movement across these two lines and shared use of UPD depot. Because of this monolithic system design approach any system-wide network issues will have an impact on both lines.

30 years later than the photo at the beginning of this article and Bishan has changed beyond recognition. CBTC is installed along the NSL line and the system is operating reliably. *Photo Shutterstock/ZDL.*

The root cause of this incident was the incompatibility of the old version and the new version of software as they cannot be connected together in the same ring. In the old version software switches run a ring resolution protocol. One switch in the ring is configured as the redundancy manager. This switch disables one of its ring ports, thus making one link in the ring stand-by. In this way, no loops are created in the backbone. This incompatibility issue was not brought to the attention of the engineers implementing it and was not captured in the installation method statement.

After this data storm incident, studies were conducted to explore the feasibility of uncoupling the NSL and EWL. However, it was found that the modification is complex with high technical risk to segregate the ATS and DCS (Data Communication System). In addition, it would impact the ability for trains to move seamlessly between NSL and EWL. Improvements were made for partial segregation of the DCS network in order to strengthen the robustness of the data communication link.

Conclusion

Today, most of the metro railway signalling system suppliers offer software based CBTC signalling systems. To achieve a highly reliable system, it is important not only to have good quality hardware but also a highly reliable software system.

It is therefore important for the system development and implementation team members to follow good engineering practices to design and develop software and deliver a highly reliable software system. Appropriate procedures and industrial practices as given in international standards and good coding practices need to be adhered to. When reusing software, the working and operating environments and the size of system need to be assessed and specified in the design specifications as appropriate. Operating practices need to be defined at the requirement capture stage to understand how the operator will run the railway and include them in the design specifications.

Halting a non-safety but a service critical system such as the automatic train supervision system should be avoided. Faults and known failure modes should be identified and addressed in design. Detection of these faults and their handling need to be defined in the design specification and managed.

Once the above issues were resolved, and the system reliability improvement program was completed, the NSEWL's new signalling system is now delivering the required performance and reliability.

"Operating practices need to be defined at the requirement capture stage to understand how the operator will run the railway and include them in the design specifications"

About the author ...

L Y Lam is a senior engineering consultant in the Land Transport Authority (Singapore). He has over 40 years experience in signalling system design and testing, project management and design management of signalling projects, working in Hong Kong and Singapore, and providing consultancy services elsewhere in the world. He was instrumental in establishing the IRSE local section in Hong Kong, and has served as secretary and chairman. He also acts as a special advisor to the Singapore section, and has published a number of papers with various engineering institutions.

What do you think?

A recent UK Rail Accident Investigation Branch report recommended that the signalling industry should capture and share safety learning from failures of complex software based systems. This article is an excellent example, and LTA Singapore are to be congratulated for their openness in allowing its publication. Do you have any examples of such learning that can be shared in a similar manner? Email us at **editor@irsenews.co.uk**.

"It's only backwards compatible"

Stephen Dapré

We first met Ruth in IRSE News December 2018 issue 250. Ruth is a fictitious signalling project engineer, who followed her grandpa Harold and uncle Bob into railway employment. She now works for a fictitious railway infrastructure manager who is organised into various regions called "Communities".

"Ruthie, why do they go and change things just for the sake of it?"

Ruth was visiting grandpa Harold in his care home. When he moved in, he had brought a few of his electrical appliances with him including a large table lamp, and he had now been asked not to use them.

"Grandpa, the thing is – not everyone here is as technically minded as you are, and they need to ensure you are all safe."

"How does sending electrical currents through plugs with differently shaped pins suddenly make it any safer than the old ones then, tell me that?", with his usual mix of genuine frustration and twinkling eyes looking for a lively intellectual debate.

In the early days of electricity their country had used plugs and sockets with round pins and holes, then some decades ago new standards were introduced, featuring plugs with what most people called square pins (although Ruth and her grandfather knew they were rectangular). For many years thereafter it had been possible to buy adapters to allow round pin plugs to be plugged into modern angular-holed sockets, and that was safe enough. However, it was now so long after the standards had changed that any remaining appliances with round pin plugs were becoming quite old, with all that meant for the condition of their wiring and insulation.

"So, grandpa, what have they actually said about it?"

"Well, I've only been told by the care staff, but according to them someone called Pat goes around testing all the appliances. They say that Pat tested my lamp and it failed. I don't see why, I covered up the frayed bit of insulation with some proper electrical tape so it's perfectly safe. I do sometimes find that when I turn it on, the circuit breaker in the corridor trips, but I have done the calculations and its just because the lady next door always leaves her TV and heater on with the window open so there's too much load on our circuit already."

Although Ruth's knowledge of signalling history was still growing, she was fairly sure that she had seen earth leakage detectors even in the older relay rooms so she decided that Harold would quickly understand domestic RCDs (Residual Current Devices) and how they differed from conventional overload circuit breakers. She brought him up to date with modern wiring regulations and observed that tripping was perhaps a sign that all was not well with his lamp.

After completing their technical discussion, a chat about family news and finishing their cups of tea it was time for Ruth to go. Ruth was about to walk down the corridor when Harold said:

Compatibility, and especially backwards compatability, can be a challenge in many walks of life.

Photo Shutterstock/KoldunovAlexey.

Photo Juergen Diermaier/Pixabay.

This is a circuit protecting safety device. It is not a light switch.

"Well, at least I now know that if I ever want to turn off the power quickly, I just need to stick my insulated-handled pliers between Live and Earth and it will trip immediately, it saves climbing a chair in the corridor." Ruth froze for a moment until she could see a cheeky grin emerge. She turned and continued, wondering whether her latest upward mentoring session had really been a good idea.

Train service pattern

"Sorry love, this ticket isn't valid on Swirly Spiral trains, its only compatible with Polka Dot services, like that train over there in the other platform."

Ruth sighed. She had got up at silly o'clock to travel in from her hometown in good time to board a long-distance train to her meeting, yet having carefully researched the complex rules on tickets it appeared she had bought the wrong one. Or the right one but boarded the wrong train. She peered through her bleary eyes at the name-badge with unnecessary Swirly Spirals branding, which told her the person standing in front of her was the Customer Experience And Door Closure Sequence Manager (CEADCSM), and that his name was Ed. Ruth felt that just putting "Ed" would have been sufficient (and allowed a larger font amongst the spirals), but that was not going to change the situation. Too tired to debate it, she gathered her belongings and adjourned to the marginally less unpleasantly patterned train on the other platform. She wondered whether travel sickness could be caused simply by décor and patterns.

Once Ruth was settled, she thought about the day ahead. She had been approached by the Binary Railway department several times about the apparent benefits of the new national in-cab signalling system called Universal Train Control System (UTCS). After a series of unfortunate diary clashes, she had finally decided to accept an invitation to a presentation already being given to another Community further afield. She was particularly interested in how compatibility between different versions and suppliers would be managed when it would inevitably take many years for the technology to be applied across all the Communities. She recalled her uncle Bob enthusing about the benefits of relays made to a standard specification by a variety of suppliers which could be individually swapped and serviced, and his frustration with electronic systems that were quickly superseded by minor updates that inevitably required slightly different interfaces and stocks of spares. Although the first computer interlockings had carefully used a modular design with elements from different suppliers being interchangeable, more recently this approach had been diluted when individual suppliers had proposed upgraded versions using their own products. It was a conundrum: insist on consistency which may stifle innovation, or allow new products with improved features such as remote diagnostics at the expense of backward compatibility. Ruth smiled because Bob's unwavering advice for anything involving connecting different electronic systems together was "if in doubt, use a relay interface", and she had seen examples of this herself.

"Teas, coffees, snacks?". Ruth's thinking was abruptly interrupted by the at-seat trolley service. She had recently started using a phone app to pay for small purchases, however it quickly became clear that this train company did not accept that option, and she had no small change with her, so after ordering her drink she and the catering host took several attempts to find a combination of debit/credit cards, machine readers and signal strength before successfully paying.

Open access

Ruth had arrived at her destination, only to find her Polka Dots ticket would not open the exit gate at the station. After queuing to file past a member of staff who was not checking tickets whilst talking to a colleague, she walked across the city to the Community head office.

"Do you have an approved sky-blue lanyard?" demanded the person sitting at what was allegedly a welcome desk.

"No, I work for another Community, but I thought..."

"Only people who are proven to be in this building for at least 27.5 hours a week for a period of a whole year qualify for a sky-blue lanyard, otherwise you are all visitors. You need to sign in and be met by your host."

Ruth compared the height of the access gates with the hurdles she used to jump quite successfully in school athletics, but decided those skills were not transferable to grown-up life. Instead, she joined the back of the queue of other disreputable intruders from outside the city to plead sanctuary. Clearly her railway's various policies on interoperability, compatibility

Traditionally at least some equipment was built to a standard specification by a number of suppliers. This particular example can also be used to interface incompatible electronic devices!

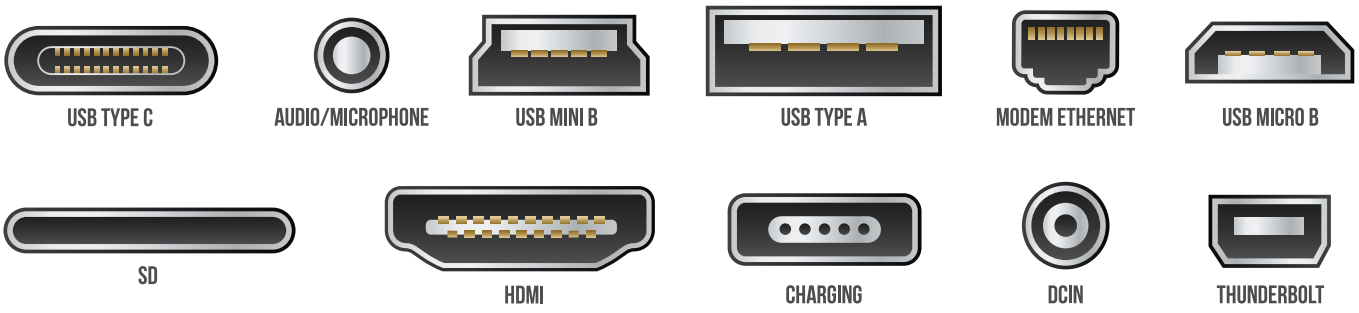


Photo Shutterstock/Mikhail Grachikov.

Even standardised connections can be bewildering.

and inclusivity did not apply to office access. After excelling at the rather less onerous entry requirements for visitors by providing a name that sounded like a name in the visitors book, she then gathered in the holding area to await her host and amused herself by trying to guess who else might be going to the same meeting.

Eventually the mystery was solved when her host announced themselves at reception and several people expressed a degree of interest by way of walking nearer. In a scene reminiscent of a film she had seen about prisons, they all shuffled obediently through beeping security gates and long corridors into a meeting room to await the start. Their host started to prepare by getting their laptop and trying to connect it to the TV screen in the room.

