RailEngineer
by rail engineers for rail engineers
JANUARY 2018 - ISSUE 159

London Bridge station
a contractor's view

TRAINING FOR 4LM IS UNDER WAY

As drivers start training on the new signalling for LU's sub-surface lines, two articles look at testing in London and in Leicestershire.

STATIONS *FOCUS*

STATIONS - WHERE NEXT?

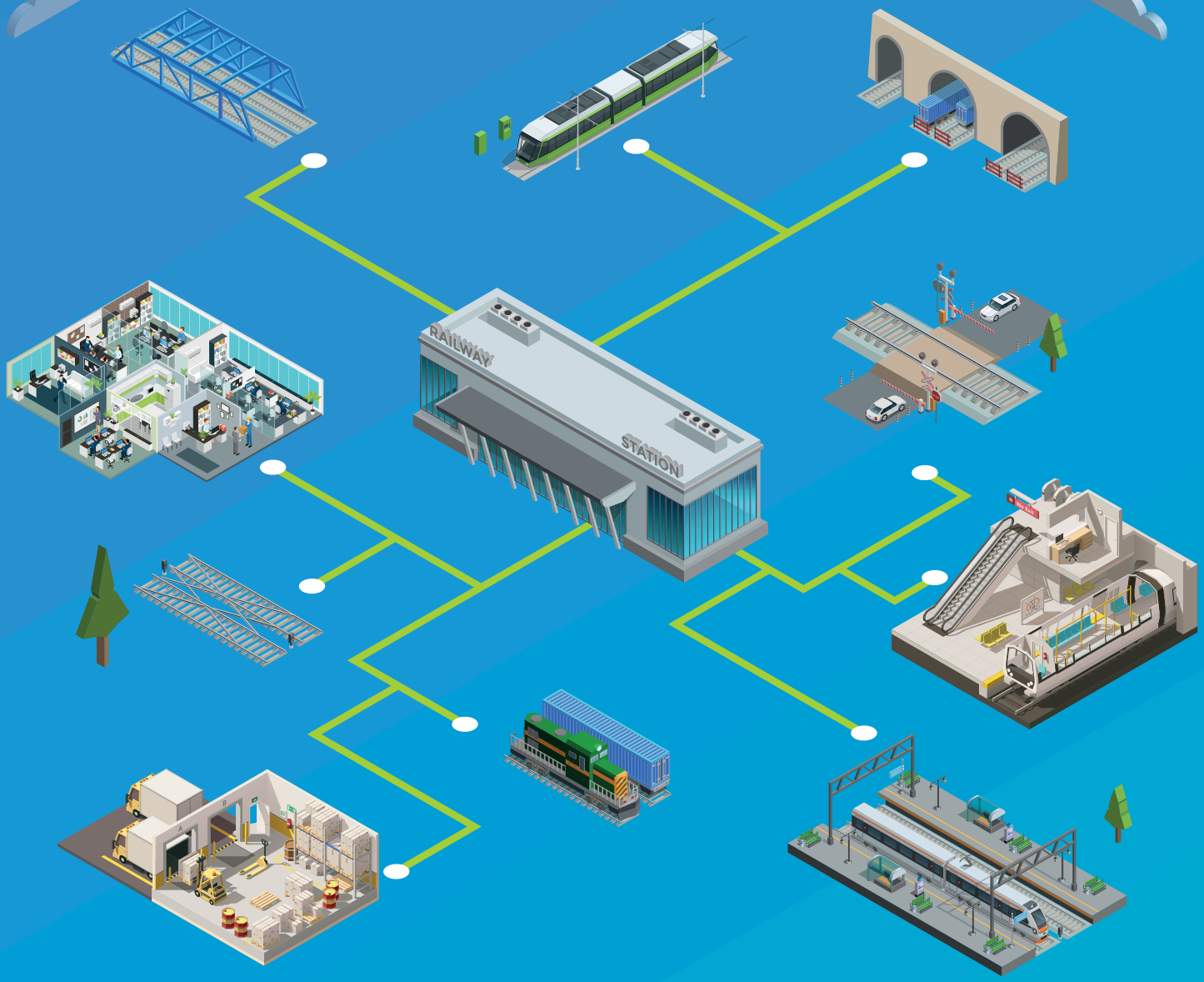
The last five years have seen several new stations opened and others rebuilt. What do the next five years have in store?

A RAILWAY AND ITS RIVER

When the river moved, threatening the railway's embankment, the answer was to move it back to its original course.

Rail Asset Management Summit

28th February 2018, London



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Stations

Feature

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Hydrogen **the new diesel**

Millions of tons of coal were burnt when railways were steam-hauled. The result was harmful pollution and working conditions that would be unacceptable today. When steam was replaced, it was by, what was then considered to be cleaner, diesel traction. Today, there is political pressure to reduce both the emissions from diesel engines and the CO_2 they produce.

With their green credentials, railways have escaped the tighter diesel engine emission standards imposed on road vehicles. The industry could also claim that, where railways aren't electrified, diesel is the only possible type of traction. However, at InnoTrans in 2016, Alstom unveiled its hydrogen-powered Coradia iLint multiple unit to show this was no longer the case.

As we explain this month, hydrogen-powered trains are now technically and economically feasible as fuel cells have become smaller and increased wind generation capacity offers significant surplus overnight power that can be stored as hydrogen energy. It is no coincidence that the Alstom iLint's first customer is Lower Saxony, Germany's leading wind-power state.

Hydrogen is not a primary fuel, it is an energy vector that can be produced on demand. Hence the price of hydrogen is the capital and maintenance cost of the equipment that produces it, and so, unlike imported fuel oil, hydrogen offers known fuel costs and self-sufficiency. These benefits drive initiatives such as proposals to increase Europe's hydrogen-powered bus fleet from a hundred to a thousand by 2020.

For all its advantages, hydrogen is not a universal solution. With diesel having eight times the energy density of the hydrogen in the iLint's roof mounted tanks, a hydrogen locomotive would require an additional rail vehicle to carry its fuel. Running hydrogen trains under the wires wastes energy by adding an unnecessary energy conversion step. Electric trains can be powered from renewables, for example Dutch railways have specified wind power for their traction supply.

It is therefore wrong to consider hydrogen trains as an alternative to electrification. Instead, they complement it by offering an environmentally acceptable alternative beyond the wires. As the environment becomes an increasingly important issue, hydrogen is a solution that Government and the rail industry must support.

The ecosystem is another environmental issue that cannot be ignored. A case in point was the urgent work needed to keep the railway open by the River Taw. As Mark Phillips explains, completion of this work within its demanding four months' timescale was only made possible by the impressive engagement with Environmental Agency and other affected stakeholders.

Another project that required constructive relationships between all concerned was transforming London Bridge's platform layout and constructing the station's vast new concourse, as Colin Carr describes. Significant capacity improvements are about to be delivered by this work and its associated signalling and track improvements that, as we describe, required 154 new switches and crossings.

In another feature, we show how signalling enhancements will enable extra trains to be run in Cornwall from December 2018.

Trains are now using the Ordsall Chord which, from May, will divert them away from the throat at Manchester Piccadilly to provide much needed capacity improvements. As we explain, uncertainty surrounds the scheme to build additional platforms at Piccadilly that would provide further capacity - it has been suggested that a digital railway solution would avoid the need for them.

Electric trains with extra coaches are now running on the main line between Glasgow and Edinburgh. This was the most newsworthy of the electrification programme's three milestones reached on 10 December. We report on an essential, but not so visible milestone, the opening of Millerhill's servicing depot.

The introduction of computer based train control (CBTC) and will provide extra capacity on London Underground's sub surface lines. Part of this project is the new Hammersmith Service Control Centre, which is featured in an article by Clive Kessell that also describes how simulators are an essential part of the programme to train hundreds of operational staff and drivers on the new system. With Hammersmith about to go live, Nigel Wordsworth explains the project's implementation strategy, how CBTC equipment is being fitted to the lines' S stock trains at Derby and the programme's intensive testing programme.

Our round-up feature on station projects shows that CP5 has seen 21 new stations and others rebuilt, with many provided with new and extended platforms. This work gives more people access to the rail network as well as supporting capacity improvement programmes. Also underpinning the drive for more capacity are improvements to the telecoms network, as Paul Darlington describes.

Malcolm Dobell's three reports from the various events he has attended shows there was much to learn from them. The Vehicle/Track System Interface Committee's annual seminar included an explanation of the work done to reduce rail breaks from the pre-Hatfield figure of around 750 a year to less than a hundred. The Rail Research UK Association's annual conference highlighted many useful joint industry/academia research projects, whilst the IMechE's technical study tour, organised by its Railway Division, provided a valuable insight into other countries' railway engineering practices.

Whether its powering trains by hydrogen, increasing capacity or reducing rail breaks, our writers have enjoyed finding out about the many worthwhile initiatives that will improve our railway. We hope you will enjoy reading about them!

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ENGINEERING
TAKE A CLOSER LOOK

It's the Year of Engineering!

2018 has been designated the "Year of Engineering" in a Government campaign to support the engineering profession in recruiting the next generation of engineers.

Throughout 2018, events will showcase the variety and creativity of modern engineering to improve understanding of what engineers do.

The campaign aims to transform perceptions of engineering among young people, their parents and their teachers, and to widen the pool of young people who consider the profession - the engineering workforce is currently 91 per cent male and 94 per cent white.

The railways are heavily reliant on engineering in all its forms, and railway companies have been quick to become involved. Bombardier, Crossrail, Hitachi, East Midlands Trains, High Speed College, HS2, East Midlands Trains, London Transport Museum, Network Rail, Thales, Transport for London, the Stagecoach Group, the National College for High Speed Rail and the National Skills Academy for Rail have all committed themselves to participate, with more joining in all the time.

They will be supporting the campaign through activities including schools competitions, community and careers events, exhibitions and giving young people the chance to meet rail engineering role models.

Teaming up with these and hundreds of other partners, the government will deliver a year of UK-wide school visits, exhibitions and open door events - all aimed at encouraging young people and their parents to take a closer look at engineering.

Commenting on the initiative, Secretary of State for Transport Chris Grayling said: "Engineering is one of the most productive sectors in our economy, but a lack of young people entering the profession is damaging growth. With major investment being made in infrastructure and new technologies that aim to improve the way we travel, work and live, it's crucial to the nation's success that more people join the profession.

"This Year of Engineering is our commitment to transforming perceptions of engineering among young people, their parents and their teachers. We need people from all backgrounds to see the creativity, opportunity and value of engineering careers."

PHOTO: WE SHOOT LONDON

L-R: Mr Andrew Jones MP, Rt Hon Chris Grayling MP, Dame Mary Archer, Mr Robert Goodwill MP, Rt Hon John Hayes MP at the Year of Engineering preview.

Terence Cuneo exhibition open until April

The remarkable career of British artist Terence Cuneo is being celebrated in a new exhibition from the Science Museum Group as part of Hull UK City of Culture 2017.

Widely recognised as the world's greatest railway artist, and drawing on loan material from across the UK to supplement the Science Museum Group's already rich collection, the exhibition features Cuneo's drawings for the Ministry of Information during the Second World War; his well-loved railway paintings and posters; depictions of industrial power and process; and his portrayal of a different type of power - the benign power of sovereign and state.

During his life. Cuneo had a highly productive relationship with the Science Museum. He received several commissions from the museum, including his monumental depiction of Waterloo Station in 1967.

The artwork, which currently takes pride of place in the National Railway Museum's Station Hall, was painted in the Science Museum building and even features some members of museum staff alongside Harold Wilson, Cuneo himself, with his wife and daughter, and one of his famous mice. From 1953 onwards, Cuneo painted a mouse into each of his works.

Central to the exhibition is the sense of Cuneo's incredible attention to detail. He worked meticulously, often in adverse conditions, to capture scenes with amazing accuracy. A painting of Clapham Junction, displayed in the exhibition, was painted in several sessions from a vantage point high above the tracks, with cinders from steam engines passing underneath landing on the still-drying canvas.

The exhibition will run at the University of Hull's Brynmor Jones Library until 15 April 2018.

coming soon...

NEXT MONTH...

RAIL INFRASTRUCTURE

Rail Engineer looks at what's involved in maintaining and renewing the UK Rail Infrastructure and the latest technology and innovations making it faster, easier and more cost effective, especially in these areas:

Asset Management, Cable Hangers, Construction, Drainage, Examinations, Lifting, Modular Systems, Painting, Plant & Equipment, Precast Sections, Refurbishment, Replacement, Rope Access, Scaffolding, Spray Concrete, Surveying Equipment, Surveying Techniques, Tunnel Boring, Ventilation, Waterproofing

MARCH 2018

SIGNALLING & TELECOMS

Three of Rail Engineer's writers specialise in this complex field that keeps the railway running and will provide the key to increased capacity and safer running in the future:

Barriers, Broadband, CCTV, Displays, Driverless Systems, Equipment, ERTMS, GSM-R, Gantries, Hazard Warnings, IP Networks, Information Systems, Level Crossing Surfaces, Loudspeakers, Operating Systems, Protection Systems, Radio, Resignalling Schemes, Signalling Power, Software, Training, Warning Systems, WiFi

APRIL 2018

ROLLING STOCK & DEPOTS

With trains and their systems becoming ever more complicated, Rail Engineer's specialist writers cover everything that improves performance, increases efficiency, and keeps customers happy:

Components, Condition Monitoring, Depots, Equipment, Fuel, Inspection, Interiors, Lifting, Light-Rail Vehicles, Lighting, Maintenance, New designs, Passenger Information & Entertainment, Refurbishment, Train Washing, Tram-Train, Underground Trains, Wheel / Rail Interface

Microsleep causes accidents

Two recent accident reports have highlighted the dangers of 'microsleep' in the railway environment.

The website Tuck.com, which claims it has the largest collection of aggregated data on sleep on the web, says that microsleeps are "brief, unintended episodes of loss of attention associated with events such as a blank stare, head snapping, and prolonged eye closure which may occur when a person is fatigued but trying to stay awake to perform a monotonous task like driving a car or watching a computer screen.

"Microsleep episodes last from a fraction of a second to two minutes, and often the person is not aware that a microsleep has occurred. In fact, microsleeps often occur when a person's eyes are open. While in a microsleep, a person fails to respond to outside information. A person will not see a red signal light or notice that the road has taken a curve, which is why this phenomenon is of particular interest to people who study drowsy driving. Similarly, during a microsleep, a pilot might not be aware of flashing alarm lights in the cockpit."

Now the problem has come to a head in two recent reports by the Rail Accident Investigation Branch (RAIB).

The first was on a passenger train which collided with the buffer stops at King's Cross station last August. The safety digest stated that four passengers and one member of staff reported minor injuries as a result of the accident, and there was minor damage to the train and the buffer stops, which were pushed back by over one metre. A brief brake application was made as the train came into the platform, and then a nine second gap before the emergency brake was applied. The train hit the buffers at around 4mph.

RAIB concluded that the accident occurred because the driver was suffering from fatigue and apparently experienced a microsleep in the last few seconds of the approach to the buffer stops. The driver reported being aware of passing the TPWS sensor but then briefly closed her eyes because they felt tired and were stinging. When she opened them, she was close to the buffer stops and, although she made an emergency brake application, it was too late to avoid a collision.

On 9 November 2016, an early morning Croydon tram service derailed when it hit the 20km/h bend at 73km/h. In addition to the seven fatalities, 61 passengers were injured in the incident, 19 seriously.

The report concluded that the driver probably "lost awareness" prior to the derailment and then became confused about his location. The RAIB believes the incident was linked to fatigue, although not as a result of the driver's shift pattern, and could have been caused by a microsleep.

The RAIB has recommended that the operator, Tram Operations Ltd (TOL), look into technology that can monitor driver alertness and automatically apply the brakes if a tram is going too fast - neither of which were available at the time.

However, drivers' union ASLEF called a strike on two separate days as the operator attempted to do just that. The union's press release stated: "This is because the company has put into tram cabs a device that shines infra-red light beams into drivers faces, and has insisted on operating this system despite the numerous health and safety concerns of our members. Drivers have reported symptoms from headaches and dry eyes to blurred vision and potentially serious eye damage as a result of exposure to this device."

The strikes never happened, and TfL released a statement stating that the Driver Protection Device uses advanced sensors that track eyelid closures and head movements to detect fatigue and distraction. When fatigue or distraction is detected, an in-cab alarm is sounded and the driver's seat vibrates to refocus the driver's attention.

Manufactured by Seeing Machines in Australia, the Driver Protection Device is not a CCTV camera recording a driver's every move. In the event that fatigue or distraction is detected and the alarm activated, the system will record the three seconds prior to the alarm to enable the incident to be investigated.

The underlying Seeing Machines technology is based on patented eye-tracking and analytics that detects driver distraction and fatigue while on the job. The company signed an agreement with Electro-Motive Diesel, manufacturer of Class 66 locomotives for the UK, to develop the technology for use in rail vehicles.

The technology has a proven track record in the road haulage industry and has been fully safety tested and certified. The system has been independently certified and is safe for indefinite/continuous use. Small amounts of infrared light are used to allow the sensor to see the drivers' eyes and face in the dark (less than 2 per cent of the level in normal sunlight).

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London Bridge station
a contractor's view

COLLIN CARR

London Bridge station - the Charing Cross platforms.

Regular readers of Rail Engineer will have enjoyed reading the many articles about Network Rail's £7 billion Thameslink programme. Arguably, the most challenging element of the project is the construction of a new London Bridge station whilst the existing London Bridge station remains operational.

London Bridge is, in fact, the oldest terminus station in London, first opened in 1836. Today the station serves over 50 million people every year and is the fourth busiest station in the UK. London Bridge station was originally two stations and the memory of the original configuration of through and terminal platforms was the underlying problem that needed to be addressed if the Thameslink project was to work effectively and efficiently.

The old station had six through platforms that lay on the Kent and southeast London routes into Charing Cross and Cannon Street. The remaining nine platforms formed the final stop for routes from Sussex and south London.

Removing old memories

The aim of the £1bn station design and construct project has been to fully remodel the station and transform the track and platform layout from nine terminus and six through platforms to six terminus and nine through platforms.

In conjunction with the construction of the new platforms, a vast new concourse, designed to provide a significant improvement to the passenger experience, is being constructed below the platforms. The end result is an emerging new station capable of coping with passenger numbers of up to 75 million per annum.

Alongside the construction of new platforms and a concourse, a substantial amount of work has been underway to improve the interchange between the Network Rail and London Underground stations.

In 2012, Network Rail appointed Costain as the main contractor for the detailed design and delivery of this £1 billion infrastructure project. As a result, Costain is both the principal designer and principal contractor. The project is now in its sixth year and is due for completion in May 2018.

Overarching objectives

Mark Howard is Costain's programme director at London Bridge. So Rail Engineer met with him to understand the contractor's role in this significant engineering undertaking, and to find out how he managed this challenge, one that must rival any railway station development anywhere in the world in its complexity.

Mark started by explaining the three guiding principles that have driven the programme's strategy, work plan and the sequence required to manoeuvre effectively the different stages of work throughout the station complex.

The overarching objectives are to maintain the safe operation of the station and its surrounds, and of the train services, and to ensure a continuing positive passenger and public experience within and around the station complex.

Incentivised partnering milestones

Costain fully understood that the station redevelopment would only be achieved if there was a successful integration of what was referred to as "The Railway Systems". These were the main packages of work that were let by Network Rail, mainly the station development itself (Costain), associated track work (Balfour Beatty) and signalling and telecommunications (Siemens Rail Automation).

There are no direct contractual links between the three parties, but the London Bridge Area Partnership (LBAP), a collaborative relationship established using BS11000, was established in 2012.

For the Thameslink programme and the individual contracts to be successfully delivered, it was and continues to be recognised that interface work is an essential element for successful delivery.

The intent of the LBAP arrangement from the outset was to ensure that the following interfaces between the parties were effective. These were the technical interfaces through the design development and approval process, programme interfaces so that 'give/get' dates could be devised, agreed and achieved, and the coordination and control of safety, health and the environment.

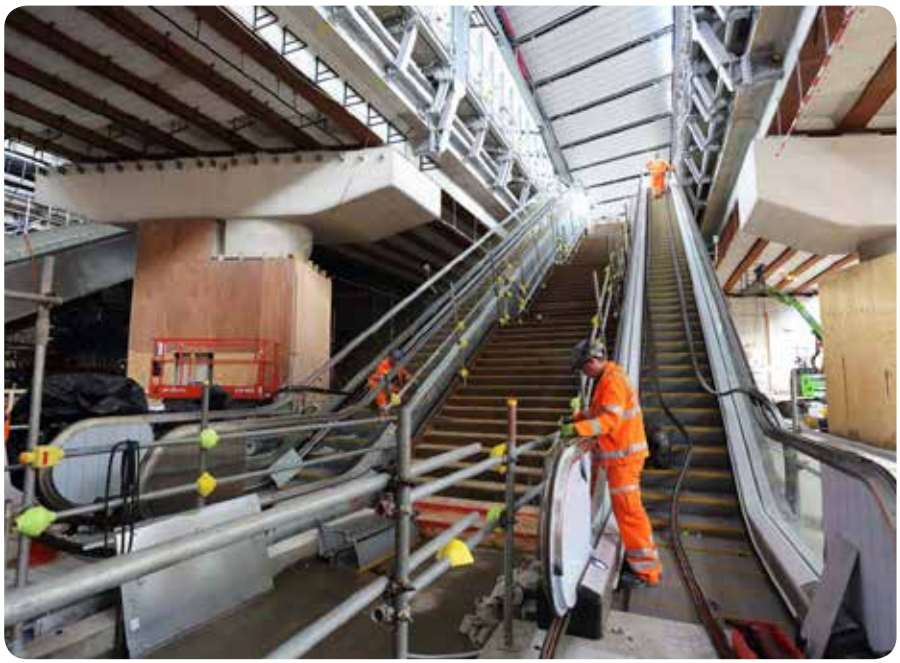
In addition, the relationship supports the sharing of best practice and innovation and also risk mitigation.

Network Rail ensured that the give/get milestones would be incentivised within each of the respective contracts to encourage focus and commitment. In total, there were 35 'give and get' dates agreed and, to date, all of these milestones have been achieved.

Transforming the station complex

Costain identified four main project objectives:

- Complete remodelling of the track and platform layout. The starting layout was nine terminus platforms and six through-running. The project will change this to six terminus platforms and nine through-running, including dedicated platforms for the Thameslink service, a critical factor.
- Creation of a new street level concourse measuring 75 metres by 200 metres, approximately the size of Wembley stadium.
- New interchange route (Western arcade) between London Underground and the new concourse.
- Full transformation and re-development of the station buildings.



Mark explained that Costain's early involvement in the design was crucial for adding value and de-risking the project. He gave two examples of key initiatives that had been introduced during the planning phase.

The first was to develop an effective safety case for using four tower cranes instead of mobile cranes, which are considered the norm for such work. The effort put into producing the necessary safety case was rewarded with a marked improvement in productivity.

The second was to design 1,100 prefabricated canopy units that would form the complex roof geometry. These were assembled off site and delivered 'just in time', enabling complex construction work to be undertaken in a much shorter time. With the assistance of cladding specialist Prater, subcontractor Severfield designed and constructed the bespoke cassette canopies.

Highlights of the work included:

- The demolition of the Victorian shed roof.
- Demolition of existing platforms and Victorian arches by Keltbray, plus complex ground engineering and the construction of more than 1,000 piles by Bachy Piling UK. The work programme was not linear but had to be carried out at different stages of the project, whilst maintaining a common high standard.
- Civils works involving placing 85,000 cubic metres of reinforced concrete, drainage, sub and superstructure, bridge and track-bed construction.
- Mechanical, electrical, communications, fire, station and building management systems. 11 new lifts and 24 new »

escalators and the construction of 15 new platforms and associated floors, finishes, cladding, glazing and canopies.

» Integrated testing and commissioning, in interim state with legacy systems and in end state. Planned and reactive maintenance of all assets entered into service before substantial completion date in May 2018.

The station construction staging had to be fully aligned to the track and signalling staging and underpinned by partnering milestones. Thousands of possessions and ten major blockades have been, and continue to be, successfully delivered whilst, and this is the key part, the station has been kept fully operational as the stages have progressed from the south side to the north.

Network Rail CEO Mark Carne at London Bridge with architect Andrew Byrne of Grimshaw

Progress milestones

Work started in late 2012 and, by May 2013, three platforms had been taken out of operation. By September 2013, pile cap and drainage construction was well underway and, by January 2015, all the six reconstructed terminal Platforms 10 to 15 were in operation. This then enabled Costain to move into the heart of the station and demolish the Victorian archways below the platforms in preparation for the new expansive and spacious concourse.

At the western end of the station is the newly constructed SAVEX Weststructure cast in-situ with a precast beam decking. This structure, plus an additional 40-metre steel-decked west approach viaduct structure built by Costain, is designed to link the existing network with the new and so far unused, 350-metre pathway which includes Borough Market viaduct.

Mark explained that the west approach viaduct was probably the most challenging aspect of the project. Partly because it impacted on London Underground, the bus station and the railway activities, but also because of the restricted site access, loading restrictions and adjacent structures.

All operational activities had to be suspended so that 90-tonne girders could be positioned using bespoke lifting gantries and self-propelled modular transporters (SPMTs). Working in this restricted environment, and controlled by skilled operators, the SPTMs manoeuvred the girders onto the bearings of the previously constructed in-situ columns. The work was completed in 2015, creating a pathway designed eventually to carry an additional two dedicated Charing Cross tracks in 2018.

By July 2015, St Thomas Street façade was completed. Thorp Precast installed 22-tonne pre-finished brick and stone-faced units which look very effective alongside the existing arch structures.

Wow factor

On 29 August 2016, the southern two-thirds of the concourse opened, along with the through-running Platforms 7, 8 and 9 - described by Mark as a genuine 'Wow!' factor for the public and travelling passengers.

So as stated before, all 35 give/get targets have been met. All tracks have been handed back to operations except those alongside Platforms 3, 4 and 5, which will be handed back after the completion of work planned for the Christmas blockade.

Alongside this outstanding work is the development of the in-situ concrete Quadrapartite Arcade arches, designed to recreate the original Victorian form. One bay is already open to the public and provides direct interchange to the London Underground station. The two parallel bays will be completed by Christmas.

There are more than 200 suppliers supporting Costain in this venture. The relationship and interface management with Balfour Beatty and Siemens, overseen by Network Rail, has and continues to be absolutely critical in ensuring that the project is a success.

Passengers can now walk through large parts of the new station, and it is truly amazing to see how it has been totally transformed. It is hard to think of a more complex undertaking and one of which Mark and his team must feel very proud. It is an outstanding contribution to the Thameslink project and even has that Wow! factor.

What more can I say?

NIGEL WORDSWORTH

Making a point on Thameslink

(149 of them to be exact)

Much has been written in Rail Engineer about the Thameslink Programme and, more recently, about the changes at London Bridge and the construction of the Bermondsey dive-under. Both alterations are designed to smooth the path of Thameslink trains through London Bridge station and on to Sussex without crossing and blocking other routes in the process.

While the civil engineering feats are impressive - London Bridge station has been changed from having six through and nine terminating platforms into nine through and six terminating, while the Bermondsey dive under has been created in the middle of a complex junction, all while keeping the station open - one thing has been forgotten. That's the track itself.

The track layout has been totally changed - in some cases several times as interim arrangements were installed and later removed.

How many points?

Look at the track plan and the sheer number of points used in the layout is impressive. To save counting them, and a few may be just out of shot, there are 154 in total.

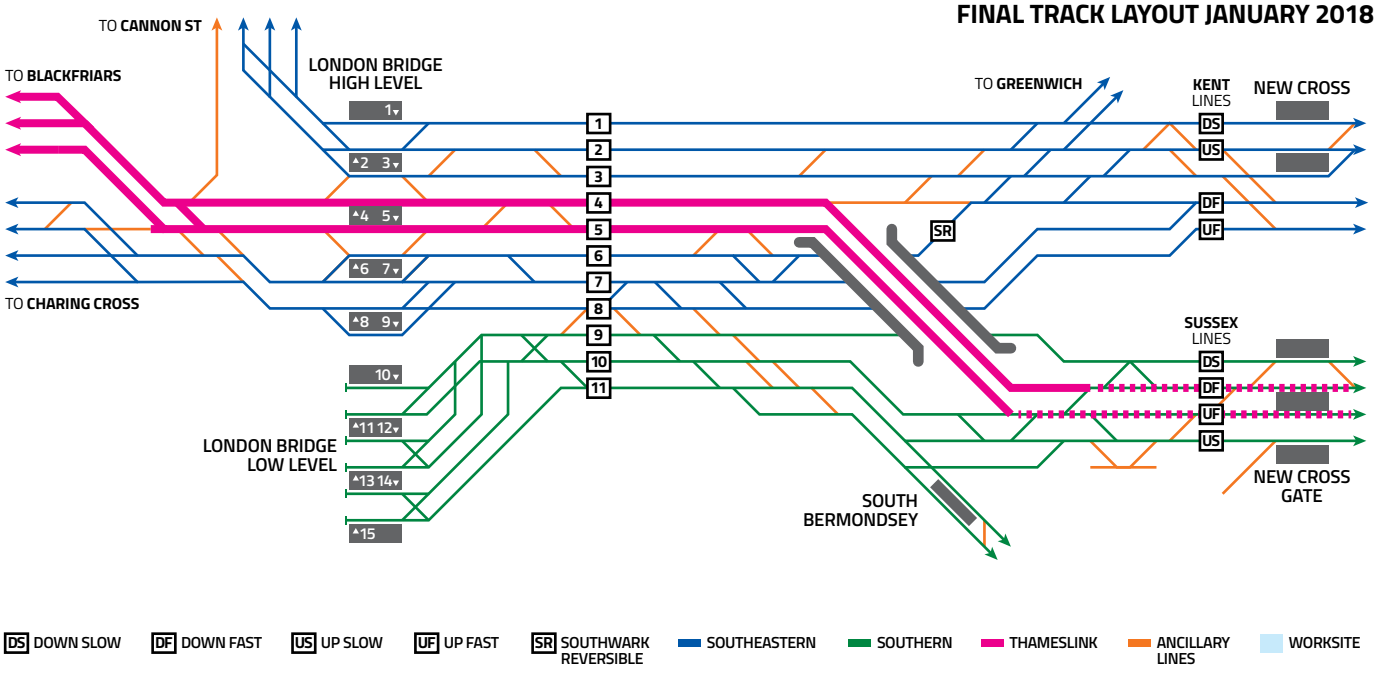
All had to be manufactured off-site, delivered, fitted, tested and connected in to the signalling system over a space of just over five years.

With such a volume to be produced, it would be natural for the contract to be split amongst several manufacturers to spread the load. And that was exactly the case - Vossloh Cogifer manufactured 149 of them at Scunthorpe, while another company made five.

Naturally, this was a major contract for Vossloh Cogifer. Although ostensibly to Network Rail's recent NR56V standard, most of the 149 units were different in detail, and even varied from simple turnouts to crossovers and more complex layouts.

First of all, Vossloh Cogifer mobilised its supply chain. Some of this was in-house - many of the cast manganese crossings for the turnouts were sourced from the Vossloh Cogifer Outreau foundry in France while switch-blade forgings came from Vossloh Cogifer Kihn in Luxembourg. Rail machining and assembly along with concrete bearers was undertaken at Vossloh's own facility at Scunthorpe.

FINAL TRACK LAYOUT JANUARY 2018



Other material was free-issued by Network Rail - the latest design of hollow stretcher bars, SPX in-bearer Clamplock point actuators and the plain rail itself. Yet more came from outside suppliers, including rollers, clips and other hardware.

Final installation

Running alongside the supply of layouts for the project, Vossloh Cogifer was actively commissioning its own under-cover facility to manufacture concrete bearers and assemble the units prior to client inspection (see right). This new facility also has rail access, so Network Rail's fleet of tilting wagons could be brought in to be loaded with the finished modules, usually three for each S&C unit, for transport to site.

It all went according to plan. Units were fully assembled and tested at both Scunthorpe sites, then broken down into modules for transport and final assembly on-site.

Additionally, Vossloh Cogifer was able to support the project with the supply of insulated joints, special structural adjustment switches and factory-assembled curved check-rail panels.

Trackwork installation at London Bridge station had to be co-ordinated with the demolition of arches below the track, where the new concourse was being built, and the subsequent installation of new structures to support the track above.

Finally, on a foggy day in November, Network Rail fitted the final set of points in Bermondsey, connecting the tracks through Platform 4 at London Bridge, which will be used by Thameslink services from May 2018, to the new flyover. This did not require a disruptive possession, as it was installed on track that was currently out of use, and formed the last part of the programme's 118 distinct phases.

Since the track was now complete, the 10-day London Bridge blockade over Christmas was primarily for signalling commissioning, but it included new track being tied into the operational railway. Four through platforms were brought into use, routes that will be used by Thameslink trains, which currently all run through Elephant and Castle. This is for driver training prior to the new timetable in May 2018.

At the same time, the new station concourse was fully opened to connect Tooley St and St Thomas Street.

Satisfying result

As the huge Thameslink Programme neared its end, railway systems project director Mark Somers was understandably satisfied: "I was impressed with Vossloh and their entire set-up. Their management team is very customer focussed and I was also impressed at the excellent working relationship and collaboration with our Network Rail team and our delivery partner Balfour Beatty. Vossloh have manufactured high quality S&C and delivered on time throughout the duration of this contract, which has been absolutely critical in delivering the major track remodelling at London Bridge.

"I am thrilled that we have successfully completed what has been the most complex track realignment the UK's railway has ever seen. By untangling the tracks surrounding London Bridge, we will provide more reliable, more frequent journeys for passengers than ever before. The Thameslink Programme is a vital part of Network Rail's Railway Upgrade Plan and I am very proud of the work we have done."

There will still be work to do in the station throughout 2018, but this will be completed during evenings and weekends, rather than on weekdays.

Once complete, London Bridge will be a modern, spacious and fully accessible station, fit for the twenty-first century and able to support the new timetables, meaning better journeys, more reliable services for passengers and, from May 2018, Thameslink services returning to London Bridge for the first time in over three years, serving a range of new destinations.

Having been a major supplier to the Thameslink Programme, Vossloh Cogifer, too, should be proud of its achievement. Manufacturing so many complex layouts over the course of the programme called for cooperation at all levels. The teams from both Network Rail Thameslink and Vossloh Cogifer developed a close working relationship so they could respond better to problem solving. The respect and trust between the teams also helped when they were called upon to react to short lead-time requests.

Wendy Preston, commercial and supply chain manager, said: "We have worked on the London Bridge scheme for the last five years, supplying 149 of the sets of points that have been used on the Thameslink Programme. It has been a challenging project but we are very proud to have been a part of such an amazing achievement."

So what next for Vossloh Cogifer and the team at Scunthorpe? Well, they have recently also completed the supply of switches and crossings for the Crossrail project, a contract which involved supplying 32 switch and crossing units - a mixture of CEN56 and CEN 60 layouts - for both ballasted and slab track.

Vossloh is now manufacturing the S&C for the Birmingham and Manchester tram extensions and looking forward to putting its knowledge of very-high-speed track to use on future UK projects.