"Ah, does anyone have one of those adapter thingies? My laptop only has the old-style blue multipin socket for plugging in projectors, but this TV uses one of those flat black ones."

Nobody was forthcoming so the host disappeared to seek help, returning after much delay with a somewhat underwhelming adapter that would hopefully improve compatibility. After a quantity of plugging and unplugging, resetting and unfamiliar words in the local dialect, a photo of what was probably the host's partner on holiday briefly appeared on the large screen, hurriedly replaced by a slightly less exciting presentation about UTCS. A further kerfuffle then took place because one attendee had asked to attend remotely from home, however nobody could work out how to allow them to speak to those in the meeting room. Eventually it was concluded that they would listen in and ask any questions by email afterwards. Ruth wondered whether working from home and virtual meetings would ever really catch on...

Forward thinking

Not unusually in Ruth's experience of railway operations, the potential for a brisk and punctual start had gradually lapsed into a belated and tentative jolt to overcome the sheer inertia. After the routine introductions and life histories, the host explained that two key visiting experts had not arrived for some reason (which made Ruth wonder if they had simply felt so unwelcome at the front desk that they had abandoned attempts to enter and gone sightseeing instead). Instead, the host and others did their best to talk through what was on the screen. Ruth listened politely whilst people explained that one of the main benefits of UTCS was that in future all trains would be able to travel everywhere seamlessly because the entire network would be using a fully compatible system. It all sounded very sensible; however, she was still trying to recall something she had heard when she first looked into UTCS a couple of years ago. Suddenly it came back to her:

"Can I just ask, I'm sure when I visited the Community of Rural Song and Sheep (IRSE News Issue 250), they said they were getting some new trains which meant they would need to upgrade the version of the UTCS infrastructure, why is that?"

"Ah, well – I'm not so familiar with that site but I'm told it's only backwards-compatible."

"But what does that actually mean?"

This resulted in a compatibility discussion with an intermingling of forwards, backwards and less precise references in a manner somewhat reminiscent of the Swirly Spirals train she had seen earlier, until the consensus seemed to be that trains using older UTCS software versions would probably work with newer UTCS signalling, but perhaps not the other

The UK's approach to compatibility in the 1980s. Plug compatible units from multiple suppliers. The systems replacing SSI offer much greater functionality and performance, but at the expense of that ability to interconnect. A suitable, yet non-ideal, interfacing device is also shown.

Photo Westinghouse archive.

way around. Just as Ruth thought she understood it and was about to ask about how this would work in the future when far more trains and infrastructure had been fitted, the door burst open and two people walked in talking to each other. One then said to the room:

"Aha, glad to see everyone else is even earlier than we are, that means we could start if people are ready?"

They were greeted by a mixture of bemusement, murmurs and comments which soon conveyed to the newcomers that they were not in fact early.

"But the invitation in our calendars say 10:00, it is clearly wrong?"

"Ah, but was that 10:00 in local time or in Universal Time?" said the host.

It suddenly dawned on the experts that because they had travelled from afar, their calendars had not allowed for the minor detail that the meeting time was quoted in local time, which made sense for most attendees but not for them. They were therefore almost one hour late.

After some clanking of chairs as the original attendees made space for those subconsciously labelled as latecomers, the room settled down. At least the arrival of the experts might mean Ruth could better understand the backwards compatibility situation. She had even decided to use the term "migration strategy" in her question, if only for her own satisfaction. Just as she was about to ask her question, the door opened again and a face appeared.

"Sorry, we have this room booked now, please can you find somewhere else."

"I don't think so, we booked this room over two months ago on the system."

The face smiled knowingly. "Surely you know that the old system was unreliable and incompatible with our calendar software, so it was replaced a fortnight ago and old bookings are no longer valid? We have followed the new process and we have people waiting outside, could you please ask reception for a different room."

After an embarrassing pause, the attendees in Ruth's meeting realised that once again today they were not welcome, so they packed up their belongings and filed out, being careful to avoid eye contact with the other attendees queuing triumphantly outside. They all huddled in the office kitchen while their host checked with reception. Upon return it was clear it was not good news.

"The only spare room they could find is in...the other building" said the host, with the tone clearly implying the other building was a place of unspeakable pain and torture.

"...but – but, that is the far side of the city centre?!" said one attendee.

"And that's no good, my sky-blue lanyard won't work there, they have purple ones instead – they might expect me to sign in as a visitor!" said one of the local attendees.

Having left home in darkness to travel half the length of the country, Ruth could not really see what was so challenging about walking to another building, however it became clear that it would be too traumatic for those normally based in the building in which they were currently not having their meeting. The host instead proposed they would stand in the kitchen to summarise and agree next steps. They did so for a few minutes until people got fidgety and then dispersed, with Ruth's question left unanswered.

Diverse routing

For the homeward journey Ruth was careful to find a Polka Dots service to suit her ticket and found a comfy seat in the first carriage immediately behind the driver's cab. She often chose to sit there: partly because there were usually more empty seats at the end of the train, also because her railway family genetics naturally attracted her to be within earshot of any interesting cab alarms or conversations that might inform the success of her journey. Before long, her decision was rewarded with a sequence of warning noises for caution signals ending with a complete stop at a signal surrounded by fields several miles from nowhere. This was a sure sign of trouble...

After the traditional pause of a few minutes to create a sense of drama and tension, complete with tantalising muffled snippets of the driver talking to someone on the radio to dilute the silence, a crackly announcement explained that due to a train failure somewhere ahead they would be held at their current unspecified location for an undefined period of time. After passing on this crumb of information, the traincrew met up next to the internal cab door for a team chat.

"Eh then driver, why don't we just couple up to that Swirly Spirals train and push it forwards to the next station?"

"Ah well, we could have done that a few years ago when these trains were new, but when Swirly Spirals took over some of the fleet they did a refurbishment that meant theirs are no longer compatible with ours. I think one of their auto-coupler circuits now carries data about seat reservations and entertainment whereas on ours the same contact pins do something more useful and powerful."

Train interconnection works nicely when the two trains are of the same type, from the same manufacturer, with the same couplers and software.

Photo Shutterstock/Ceri Breeze.

London Underground embodies many of the complexities of compatibility. Although the fare collection system, telecoms and traction power supply are (more or less) common across the network, there are multiple types of rolling stock and signalling systems leading to different operating procedures. The lines have a mixture of platform heights and even tunnel sizes. Most lines (i.e. the services depicted on the Underground map) have interconnections to at least one other line, some platforms and tracks are routinely used by trains from more than one line (or main line trains), and some Underground trains use Network Rail main line infrastructure to reach outer London destinations.

This leads to safety-critical requirements such as making sure that a big train doesn't try to go into a small tunnel.

Photo Shutterstock/Mark Broomfield.

"How about we ask to take the diversionary route via the branch line down the valley then?"

"Ah, these trains are no longer permitted that way, our axle loads are too heavy for some of the underbridges."

"Or what about that freight line? Surely that can take us?"

"I haven't driven that way for years, I don't know the road anymore, don't have route knowledge."

Ruth was thus able to deduce well before the other passengers that they would be in for a long wait. She unpacked her earphones from her bag to listen to some music, until she realised she had only brought the pair for her work phone which had a different connector to her personal phone where her music was stored. She instead passed the time by amusing herself with other incompatibilities on the train: how the rolling stock designers had carefully designed the window sizes and seat spacings to maximise the scope for window pillars blocking views from seats, and how the overhead luggage racks were fractionally smaller than the widely recognised (and thus incredibly popular) dimensions of airline hand baggage, hence various hand baggage cases could be found on seats, under tables and in the larger floor-mounted racks. And then there were the seats themselves: Ruth felt she was a human of average dimensions in all directions, yet she knew the prolonged journey would soon make her ache.

Ruth was finally arriving home after her long tedious journey and a busy week, so was looking forward to a glass of wine to start the weekend. Upon arrival she was somewhat surprised to find a large parcel inside the porch, so she decided to open that first. It was from her mum, with a note saying: "Grandpa said you might like one of these so I bought it for you xx". She carefully unwrapped the parcel and found a small table lamp inside. Very grandpa, she smiled to herself. Now, to try it out she just needed to find what at work she would always call a lamp (she got told off for not calling it a lamp in her very first week) but in the safe privacy of her own home it really was just a light bulb.

Having rummaged around to find a spare bulb in the cupboard, she tried installing it – only to discover the table lamp had a screw thread fitting, unlike all the existing light fittings in her house which used bayonet fittings. Hmm, this lack of attention to boring technical detail suddenly felt more like mum than grandpa, she thought. She was too tired to phone either of them that night to thank them, only to have to explain the complication. Instead, she found the corkscrew in the drawer, chose a new bottle of wine that looked rather appealing, fumbled with the top until she realised it was a screw top bottle, unscrewed it and poured herself a glass. Ruth finally sat down exhausted and quietly digested the symbolism of the screw top lid and unnecessary corkscrew in front of her, and relaxed.

What do you think?

Have you had similar experiences to Ruth when it comes to compatibility in all of its different forms? Do you think that we as an industry have taken the wrong approach? Perhaps it is different in your country or on your railway and you have managed to deal with backwards compatibility. Maybe initiatives like EULYNX offer a way forward, or maybe you think that standardisation can stifle innovation?

We'd love to hear your views and share them with other IRSE News readers. Email us at **editor@irsenews.co.uk**.

About the author ...

Stephen Dapré started his career with British Rail Southern Region. He then moved to Reading, working for Interlogic/Adtranz in construction/commissioning roles and MHA/Lloyd's Register in consultancy. Between 2005 and 2020 he worked for Network Rail's in-house design group on a variety of projects ranging from Reading remodelling and Crossrail to Liverpool Lime Street. At the end of 2020 he returned to his roots, becoming asset strategy manager (S&T) for Network Rail's Southern Region! Stephen is a long-serving member of the IRSE Examination Committee.

Industry news

For more news visit the IRSE Knowledge Base at irse.info/news.

Main line and freight

JR East to trial driverless trains

Japan: JR East has announced plans to use a 12-car Series E7 high speed trainset to undertake a series of driverless test runs in October and November 2021 as part of its Change 2027 programme. The trials are intended to test automatic operation to support the railway's longer-term objective of running driverless trains in revenue service on the Shinkansen network.

The tests will also assess the potential transmission of high-definition video using local 5G wireless networks, with a view to future use on the national network.

High speed rail for North America

USA: The US High Speed Rail Association (USHSR) has announced a five-point High Speed Rail Plan for the new president Biden administration. The plan has recommendations for the high-speed rail programme including specific high-speed rail projects. It includes:

Creating a new High-Speed Rail Development Authority to direct and coordinate the national programme. This new Authority would be tasked with initiating new high-speed rail projects, conducting route studies, filing for permits, land acquisition, hiring contractors and consultants, and hiring concessionaires to operate the trains. This includes streamlining the approvals process by allowing simultaneous approvals, shortened timelines, and single agency approvals.