Upgrading stations

With Network Rail's comprehensive Railway Upgrade Plan well underway and the modernisation of Britain's railways firmly in the spotlight, there is a growing need and expectation for first-class stations and infrastructure to accommodate growing numbers of passengers nationwide.

One business with a huge role in the modernisation programme has developed a reputation as an exceptional multi-disciplinary contractor, with extensive capabilities in civil engineering, building and rail, meeting the demands of a wide range of clients across multiple disciplines. It is this consolidated approach that has helped VolkerFitzpatrick deliver several high-profile UK railway station schemes in the last 10 years.

Following the five-year period of the CP5 determination, the Government's modernisation of the UK rail network has created opportunities for the delivery of significant engineering schemes for Network Rail. Part of VolkerWessels UK, VolkerFitzpatrick has played a pivotal role in the design, construction, modification, upgrade and renewal of Britain's railway infrastructure.

Glancing backwards

Over the years, VolkerFitzpatrick, which has a long and established history of operating in the rail sector, has successfully delivered several high-profile station projects.

In 2006, the business delivered the £7 million design and build of the new Imperial Wharf station on London Overground as part of the St George Development on the Up and Down West London line in Fulham. The scheme was completed and handed over in November 2007. VolkerFitzpatrick was involved from conception and initial planning and approval, through to delivery of a range of disciplines including civil and structural construction, mechanical and electrical works, signalling, permanent way, retail and operational telecoms.

South of London, a £31 million platform extension scheme at Gatwick station was a challenging project for VolkerFitzpatrick, as the station had to remain operational throughout the works. Because of this, the team conducted activities during the night, to prevent critical passenger announcements being drowned out by work during the day.

The project involved the construction of a new 12-car platform for Fast trains, with associated signalling, track and access. The replacement of a stairway with an escalator and lift improved passenger circulation on Platforms 5 and 6, while upgrading the track and signalling improved performance and reliability of trains passing through and travelling to and from Gatwick Airport.

One major engineering challenge the project team encountered during the works involved the structural columns supporting the station's concourse, which directly conflicted with the new Platform 7 track alignment. Removing the columns was a delicate operation, involving supporting the 500-tonne operational concourse on temporary works during the transfer onto its new columns. With careful planning, the team co-ordinated a seamless transfer which took place in a single morning with only 2mm deflection, and no negative effects on passengers.

Cambridge North

Earlier this year, VolkerFitzpatrick completed the design and construction of a new rail station between Waterbeach and Cambridge stations on the West Anglia main line. The new station provided rail access onto the wider Cambridge public transport network, interfacing with a guided bus service, and has helped ease congestion both on the city's roads and for passengers using the existing Cambridge station.

The works involved the construction of three lines to serve a single-faced platform and island platform, both capable of accommodating up to 12-car trains. The new station building contains waiting areas, a new ticket office and modern toilet facilities. A footbridge provides access from the station building to all platforms via lifts and staircases, and access was further enabled by a new 450-space car park, an interchange with the guided bus-way and an extension of Cowley Road to provide a vehicle access route to the station.

The original platform design called for ground improvements due to poor conditions. The team used a lightweight polystyrene backfill that required minimal ground preparation. This improved installation times, reduced the amount of possessions required and reduced the overall cost of the station.

The scheme also incorporated green technology, including solar panels that provide up to ten per cent of the station's power.

Two further VolkerWessels UK business units worked on this project. VolkerRail delivered the rail systems work for the station, along with associated remodelling work of the old Chesterton sidings yard, as part of the CP5 Multifunctional Framework in Anglia.

VolkerHighways also worked on the new station, installing street lighting, ducting, cabling, signage and street furniture and building the station's two new car parks, along with a new plaza area and three new roads.

Lea Bridge

Lea Bridge Station re-opened to passengers in 2016, thirty years after it was closed. VolkerFitzpatrick worked with Network Rail and the London Borough of Waltham Forest Council to redevelop the disused station into a new facility which will be able to accommodate around 352,000 passengers a year by 2031.

VolkerFitzpatrick provided a full scope of civils, mechanical and electrical, energy and power, telecoms and permanent way, constructing a new station entrance, two new platforms, a new footbridge, passenger lifts and a station canopy.

Today, regular half-hourly services run from the new station to Stratford in five minutes, with connections to lines including the Jubilee, Central and the DLR, and Stratford International. In the other direction, towards Tottenham Hale, passengers have access to the West Anglia route to Stansted Airport and Cambridge and the Great Eastern main line to Chelmsford, Colchester, Ipswich and Norwich.

Discussing this scheme, John Cox, managing director of VolkFitzpatrick's rail division, said: "Working closely with our stakeholders within Network Rail and London Borough of Waltham Forest Council, we have delivered a new station that will provide a boost to the local economy and offer faster links to some of London's crucial transport hubs, benefitting both residents and local businesses.

"Lea Bridge Station is a prime example of our multi-disciplinary project expertise, while also providing positive implications for the area, providing commuter links to wider areas of London, and opening the Leyton area for further growth. Our project team overcame the significant challenges associated with building the station next to an operational railway, and safely delivered this vital link between north-east London and Stratford."

Hackney Wick

As part of the London 2012 Olympic Games, the London Legacy Development Corporation (LLDC) made a commitment to provide a lasting legacy for the host boroughs surrounding the Olympic Park, including Hackney Wick and the surrounding area. This included a Network Rail-delivered scheme to transform the Overground station at Hackney Wick, delivering major improvements for residents and businesses in the surrounding area.

VolkerFitzpatrick, as Network Rail's principal contractor, has delivered the cut and cover installation of a pedestrian subway box linking the north and south side of the station. It is also undertaking the construction of a new station building including ticket office, gate line, lift and stairs.

A key element of the scheme was a 99-hour blockade to accommodate the installation of the pedestrian subway over Easter 2017. The 2,000-tonne concrete structure was driven into place during the extended weekend, following its construction on the land next to the station.

In an operation that took only four days, VolkerFitzpatrick's project team removed the existing tracks and platforms and excavated the land underneath to create space for the subway. The subway was then driven into place using self-propelled modular transporters, and the track and platforms were then rebuilt so that train services could run as normal the following week.

Discussing the works, John Cox said: "The installation of the pedestrian subway was a complex undertaking which went smoothly due to the forward planning and engagement of all stakeholders. We look forward to completing the remainder of the works to the station and enabling the benefits this will have once finished in spring 2018."

Lea Valley Rail Programme

With the West Anglia main line (WAML) route currently at capacity, and with commuter demand increasing, major housing schemes along the route and the construction of Crossrail2 will result in the need for still more trains. The ability to meet this demand is limited by the capacity of the current line - only two trains per hour over a critical 5.5km section.

Network Rail selected VolkerFitzpatrick as the main contractor for the work to deliver upgrades to the WAML between Stratford and Angel Road - known as the Lea Valley Rail Programme. Due to be completed in 2019, the project will enable two extra trains per hour and help to boost regeneration in the boroughs of Haringey and Enfield.

In November 2017, as part of the £170 million programme, VolkerFitzpatrick successfully removed a 125-tonne bridge, which was used to carry the old track over the River Lea Navigation, by lifting it out in one 30-metre-long section. The intricate operation involved using a crane to lift sections of the bridge 30 metres into the air and over the existing line, which was closed to passenger services over the weekend. The new bridge will be installed early next year to support the extra track and two additional trains per hour running between Stratford and Enfield's brand-new station, Meridian Water, which will replace the existing Angel Road station.

Planning for tomorrow

VolkerFitzpatrick is committed to delivering challenging on-network schemes safely to the highest quality with minimum impact on rail operations. To achieve this, the business has established a strong permanent workforce and provides regular learning and development opportunities.

During 2017, VolkerFitzpatrick has undertaken a complete review of its corporate sustainability strategy, introducing a LIFE (Lead, Innovate, Futureproof, Evolve) sustainability model designed to make a real difference to the collective understanding of priorities and actions required to achieve business goals on the WAML programme.

In 2018 and beyond, VolkerFitzpatrick will continue with its aims to excel in collaborating with its partners to provide innovative and value-engineered solutions that manage costs and achieve efficiencies in delivery.

John Cox said: "We look forward to 2018 with great optimism, as we approach what is going to be a landmark period in UK rail history. We are involved in a large number of multi-year contracts and will continue to explore opportunities to deliver our full range of multi-disciplinary services, to provide unrivalled quality on the back of dependable safe delivery and a collaborative approach."

VolkerFitzpatrick

Industry leaders in rail engineering and construction

VolkerFitzpatrick offers a fully integrated approach that delivers efficient and innovative solutions.

Our national rail business undertakes the design and construction of civil engineering and multidisciplinary rail projects including:

- Major enhancements
- Structures
- Stations
- Depots
- Earthworks

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NIGEL WORDSWORTH

Stations where next?

NEW, PLANNED AND UPGRADED STATIONS

Forres
INVERNESS
ABERDEEN
DUNDEE
PERTH
STIRLING
Falkirk High
Edinburgh Gateway
Croy
Polmont
EDINBURGH
Linlithgow
GLASGOW
Robroyston
Shawfair
Eskbank
Gorebridge
BERWICK-UPON-TWEED
Stow
Galashiels
Tweedbank
STRANRAER
NEWCASTLE
South Shields (Metro)
CARLISLE
SUNDERLAND
Horden Peterlee
HARTLEPOOL
DARLINGTON
MIDDLESBROUGH
James Cook
SCARBOROUGH
BARROW
HARROGATE
YORK
Kirkstall Forge
Apperley Bridge
BLACKPOOL
PRESTON
BRADFORD
LEEDS
HULL
HALIFAX
Low Moor
WAKEFIELD
HUDDERSFIELD
BOLTON
GRIMSBY
Maghull North
MANCHESTER
DONCASTER
Rotherham Parkgate
LIVERPOOL
Warrington West
SHEFFIELD
HOLYHEAD
RETFORD
LINCOLN
CHESTER
CREWE
NEWARK
STOKE-ON-TRENT
Ilkeston
DERBY
NOTTINGHAM
GRANTHAM
STAFFORD
KINGS LYNN
SHREWSBURY
LEICESTER
NORWICH
WOLVERHAMPTON
PETERBOROUGH
BIRMINGHAM
Bermuda Park
Coventry Arena
KETTERING
ABERYSTWYTH
Bow Street
COVENTRY
RUGBY
Kenilworth
WORCESTER
Worcester Parkway
NORTHAMPTON
Cambridge North
CAMBRIDGE
IPSWICH
FISHGUARD
HEREFORD
STANSTED Airport
MILTON KEYNES
CHELTENHAM SPA
COLCHESTER
HARWICH
GLOUCESTER
Ebbw Vale Town
Oxford Parkway
OXFORD
SWANSEA
Pye Corner
NEWPORT
SWINDON
Brent Cross West
Lea Bridge
SOUTHEND
READING
LONDON
Barking Riverside
Wokingham
Waterloo
London Bridge
CARDIFF
Portway Parkway
BRISTOL
Reading Green Park
Ascot
Virginia Water
Camberley
MARGATE
RAMSGATE
BATH SPA
CANTERBURY
GATWICK Airport
ASHFORD
DOVER
FOLKESTONE
SALISBURY
TAUNTON
SOUTHAMPTON
CHICHESTER
LEWES
HASTINGS
BRIGHTON
WORTHING
EASTBOURNE
Okehampton Parkway
EXETER
Cranbrook
Newcourt
Marsh Barton
BOURNEMOUTH
PORTSMOUTH
POOLE
WEYMOUTH
NEWTON ABBOT
PLYMOUTH
PENZANCE


Ilkeston.

The current control period (CP5 - 1 April 2014 to 31 March 2019) has been a busy time for station development, with both new stations coming online and older ones being redeveloped. On the new stations front, Ilkeston in Derbyshire (issue 150, April 2017) opened on Sunday 2 April. It was one of five stations given the go-ahead as part of the New Stations Fund. This £20 million initiative was launched in 2013 to give local communities improved access to rail services in England and Wales.

The funding was distributed through a competition, giving all promoters of new stations meeting the conditions an equal opportunity of securing a funding contribution. In all cases, additional funds came from local councils and other interested stakeholders.

The first competition period ran from 24 January 2013 to 25 February 2013. A cross-industry awards panel met to consider all applications received by the closing date and selected five projects to be taken forward. In addition to Ilkeston, these were

- Pye Corner, on the line from Cardiff to Ebbw Vale in South Wales (opened 14 December 2014);
- Newcourt, on the Avocet line connecting Exeter with Exmouth (opened 4 June 2015);
- Lea Bridge, on the Lea Valley lines between Stratford and Tottenham Hale, London (opened 16 May 2016);
- Kenilworth, on the Coventry to Leamington line in Warwickshire (due to open February 2018).

Also in CP5

Of course, other station developments took place as well. Coventry Arena and Bermuda Park stations, on the Coventry-Nuneaton line, both opened on 18 January 2016 and were partly funded by the Department for Transport and Warwickshire County Council.

Apperley Bridge, on the Airdale line between Leeds and Shipley in West Yorkshire, opened on 13 December 2015 as a Park and Ride station, alongside the A658, while Kirkstall Forge, on the same line, opened on 19 June 2016.

A third West Yorkshire station, Low Moor on the Calder Valley line between Bradford and Halifax, opened on 2 April 2017.

And that's still not all. Forres station, to the east of Inverness on the line to Aberdeen, opened on 20 October 2017 having been relocated.

Edinburgh Gateway opened on 11 December 2016, just north of South Gyle station, connecting the main line to the Forth Bridge with Edinburgh Trams' service to the airport.

Cranbrook, on the West of England Main Line between Whimple and Pinhoe in Devon, opened on the same day as Apperley Bridge - 13 December 2015. Oxford Parkway was opened by the Prime Minister on 26 October 2015 as part of the Chiltern line improvements between Oxford and London Marylebone, although the first trains had actually called the day before. »


Ilkeston.


Newcourt.


Edinburgh Gateway.


Bermuda Park.

Cambridge North.

The reopening of the Borders railway, on 6 September 2015, brought with it new stations at Shawfair, Eskbank, Newtongrange, Gorebridge, Stow, Galashiels, and Tweedbank.

In Wales, north of Newport, the railway was extended from its existing terminus at Ebbw Vale Parkway to the new Ebbw Vale Town, which opened on 17 May 2015.

Cambridge North, actually at Chesterton, close to the Cambridge Science Park, opened on 21 May 2017. It is on the Fen line, from Cambridge to King's Lynn, and has three platforms and space for 450 cars and 1,000 bicycles.

And finally James Cook University Hospital got its own railway station, on the Esk Valley Line south east of Middlesborough, on 18 May 2014.

Larger stations

While all of the above have been fairly modest, low cost new stations, some of the largest stations on the network have been undergoing major refurbishment.

London Bridge is the obvious one. A layout of nine terminus and six through platforms has been completely changed over to six terminus and nine through platforms. Add to this a brand new concourse and new connections with London Underground and it almost becomes a complete new station. It has been open throughout and will be complete in the Spring.

Liverpool Lime Street reopened on 23 October 2017 after 23 days of work during which two new platforms (7 and 8) were built and others lengthened. Work will continue until 2019.

Work also continues at London Waterloo, where the five former-international platforms (20-24) are being shortened and brought back into use for normal domestic services. At the same time, Platforms 1 to 4 are being extended to accommodate 10-car trains. The project should be complete by December 2018.

Meanwhile, platforms at Ascot, Bracknell, Camberley, Chertsey, Egham, Feltham, Martins Heron, Sunningdale, Virginia Water and Wokingham are also being extended for 10-car trains.

The redevelopment of Birmingham New Street was completed in 2015. The new concourse is three times larger and is enclosed by a giant atrium, allowing natural light throughout the station. The redevelopment has transformed the experience for passengers, improving links to and through the city centre and is a catalyst for growth for the local area's economy.

Reading station was redeveloped to both remove a bottleneck and to prepare for the electrification of the Great Western main line and the extra traffic to be generated by Crossrail. Five new platforms were built along with a new footbridge, a new entrance, and track improvements including a new flyover to the west of the station. It was opened by HM the Queen on 17 July 2014.

Platform 12 at Edinburgh Waverley is being extended as part of the Edinburgh to Glasgow Improvement Programme (EGIP). At the same time, Platforms 5 and 6, for the new Intercity Express Programme trains, the Virgin Azuma Class 800/801 trains, are being created from the old Motorail bay platforms.

Also as part of EGIP, platforms are being extended at Croy, Falkirk High, Polmont, and Linlithgow.


Liverpool Lime Street.


Manchester Victoria.

The old station roof at Manchester Victoria was completely removed and replaced with a £17 million modern ETFE 'plastic' roof, using material similar to that used at New Street. The upgrade was completed in August 2015.

Still to come

Of course, there is still over a year of CP5 to go yet. And that will bring still more stations.

In addition to Kenilworth, mentioned above, Maghull North will bring a new station to Merseyside, serving Moss Side and Ashworth Hospital. It's due to open in May 2018.

The new Sheffield tram-train will start operating over the summer, and that brings with it Parkgate station in Rotherham, a single-platform terminus at the end of a short extension from Rotherham Central.

Worcestershire Parkway is being developed at the junction of the Cotswold and Cross Country lines near Norton, Worcestershire. Although plans for this station have existed since 2007, funding has been a problem. It failed to be chosen for the New Stations Fund but has since received other government funding through the local enterprise partnership. Buckingham Group was awarded a design and build contract and opening is anticipated over the winter of 2018/19.

Then there is Crossrail. Set to open eastwards from Paddington in December 2018, the project brings new or heavily modified stations at Paddington, Bond Street, Tottenham Court Road, Farringdon, Liverpool Street, Whitechapel, Canary Wharf, Custom House and Abbey Wood.

Later, when Crossrail services to the west commence in December 2019, a new station building and facilities will come online at Ealing Broadway, Hayes and Harlington, Pudding Mill Lane, Southall, West Drayton and West Ealing.

New Stations Fund 2

The second New Stations Fund was announced by Rail Minister Paul Maynard last July. Five more stations were selected to receive DfT funding. These will be:

» Horden Peterlee, on the Durham Coast line between Seaham and Hartlepool in County Durham, will deliver improved access to employment opportunities to the area, which has low levels of car ownership, making it easy for people to get around. A two-platform station, it will receive £4.4 million of DfT funding towards a scheme worth £10.55 million and should open in March 2020.

» Warrington West in Cheshire will have two platforms and a 268-space car park. Key benefits include reducing congestion on the M62 motorway and supporting the Chapelford Urban Village housing development. Located west of central Warrington on the existing southern Liverpool to Manchester Line route between Sankey and Warrington Central stations, this project will receive £4.23 million towards a total project cost of £17.2 million.

» Reading Green Park, south of Southcote Junction on the Reading to Basingstoke


Maghull North.


Warrington West.


Crossrail Custom House.


Crossrail Canary Wharf.


Reading Green Park.

line, is sponsored by Reading Borough Council and has the potential to unlock 7,500 new jobs and 1,500 homes, serving an area currently only accessible by road. It will have two platforms and will receive £2.3 million towards a total project cost of £16.5 million.

» Bow Street, on the Cambrian line in Ceredigion, Wales, was opened in 1876 and closed in 1965. It is now scheduled to be reopened in March 2020, along with a car park for 110 vehicles, acting as a park and ride site for Aberystwyth and Borth stations and helping reduce traffic congestion in Aberystwyth. This scheme will receive £3.945 million towards a total project cost of £6.76 million.

» Portway Parkway is planned for the Severn Beach line in Avonmouth, Bristol and will serve the existing Portway park and ride site. Part of the MetroWest scheme, it will receive £1.672 million towards a total project cost of £2.23 million.

Also planned for CP6

Marsh Barton lies on the Riviera line between Exeter St Thomas and Starcross stations. Devon County Council is backing this one, which is to be built by Graham Construction. Failing to secure DfT funding through the New Stations Fund - the application was unsuccessful - has thrown plans into some doubt but Devon County Council is keen to see construction proceed.

As part of the Edinburgh to Glasgow Improvement Programme, work to demolish buildings in front of Glasgow Queen Street station started in August. This was the first step in the station's transformation that will see its frontage extended onto George Square and platforms lengthened to accommodate eight-car trains at the end of 2019, with the station work completed in 2020.

Robroyston is planned to be a park and ride station alongside a new housing development in northeast Glasgow. The Scottish government is funding 50 per cent of the cost and the new station is expected to open at the end of 2019.

Barking Riverside is planned as part of the extension of the Gospel Oak to Barking line, which forms part of the London Overground network. Approval for the extension, and for Barking Riverside station, was granted in August 2017. Construction is expected to start in the summer of 2018 and the line should go into service late in 2021.

Plans for the extension to Barking Riverside also included a simple island-platform station at Renwick Road. The government approval for the extension granted permission for a stop at Renwick Road "if needed".

Also in London, the Northern line extension to Battersea, with tube services expected to commence in 2020, will feature new stations at Nine Elms and at Battersea Power Station.

In South Shields, the current Tyne and Wear Metro station, which is itself situated about 200 metres from the site of the former British Rail station which it replaced, is itself being replaced by a new interchange a short distance away. Work will start early this year.

Barnet Council has plans to construct Brent Cross West station on the Midland main line section of the Thameslink route, to be open by 2022. This will form part of the Brent Cross Cricklewood scheme, one

Glasgow Queen Street.

Brent Cross West.

of the biggest regeneration projects in Europe, which will see the comprehensive regeneration of 151 hectares to create a sustainable new town centre for Barnet and North London, including substantial residential and commercial uses.

Cardiff Parkway is being privately funded and will be located between Cardiff Central and Newport stations to serve a new business park. It is anticipated to open in February 2020. The new station has already been factored into the South Wales Metro map, along with a further stop at Newport Road.

Okehampton Parkway station in Devon is under construction following an announcement by Secretary of State Chris Grayling of plans to reintroduce a trial rail service between Okehampton and Exeter by the end of 2018.

At Coventry, Network Rail is asset protecting the site of an £82 million new station. This will include a new platform for Coventry to Nuneaton services, a new multi-storey car park for 644 cars and an additional footbridge.

Wolverhampton station will be demolished and rebuilt as part of the £132 million interchange project. Galliford Try has been named as the preferred contractor for the £40 million station element and the transformation should be completed during 2020.

Footbridges and shops

So many stations have been built, are being built, are planned or even wished for, that it is difficult to keep up. There may well be a few that have been omitted, but it must be clear that stations are a vibrant part of the UK's busy railway.

In addition to new build and major redevelopments, many stations are receiving new footbridges, entrances and facilities as part of the Access for All scheme. Some 186 stations have already been upgraded, six more are currently underway, and there are plans for a further 63 over the next three years.

And then there is retail. Shoppers, and not just passengers, continue to visit stations for some 'retail therapy' in ever-increasing numbers. Between July and September 2017, 63 million retail customers visited station retail outlets around Britain, with sales growth in Birmingham (+11.1 per cent) featuring prominently, alongside Manchester (+5.2 per cent) and Edinburgh Waverley (+6.8 per cent).

So interest in stations is up across the board. But, with 2,560 mainline stations in Great Britain, not including Transport for London, tram systems and some metros, there is a lot more still to do.

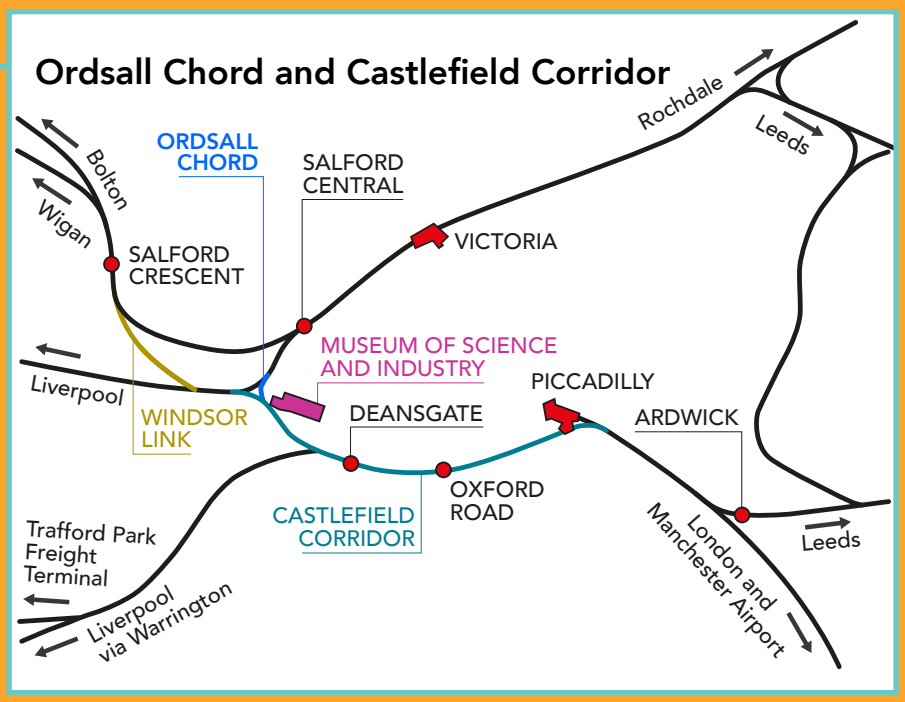

Wolverhampton.


Wolverhampton.

Coventry.

Manchester United by Ordsall Chord

DAVID SHIRRES



With the timetable change on 10 December, passengers were able to travel directly between Manchester's Victoria and Oxford Road stations over the Ordsall Chord for the first time. Although initially there are only six trains a day each way over the chord, May 2018 will bring big changes with a major timetable recast for the North Western electrification and to make best use of the Ordsall Chord.

This will increase the train services over the chord to three trains an hour each way and provide a direct link between Piccadilly and Victoria station. These trains will be a mix of TransPennine Express and Northern Rail services from Manchester Airport to Leeds and beyond. Liverpool to Scarborough trains will be routed via Victoria instead of Piccadilly.

Benefits of going further

Routing trains from the city's airport to Leeds and beyond through both Piccadilly and Victoria stations will add four miles to their route. The rationale for this is that it avoids the need for them to reverse at Piccadilly's terminating platforms and move across the station's throat. Similarly, routing the hourly Liverpool to Scarborough trains via Manchester Victoria removes these trains from Manchester Piccadilly's congested through platforms and thus avoids two train movements an hour across the stations throat. Furthermore, the travelling time for these extra four miles will not be much different from the time it takes trains to reverse at Piccadilly.

In this way, the Ordsall Chord provides significant additional capacity at Manchester Piccadilly. It also makes best use of the recently enhanced Victoria station, which will become Manchester's main station for services to Leeds.

The 2010 Manchester Hub study that developed the Ordsall Chord option concluded that, together with other associated infrastructure enhancements, it would deliver benefits with a net present value of £4.23 billion over a 60-year period, along with 20,000 to 30,000 new jobs. Thus, whilst it is good to see a direct connection between Manchester's main stations, this is far from the Ordsall Chord's main benefit.

The rusty bridge

The £85 million Ordsall Chord project was delivered by the Northern Hub Alliance, made up of Network Rail, Skanska, BAM Nuttall, Siemens and Amey Sersa. The most visible aspect of the Ordsall Chord project is its unique network arch bridge over the River Irwell. The bridge's much-commented rusty appearance is due to the use of weathering steel, which weathers to form a protective oxide-layer coating. The design and construction challenges of this bridge were described by Mungo Stacy in issue 150 (March 2017).

Although it is only 300 metres of railway, the Ordsall Chord presented many other challenges, including extensive track alterations to accommodate its new alignment, other bridges on its elevated route, tie-ins to other viaducts and complex signalling arrangements, as described by Paul Darlington in issue 148 (February 2017).

Furthermore, the chord was built through a sensitive historic part of Manchester, which presented significant challenges and resulted in an objector delaying the project by nine months.

The Castlefield conundrum

In Victorian times, Manchester's railways were split between its Lancashire & Yorkshire lines north of the city, which went to Victoria station, and those of various other railway companies to the south. These included main lines to the south and east which terminated at Manchester's London Road (now Piccadilly) and one that connected these lines to the original Liverpool to Manchester Railway at Ordsall Lane in Salford on a 1½ mile viaduct through Castlefield, just south of the city centre.

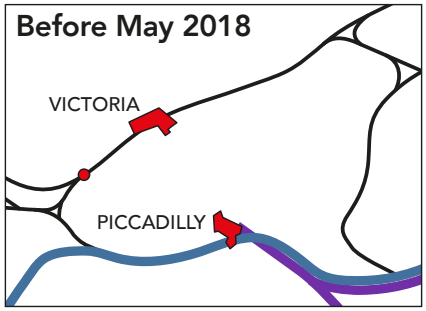
As a result, passengers with a north-south journey across Manchester faced a one-mile trip between the city's two main stations. This situation continued until the Windsor link was opened in 1988, which enabled trains from the North West to reach Piccadilly via the Castlefield lines. Traffic over this corridor was further increased with the opening of the line to Manchester Airport in 1993.

In the same year a multimodal rail freight terminal was opened at Trafford Park from where container trains are routed through the Castlefield corridor.

The corridor has three stations, from west to east are Deansgate, Oxford Road and Piccadilly. It is double tracked except at Oxford Road, which has a bay platform and four through platforms.

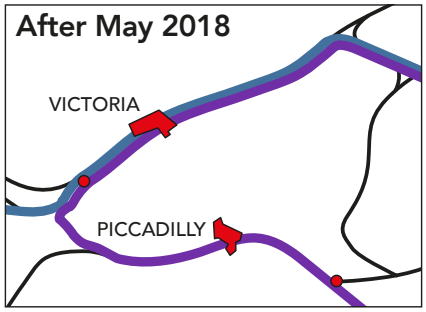
Following privatisation, traffic has increased significantly. Four train operators (TransPennine Express, Northern Rail, Arriva Trains Wales and East Midlands Trains) run services through the corridor. The introduction of the new timetable in May routes three trains an hour each way over the Ordsall Chord and so requires more trains to be routed through the already busy Castlefield corridor, increasing the number of train paths from 12 to 15 per hour. »

Removing conflicts at Piccadilly



Hourly Liverpool to Scarborough service crosses Piccadilly throat

30 minute Manchester Airport to Leeds service crosses Piccadilly throat whilst reversing at Station



Hourly Liverpool to Scarborough service diverted via Victoria

30 minute Manchester Airport to Leeds services goes through Piccadilly & Victoria via Ordsall Chord

Ordsall Chord's network arch bridge.


Unlike Piccadilly, Oxford Road station has four through platforms.

The Piccadilly solution

On a mixed-traffic railway, on which it is difficult to manage dwell times at crowded station platforms, fifteen train paths an hour is a demanding requirement. Thus Manchester Piccadilly's through platforms (numbers 13 and 14) present a performance risk. Mitigation of this risk requires dwell times to be carefully managed.

To support this, clutter is being removed at Platforms 13 and 14 - despatch controls and customer information screens are also being moved to optimum positions. There is a customer waiting area above these platforms with bookstalls and coffee bars in which passengers are encouraged to wait to avoid overcrowding the platforms below.

Dwell times will also be reduced as new rolling stock is introduced, offering longer trains and more doors per coach. There is also an initiative to ensure more efficient train despatch, with better arrangements for platform staff from different train operating companies to work together to support each other.


Manchester Piccadilly Platforms 13 and 14.

Although these arrangements provide the required number of train paths through the Castlefield corridor for the Ordsall Chord to deliver its objective of eliminating conflicts at Piccadilly, in the not-too-distant future there will be a demand for more services including additional freight paths. This can only be met by a significant infrastructure intervention.

In September, Secretary of State Chris Grayling appeared to suggest that the digital railway would resolve this capacity issue when he advised business leaders in Manchester: "We are about to see a digital revolution in our railways, and we want the north to lead the way." As a result, the Department for Transport (DfT) has remitted Network Rail to undertake a detailed study of how digital technology can contribute to enhancements on the Castlefield corridor. This study is at an early stage.

Whilst the digital railway may, in the medium term, offer the north some capacity benefits, it is not clear how this will benefit the Castlefield corridor in the foreseeable future. Unlike Thameslink, the Castlefield corridor does not have dedicated trains. Instead, the four operators concerned have services to destinations such as Norwich, Llandudno, Scarborough and Glasgow. Fitting the required signalling equipment to all these trains over this two-mile corridor is unlikely to be feasible for a long time as this would require widespread use of in-cab signalling throughout the network.

The solution proposed in the 2010 Northern Hub report was additional through platforms (15 and 16) at Piccadilly, which it considered would increase the capacity of the Castlefield corridor by 25 per cent by easing the ruling constraint of dwell times at platforms 13 and 14. This proposal also required longer platforms and signalling alterations at Oxford Road.

This proposal was developed to the outline design stage and was the subject of an extensive consultation exercise after which, in 2015, Network Rail submitted an application for an Order under the Transport and Works Act for its Manchester Piccadilly and Oxford Road capacity scheme. Network Rail advises that, over two years later, this application is still under consideration by the DfT.

Whilst Piccadilly's extra platforms may not be required in the short term, Transport for Greater Manchester is "very concerned about the ongoing uncertainty associated with this scheme" and considers that Piccadilly station has to be "sufficiently future-proofed".

Stephenson's viaduct revealed

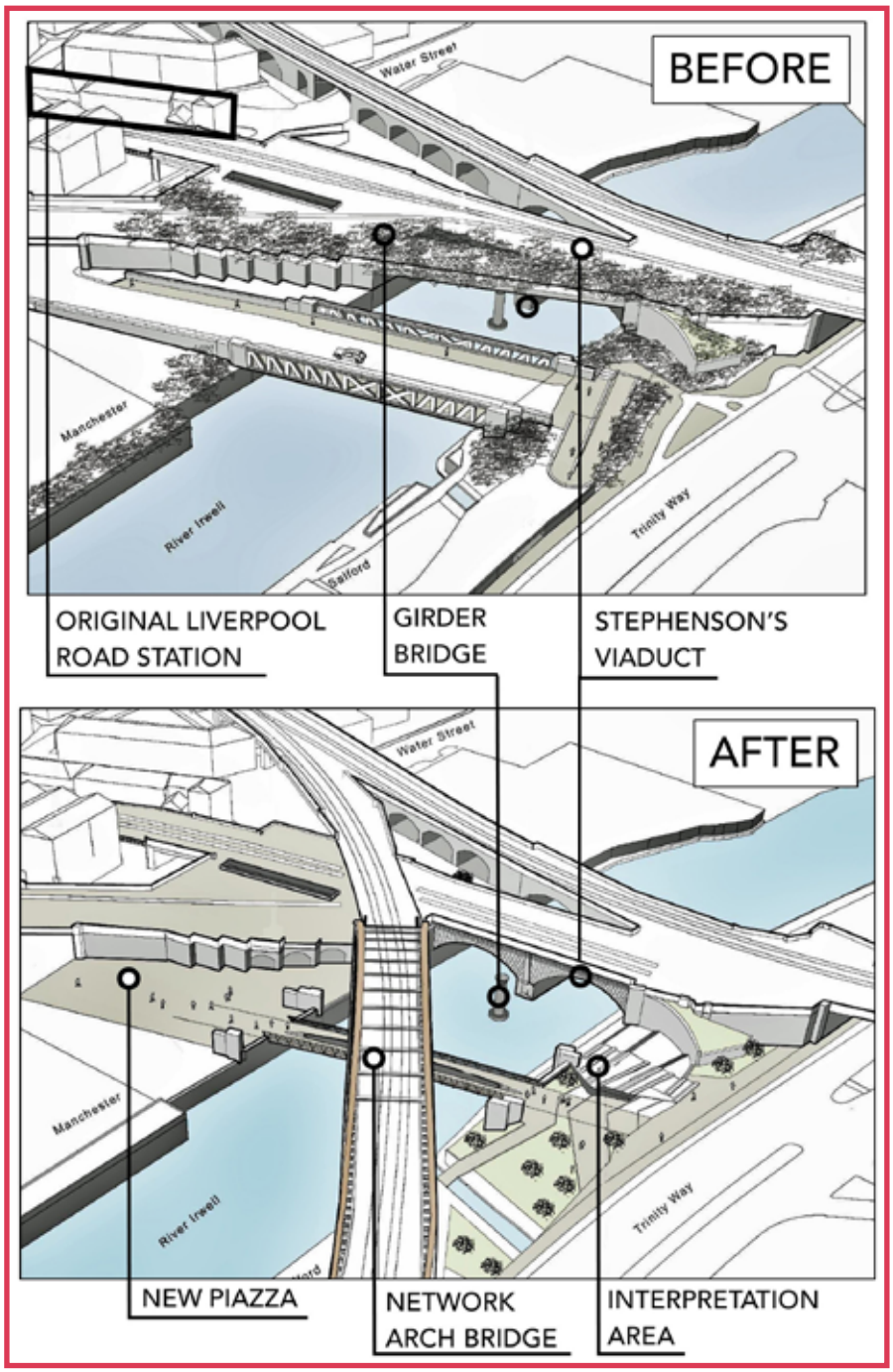
At the Transport and Works Act inquiry into the Ordsall Chord scheme, English Heritage advised that they considered the area to be "the Stonehenge of railway

history" and that it had never come across a project "so exceptionally damaging to the historic environment as Ordsall Chord". With no buildings damaged by the scheme and only one structure affected, the concern about this substantial harm related to damage to the setting of this historic area.