Selecting the top five high speed rail priority projects, designate them "Special Projects of National Significance" and fast-track each to completion with the full support of the federal government. They are California High Speed Rail – $60bn. Texas High Speed Rail – $20bn. iNEC upgrade, New York City tunnels – $50bn. Cascadia Ultra-High-Speed Rail (Pacific NW) – $40bn. Florida High Speed Rail (Tampa-Orlando) – $2.5bn.

Selecting second-tier projects and immediately fund and assist them into early works – planning, route studies, permits, land acquisition, and pre-construction works. These include Chicago-Milwaukee high speed rail – $8bn. Atlanta-Charlotte high speed rail – $18bn. Louisville-Nashville high speed rail – $15bn. Denver-Albuquerque high speed rail – $40bn. Chicago – St. Louis high speed rail – $18bn. Tulsa-Oklahoma City high speed rail – $8bn. Chicago-Detroit high speed rail – $30bn. Nashville-Memphis high speed rail – $15bn. Kansas City – St Louis high speed rail – $19bn investment. Chicago-Indianapolis high speed rail – $17bn investment.

Working with airlines and airports to replace short-haul flights with high speed rail, and extend high speed rail connections to major airports. Encourage partnerships with airlines on combined tickets for trips with part of the journey on a train and part on an airplane.

The US High Speed Rail Association is a membership organisation that has been promoting a national state-of-the-art high-speed rail network since 2009, showcasing the many benefits high speed rail will bring to America. The previous transportation secretary Anthony Foxx said, "there is no such thing as a Democratic or Republican road, bridge, port, airfield or rail system. We must work together across party lines to enhance this nation's infrastructure."

10-year investment plan for Portugal

Portugal: Prime minister, António Costa, has announced a €10.5bn (£9.5bn, $13bn) for 16 rail projects over the next 10 years. The plans include a new Lisbon – Porto high-speed line, with a travel time of 1h 15min; a new cross-border Porto – Vigo line with a one-hour travel time; modernisation and complete electrification of the network by 2030; an increase in capacity in urban areas; and new rolling stock.

€290m (£272m, $352m)has been allocated to increase capacity for suburban services, including increasing the frequency of passenger and freight services in Lisbon and Porto, while another €270m (£244m, $328) has been allocated to implement ERTMS.

Another €370m (£334m, $449m) will support a safety, renewal and upgrade programme, which focuses on noise reduction and climate change protection. The plans include the removal of 155 level crossings and the automation of a further 79, improvement to crossings at stations, the installation of train radios, and the implementation of noise mitigation measures.

City railways

3D augmented reality navigation for passengers

Taiwan: Railway and bus stations in Taiwan are launching a 3D "immersive" augmented reality (AR) navigation system to display schedules, announce delays, facilitate remote electronic payments, provide travel guides and tips, and to lead passengers to their booked seat. The system is being provided by Taiwan's Industrial Development Bureau's "Smart City Taiwan 360" and combines Multi-Access Edge Computing (MEC) servers and beacons to provide precise positioning and navigation services. The system can be viewed inside the station precincts via augmented reality and can be seen at www.smartcitytw360.com.

Communication and radio

Allocation and harmonisation of FRMCS frequencies

Europe: The UIC (International Union of Railways) has announced that the Electronic Communications Committee (ECC) has approved the draft for the official recommendation allocating 5.6MHz in the 900MHz band and 10MHz in the 1900MHz band for Future Railway Mobile Communication System (FRMCS). The decision grants specific conditions of usage, protecting railway operations and providing relevant levels of emissions, thus reducing levels of infrastructure investment in comparison to conventional telecoms networks.

The UIC says it is an excellent and valuable achievement for the entire railway community, and demonstrates that unified objectives and actions in the railway sector can result in highly positive outcomes, even in the event of difficult and sometimes controversial situations, such as fierce competition between industries to obtain 5G frequencies for their own usage.

With this major step forward, and the official launch of the 5G Rail European

project to build and test the first 5G prototypes adapted to rail operations, UIC say the FRMCS is well on its way and is becoming increasingly tangible, paving the way to further train digitalisation.

FRMCS demonstrator

Europe: A demonstrator version of the Future Railways Mobile Communication System, as a successor to current GSM-R technology is under way. The 30-month 5GRAIL project has eight work packages with an overall budget of €13m (£12m, $16m). It will be funded through the EU's Horizon 2020 research programme,

The International Union of Railways is in the lead as project co-ordinator. UNIFE represents the supply industry, along with communications and IT specialists Nokia, Kontron, Alstom, Thales, Siemens, CAF and Teleste. Infrastructure managers are represented by DB Netz, SNCF Réseau, SBB, ÖBB and Infraestruturas de Portugal, while the academic and research partners are IFSTTAR-Université Gustave Eiffel from France and DTU from Denmark.

5GRAIL will liaise closely with Shift2Rail, as well as regulatory and standardisation bodies and co-ordination with the EU Agency for Railways will check that FRMCS is compatible with the requirements of the Technical Specifications for Interoperability for Control Command & Signalling.

The development will be based on UIC's Version 1 of the Functional and System Requirement specifications, including interfaces, using 5G to 3GPP Release 16. 5GRAIL aims to validate the draft specifications and have a production version available in 2025, so that railways can start their own national pilot projects, based on the future 3GPP Release 17. The 5GRAIL prototypes will be tested in laboratories and real-world conditions, to ensure FRMCS will be able to support ETCS data, voice group calls and railway emergency calls. The project will also look at cross-border scenarios and coexistence with road-based intelligent transport systems.

Research & Development and Universities

New railway research centre at the University of Birmingham

UK: A new purpose-built centre to deliver specialist research in digital railway engineering has been opened at the University of Birmingham. The university has partnered with the UK Rail Research and Innovation Network (UKRRIN) to commission the facility, with £16.4m (€18m, $22m) in funding from Research England, which will be called the Centre of Excellence for Digital Systems

The centre sits within the Birmingham Centre for Railway Research and Education (BCRRE) and is set to unite existing academic and industry capabilities to innovate and support transformational change within the rail technology sector, globally. It is the first phase of construction work for a £46.5m (€52m, $63m), School of Engineering development. The 3,000m^2 facility offers a variety of contemporary and flexible design and research spaces.

The facility also has project labs, light labs and state-of-the-art equipment including cab simulators, signalling control centre, cybersecurity test lab along with electronic fabrication and technology assets to enable high quality, fast-paced research, through to proof-of-concept and testing. The centre will house specialist research in digital railway engineering, focusing on railway control and simulation, data integration, cybersecurity, condition monitoring and sensing, and improved methods for technology introduction.

Safety

Level crossing near miss due to railhead contamination

UK: On 24 November 2019, the barriers at Norwich Road Automatic Half Barrier (AHB) level crossing, near New Rackheath, Norfolk, England, lifted as a passenger train from Norwich to Sheringham was approaching. The control system at the crossing is a 'constant warning time' type used extensively in the USA but is relatively unusual in the UK. Two road vehicles crossed the railway in front of the train, which reached the crossing less than half a second after the second road vehicle was clear.

The investigation found that there was contamination of the railhead in the area caused by leaf-fall and atmospheric conditions. This contamination had not been removed because there were no railhead treatment trains on the Norwich to Sheringham line at weekends. The narrow band on which trains' wheels were running on the contaminated railhead, which was a consequence of the introduction of new trains, left the wheel-rail interface vulnerable to a poor electrical contact in the event of contamination.

This caused the level crossing equipment to misinterpret the position of the train, and consequently it opened the crossing to road traffic while the train was closely approaching. Since the incident Network Rail have altered the configuration of the control system to reduce the risk of this happening again. The investigation has made three recommendations regarding the planning of autumn railhead treatment, guidance on the introduction of new trains and the configuration control of signalling equipment. The report also identified two learning points concerning the investigation of incidents and the signalling design process and can be found along with a video of the incident at **irse.info/tyodr**.

Safety in the future

Switzerland: An interesting white paper looking at safety in the future has been published by the International Electrotechnical Commission (IEC). Using real life examples, the paper addresses safety in the future by referencing current social trends and initiatives such as the UN Sustainable Development Goals and various real-life examples of projects, works and companies that are pioneering innovative safety solutions. Common to such solutions is the underlying realisation that the concept of safety will be delivered in an integrated system in which humans, machines and the environment must collaborate.

The paper also introduces a collaborative framework called the "tripartite system for safety". This concept facilitates a systematic approach to examining key elements of safety. The recommendations make interesting reading for rail signalling and telecom engineers, and the paper can be found at **irse.info/ps9n0**.

Government, regulators, trade bodies and economy

European Year of Rail 2021

Europe: The European Parliament Committee on Transport and Tourism (Tran) has accepted a proposal to dedicate 2021 as the European Year of Rail. This is to support the delivery of its European Green Deal objectives for transport, which calls for accelerating the shift to sustainable and smart mobility. While transport accounts for a quarter of the EU's greenhouse gas emissions, the EU is targeting a 90 per cent reduction by 2050.

As part of the Green Deal, the European Commission (EC) has called for a substantial amount of the 75 per cent of inland freight currently carried by road to be shifted onto rail and inland waterways. While rail share has increased to 7.6 per cent of the passenger market, its share of the freight market has dropped from a peak of 19 per cent in 2011 to 16.65 per cent in 2017.

The Year of Rail will include a number of initiatives across Europe, including:

- Initiatives and events to promote debate, raise awareness and facilitate citizens, businesses and public authorities' engagement to attract more people and freight to rail.
- Exhibitions, information, inspiration, education and awareness-raising campaigns to encourage changes in passenger, consumer and business behaviour and to stimulate an active contribution of the general public to achieving the objectives of more sustainable transport.
- Sharing experience and good practices of national, regional and local authorities, civil society, business and schools on promoting the use of rail and on how to implement behavioural change at all levels.
- The undertaking of studies and innovative activities and the dissemination of their results on a European or national scale.
- The promotion of projects and networks related to the European Year, including via the media, social networks and other online communities.

Competition in the UK signalling market

UK: The rail regulator, the Office of Rail & Road (ORR), is to investigate whether the market for the supply of signalling systems in the UK is fair and competitive. A previous study closed in April 2020 to enable the ORR to focus on the impact of the coronavirus pandemic.

The new study will build on ORR's previous work in the signalling market, including its work with the European Commission on the subsequently abandoned plans for a merger of Siemens Mobility and Alstom. The ORR were concerned that a merger would significantly reduce competition and increase costs.

It will focus on the supply chain for the delivery of major signalling projects, looking at competition and incentives to compete. It will investigate whether there are any barriers to innovation, market entry and the introduction of new technology, and look at the ability of the supply chain to build up capacity for the rollout of Network Rail's digital railway programme. Signalling accounted for more than £4bn of Network Rail's spending between 2014 and 2019, and is forecast to significantly increase as ETCS is rolled out across the network.