Manchester's Museum of Science and Industry is housed in a complex of old railway warehouses together with the world's oldest surviving station building, Liverpool Road. This was the Manchester terminus of the world's first inter-city railway, the Liverpool and Manchester Railway that opened in 1830. Liverpool Road closed to passengers in 1844 when Manchester Victoria opened, became partly a freight depot.

Restoration of Stephenson's viaduct.

Liverpool Road station was at the end of Stephenson's viaduct across the River Irwell. This elegant segmental-arched bridge has two 63ft spans and is Grade 1 listed. Such is its importance that the Institution of Civil Engineers considers it to be one of its sixty most important English masonry bridges. However, for the past 150 years, it has not been possible to appreciate this bridge.

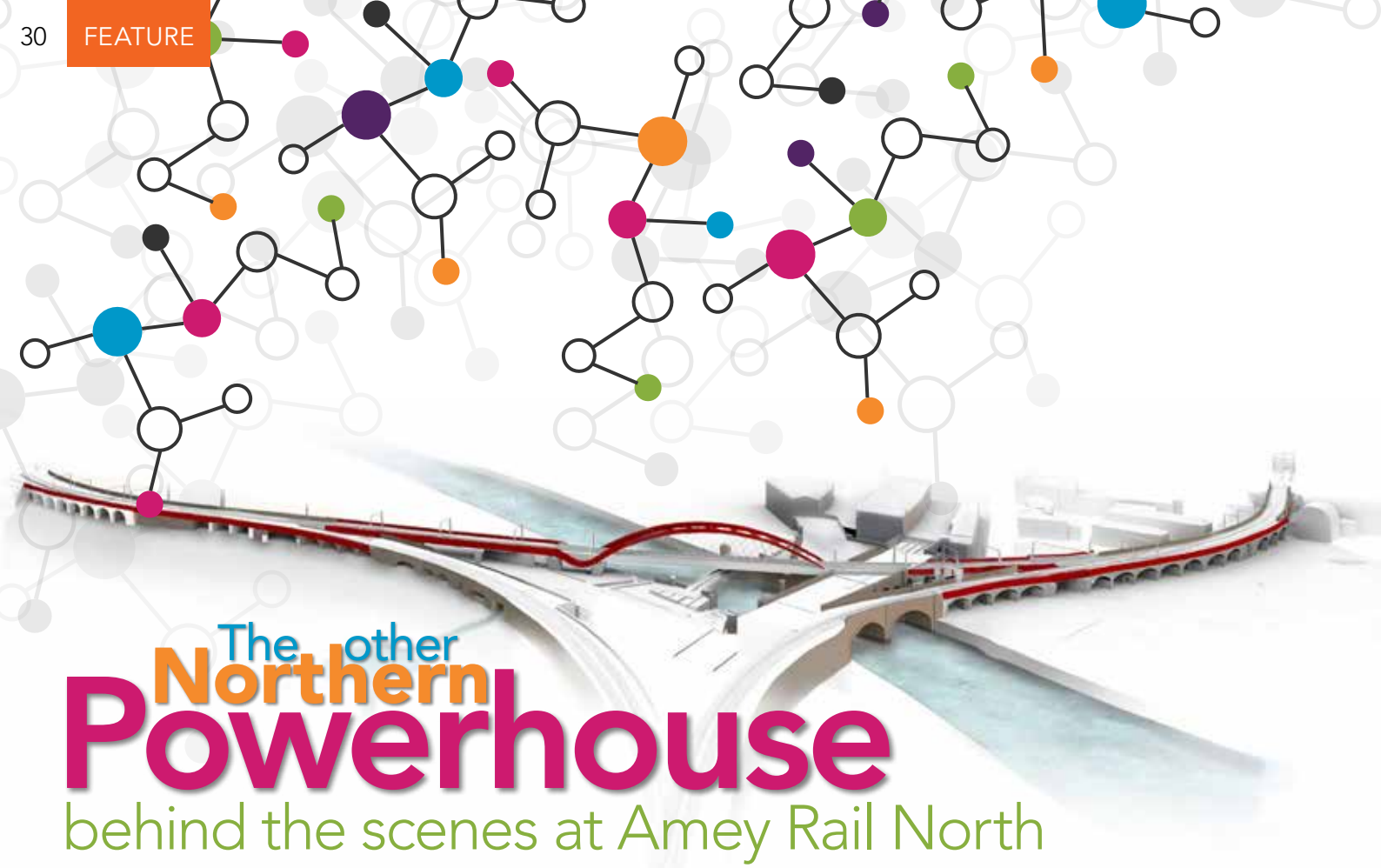


During the construction of the Castlefield corridor in 1845, a viaduct was built immediately to the south. To widen the approach to the freight depot in 1869, a girder bridge adjoining the viaduct was built on the other side that both hid it from view and removed some of the viaduct's stonework. Judged by today's standards, this girder bridge would not have been built in view of the substantial harm caused to the viaduct.

The Ordsall Chord project has undone this harm as the girder bridge had to be demolished to construct the network arch bridge. However, there were still objections to its removal even though this reveals Stephenson's viaduct, which the project has painstakingly restored and repaired by replacing the stones removed when the girder bridge was built.

The restored viaduct will be floodlit and will be the subject of an interpretation area as part of 7,000 square metres of new public piazzas that will be provided on either side of the River Irwell. These will open in spring 2018 to replace a previously run down and overgrown area. It is difficult to understand how this work could have been considered to cause substantial harm.

Few, if any, of Network Rail's projects have had such a difficult birth as Ordsall Chord. Soon, it will be carrying hundreds of passengers a day, its worksites gone and new landscaped public spaces created. Then, the controversy that saw the start of this project should be forgotten as this short new line brings economic benefits to the north, just as the Liverpool to Manchester Railway did almost 200 years ago.



The other Northern Powerhouse

behind the scenes at Amey Rail North

In a year that has seen it take on joint operation of the Greater Manchester Metrolink and be announced as a key partner in the new Transpennine upgrade contract, the size of Amey's footprint in the north has grown dramatically.

Its involvement in the iconic Ordsall Chord installation as part of the project alliance demonstrates a rail business that has matured into the organisation capable of being a leading player in delivering the major, multi-disciplinary works it has long aspired to be.

To some, on paper, Ordsall Chord probably looks like the stuff of nightmares; a concept of such complexity as to have been created to scare naughty rail engineers into eating their vegetables.

The success of the Chord - a unique bridge that connects Manchester's major stations for the first time in history - has been dependent on the daunting prospect of complex and ground-breaking engineering techniques, delivered by teams that are normally industry competitors; whilst surrounded on all sides by some of the most precious and important remnants of railway heritage.

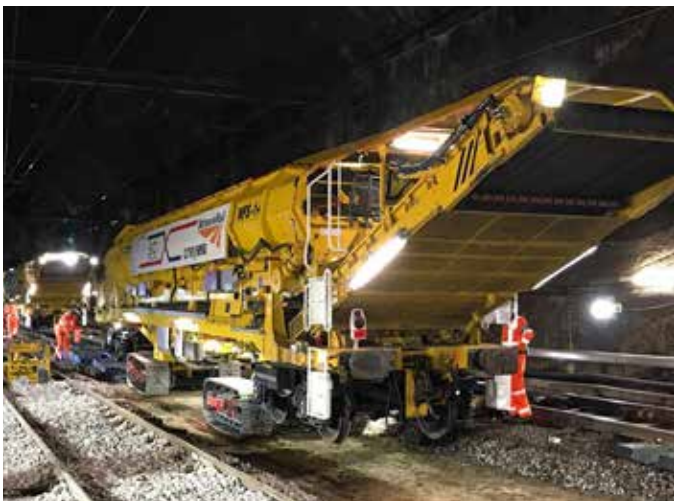
Collaboration

The reality has been a feat of collaboration and combined expertise to deliver an eye-catching landmark in the shape of the new network arch, and create an extra 40 per cent capacity for a vital artery of Manchester's rail network.

Whilst the project is likely to feature in many future case-studies, history books and, more than likely, more industry award shortlists, in the shadow of the new arch lies a vital piece of the puzzle; 300 metres of new track that forges the connection between Castlefield Viaduct in Manchester and Middlewood viaduct in Salford, creating the all-important link between Piccadilly and Victoria stations via Oxford Road.

As well as being principal contractor for the alliance, it is this connection that Amey, through its AmeySersa joint venture, has contributed to the next chapter of Manchester's rail history. Before the chord, junctions were overloaded and unable to cope with the number of trains arriving on single sections of track.

The short, but hugely significant new section between the Chat Moss and Bolton lines now creates extra capacity for a criss-cross of key links between



Liverpool, Edinburgh, Newcastle, Birmingham and London including the West Coast main line and the freight traffic between Liverpool's docks and Trafford Park.

All of this runs alongside the newly revealed and revitalised Grade I George Stephenson bridge, allowing a previously lost piece of railway history to be seen and enjoyed by a new generation of rail enthusiasts.

Something as fundamental as track works was, naturally, going to be a disruptive element to the daily commutes of passengers coming into the city from the Greater Manchester area and surrounding towns and cities. Therefore most of the work was delivered as part of a series of blockades coinciding with the holiday periods - Easter and Christmas.

Christmas blockade

One of the most significant blockades was during Christmas 2016. Like the well-loved beer commercial, where different utility workers come together to make use of a single dug trench in the road, a whopping 1,500 employees descended on the Ordsall Lane junction to take full advantage of the blockade and complete a wide range of signalling, track and civil engineering works.

For AmeySersa's part, that included reconfiguring the various existing tracks between Eccles, Victoria, Deansgate and Salford stations as well as the installation of one kilometre of new track, and eight new sets of switches and crosses, with a hefty 9,000 tonnes of ballast. This was key in facilitating connection of the Chord to the new layout, ahead of the track being commissioned this winter.

This period saw the utilisation of a Kirow 1200 rail-mounted crane, with 125 tonne capacity, to install the new track, with the use of two Kirow 250 cranes used on Christmas Eve and Christmas Day itself to undertake 25-tonne lifts, both individually and in tandem.

New points and overhead lines were installed in conjunction with this work and line speed was able to be set at a consistent 30mph through the junction.

For the next major blockade, during Easter 2017, significant track realignment was required for the integration of the Chord at Salford. AmeySersa used a real mix of track types to successfully integrate the Chord - S&C, conventional plain line, check rail panels and plain line with guard rails.

By following a regime of enhanced quality assurance checks at each stage, the track team was able to ensure consistency in the standard of work. This minimised the variation to the schedule during the 11-day blockade and ensured works were completed on time.

This methodical approach has also been a key feature in Amey and the wider Alliance's approach to safety. Amey has been able to play a proactive role in driving a robust safety culture throughout the works.

Safety first

Throughout the life of the alliance, a mixture of visible leadership on site, regular site inspections and clear channels of communications have been reflected in a remarkable safety record.

This has included zero accidents during the Christmas blockade - a remarkable feat during a time where 1,500 people worked various daytime and night-time shifts. A more astonishing number is the 1.5million man-hours worked without a RIDDOR reportable injury.

But Amey and its alliance partners are not ones for complacency when safety is involved. Already, the careful monitoring of the levels of dust produced during this year's Easter blockade has provided the team with data that can be used to improve future projects.

Best practice has also been set in areas such as mental health, healthy diets, occupational health, work/life balance and fatigue management, thanks to an innovative 'dashboard' approach to sharing health and safety critical messages, and the use of biometric fingerprint technology that flagged up early warnings to protect employees against fatigue by being on site for too long. »

All of these initiatives align with Amey's own approach to safety and performance, where it has regularly embraced and leveraged from the latest developments in technology and data to help drive an improved safety culture throughout its business as a whole as well as within the Alliance. In its Northern Hub partners, it has found kindred spirits willing to similarly push for better standards of working practices.

The 'pure alliance' model - where success and pain is shared equally throughout Amey and the other principal partners - has quickly established itself as a textbook approach to future works of this complexity.

With each partner having an equal stake in project management, change and delivery, there has been a united goal of achieving best value for money; a philosophy that will set the standard for many joint enterprise projects to come, potentially delivering substantial savings at a time where rail spending is under immense scrutiny.

Line-speed handbacks

With an imminent end in sight to the remarkable journey of the construction of Ordsall Chord, Amey must now turn its sights to how to maximise the experience and learnings from the project.

Amey's management team is clear that the shared attitude of 'living within our means' as an industry - something that has been core to the economic success of the Chord - will remain a mantra for Amey's rail business going forward.

However this will be delivered in a way that ensures Network Rail and its other clients see a real 'value-add' to the work delivered, rather than being cheap at the expense of quality, particularly in Amey's work in the North.

This has long been a feature in its other partnership with Network Rail, the S&C North Alliance. Quietly and consistently, the S&C North team has incrementally improved the quality of installations to the extent that its ability to hand back possessions at full line speeds of 125mph - something that seemed a distant pipe dream as little as 18 months ago - is now delivered with such regularity as to almost be boring.

Designed to minimise disruption to passengers and train operating companies through more reliable S&C renewals completed sooner, the 'progressive assurance' approach, like that seen in the delivery of Ordsall Chord, sees quality, with objectively measured tolerances, built in at each stage of the construction process.

Progressive assurance has turned the conventional way of determining handback speed on its head, paving the way for making high speed handback the norm, creating better passenger journeys and saving more than £2 million in compensation payments in 2016/17, by allowing trains to run to their normal timetable immediately after work is completed.

New plant, new techniques

One of the key features of the alliance has been its ability to tap into the best of European plant and, after much anticipation, parts of the new machine group that have long been on Amey's Christmas wish list have finally been deployed as part of its work at Liverpool Lime Street station, where track, signalling and platform upgrades will facilitate longer trains and more frequent services.

It was the first time that the plant had ever been used on a live site in the UK - and in incredibly challenging surroundings, with tight curves and restricted clearances - and it performed safely and without incident.

The S&C North Alliance machine group utilised 2 MFS+ hopper wagons to transfer 800 tonnes of new material required to reballast Platform 7. Travelling to site in train formation with 19 standard MFS wagons, the MFS+ wagons detached and activated crawler units to climb off the rail into the excavation.

They received the ballast 60 tonnes at a time from the standard MFS wagons and travelled over the prepared formation to unload in the platform area, which would only normally be accessible with much smaller capacity dumper trucks. The dedicated operators unloaded the material, in a controlled manner by remote control, in front of a bulldozer, levelling to design.

Metrolink

Whilst Amey's experience in the major projects side of the industry has increased, this year has also seen it flex its muscles in the light rail arena as well, as it takes on its second operating contract in partnership with the international transport group, Keolis, to manage and maintain the Greater Manchester Metrolink network.

This partnership follows on from the award-winning delivery of the Docklands Light Railway together, now into its third year. For Amey, it provides another opportunity to demonstrate the marriage of its consulting brainpower and the operational expertise it has long boasted in the rail sector.

Already, by working in harmony with Keolis to develop the latter's previous use of data visualisation, the KeolisAmey Metrolink (KAM) team has been able to drive substantial change into the operation of the network by having a clear view of how the network is performing and, more importantly, the impact this has on passengers and their experience of using Metrolink.

Some of this has been as part of a remarkable turnaround from crisis. In what was an operational 'worst nightmare', a legacy IT issue reared its head after only one week of operation, causing a critical communications failure that saw the network come grinding to a halt.

KAM's response was swift and robust, tapping into the engineering might of both parent organisations to replace nearly a kilometre of fibre optic cable and create a network resilience that had been previously absent, achieving a simple goal of being able to keep people moving.