ORR has invited submissions from interested parties and will publish a market study report setting out its findings and any actions which it proposes to take no later than November 11 2021. Studies such as this can lead to a variety of outcomes including no action, referral to the Competition & Markets Authority for an in-depth investigation, consumer or competition law enforcement action, recommendations to the government to change regulations or public policy, actions to improve the quality and accessibility of information, or to encourage self-regulation.

European harmonisation

Europe: The EU Agency for Railways (ERA) is now the single certification body for train operators and rolling stock in Europe, as well as for the approval of ERTMS trackside equipment.

31 October 2020 was the formal deadline for EU member states to transpose into domestic legislation the railway safety and interoperability directives that form the technical pillar of the Fourth Railway Package, adopted by the European Parliament and Council in 2016.

Previously, train operators and manufacturers had to apply for separate vehicle authorisations and safety certificates in each member state. ERA has now been given additional responsibility to manage the harmonised procedures with a view to reducing the cost, time, and administration for obtaining approvals. Under the simplified procedure, a single application must be filed through the agency's "One-Stop Shop". This is also expected to reduce the time-to-market for emerging technologies.

ERA executive director Josef Doppelbauer said, "Having started our new role of European authority with initially eight member states in June 2019, we are now crossing the finish line. We have already taken more than 1000 decisions and authorised more than 10 000 vehicles. With the extension of our competence to the whole EU, we reach another milestone on the way to the Single European Railway Area."

Long-term importance of rail

UK: The Railway Industry Association (RIA), the trade body for the UK rail supply community, has called for the Government to consider the long-term importance of the rail network, publishing ten reasons why rail investment should continue, in light of the debate over the impact of Coronavirus on the future of transport.

1. Rail is a long-term game – Investments in infrastructure or rolling stock are usually delivered, and create continuing value for passengers and the wider economy, over years.
2. The reduction in passenger numbers is likely to be temporary – Based on previous economic slumps in the 1980s, 1990s and post-2008, as well as past health crises, passenger numbers have always recovered to continue their pattern of growth.
3. Rail is not just for passengers – It is also vital for freight, with over 4 billion tonne-km being delivered annually before Coronavirus.
4. Rail travel is clean and safe – A study undertaken by RSSB in August 2020 estimates that the risk of infection per passenger journey is 1-in-11 000 journeys, with similar results found in other countries.
5. Investment can support the whole of the UK – The rail network touches almost every part of the country and has the potential to unlock a new generation of talent.
6. Rail can lead the green recovery – It is not possible to meet zero carbon goals for transport without rail. Rail is a green mode of mass transit, contributing just 2.5 per cent of greenhouse gas emissions from transport and only 0.6 per cent of total UK emissions.
7. Rail cannot easily be mothballed – Once rail infrastructure is decommissioned it is not easily reopened.
8. Rail investment has a knock-on economic impact – For every £1 spent on the rail network, £2.20 value is delivered in the wider economy.
9. Investment cannot wait – Much of the rail spending planned cannot be postponed, in order to meet our decarbonisation and digitalisation targets.
10. There is a clear window to get work done – The Covid-19 pandemic has provided an opportunity to get work done with less impact on services, which should be capitalised on before passenger and freight numbers return.

Education, skills and training

Western Australia signalling training facility

Australia: A purpose-built training facility for rail has been completed in Western Australia (WA) to address a critical skills shortage in the rail industry. The Metronet Trade Training Centre at North Metropolitan TAFE's Midland campus is now complete and is focused in addressing the lack of rail signalling engineers. Students at the facility will progress through courses in railway signalling and associated electrical systems qualifications.

News from the IRSE

Blane Judd, Chief Executive

It's a Digital World

When circumstances demand rapid change, the outcomes are frequently beneficial, hastening developments that would usually take far longer to achieve. They say, "necessity is the mother of invention".

That has certainly been the case here at IRSE. The pandemic challenged us all to up our game, and the speed with which our staff, sections, committees, members, and volunteers stepped up to the plate has been impressive.

As engineers we are natural problem solvers, but It is fair to say that if someone had said that within a few short months we would be running a full programme of presidential paper webinars, holding our Professional Examination online and running virtual section meetings we would have applauded the optimism but doubted the reality!

But it is a reality. Whilst Covid has of course had a devastating effect on the world, it also opened up opportunities for us to further raise the profile of the Institution amongst a far wider audience, building on the work we had already started last year with the Future Integrated Railway Think Tank (FIRTT). In a first for the IRSE we collaborated with three other professional institutions (IMechE, IET and PWI) to run the very successful paid-for online Rail Automation seminars in September and October. As major industry events had to be cancelled, organisers moved quickly to set up virtual conferences. Under normal circumstances conference programmes are set up to a year in advance, but the last-minute nature of these digital events put us in a good position to offer our president, Dr Daniel Woodland as a speaker. As a result, he presented at both the 2020 Next Generation Train Conference and the ERTMS & ETCS: The Future of Railway Signalling Conference and was a panellist in the Railway Gazette Rail Broadcast Week.

We hope face to face meetings and events will be able to resume as soon as possible, but the learnings from the past months have been invaluable. Now we have the technology and experience of using it successfully, all future presidential papers will be presented as an online webinar for those members unable to attend in person, opening up the events to our full international membership with the option to watch in real time or on demand later.

Council elections

All associate members, members and fellows will have received their voting papers for this year's Council elections. Voting opens at 0900 GMT on Monday 8 February and closes at 1700 GMT on Friday 5 March. If you would like another copy of the voting form it can be obtained by contacting **electionservices@civica.co.uk**.

Please ensure you vote as it is important that the IRSE Council is representative of all our members. Council members make decisions on the strategic direction of the IRSE, act as trustees of the IRSE charity and ensure that the IRSE's charitable objectives are progressed. Council members also appoint the directors of IRSE Enterprises, the company which, amongst other things, operates the licensing scheme.

Professional Examination

The 2021 date for our professional exam is Saturday 2 October. If you are, or you know someone, planning to take modules B, C or D in October 2021, please note that you must be an IRSE member. For your membership application to be processed in time for you to apply for the exam, please email your application to **membership@irse.org** by 12 February. For details on membership see **irse.info/membershipoptions**. Applications to sit the exam will open soon, keep an eye on the exam page **irse.info/irseexam** for announcements and details.

Merit award

At the Council meeting held on 3 December it was agreed that Mark Glover should receive a Merit Award in recognition and as a sign of appreciation for his voluntary service in the creation of numerous publications, including the annual report, the IRSE Proceedings, IRSE News, publicity material for major events, and the updated CS&TE booklet. The award plaque will be presented to him just as soon as social distancing rules allow. Mark is a fellow of the IRSE and head of strategy support & marketing at Siemens Mobility Limited. He has been a member of the Institution for over 30 years.

Merit Awards were introduced in 2007 In order to recognise meritorious service to the Institution by a volunteer or staff member. The award is made by the Council following receipt of nomination from peers. Meritorious service is defined as making a substantial contribution to the Institution's work over a period of time by organising activities or carrying out specific tasks which have furthered the Institution's aims and objectives.

Presentations competition

The Midlands and North Western section is to launch a short presentations competition in March with prizes for the winner and runners-up. The final will be at the first meeting of the 2021/22 session for the section in September. For full details visit the MNW section page on the website. Visit **irse.info/nearyou** for information about all section activities.

IRSE Council

Daniel Woodland, President

The IRSE is an international global organisation and professional institution for all those around the world engaged in or associated with railway signalling and telecommunications, train control, traffic management and associated professions. While our headquarters is in UK, we are immensely proud of our international organisation, with members in 54 countries, and we are passionate in establishing and maintaining a diverse and inclusive membership. The IRSE is committed to a policy of equality and inclusion for all its members and recognises the value and importance of increasing diversity in the workplace. January IRSE News explained the review of the governance of the Institution which is under way and the need to do all we can to advance the science of railway signalling and communications around the globe.

The governance review will consider how we ensure there is a measured representation across the membership at Council, the governing body of the Institution. We are always mindful that 47 per cent of our members are from outside the UK and it is important the Institution allows all its members to be involved in how it is run.

Council members are elected by the corporate members of the Institution, i.e., Fellows, Members and Associate Members and you will shortly receive an invite from Civica Election Services (formerly Electoral Reform Services) to vote for members standing for election to Council in April. The IRSE is not just for 'signal' engineers and our members include engineers involved in research and development, design, installation, testing, asset management, maintenance, technical support, software, system engineering, telecoms, safety assurance, cyber-security, training, and much more. The organisations they work for include infrastructure managers, train operators, light rail, large manufactures, SMEs, consultancies, heritage railways, universities and training organisations. Therefore, the Council must represent all Institution members wherever they are in the world and in the wide range of activities related to command, control and communication systems. We therefore request members to vote in April for the Council nominations they believe will best represent members in achieving these objectives.

Why not consider standing for Council yourself next year? Being a member of IRSE Council will assist your continuing professional development and you will have the opportunity to develop new skills, make new friends, gain networking opportunities with fellow professionals, and contribute to the objectives of our truly global international Institution. Council meetings have been held remotely via video links for many years and long before Covid -19. It is therefore not a new feature of the Institution and we have developed techniques to ensure all Council members are involved in key decisions. The time difference can be a challenge for Council members located in the east of the world, but we try and vary the time of meetings to accommodate as many Council members as possible.

A Council member's view of the April 2020 meeting with participants from Australia, Hong Kong, Japan, The Netherlands, Singapore, South Africa and the UK. Why not join us?

Professional development

Why is the IRSE Professional Examination important?

John Alexander

As a society we use exams for a number of purposes and most people will sit a variety of these in their lives. Each examination has a different purpose and the emphasis or the focus of these changes depending on one's progress through life.

Many tests are of knowledge – what has been learnt and can it be regurgitated on request. Other times it is skills which need to be proven through practical demonstration, but the most common objective is to assess the application of the skills and knowledge. As children progress through school they see their tests evolve from pure memory to being able to use a range of facts and skills in a particular scenario.

So, what are exams for? Well we use them to confirm that people have reached a minimum acceptable level of knowledge or ability in an area – for instance the UK Standard Attainment Tests (SATs), which are designed to check children have reached an acceptable educational standard at key points in their academic development. A driving test is another example. They can also be used as a means of selection – are you sufficiently advanced in a subject to be able to move onto a higher level of study/qualification, or have you achieved an entry standard for a career or role? And, of course, they are used to rank individuals where opportunities are scarce either in education or the workplace.

What makes the IRSE Professional Exam different from the exams discussed so far? It is the addition of the word 'professional' which you will also see in the legal, medical, accountancy and other professional careers. It is about moving on from testing learnt knowledge, acquired skills and the regular application to the understanding of the reasons behind principles and the ability to develop and justify new solutions. It is often said that professionals make the rules for others to follow.

Each of the IRSE Exam papers tests a variety of areas of knowledge, application, and the underlying principles – whether you are considering the application of standard equipment or the development of a new signalling or telecoms system. Whilst confirming that candidates know "what" should be done, the top marks go to those who can also think "why" it should be done and apply that analysis to new or novel situations and solutions.

Module 3 has for many years addressed signalling principles and the questions have focused on the "why". This emphasis is deliberate to move future lead engineers out of their comfort zones and start them thinking as the professionals of tomorrow.

One exception in module 3 has always been the control tables which are almost purely a demonstration of knowing the rules and being able to apply them in a new, but constrained, situation. The approach taken in marking a candidate's control table is generally to deduct marks for the mistakes and omissions since, with plenty of practice, almost anyone should be able to provide a near perfect answer. When I started marking this module the control tables were the equivalent of two questions, but I never felt they really distinguished the budding professional from the thorough engineer who had learnt the process.

Exams are often regarded as being separate to the workplace – how many of us can list more than a few things that we learnt in higher education which we still use in our daily work? I still use the four Newton equations of motion and occasionally Ohm's law, but other than that I struggle to think of anything else. That does not mean that a degree was a wasted experience because the techniques learnt of research, analysis, discussion, documentation, and justification are very relevant in a role as a professional engineer. What we have examined in module 3 should be equally applicable to the challenges faced in the workplace (and as the more astute will have noticed, some of the questions reflect debates which are taking place – for instance, around cab signalling).

Let us turn to one of the questions from the 2020 paper and see how it is designed to evaluate how far a candidate is on the route to being a professional, chartered engineer.

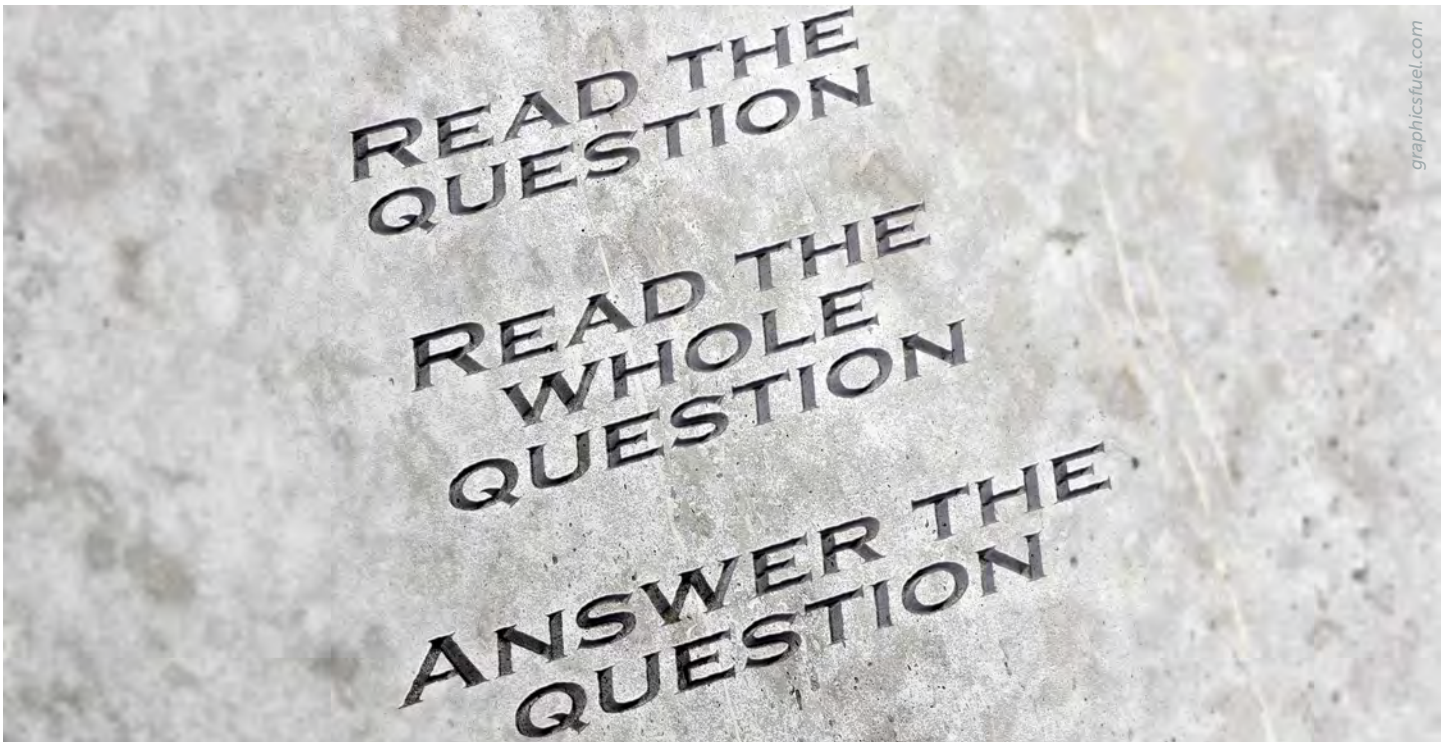
Question 8

There are many signalling systems in use including semaphore, colour light three-aspect, four-aspect, distance based, speed based and cab signalling.

a) For two signalling systems/arrangements you are familiar with describe how a transition between them should be arranged (in both directions) giving reasons. [10 marks]

b) A railway is progressively introducing cab signalling. Considering particularly drivers and signallers, what issues need to be considered where train journeys are mainly in a cab signalled area? [7 marks]

c) In an area of lineside signalling adjacent to the cab signalling area, the frequency of signals passed at danger rises. List possible reasons for this and discuss potential mitigations. [8 marks]



The rules of exam success are set in stone.

The question looks at a common challenge experienced by engineers working on upgrades of an existing railway where there will be times that you have to interface one signalling system to another. With so many potential combinations to be considered, there are not many rules that one can rely on so the professional needs to work out what matters.

Part a) is asking for a description of how two signalling systems could be managed at an interface. Whilst not implicitly stated, to describe the transition you also need to describe the key features of the two systems. With 10 marks on offer a candidate should be considering a description of the technical rules, the driver's experience, degraded situations and, as requested, explain why the arrangement is appropriate.

Looking at the answers submitted for this question a common failing was to describe how the transition would be arranged but very little thought given to the driveability, where the transition should be placed or the hazards associated with such a transition (and hence how they are mitigated).

If we took a UK semaphore transition to UK colour light – as some candidates did – then there are a number of issues to consider including that one is normally moving from Absolute Block rules and principles to those for Track Circuit Block. I was always concerned when reviewing scheme plans where semaphore signals were being replaced by colour lights but retaining the Absolute Block principles. Would a driver less familiar with a route seeing a colour light in the distance at night remember it was an outer home and not part of a three aspect sequence?

The obvious area for consideration is the "aspect" sequence in each direction which will also lead you to thoughts on where any transition can sensibly take place. Going from semaphore to three-aspect one would probably want it to be a clear boundary with a physical separation between the two systems. By completing the signalling for one block post and then, after a distance, starting a three-aspect sequence with a colour light distant could provide a clear demarcation for the driver, helping them to adjust their driving style and also avoid any messy sequences or controls.

The same could be applied for the opposite direction but now we do have some extra considerations. If you have been driving for some time with modern colour lights and you suddenly enter an area of signalling where the semaphore spectacles are lit relatively dimly, then the risk of late detection of signals is high. This can be made worse if the distant signal for the semaphore area is colour light and so consideration needs to be given to providing some form of intensified lighting, the effectiveness of warning systems, such as AWS, and whether the risk of SPAD needs mitigation.

Hopefully, you can see that part a) is not just about stating some rules but is applying the type of analysis a scheme engineer needs to follow when developing a project solution. The reasons for the arrangements and the issues to be considered are what makes the difference between a pass and a credit or distinction.

Part b) addresses a live issue for Network Rail and the GB network – as we progressively move to cab signalling then it is going to affect many people who work on the railways. Obviously, drivers will see different things, but we must also consider the changes for the signaller and for maintenance staff.

Any engineers who have attended the exam reviews will know that the mantra of RTQ (Read The Question), RTWQ (Read The Whole Question) and ATQ (Answer The Question) has been consistent from the examiners of all the topics. RTQ is the first stage in getting some marks and it is disappointing that we often get answers where it is obvious that even if the student has read the words they have failed to think about what they are being asked. In the work environment this is equally important – do you understand what it is that you are being asked to do? If not, then before starting it is important to obtain that clarity and a good professional will challenge and test the remit, establish the stakeholders and what are their real needs compared to their perceived needs, and make sure that it is clearly documented.

RTWQ could be relevant to the question being considered. Many of our exam questions have lead candidates through a series of steps towards the key issues of the syllabus that we are examining. Reading The Whole Question before you start can often prevent you getting into a trap or blind alley. It can also save you effort since if your answer is working progressively towards a goal then there will be less need to repeat information and fewer chances you will confuse yourself or the reader. In a work environment it is equally important that we understand the bigger picture but also that as professionals we break the problem down into a number of stages where we can stop, review and get buy-in from stakeholders before we move on.

In the case of Question 8, several scripts started off by talking about semaphore to colour light but then, in part b) moved on to consider cab signalling. That did mean that, perhaps with time pressures, some of the issues about the arrangement and location of transitions did not feature and they missed an opportunity to demonstrate their understanding of the issues when planning progressive staged deployments.

Probably the biggest failing with this part of the question was that students did not 'answer the question'! This is often witnessed as an answer to the question they would have preferred to have been written, but in this case it was frequently some technical issues totally ignoring the drivers and signallers.

We often encourage young professionals to look at transferring knowledge or experience from outside signal engineering to their work challenges and our IRSE questions. In this instance a good real-life example would be driving along the motorway for a couple of hours and then turning off into a town where the items to monitor and react to change dramatically. Can this be used to think about a driver in a cab signalled train just monitoring the cab display and not having to search for, identify and interpret information outside? What are the risks when the context changes, how can that be mitigated?

So, part b) is a very real challenge for projects about how many stages to have, where to put the temporary boundaries, how to make sure the temporary transitions are as robust and safe as the final ones, how to liaise with all the affected stakeholders, the training needed, etc.

Moving on to part c), this is a good example where reading the whole question (RTWQ) can be to a candidate's advantage since it gives a suggestion of a consequence of the scenario in part b). We received a lot of answers about managing signal sighting, provision of a protection system, such as TPWS, signallers managing route setting, but very little on human factors.

A professional should not be a 'one trick pony' but have a diverse knowledge of disciplines around their core skill set. The ability to identify that there are things that one does not know and then undertake the research is a key part of a professional engineer's behaviour. As discussed earlier, taking your personal experience in another context and applying it to a situation can help to identify hazards or potential problems.

In the answers submitted there was a lot on the potential mitigations but very little on the causes of the problems – without being able to identify what may be going wrong, how can we hope to select the most effective measures? Another key role of the professional is not to accept the status quo but to be continually asking ourselves whether things could be done better, whether things are still necessary, and what is the balance of the effectiveness of the different policies being applied.