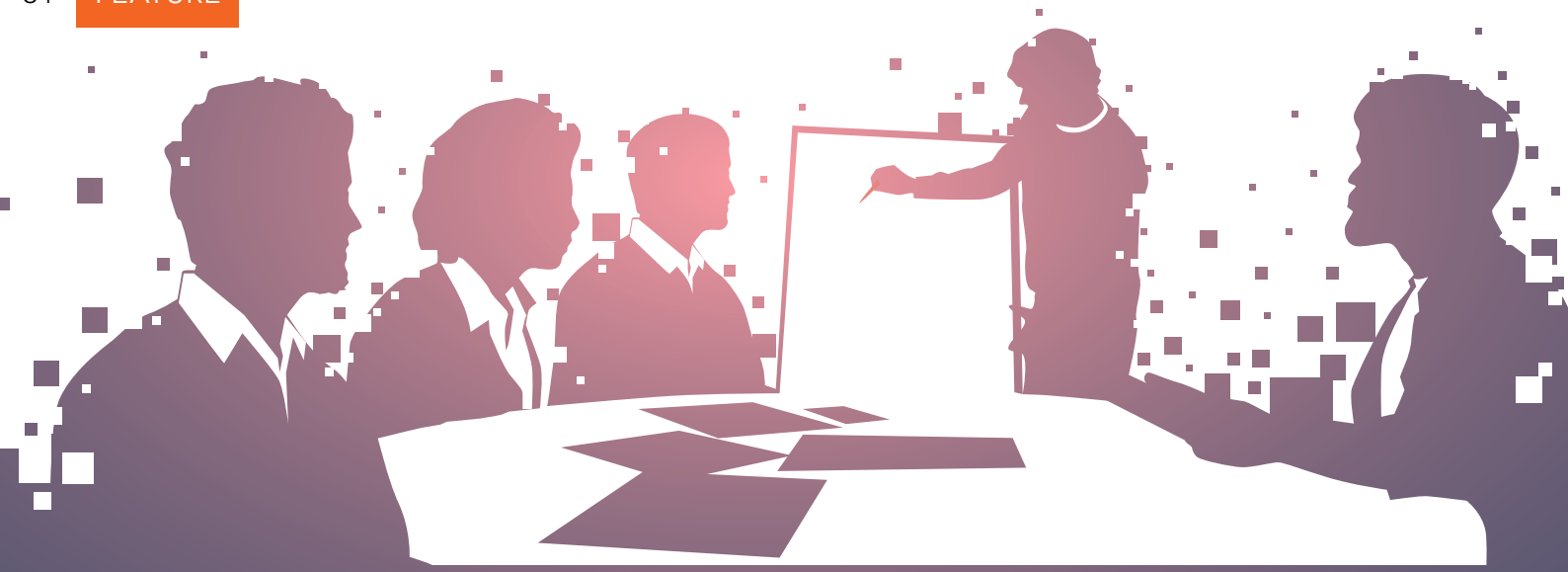
This ability to access a depth of experience in signalling, electrification and civil engineering, as well as other knowledge and expertise in the wider business, arguably makes Amey an attractive choice, both as a sole supplier and as a joint venture or consortium partner.

The consulting capability enables Amey to be a key player in the early GRIP stages of projects and will certainly inform its input into the development of potential infrastructure options for the Transpennine Route Upgrade with Network Rail and their alliance partners, BAM and Arup. These options are due to be submitted to the Government imminently.

Amey, then, seems to have its fingers in every pie. This runs from the securing of enabling works for HS2 through to Amey's securing of its pre-qualification questionnaire passport from the Department of Transport (DfT) that will allow it to express interest in future rail franchise opportunities.

To the critics, it may appear that Amey is trying to be too big for its boots. But being the first rail infrastructure business to achieve this is nothing to be sniffed at and the DfT states that pre-qualification questionnaire (PQQ) passports are only issued to those companies that provide high standards of safety, integrity and professionalism, as well as exemplary technical and management abilities.

2017 has clearly been a remarkable year for the business and it looks like 2018 will be another where Amey remains a fixed presence in the big projects of the rail industry.



Training for 4LM is Under way

CLIVE KESSELL

The resignalling (or, more correctly, re-control) of London Underground's sub-surface lines (Metropolitan, Hammersmith & City, Circle and District) has reached the stage where training of staff has begun. This huge project, now known as the Four Lines Modernisation (4LM), had a couple of false starts which took time to resolve but, finally, the fruits of the multi-billion pound investment are emerging.

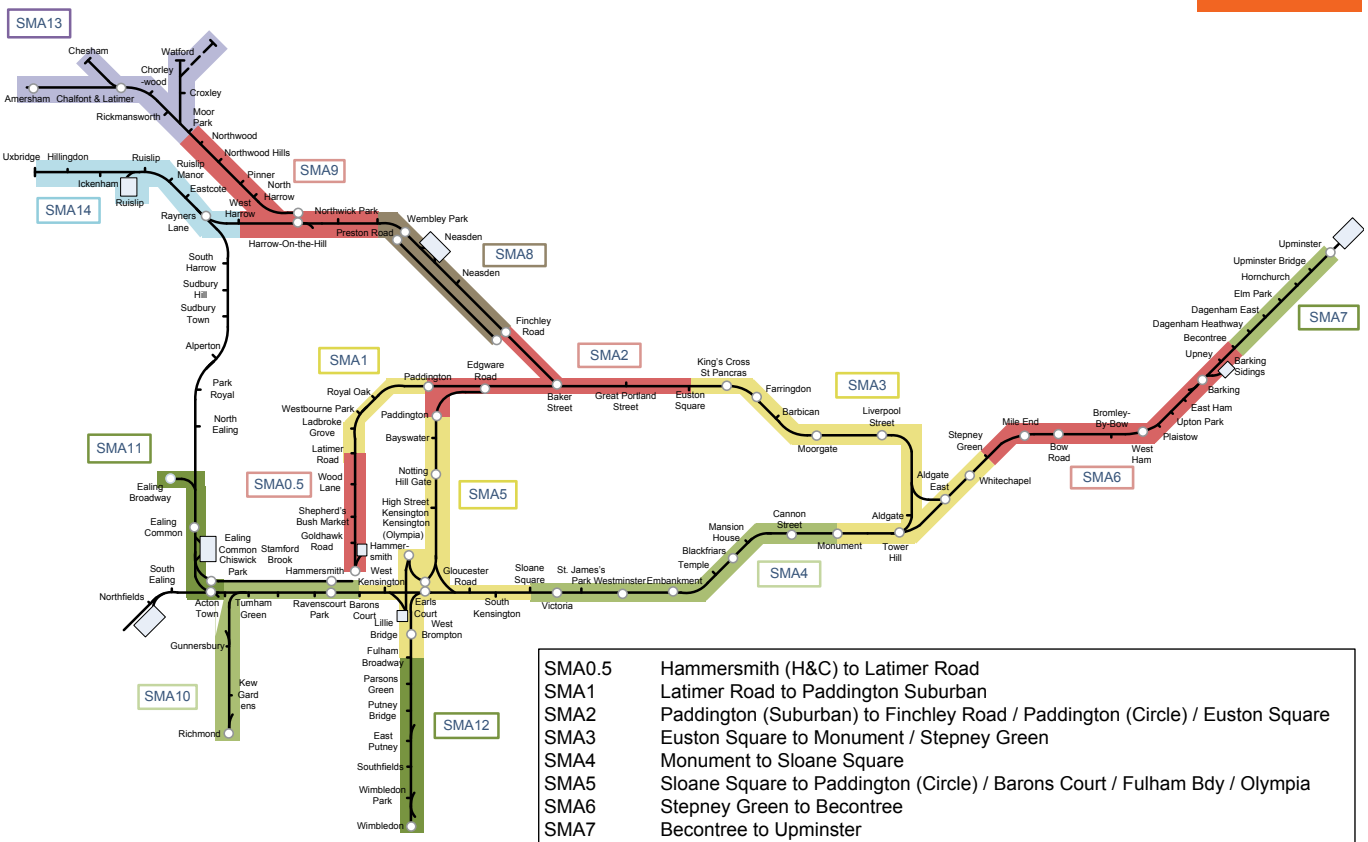
Rail Engineer visited the new Hammersmith Service Control Centre (SCC) to see first-hand what has been achieved to date and to meet with Mark Warner, the service control manager, together with members of his team, to learn some of the logistics on what is involved.

The principal contractor for the project is Thales, and members of their engineering and publicity teams were also present to explain the technical elements and the continuity that has resulted from previous contracts on the Jubilee and Northern lines.

Rail Engineer published an engineering overview of the project back in issue 132 (October 2015) and various other articles have appeared since then on different aspects of the project. The work centres around the Thales communications-based train control (CBTC) SelTrac system, which has been deployed on many metro railways around the world. First rolled out on the Vancouver Skytrain network, the system is used in the UK on the two LU lines referred to as well as the Docklands Light Railway.

Whereas these lines used track-based loop technology for control, command and positional information, the sub-surface lines will use radio technology to continually communicate with the trains together with sleeper mounted transponders (RFID TAGs) to give train position information. The radio will employ free space transmission, even in tunnels, using the 2.4GHz Wi-Fi band. This technology has already been proven in South Korea, China, Canada, America and Singapore, so deploying it in the UK is not seen as a technical risk.

Information suite desks with full line diagram.



SMA0.5	Hammersmith (H&C) to Latimer Road
SMA1	Latimer Road to Paddington Suburban
SMA2	Paddington (Suburban) to Finchley Road / Paddington (Circle) / Euston Square
SMA3	Euston Square to Monument / Stepney Green
SMA4	Monument to Sloane Square
SMA5	Sloane Square to Paddington (Circle) / Barons Court / Fulham Bdy / Olympia
SMA6	Stepney Green to Becontree
SMA7	Becontree to Upminster
SMA8	Finchley Road to Preston Road*
SMA9	Preston Road to West Harrow / Moor Park
SMA10 /11	Barons Court to Noth Ealing / Richmond / South Ealing / Ealing Broadway
SMA12	Fulham Broadway to Wimbledon
SMA13	Moor Park to Amersham / Chesham / Watford
SMA14	South Harrow / West Harrow to Uxbridge

Anyone wanting more detail on the engineering aspects should refer back to the original 2015 article 'London Underground Sub Surface Re-Signalling', available online at www.railengineer.uk.

The control room

It is big, but then the sub-surface lines are a lot of railway. Not yet operational, Hammersmith SCC will go live in March 2018, when the Metropolitan and District line control, currently at Baker Street, moves to Hammersmith. Arranged in a series of 'half moon' suites, this layout has been found to be the most practical following experience from other control room upgrades and new builds.

Each suite will have its particular responsibilities. These are:

» Signalling - under Automatic Train Supervision (ATS), the signallers should, in theory, have little to do. However, there is a considerable amount of shared operational running that will take place both within the four sub-surface lines and, more importantly, with the Piccadilly line to Uxbridge and Network Rail lines to Amersham, Wimbledon and Richmond, so it is useful that the control system undertakes many of the routine functions allowing the signalling staff to focus on the strategic control of the service.

» Communications and customer information - the service controller for each line also uses the workstations. They have responsibility to communicate with all stations on the four lines should any incident occur and to arrange the recovery from any problem. Supplying timely and relevant information on line performance to stations »

Service control manager Mark Warner in the simulation room.

will be important as will feeding the social media networks with train service updates.

» Train maintainer - managing the rolling stock performance is seen as very much part of the integration of the train service, hence having the control of this within the same room.

» Service managers - two workstations that will provide the overall management control of the four lines with responsibility to make strategic decisions when any major perturbation to the service occurs.

Not included, as yet, is the civil engineering management of the lines including day-to-day maintenance of the permanent way. This will remain separate for the time being.

Every desk suite is capable of showing the complete sub-surface railway on the large screens above the workstations. However, it is unlikely that any one controller would require this view alone for their particular task and thus a 'zoom in' on the main system management centre workstations for specific areas of the railway will be the normal choice of view for individual controllers.

No video wall will be provided. Whilst impressive for anyone visiting the centre, these have been found to be of little value for control room staff in other places.

The desk screens, and indeed much of the hardware associated with the desk positions, are COTS (commercial off the shelf) equipment and thus moderate in price and easily upgraded or replaced should the need arise.

Interlocking and telecommunications

The entire sub-surface network will have 14 computer-based 'interlockings' (VCCs - Vehicle Control Centres) that dynamically manage safe separation of trains, which will be located at Hammersmith. For reliability reasons, these will be backed up by a 'two out of three' system, meaning that if one of the computers fails the system will still be able to run. Thus, the control of points, and other signalling equipment out on trackside, will be activated from this one location and then implemented by local signalling equipment rooms around the network, from where connections to points, axle counters and other trackside equipment will be made.

Such a configuration demands very robust telecommunications links and so every junction and point location, including those that control access to train depots, will have a diverse link back to the control centre. A new fully duplicated fibre cable network is being laid for the CBTC network.

LU has its own general-purpose fibre-based telecommunications network known as CONNECT, which was also provided by Thales a few years ago. This will be integrated into the 4LM control room and, as well as giving access to all parts of the network, it provides the

backbone for the voice radio communication to the trains and handhelds.

Simulation room and ongoing training

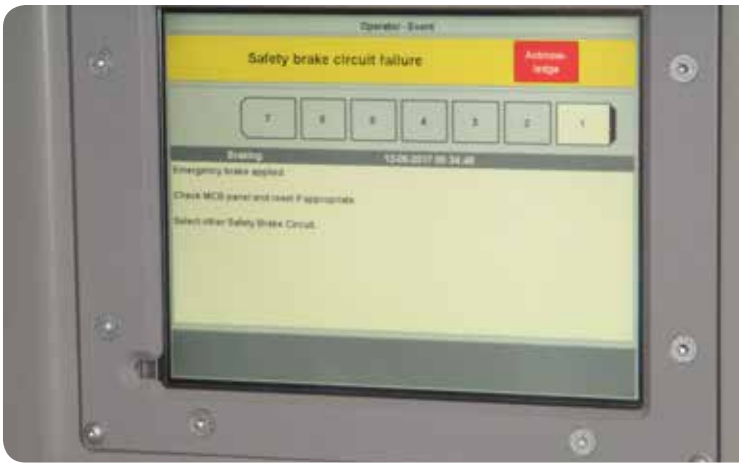
The logistics that have to take place before 'going live' are significant. Around 200 operational staff will require to be trained on the new system, but to try and do this on the actual control consoles is impractical since it would disrupt day-to-day operation and anyway it would be impossible to replicate all the conditions likely to be encountered.

A separate training room is therefore part of the Thales contractual provision, containing identical screens and desk devices that mirror the real railway. Simulated train services provide a typical day's operation with the controllers first learning how to manage and use all the facilities under normal conditions.

After that it gets harder, as the simulator is capable of imposing fault conditions of a bewildering variety. Every conceivable situation can be replicated and covers, amongst others, train failure, signalling system failure, station closure, passenger disruption, power failure, differing weather conditions and out-of-turn running.

The northern part of the Metropolitan line is in the Chiltern hills, where leaf fall and low adhesion can be a problem. When this occurs, different braking profiles have to be introduced, which will be part of the training regime. Alarm generation and understanding of the alarm status will be an important element of the training.

Of course, once the system goes live, a failure situation will undoubtedly occur that had not been anticipated. One description of the simulator is that it is the 'ultimate play station', and the product and facilities will grow as the project roll out progresses.



Alarm Simulation on Driver's Screen.

It is anticipated that each controller will require six or seven weeks of training and, for all the staff, this will take over three years, in line with the project programme. Re-training of controllers will be a regular requirement, particularly when new or changed facilities to the system are introduced.

Passenger information

Most stations on the sub-surface lines already have 'next train count down screens' on platforms and ticket halls. »

Driver's cab in the simulator.

These will not be changed, but will have to be re-controlled from the new centre.

The fragmented signalling that currently exists is often unable to predict the next train until it is very close to the station. This is particularly true where there are flat junctions. Typical is Edgware Road (its signalling interlocking and miniature lever frame date from 1926), where the Circle and Hammersmith & City lines diverge. The next eastbound train will only display when virtually in the platform.

Once the new signalling is operational, the system will have a complete overview of train position on the railway and, coupled with the inbuilt automatic train supervision capability, much more timely information will be displayed, thus increasing customer confidence in the train service.

One oddity is at Earls Court, where the present 'light box arrow' indicators for the Next Train have to be retained as they are now a listed feature. To overcome this anachronism, LED displays are being mounted under the old indicator framework.

Loudspeaker audio information will be broadcast from the Hammersmith SCC, where the station systems have the functionality enabled to do so. However, local stations and control rooms, where the local staff sometimes have a better sense of immediate need, will also continue to make some announcements. Clearly, local stations will be made aware of any out-of-turn running or train delays by the central control.

Interworking with other lines

Shared operation with other lines and train services has been referred to. On most of these - from Chiswick Park to Hanger Lane (where the District line uses Piccadilly line track), London Overground from Gunnersbury to Richmond, South West Railway from Putney to Wimbledon - the SelTrac system will be overlaid on to the existing conventional signalling on these sections such that ATO can be maintained. The ATO overlay will align with the block sections of the conventional signalling so not all CBTC features, such as moving block, will be possible. However on these extremities, this is not seen as a problem since the service density is lighter.

On the Chiltern Lines from Harrow on the Hill to Amersham and Piccadilly line from Rayners Lane to Uxbridge, an 'underlay' system is being provided, whereby the present signalling is being replaced with a conventional three-aspect system for Chiltern trains but incorporating a blue aspect for Metropolitan line trains working in ATO mode.

The system will know which type of train is where and will display the appropriate aspect on the signal. The system will not show a blue light when either a red, yellow or green aspect is displayed and vice versa. This 'underlay' approach will allow following Metropolitan line trains to operate in moving block operation whilst Chiltern Line and Piccadilly line trains will remain in fixed block operation.

Train stops must be retained at all lineside signals on these routes with 'other lines' trains retaining associated trip-cock braking equipment.