This is of particular relevance to signal engineers when applying for a deviation from a standard or justifying a non-compliance. What is the reason for the rule in the first place? What risks is it meant to address? Is the context in which it was formulated applicable or consistent with the situation in which it is being applied? As a mitigation how good is it and are the potential downsides balanced by the benefits?

Hopefully I have managed to explain why the IRSE Exam is not just any old test which you can revise for and then answer almost automatically, but a challenging and stimulating exercise to demonstrate to yourselves and others that you have the core qualities of a professional engineer. I also hope that you have gained an insight into how the questions explore the behaviours which apply equally to the working environment. The questions are tough, but professionals are a tough breed and need to be able to handle adversity in a positive way.

The article above is equally relevant to the new advanced modules B, C & D being introduced for the 2021 examination. The style, format and standard of the questions will remain the same. The time allowed will not change. The examiners will give candidates credit for the same things. Only the grouping of the questions will change. For example, module 3 questions will appear alongside module 4 questions in the new module C. As now, candidates will be asked to answer three questions. The 2021 questions have not yet been set, but it is expected that four of the available 12 questions will concentrate on signalling with four on telecoms. A further four questions could be answered from either speciality or would be based on the application of knowledge that either a signalling or telecoms professional should know.

About the author ...

John Alexander is a principal engineer working for Network Rail and has been volunteering on the IRSE Examination Committee for the last 15 years. Module 3 (in the pre-2021 format) concerns signalling principles and John has been the lead examiner for the last eight years. Attendees at the Younger Members Exam Review will recognise the emphasis on understanding why we do things rather than blindly following what has been done in the past.

He is currently developing Network Rail's policies on the implementation of ETCS where the challenges are what needs to be achieved and how do you demonstrate that what is being done meets the safety targets. This involves a detailed challenge of why the ETCS subsets say what they say.

Midland & North Western Section

Suitable and sufficient risk assessment at level crossings

Report by Ian J Allison

On the evening of Wednesday 18 November 2020 the Midland & North Western Section had its largest attendance to a virtual meeting to date with more than 150 viewing the live event. Andrew Allen of AEGIS Engineering Systems Ltd, based in Derby, United Kingdom, delivered his technical presentation entitled "Suitable and sufficient risk assessment at level crossings" with ease and confidence.

There are approximately 7,500 level crossings in the United Kingdom. Network Rail manages around 6,000 of these, with the others located on metro systems and industrial/heritage railways. Andrew started the presentation explaining the definition of a level crossing and why the management of level crossing risk has become so important. As level crossings account for nearly half of the catastrophic train accident risk on the United Kingdom's railways, he reminded us that the Office of Rail and Road believes that the safe design, management, and operation of level crossings can reduce risk, have a positive effect on user behaviours and so reduce the number of fatal and serious incidents.

Andrew continued to explain the different types and requirements for level crossings, including the difference between an "occupation crossing" and an "accommodation crossing". He explained about manually controlled gated crossings, manually controlled barriers with closed circuit television and now with obstacle detection. Automatic barrier crossings were covered with a mention as to how the automatic barrier crossings of various types work. He continued with a review of user worked crossings and the various types currently in operation with miniature warning lights and telephones. Following a brief review of the Power Operated Gate Opener (POGO) system and the challenges of their introduction, Andrew expanded to talk about footpath and bridleway crossings.

Having provided pictorial examples of specific sites for the many types of the level crossings described, Andrew changed his direction to discuss risk assessment and the requirement that it should be suitable and sufficient when considering the use of each level crossing and any proposed changes to them. This includes consultation with those who may be affected, dealing with obvious significant risks, ensuring the precautions are reasonable and the remaining risk is low, to ensure the level of detail in the risk assessment is proportionate to the risk and appropriate to the nature of the work.

Andrew then talked about how he applied the processes and procedures used within AEGIS and how his organisation applied the Network Rail All Level Crossing Risk Model (ALCRM). This included discussion regarding the level crossing order, current asset condition, planning information regarding potential future rail and road traffic, along with specific data capture applicable to each level crossing. Data capture can include (but is not limited to) photographic evidence, position of the sunlight at certain times of the year, potential flooding, local school access, local authority strategic planning, sectional appendix information and a traffic census for a defined period of time.

Tragically train vs car always has one winner.
Photo Network Rail.

Continuing with this, Andrew explained about how the ALCRM output provides a simplified alphanumeric risk categorisation to assist with evaluating the potential risk reduction options against the legal requirement to reduce risk "as far as is reasonably practicable". This includes calculation of the collective risk to the exposed populations and is expressed in fatalities and weighted injuries (FWI) per annum, along with the calculation of the individual risk to the user which is expressed as a probability of a fatality per year (based on 1 in 100,000). For the purposes of calculating the financial safety benefit, FWI is used, which allows ALCRM to provide the safety benefit and cost ratio as an output.

Whilst reference to the level crossing risk management tool should always be considered in the United Kingdom, optioneering and workshop participation of relevant responsible roles in connection with a particular level crossing is vital before any level crossing decisions are to be made. Andrew walked through two case studies of how AEGIS and Network Rail have applied these processes and tools, and how they came to the final decisions for changes at Brook level crossing and the closure of Matlock Bath pedestrian level crossing.

Whilst there were one or two technical inaccuracies in the presentation, Andrew delivered a robust presentation for somebody who is not trained as an S&T Engineer. The Midland and North Western Section would like to thank Andrew and AEGIS Engineering Systems Ltd for presenting their work and their opinion regarding this interesting subject.

London & South East and Midland & North Western Sections

Interlocking principles and infrastructure data for ETCS

Report by Ian Mitchell

Since the Covid-19 pandemic has prevented face to face meetings, IRSE sections have been moving their activities online. This has turned out to be very successful, with much larger number of participants from a wider geographical area. By coincidence, two of the UK sections recently heard presentations linked to the same ETCS project in the UK, a level 2 overlay onto existing lineside signalling between London Paddington and Heathrow Airport.

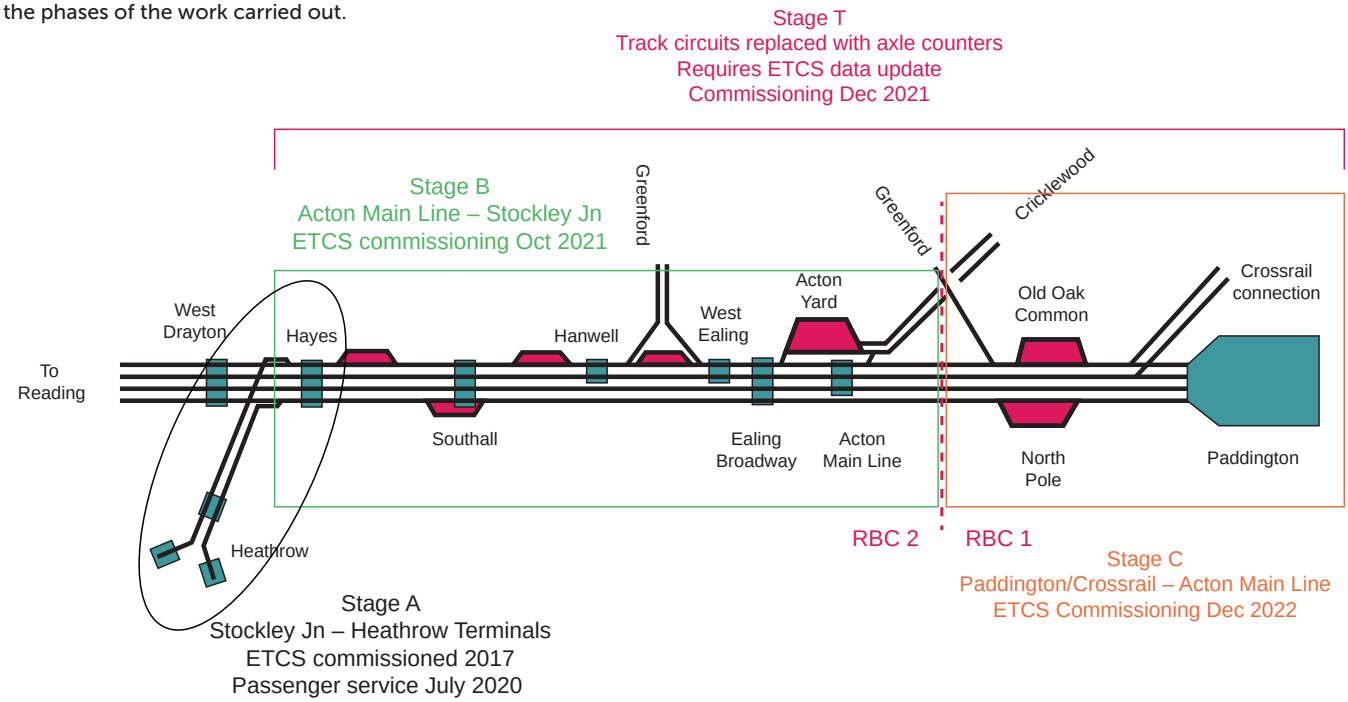
ETCS Interlocking principles on the Paddington to Heathrow project

The London & South East Section talk on 26 November was by Aidan McGrady of Network Rail. Aidan explained the project arose because Crossrail (Elizabeth line) trains to Heathrow Airport will operate through tunnels constructed in the 1990s that were equipped with the obsolete Great Western ATP system. Installation of ETCS level 2 as an overlay allows the large fleet of new trains to be equipped with standard ETCS onboard equipment. The project is being commissioned in three stages, the first stage covering the Heathrow branch is already in service, and the complex section of route along the main line into London follows in 2021 and 2022.

The ETCS onboard system and track to train interfaces are standardised, but the Radio Block Centre (RBC) and its interface to the interlocking needs to be adapted to national signalling principles, especially in an overlay application where there is an existing layout of lineside signals and train detection systems. Aidan described several examples where careful consideration was required on how to configure the new ETCS functionality to work with the existing interlocking principles, and the data to be exchanged between the interlocking and RBC.

Approach locking ensures that if a signaller cancels a route in front of an approaching train, the route remains locked unless it can be proved that the train will stop before entering the route. In conventional UK signalling this is achieved by a timer which maintains locking for the time taken for a train running at line speed to come to a stand, by which time either the train has been able to stop at the signal, or it has entered the route. In some locations this is supplemented by 'comprehensive' approach locking release logic which checks the train detection sections on all possible approaching routes and allows the route locking to be released immediately if there is no train within braking distance of the route entrance. In a complex area, this function can be difficult to specify and test rigorously, so it is used sparingly.

The Great Western Main Line approaches to Paddington showing the phases of the work carried out.



The ETCS equivalent to this function is to send a 'Request to shorten movement authority' to the train. The ETCS onboard equipment then calculates whether the train can stop within the shortened movement authority and responds to grant or refuse the request; if the request is granted the route locking can be released immediately, mirroring the comprehensive approach locking functionality. This is a significant improvement over the conventional approach, as it is tailored to the actual speed and braking performance of the approaching train, and avoids complex interlocking logic, but for an overlay project, it is necessary to consider how to combine this with the existing system.