Controllers and signallers will require a full understanding of the train services and operation on these routes with direct communication links to other signalling centres and control rooms to sort out problems as they occur.

Training the drivers

In parallel with what is happening at the Control Centre, simulators are being provided at four locations - Hammersmith, Neasden, Upminster and West Kensington (Ashfield House, the main LU training centre) - to train some 1,200 drivers who operate the sub-surface lines. The simulator equipment is provided by SYDAC, now a company within the Knorr-Bremse group, and Rail Engineer went to see the one located in an office block near to Hammersmith station.

The simulator provides a full-sized S Stock cab equipped with the SelTrac train control equipment and a graphic simulation of the route ahead including signals, stations and junctions. Drivers will be trained on three modes of operation - full ATO mode, manual driving under full supervision conditions, emergency driving with the CBTC system failed.

ATO will be the normal operation, with drivers having to press two 'start' buttons to begin movement, whereupon the train will proceed automatically to the next station stop. Drivers will continue to be responsible for door opening and closing.

Manual mode under supervision will require drivers to operate the combined power and brake controller and drive to a movement authority indicated as a circular band around the speedometer. Should the driver exceed the permitted speed, then braking will occur automatically.

In the emergency mode, the driver will be able to move the train at a maximum 10mph, subject to the route ahead being confirmed, with points set in the correct position and in conjunction with trackside route secure indicators. Various alarm and failure conditions can be imposed, which the drivers must be able to deal with.

Two types of training will take place, firstly on the simulator and then with an instructor

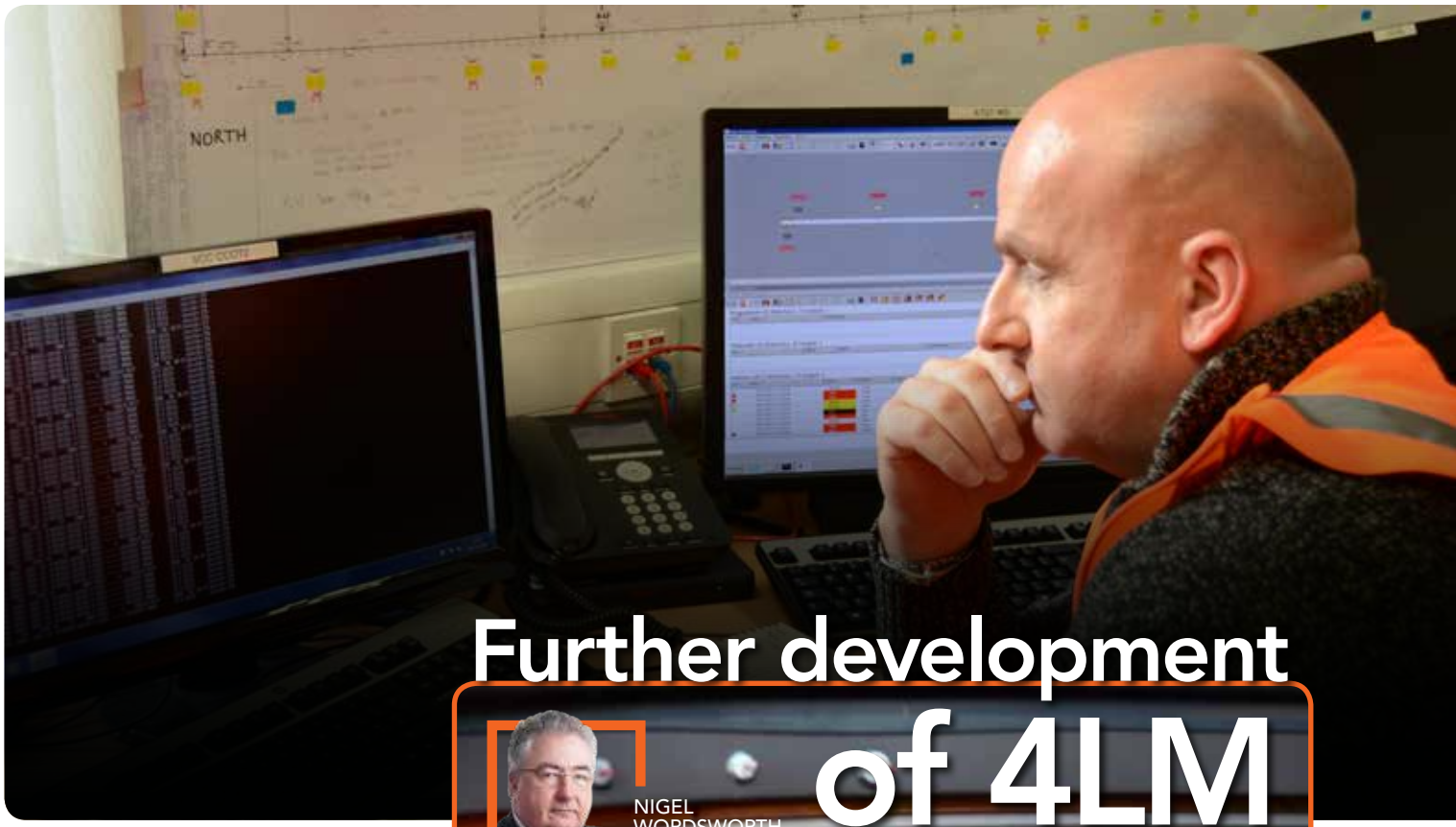
out on the line. Training of the trainers took place first and actual driver training began in December. The training is being phased in line with the programme for introduction of the new signalling system. First will be around 330 drivers on the Hammersmith & City and Circle lines, then some of the approximately 575 drivers on the District line who work trains to Edgware Road, after that the 330 drivers on the Metropolitan line and, finally, the remaining drivers on the District line.

System introduction

Both LU and Thales are rightly cautious about introducing the CBTC operation into service. In all, there will be 15 migration stages, each one of which has to be extensively proven before going live. The first section, from Hammersmith to Latimer Road, is already under system test and running test trains under ATO with the commissioning into passenger service scheduled for mid-2018. Thereupon, the system will extend to Paddington followed by the north and then the south sides of the Circle line. Both of these sections embrace part of the District and Metropolitan lines, hence the need to have their drivers trained. Following that will be the eastern end of the District line, the Metropolitan line up to Moor Park, the western end of the District line and, finally, the rest of the Metropolitan line branches to Amersham and Uxbridge. The programme completion date is planned for 2022.

The trains also have to be fitted with the SelTrac equipment, which involves them being sent back to Bombardier at Derby. This is a 23-day process and, so far, 25 of the S7 stock have been converted and a smaller number of S8s. The migration approach requires both finished infrastructure and enough CBTC-fitted trains to run the service to be available for any section to be cut over as non-CBTC fitted trains cannot operate over the new CBTC-commissioned sections. All trains will need to retain the old trip-cock signalling system equipment, where they operate over sections still to be converted.

Whilst modernisation is long overdue for some of the equipment on the sub-surface lines, the overall objective is to get a big capacity improvement on the lines concerned. Anyone who lives or works in London will recognise this urgent need.



Further development of 4LM

NIGEL WORDSWORTH

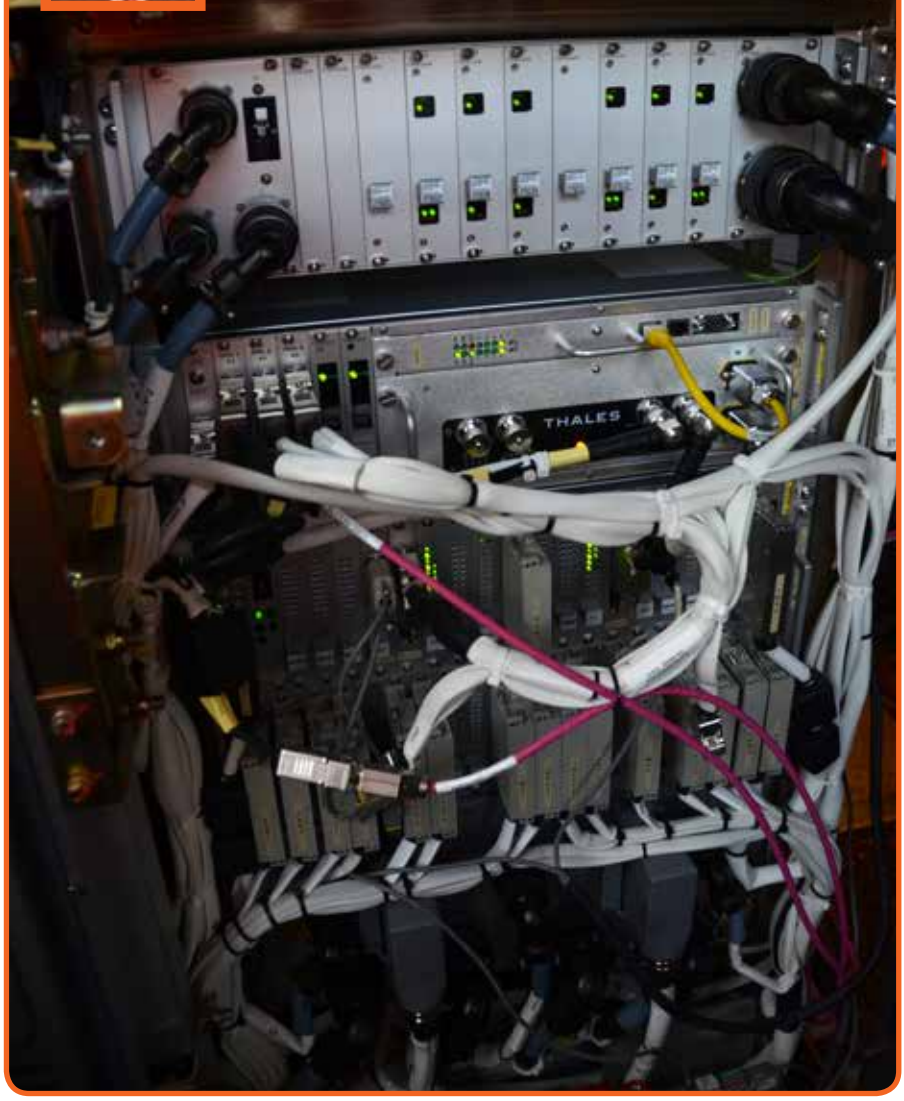
While the new control room at Hammersmith is just commencing the first stages of testing, the new Thales SelTrac communications-based train control (CBTC) system has already been undergoing full dynamic testing for some time - 100 miles away.

Rail Engineer reported on the first stage of testing early last year (issue 138, April 2016). At that stage, a Bombardier S Stock train, fitted out with aerials, sensors and electronics, was running up and down the track at RIDC Melton (the Rail Innovation and Development Centre at Old Dalby) testing the basics of the system.

The installation was very much 'prototype' - lots of duct tape and electronics balanced on trestle tables - but the train stopped where it was meant to, opened and closed its doors on command, and obeyed speed instructions.

Testing continues

Eighteen months later, those tests are still going on. Now, however, the train looks completely standard - all the aerials and wires have been hidden away and the electronics are tucked into a cabinet in the driver's cab. The software, too, is the latest version, just going through a series of checks before it is rolled out at Hammersmith.



The Thales control equipment is now fitted into a cabinet in the driver's cab.

There are still a few wrinkles to iron out. The driver's display, a combination speedometer, speed limit indicator and door status warning, has yet to be integrated into the control desk - for test purposes it is bolted to a handy post about one metre away.

Inside the train, a few extra cables are still around, but these are just for the test equipment that is checking the train's performance.

And, of course, there is the inevitable blue 'safety' string across the doors, so that test personnel don't fall out as the train opens its doors at virtual stations.

Externally, the train looks as it did before. There are a couple of antennas mounted high up, and natty little sleet deflectors on the covers for the OPO (one person operation) receivers, mounted under the buffers. These relay the CCTV images from the platform to the drivers' desks, so they can check when it is safe to close the doors and launch the train. The receivers were being affected by ice build-up in the open-air sections of the line in winter - and it took a test trip to Norway to fine-tune the answer!

The trains are being returned, one at a time, to the Bombardier works in Derby to be retrofitted with all of the kit. It's a very invasive process, as most of the train's interior has to come out so that the cables can be installed.

Only a few of the production trains are being tested at Old Dalby, and that's to develop the system and check the interfaces between the trains and the track. Every other train will undergo static and dynamic testing at Bombardier's Derby site and back in London on its return.

Transponders fitted to the track every 25 metres (more in some locations) allow the train to fix its position. This is at RIDC Melton – in London the baseplate is painted yellow.

4LM programme

London Underground's acting head of the 4LM programme, Chris Hobden, explained the programme.

The new signalling system will be introduced in 15 stages, termed signal migration areas (SMAs), numbered 0.5 to 14. The original first migration, from the Hammersmith terminus to Paddington, has been cut in half to make the very first implementation simpler and allow maintenance and operations staff, as well as train operators, to get used to the new equipment and operating methods. This is why the first SMA, which goes to Latimer Road, has rather strangely been termed 0.5.

The programme is not without its challenges. SMA 6 and 7, from Stepney Green to Upminster, runs alongside a]Network Rail line fitted with 25kV AC overhead line equipment (OLE), so the new equipment has to be proofed against electro-magnetic interference.

S Stock train at Wood Lane, which is in SMA 0.5. (Inset) Close up of sleet deflector on the OPO receiver.

The District line tracks to Wimbledon and Richmond (SMA 10 and 12) will be an 'overlay' system, whereby the Network Rail signals will remain in place and the Thales SelTrac will take its information from them.

In contrast, the Metropolitan lines between Harrow-on-the-Hill and Amersham (SMA 9 and 13) will be an 'underlay' system - the Thales CBTC system provided by Thales to London Underground will control new lineside signals on this part of London Underground's infrastructure that are compliant with Network Rail standards for Chiltern Services.

The implementation of the new signalling is very much a cooperative effort. London Underground is providing the basic infrastructure, the control room, equipment rooms, cable routes and power supplies. Thales is providing the signalling system and Bombardier is upgrading the passenger trains.

To complement the programme, Track Partnership (LU and Balfour Beatty) is making track modifications and the traction power system has been upgraded to 750V DC with regeneration up to 840V.

As the new S Stock fleet of 192 trains is larger than those it replaces, additional sidings have been built to accommodate them.

Onward to the future

Jeremy Hooper is Thales' delivery director, and he gave more detail on the programme.

The core of the new system, represented by SMA 0.5 to 7, is effectively one design. As mentioned above, this will be modified to provide the underlay and overlay systems that will run alongside Network Rail in other areas.

As well as the 192 Bombardier S Stock trains, all of the London Underground fleet of engineering trains which work on the Sub-Surface Railway will also need to be fitted with the new in-cab signalling system. Thales has done the design, developed the kit that London Underground is fitting in its own workshops, and is assisting with the first-of-type testing.

Signalling equipment rooms (SERs) are now in place at Hammersmith, Paddington and Edgware Road, the first of 46 such facilities that are being built across London, including one under Sainsbury's at High Street, Kensington. Here, access is so restricted that materials have to go in and out by engineering train, run within the passenger timetable, and only on a Thursday!

Data is being gathered on powered-up signalling equipment and the Hammersmith Control Centre is under test with night-time test train running now taking place as far as Edgware Road.

The whole development programme has very much been a collaborative effort between London Underground, Thales (signalling supplier), Bombardier (train manufacturer), Network Rail (some running line and owner of RIDC Melton), Serco (operator of RIDC Melton) and even Crossrail (interference assessment at Paddington).

The main London Underground and Thales teams are co-located at Stratford. In addition, a team from LU spent some time in Canada, working with Thales engineers to develop the functionality of the software.

The development team has been pleasantly surprised by the performance of Bombardier's trains. When under automatic control, stopping distances and locations are very consistent and the train is very reactive, even at low speeds. This is important when trains have to stop at the same place on a platform every time, particularly since the required tolerance can be as low as ± 0.5 metres.

The use of the test track at Old Dalby has been a blessing too, making system development much easier than those for the Northern and Jubilee lines, which didn't have that facility.

By the time that SMA1 to Paddington goes into passenger service, 53 of the 133 train strong S7 (seven-car S Stock) fleet will have been fitted with the new in-cab signalling. All 58 of the S8s, and some of the engineering vehicles, will be fitted out before services start on SMA2 (Edgware Road to Euston Square). The entire fleet will be converted for SMA3 (King's Cross to Aldgate, Monument and Stepney Green).

The current plan, as revealed by David Hughes, TfL's director of strategy and network development, is for SMA1 to be in service by the summer, and SMA2 by October.

The true benefits of 4LM will become visible once SMA6 is complete (Mile End to Becontree). The timetable changes will be possible, taking the current 28 trains per hour (tph) in the central section to 30tph at peak times (Timetable 'A' - December 2021) and then on to 32tph by May 2022 (Timetable 'B'). Further enhancements, expanding the 90-minute high-density peak period to three hours and enhancing off-peak services, will continue until December 2023.

It's all going well. As David Hughes commented last October: "The 4LM Programme is expected to deliver benefits earlier then planned at a cost £144m less than planned."

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Hydrail comes of age

DAVID SHIRRES

Hydrail, the term coined for hydrogen-powered trains, started to become well known when the first annual international hydrail conference was held in North Carolina in 2005. While the first conference was largely an academic affair, by the time the 2017 hydrail conference was held in Graz, Austria, most of the speakers were from hydrail related businesses, a sure sign that the technology has come of age.

Visitors to InnoTrans in 2016 were provided with definitive evidence that hydrail is now a viable technology as Alstom launched its hydrogen powered Coradia iLint train. With the creation of the Hydrogen Council in January 2017, hydrogen is becoming big business as the Council's founding members, 13 transport and energy companies (including Alstom), plan to invest 10 billion euros in hydrogen technologies over the next five years.