At first sight the implementation of this ETCS function may seem simple, if a request to shorten the movement authority is granted by the ETCS train, then the conventional interlocking logic can be overridden, and the route can be released. If the request is not granted, then the standard approach locking timer can apply. But what if there was a loss of communication with the train when the signaller cancels the route? The train will not receive the shortened movement authority, and the information the driver sees on the cab Driver Machine Interface (DMI) will display a less restrictive condition than the lineside signals, until the onboard system recognises the loss of communication and applies the brakes. If the driver follows the cab display and not the lineside signals, the ETCS train may brake later than a conventional one would have.

The time to recognise loss of communication is defined by the ETCS 'national value' T_NVCONTACT, which must be chosen carefully – too short a value risks an unnecessary intervention for a short loss of communication – too long a value means the train response to a shortened movement authority is not compatible with the existing approach locking timers in the interlocking. This required the project to review and if necessary, adjust the existing approach locking timers in the interlocking to ensure the following equation is always satisfied:

T_NVCONTACT + Longest time to brake to a stand < Approach locking timer

Aidan finished by looking forward to future ETCS applications without lineside signals – the issue described for approach locking timeout would still apply, but other complications in existing interlockings such as approach control of junction signals would no longer be needed.

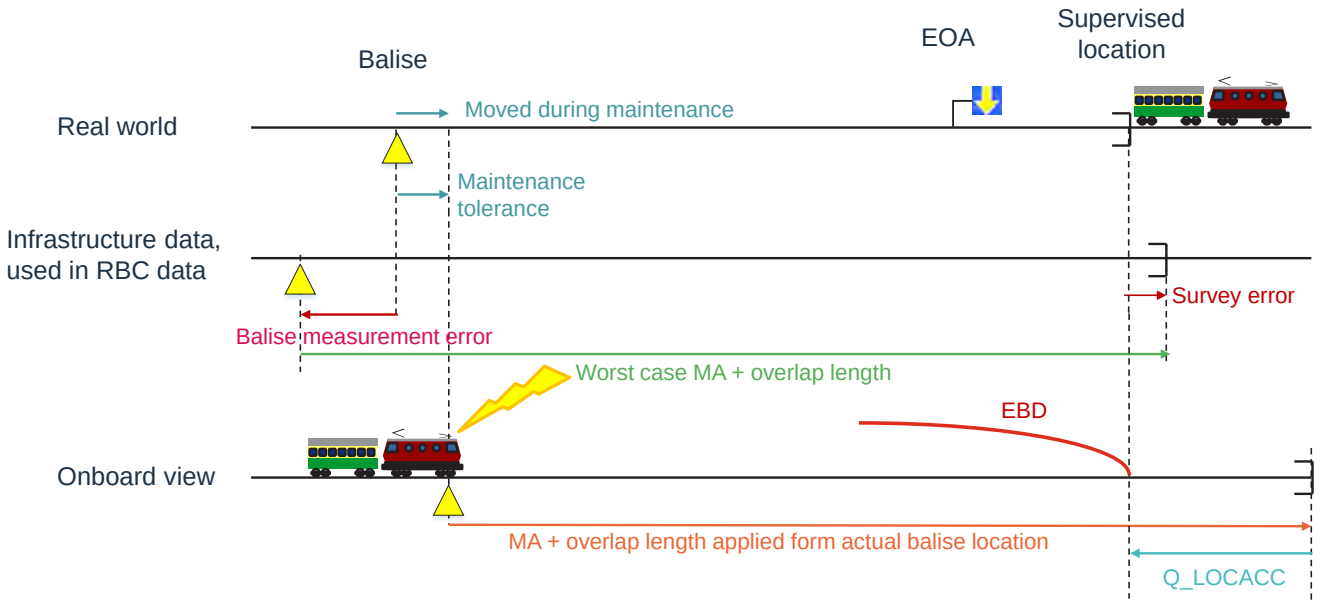
Infrastructure Data for ETCS

The Midland & North Western Section talk on 9 December was by Tom Corkley of Alstom, who are the suppliers of the interlockings and ETCS trackside equipment for the Paddington-Heathrow project. He started by explaining the scale and complexity of the project, with 251 signals, 584 balise groups and 658 ETCS routes, and delivered in parallel with other infrastructure works including replacement of track circuits with axle counters and enabling works for HS2 at Old Oak Common.

Infrastructure data is required to ensure the ETCS movement authority sent to a train accurately matches the track over which the train is running. The data needs to be referenced to distances measured along the centreline of the track, taking curvature into account.

- Asset data – position of assets that are relevant to ETCS, e.g., points, signals/marker boards, train detection sections, buffer stops.
- Gradient data – vertical profile of the track, which is converted into gradients
- Speed data – positions at which there is a change in permissible speed

The starting point must be an accurate survey of the existing track, but how accurate? The calculation of position by the ETCS onboard system includes a data accuracy factor Q_LOCACC . This is combined with the cumulative odometry error to calculate pessimistic values for the train front end and rear end locations. But survey accuracy is not the only factor to be considered. All the positioning is with reference to the location of the balises in the track, and there needs to be an allowance of how accurately they can be installed, and for subsequent movement because of track maintenance.



Q_LOCACC > Survey error + Balise measurement error + Maintenance tolerance

The balise measurement error is itself dependent on the survey accuracy of the reference point used to measure balise position for installation, and a rounding error due to the RBC resolution. For the Paddington-Heathrow project Q_LOCACC is set to 3 metres, and this is compatible with the achievable survey accuracy of +/-0.1 metres.

The correctness of infrastructure data is crucial to the safety of the delivered system. Verification and validation of the trackside ETCS is predominantly laboratory based, and the correctness of test results is referenced back to the original data. On site testing with a test train cannot exhaustively test every route and stopping point, and in any case, errors may only be apparent in specific operational circumstances. It is therefore important to maintain integrity of data throughout the design process. For instance, when data is being transformed by manual processes, a 'double branch' approach can be used by which two people independently complete a task and the results are compared. When automated tools are used, there needs to be a diverse process with another tool or a manual check to verify the transformation. File integrity checks to guard against corruption of data or use of a wrong version are also necessary.

Challenges occur when the infrastructure is changing during the project – assets that do not already exist cannot be surveyed, and installation tolerances may be too great to simply use as-designed positions. There may be a need to accept a lower accuracy for some assets that are installed at the same time as the ETCS commissioning and follow up with a new survey and update to RBC data later. Maintaining data during the lifespan of the signalling system will be essential – there needs to be a clear understanding of which changes to the infrastructure may require an update to RBC data.

Tom finished by considering how infrastructure data can be managed in the context of the Network Rail ETCS long term deployment plan, which envisages 600 miles of ETCS installation every year – Paddington-Heathrow is just 16 miles. For this to be achievable further automation of the survey process will be needed, together with standards for infrastructure data, such as RailML. The adoption of BIM (building information modelling) standards across all the engineering disciplines may be the way ahead.

These were two fascinating talks, looking into some of the practical detail of ETCS applications, but pitched at a level to be understood by engineers who have not yet worked on this type of project. There are now a few hundred more people in the world who know about T_NVCONTACT and Q_LOCACC. If your local section has had a presentation about ETCS please provide a write-up for IRSE News and tell us about your favourite ETCS variables.

Please don't keep us in the dark!!

Do we hold the correct email address for you? If you have just joined the digital community or recently changed your email address you will not be receiving important membership information or IRSE e-communications.

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Past lives: Joe Noffsinger

Sadly, Joe Noffsinger FIRSE of Lee's Summit, Missouri, USA died aged 69 on 29 November 2020.

Joe joined the IRSE as a Fellow in 1993, and served for many years as a member of both the North American Section Local Committee and the International Technical Committee. He was a second generation railroader and put himself through college studying electrical engineering at Case Western Reserve University by working as a brakeman on a short line railroad in Cleveland, Ohio. After graduating, he started his career with Conrail in the Communication and Signal department. He rose through the department to become regional chief engineer, assistant chief engineer and chief engineer, C&S. He served as chair of the Communication and Signal Division of the Association of American Railroads in 1995-1996. He later joined Harmon Industries as vice president of Engineering and led Vaughan Harmon, the UK based subsidiary of Harmon Industries and later GE Transportation.

After returning to work in Grain Valley, Missouri, Joe held various positions at GE Transportation including having responsibility for strategic planning, signal products, and market and product development. He retired in May 2016.

Joe was a licensed engineer and the holder of many patents. He travelled all over the world and was a very innovative engineer with an excellent reputation worldwide. He was a lover of French wine and food and spoke French fluently. He enjoyed many hobbies amongst them, car restoration, growing grapes, making wine, photography. He very much enjoyed attending IRSE International Conventions with his wife Helga as they combined his love of both communications and signals with their love of travel.

Joe will be missed by his many friends and colleagues.

W J Scheerer, HonFIRSE

Your letters

Swiss C-DAS experience

After reading the article of C-DAS in the December 2020 issue of IRSE News I would like to give some feedback based on my experience. I have seen many discussions about C-DAS in last 10 years and I think a technical clarification (or classification) of what 'C-DAS' is would help the article.

1. There are different ways of updating the train with information, including:
   a. Raw data: i. Dynamic train (onboard) information from systems belonging to the Railway Undertakings (RUs) e.g. onboard sensors, TCMS (Train Control Management System). ii. Dynamic trackside information from systems belonging to the Infrastructure Manager (IM) e.g. trackside sensors, digital map, TMS (Traffic Management System), GNSS. iii. A combination of train information and trackside information from systems belonging to both RU and IM.
   b. Processed data with actions for i. speed control, ii. traction/brake control and iii. door control.
2. The processed data for the core calculation of C-DAS (e.g. train speed profile) can be calculated in several ways.
   a. Calculated trackside by the IM and the result transmitted to the train.
   b. Calculated onboard by the RU based on raw data received from the trackside.
   c. Partially calculated trackside and partially calculated onboard the train.

Many products are called "C-DAS", but they have fundamental difference in architecture meaning. They could be C-DAS-Central(IM), C-DAS-Onboard(RU), or C-DAS-Integrated(IM+RU). When it is C-DAS-Central or C-DAS-Integrated, part of the core calculation is redundant with TMS functionality.

I think a clear definition or the classification of C-DAS is needed and defining the requirements, architecture and interfaces is essential for interoperability. 2.c is very close to the current ATO specification workshops in Shift2Rail. Because the trackside (TMS) calculation might be the same, only the execution on the train is different, which is done either by driver (DAS) or automatically (ATO).

3. The other concern is about "frequency":
   a. How frequent should the information for the driver be sent?
   b. How frequent should the system update the driver if he does not adhere to the advice?
4. When the C-DAS model is the type 1.b + 2.a/2.c, it is necessary to analyse why the driver is not adhering to the advice. The reasons could be:
   a. the inaccuracy of advice calculated from trackside, for example, the practical train maximum acceleration is not taken into consideration by TMS.
   b. The inappropriate display of the advice on DMI or other GUIs.
5. The architecture design of C-DAS should consider additional future technical possibilities, for example interfaces to other systems.

Xiaolu Rao
Senior project manager ATO
Swiss Federal Railways

Safe software

In the article "Configuring safe software driven systems" by Rod Muttram in December IRSE News, the author has rightly emphasised the catastrophic consequences of incorrect input data provided by a single source in a safety critical system. Irrespective of how much defensive architecture we employ and how much redundancy is provided in the architecture, if the input data itself is corrupted, the system is likely to produce wrong output which may be unsafe too. In the case of the recent crashes of Boeing 737 MAX discussed, although the aircraft had two angle of attack sensors, the flight control system continued to rely on the output of the defective sensor; this was a problem of the Redundancy Manager system, which should have detected the error in the defective sensor and brought in the good sensor to service, or it should have shut down the Manoeuvring Characteristics Augmentation System (MCAS), given an alarm to the pilot and let the pilot control the aircraft inclination. After all MCAS, similar to Automatic Train Protection (ATP), is not critical for the flight operation; the pilot can very well manage the function manually. Perhaps this was the intention behind providing only two sensors in the Boeing aircraft, while its competitor, Airbus, has 2oo3 architecture for the sensor.

Can this happen in railway signalling? Well single source of input data cannot be avoided in case of railway signalling. For instance, track circuit relays, point indications (NWK and RWK), Signal ECRs – they all provide single source data. Their correctness up to the point of relay contacts is time tested and considered to be fail-safe as a 'grandfather's right'.

What happens at the interface of the relays with the electronic subsystem? We either convert the relay status into two orthogonal inputs by reading both the front and the back contacts of the relay and check the consistency of the inputs, or take the front contact and use reactive safety techniques for verifying the integrity of the electronic part of the circuit. Both techniques are considered to be fail-safe and are compliant with the safety requirements of the CENELEC standards. Where the inputs cannot be fail-safe, like the one coming from the tachometers, we employ two independent sources for the input. For instance, in CBTC/ETCS level 2, Doppler radar/accelerometers are used as the second source of the speed data. Although the main reason for using the second source is to correct the error arising out of wheel slip/slide, I am sure, data consistency and plausibility checks between the two sources must have been included in the software. If not already done, we must learn the lesson from the accidents of Boeing 737 MAX and include this feature in the software.

On a different note, the various architectures of safety systems explained in the article, brought back the fond memories of early 1980s when electronic interlocking systems were being developed by various railways/companies around the world. While the then British Rail, in association with Westinghouse (-> Invensys Rail -> Siemens) and GEC (-> Alstom), and Japan National Railways (JNR) were developing 2oo3 hardware redundancy. Ericsson (-> ABB -> Bombardier) and Union Switch and Signals (-> Ansaldo -> Hitachi) were relying on single hardware/diverse

software architecture. At the same time, Indian Railways were developing a loosely synchronised 2oo2 architecture, which allowed, at a given time, one unit in active mode and the other in self-check mode, thus utilising a common shared bus and associated hardware. Their outputs would be compared after the full cycle when both the processors had completed the processing.

It was interesting to listen to the arguments put forth by the hardware and software redundancy lobbies. The former argued that any fault in one of the units of hardware, would be detected in time and the system would perform a reconfiguration or safe shutdown before occurrence of any unsafe event, while the software redundancy lobby would argue that the independent and diverse versions of the software would not only detect the random faults in the hardware, but the systematic faults of the hardware as well as software, as the two versions of software were using inverted data and inverted logic. However, the claim of independence and diversity of the software versions should not be taken at face value; it should be examined critically as the software designers/programmers tend to adopt similar procedures and are liable to make similar mistakes. Experiments conducted on this subject have shown that software programs developed by 'independent' agencies are not adequately independent.

Reliability as well as safety comprise a long chain of too many links where strength of the chain is finally determined by that of the weakest link. We need to be careful to strengthen each link from data input, processing, redundancy, redundancy management and data output to get the desired reliability and safety levels. The instance cited by the author, where all the three channels of a 2oo3 system were powered by a single source (the other power supply catering to the fans) is a good example where the weak link of the shared power supply would largely annul the RAM benefits of the 2oo3 architecture.

Mukul Verma, India

Re Lessons from a different railway

Thanks for the December edition of IRSE News. Just a couple of comments about Karl Davis's article:

He mentioned that "One characteristic of railway work is repetitive routine.....". This is not a novel idea, indeed, historically, it was well understood with regard to the deployment of the AWS on the former Southern Region. There was a fair bit of opposition to it on the grounds that there were many normal situations where drivers had to respond to it frequently. There was even some experimental work done to develop a more sophisticated system that could differentiate between double yellow and yellow aspects (SRAWS – **irse.info/f6rj8**), but it was abandoned around 1975 . There were (and quite likely still are) many situations where anything better than double yellow was unusual.

Worth noting that the implementation of more complex arrangements using 'flashing yellow' displays, such as that at Colwich junction, increased over time. On the front cover, there is an image of the well-known HST which, kind of, led to the development of this arrangement in the first place, on account of the improved braking system operation, and the need to make best use of the available layout. I think the first location where it was used was a 125/70 mph junction (Wootton Bassett – not "Royal" in those days!). The continued use of "route signalling", rather than "speed signalling" was the real issue, perhaps, but it was necessary to enhance the performance of the available system. The interface between permanent way design, traction, and that of signalling was often a significant factor. Not much point in building something that could not be used; it would be a waste of expenditure.

With regard to the development of TPWS, it might be worth noting that there are quite a few failure modes which result in its absence altogether. Quite controversial at the time, but as the article says, it's a much cheaper alternative. A philosophical shift led to its implementation to a large degree, so 'something was done'. In this context, the other article which mentions the definition of Safety Integrity Levels (1-4) is relevant.

John Keepin, UK

Possessions and blockades

It was gratifying to read the article by Frank Heibel in the December IRSE News. At least one engineer seems to have a conscience about the disruption and heartache that prolonged blockades can cause to the travelling public.

In the UK, the situation seems to be getting worse and the recent blockade on the East Coast Main Line (ECML) is sadly typical of what has become the norm. Network Rail, the infrastructure Manager in Great Britain has a slogan "Put Passengers First". Well, they have a funny way of showing it.

It never used to be like this so what has changed? To have put forward blockade proposals that shut main lines for days on end would never have been contemplated at one time. There were line closures when a major resignalling took place, but these would have been restricted to an overnight Saturday/Sunday possession with services needing to be restored by late Sunday afternoon. It might have been granted longer if alternative routes were available or if two lines of a four-track railway were kept operational. I lived on the ECML during the 1970s when the resignalling at Kings Cross took place. The station never closed during the entire remodelling work with the station operating in two halves. The train service was cut back slightly, and use was made of the connections to and from the lines to Moorgate. Admittedly that option is no longer there but instead the Thameslink lines to St Pancras in London now exist to offer a service from Finsbury Park if the main line trains must be terminated there.

It seems to me that the engineering ethos these days is one of 'how long a blockade dare we take'? Much of it I know is driven by the reduction in cost that a full closure allows. The civil engineer is dominant in this thinking and regards even the most straightforward relaying as needing a full blockade over a weekend. What has happened to single line working? Are the relaying machines so complex that both tracks of a two-track railway are needed? Or is it just laziness on the part of the engineer to take the easy way out? Signal engineers are not immune from this paralysis and when things go wrong, lines can be shut for weeks on end, viz the Manchester South resignalling closed the main line from Cheadle Hulme to Crewe for months whilst the new signalling was being made fit for UK conditions.

Some will claim it is enhanced safety rules, but overzealous safety is as bad as insufficient safety. What happens to the elderly who must cross bridges and clamber up steps into buses often with heavy luggage? Is this a safety risk in itself? Never mind all the anxiety and worry as to whether 'meeters and greeters' will be in the right place. Does the travelling public really accept these conditions without being put off rail travel for future journeys?

I look forward to the day when engineers only ask for blockades as a last resort and do everything within their ability to keep the train service operational during engineering work. As Frank Heibel says, it is all a question of mindsets and at the moment, the mindset is completely wrong.

Clive Kessell, UK
past president IRSE

December issue

Thank you for the shorter articles published in the December 2020 IRSE News. They are super informative but also readable as simple two-page articles. Perfect to read during a coffee or lunch breaks. I hope that the IRSE continues to provide articles just like these, short but informative. Instead of 8 or 10 page articles which are really time consuming which I never get to finish reading. Thanks very much for your service.

Sri Sai Moulya Chandra Bose, UK

Editor: We try to provide both shorter, easy to read, articles and longer, more academic papers. If you have anything you would like to share with other members email me at editor@irsenews.co.uk.

RePast Lives: Michael Page

I worked with Mike Page on KCR, and recognise the picture at University South – because I took it!

I used to come into my office in Hung Hom goods yard to find a 'Post-it' note signed "IMP".

I also worked for David Norton in the Westinghouse R&D department – after KCR – though he had signed my IRSE application form some years earlier – when he probably did not know who I was.

So a sad issue of many memories.

Nicholas T Smith, UK

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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 editor@irsenews.co.uk.

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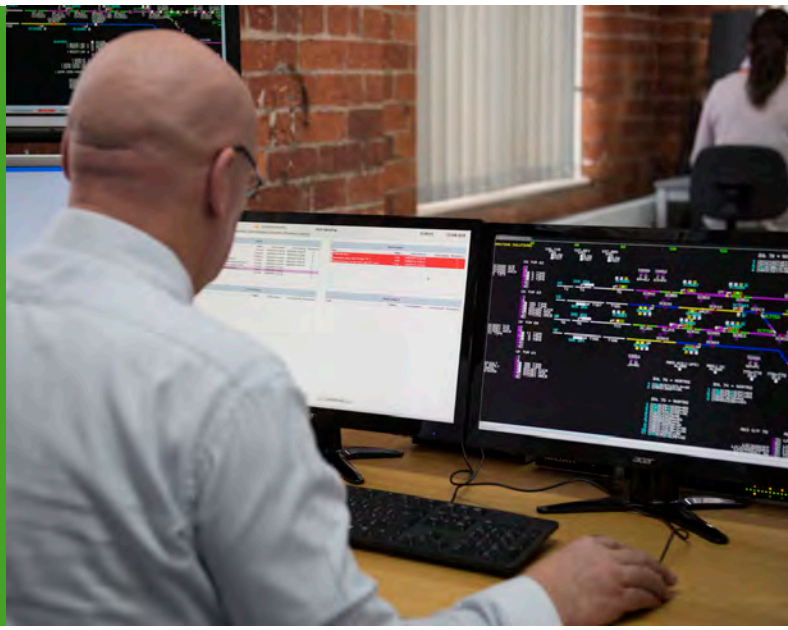

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