Alstom's iLint is the latest and most promising of a number of hydrail vehicles produced since the first Hydrail conference. In 2006, the East Japan Railway Company unveiled the world's first fuel-cell hybrid railcar powered by two 95kW fuel cells.

Other pioneering light-rail hydrail vehicles were a tram powered by two 12kW fuel cells unveiled by Spanish metre-gauge operator FEVE in 2011 for use in Asturias, and 200kW hydrogen-powered trams which started operation in Qingdao, China, in 2015.

The first hydrogen powered locomotive ran in 2010. This was a 130-ton diesel shunter which was developed by the US Army Corps of Engineers, BNSF rail freight company and Vehicle Projects Inc which used a 240kW fuel cell provided by Ballard. Vehicle Projects and Ballard also collaborated in the production of five 17kW hydrail mine locomotives for the Republic of South Africa in

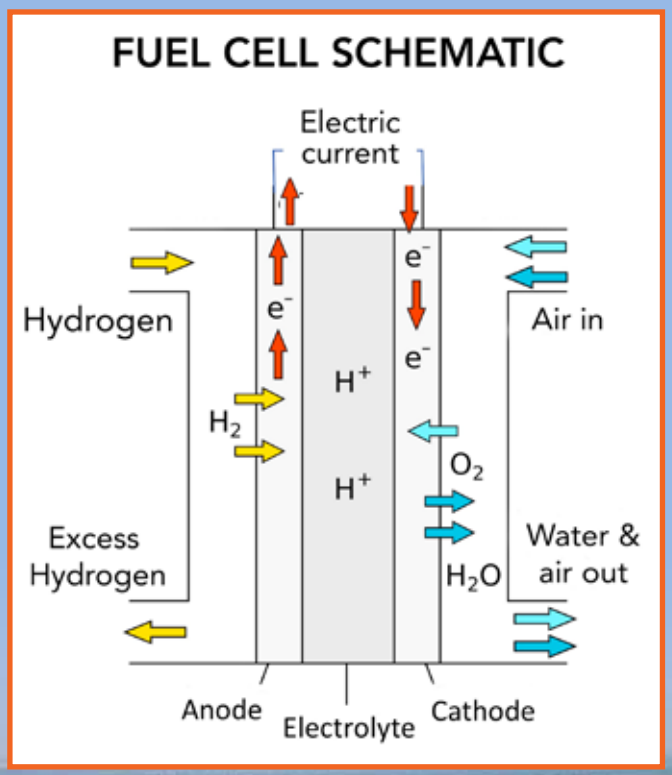
BNSF's hydrogen-powered shunter.

2012. A year later, China's South West Jaitong University successfully ran a 45-tonne fuel-cell locomotive with a 150-kW fuel cell.

In the UK, the University of Birmingham produced Britain's first hydrogen powered locomotive. This was a 10¼ inch gauge locomotive with a 1.1kW fuel cell supplemented with batteries to give a total power output of 4.4kW. This competed in the Institution of Mechanical Engineer's Railway Challenge in 2012. Later that year, the University had its locomotive on show when it hosted the seventh Hydrail conference.

An energy vector

The chemical substance that is water has two hydrogen molecules for every oxygen molecule. Hydrogen is thus available in abundance, yet it is too chemically active to occur naturally. Its main use is for oil refining and the production of ammonia.



Most hydrogen is produced from fossil fuels by steam reforming. 'Green' hydrogen is produced by electrolysis of water, which splits it into hydrogen and oxygen. This does not consume fossil fuels or produce CO_2 but is around twice the cost of steam reforming, although this can be reduced using off-peak wind-generated electricity.

In a hydrogen fuel cell, the process is reversed as the reaction between hydrogen and a catalyst on an anode produces positively charged hydrogen ions, which are then allowed by an electrolyte to pass to a cathode. Electricity, water and heat are produced as a result.

The increasing use of wind power to generate electricity produces large amounts of surplus power overnight. This changes the economics of electrolysis and offers an entirely carbon-free way of producing hydrogen on demand. Hydrogen is thus an energy vector, a medium for conveniently transporting, storing and converting energy into electricity and vice versa.

For this reason, hydrogen powered trains have been described as electric trains as their fuel is produced by electricity. The difference between them and conventional electric trains is that, instead of the catenary, there is a hydrogen production and distribution network. The efficiency of converting electricity to hydrogen and back for rail traction is just under thirty per cent, which is about the same as a diesel engine but much less than conventional electric traction.

Using hydrogen produced from natural gas to power rail vehicles instead of diesel reduces CO_2 emissions by about forty per cent and gives broadly similar fuel costs. Green hydrogen is currently almost twice the cost of diesel but offers zero emissions, enabling a single iLint unit to save 700 tonnes of CO_2 emissions per year.

Landesnahverkehrsgesellschaft Niedersachsen (LNVG)

LNVG is the public transport service for Lower Saxony, Germany's second largest state, most of which is made up of the North German Plain that is bordered by the North Sea and, to the west, the Netherlands. It is therefore not surprising that it is Germany's leading wind-power state. With an installed wind power capacity of over 9,000MW, it produces twenty per cent of Germany's wind-generated electricity and has plans to increase this to 20,000MW by 2050.

Lower Saxony is thus an ideal place to introduce hydrogen-powered trains and so was one of four German states (the others being North-Rhine Westphalia, Hesse and Baden Württemberg) that signed letters of intent with Alstom for a total of 50 hydrail units in 2014, leading to the production of the Coradia iLint.

On 9 November, contracts for the delivery of 14 hydrogen-powered iLints, complete with 30 years of maintenance and fuelling, were signed by LNVG, Alstom and Linde. Lower Saxony is making a contribution of €81 million to the cost of these trains, which will carry passengers on the 240km Cuxhaven, Bremerhaven, Bremervörde and Buxtehude network from 2021. Until then, the two prototypes will operate on these lines from 2018. »


Wind farm in Lower Saxony.


Roof mounted fuel cells.

Alstom will maintain these trains at a modified Bremervörde depot, which will have the world's first hydrogen train refuelling facility, to be built and operated by the Linde Group. This facility will cost around ten million euros, for which the federal government is providing a grant of €8.4 million. At a later stage, green hydrogen will be produced by on-site electrolysis powered by a wind turbine.

Salzgitter's hydrogen train

On the day after these contracts were signed, Rail Engineer was in Lower Saxony to inspect the hydrogen Coradia iLint at Alstom's Salzgitter plant. This provided an opportunity for a close inspection of the roof mounted fuel cells and hydrogen tanks as well as the fuelling arrangement.

Having done so, it was 'all aboard' for a ride on the test track at up to 80km/h. As expected, the ride was smooth and, for a self-powered unit, eerily quiet. In the cab, a display showed the power status of the fuel cell and batteries. When the iLint is accelerating, the fuel cell supplies traction power as demanded by the inverter, supplemented by power from the battery depending on the rate and duration of acceleration. The fuel cell only operates at full power during high-power demand.

At lower acceleration, constant speed running or coasting, the fuel cell delivers a lower output to recharge the battery and supply the on-board systems. When the battery is fully charged, the fuel cell output is reduced so that it only supplies the auxiliary converter/on-board systems. During braking, the fuel cells are almost completely powered down and power generated from regenerative braking supplies the on-board systems and recharges the battery.

A development of the Coradia Lint unit - Alstom's most successful train with over 2,500 units operating throughout Europe in various configurations - the iLint is based on the 100-tonne Lint 54, which is a two-car unit which has 138 seats with capacity for 190 standing. In this configuration, each car has a 390kW underframe-mounted diesel engine driving the powered axles by a cardan shaft.


From the driver's perspective, there is little difference between the iLint and the diesel powered Coradia Lint.

Instead of diesel engines, the iLint has underframe-mounted traction motors driven by a traction inverter. Also mounted on the underframe is a lithium-ion battery pack supplied by Akasol and an auxiliary converter to power the train's systems. On the roof is a Hydrogenics HD200-AT power pack which packages six HyPM™ HD30 fuel cells, with common manifolds and controls, and X-STORE hydrogen tanks supplied by Hexagon xperion which store 89kg of hydrogen on each car at 350 bar. These lightweight tanks have a polymer inner liner, covered with carbon fibres soaked in resin and wrapped in fibreglass.

At maximum power output, each car's fuel cell operates at 200kW and the battery at 225kW. The iLint weighs in at 107 tonnes, which compares well with the Lint 54's 100 tonnes.

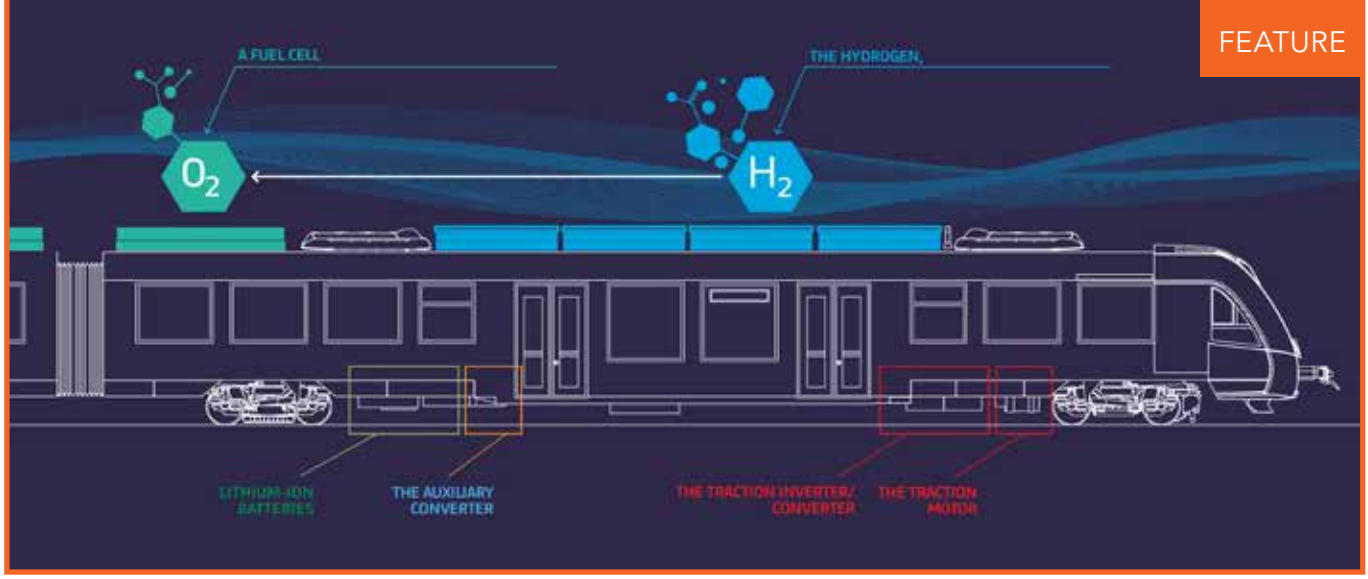
Fuel cells from Canada

Hydrogenics is a Canadian-based company that develops and manufactures hydrogen generation and fuel cell products. It also has plants in Belgium and Germany. The company has contracts that include the supply of fuel cells for thousands of buses throughout China and support for California's heavy-duty fuel cell vehicle projects.

It has supplied electrolyzers for over 55 hydrogen fuel stations worldwide, including two in Britain. In 2014, Hydrogenics was awarded two contracts to install them in Aberdeen, to fuel the city's fleet of ten hydrogen buses, and at Honda's Swindon factory to support the development of the company's fuel cell cars as well as fuelling the Council's small fleet of bi-fuel Transit vans.

In 2015, the company announced that it had signed a ten-year exclusive agreement with Alstom to supply at least 200 fuel cells over a ten-year period based on the company's second generation HyPM™ power modules.

The development of the company's fuel cells shows why it is only recently that hydrogen power trains have become a viable proposition. In 2001, its 25kW fuel cell weighed 290kg and had an efficiency that ranged between 38 and 45 per cent. The iLint's HD30 fuel cell has an output of 33kW and weighs 72kg with an efficiency ranging between 48 and 55 per cent. Thus, since 2001, the company's fuel cells have become much more compact because of a fivefold increase in their energy density (from 86 to 458W/kg).



Supplying hydrogen

It takes 15 minutes to refuel the iLint, which holds 178kg of hydrogen supplied at a pressure 350 bar. It consumes this at the rate of 0.3kg per kilometre. Thus, Lower Saxony's fleet of 14 trains, covering, say, 600 kilometres a day, will require 2.5 tonnes of hydrogen per day. If this was produced by electrolysis, a wind farm of 10MW generating capacity would be required to power the required electrolysis plant with suitable back up. This, and sufficient hydrogen storage, will be required to ensure resilience of supply.

Although it will be a few years before Lower Saxony has the world's first railway hydrogen refuelling station (HRS), there were, as of January 2017, 274 HRSs throughout the world, of which there were 106 in Europe, 101 in Asia and 64 in North America.

A typical HRS would require a 15MW power supply to produce the 280kg of green hydrogen per hour needed for 300 buses or 30 trains a day. It would consist of three 5MW electrolyzer modules with 30 bar feed pumps which feed six 30 to 300 bar compressors which pump the hydrogen into storage tanks holding up to 3,000 kilogrammes of hydrogen. When required, ten booster compressors raise its pressure from 300 to 450 bar and pump it into a 150kg buffer storage unit which feeds five dispensers and delivers the hydrogen at 350 bar.

With an increasing number of fuel cell electric vehicles (FCEVs), the number of HRSs is set to increase dramatically. California currently has 5,000 FCEVs fuelled by 49 HRSs and expects there to be 18,000 FCEVs by 2020. Japan has 92 HRSs and expects its FCEV fleet to increase from 3,000 to 40,000 by 2020. In Europe there are currently 100 fuel cell powered buses, a figure that is expected to rise to 1,000 by 2020.

Whatever the rail industry does, worldwide production of hydrogen for transportation is expected to increase to the extent that, by the mid-2020s, it will exceed that required for industrial processes. As hydrogen becomes more readily available because its supply infrastructure expands, costs are also likely to reduce, making it an increasingly attractive fuel for rail vehicles.


Aberdeen's fleet of 10 hydrogen buses.

Looking to the future

Pollutants from rail diesel traction may soon become increasingly unacceptable. In California, a study has shown that the nitrous oxide emissions from diesel locomotives hauling freight trains from the ports of Los Angeles is equal to that from all Southern California's industrial plants. In the USA and Europe, emissions standards for railway diesel traction are more relaxed than those for lorries and buses on the basis that railway emissions are low per tonne hauled. This may change with increasing concern about total emissions.


iLint's hydrogen fuelling point.

For example, Canada's fleet of 3,000 locomotives consumes two billion tonnes of diesel to produce six million tonnes of CO_2 and 100 thousand tonnes of pollutants that are hazardous to health. This is one of the reasons why Transport Canada has funded a study into the feasibility of using Hydrail vehicles for commuter trains in Ottawa and Toronto.

In Toronto, such trains are hauled by diesel locomotives of 3,000kW, which is far greater than the power of any hydrogen powered rail vehicles to date. Initial feasibility work shows that a hydrogen-powered locomotive with this output would have to be a two-unit locomotive with one unit containing only the hydrogen storage. Such a hydrogen locomotive would thus need the train to be extended by another coach length, or require a passenger coach to be removed from the train.

This indicates that the space required to store hydrogen is such that its use to fuel freight locomotives or high-speed trains may not be viable. For high-powered rail traction applications, electrification is likely to remain the only non-polluting, low-carbon option, dependant on how electricity is produced. For lower-powered applications, such as shunting locomotives and multiple units, it will be difficult to persuade legislators to continue to accept higher emissions from railway diesels when hydrogen offers a zero-emissions alternative.»

The UK's first hydrogen-powered locomotive at the 2012 Railway Challenge - what next?

Replacing 3,000 DMUs?

Of Europe's 15,000 DMU vehicles, 3,000 operate in Britain. Although the UK loading gauge presents problems, Alstom does not consider that this would prevent hydrogen units operating in Britain and advised Rail Engineer: "We are in dialogue with a number of city regions, government and rolling stock operating companies. We are excited about the potential to bring a hydrogen train to the UK."

In another development, a consortium of Hitachi Rail Europe, the University of Birmingham and Fuel Cell Systems Ltd recently undertook a modelling exercise to assess how fuel cells could be used to either re-power existing diesel multiple units in the UK or produce a hydrogen-powered Hitachi AT200 unit. The model showed potential for a reduction in energy consumption of up to 52 per cent on the Norwich to Sheringham line.

As fuel cells have become more compact and efficient, and hydrogen provides a means of storing otherwise unused energy from the increasing number of wind farms, hydrogen has come of age as a viable fuel for road and rail vehicles. It offers zero-emissions and self-sufficiency. It is a fuel that does not consume resources and has known fixed costs, which are only those of the provision and maintenance of the equipment to generate, transport and use hydrogen.

With all these benefits, a long-term future in which all DMUs have been replaced by HMUs is a realistic goal. However, the replacement, or retrofitting, of 3,000 DMUs and the provision of the required hydrogen infrastructure would be a costly investment taking many years.

Germany has already taken its first steps towards this goal. It will be interesting to see when the University of Birmingham's miniature hydrogen locomotive is followed by Britain's first standard-gauge hydrogen-powered train.

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A short story of a railway and its river

MARK PHILLIPS

Diversion of water into the river's new channel.

This article will make only brief reference to the railway. It is mainly concerned with otters, bats, fish, birds, trees, farmers, fishermen and river engineering. One of Devon's major rivers, the Taw, flows roughly north-west from the northern flanks of Dartmoor and out to sea at Barnstaple. Along its route it collects many incoming tributaries, some flowing in from the southern edge of Exmoor.

It is a river with a dramatic personality. From a gently flowing stream passing serenely through a pastoral valley and broad flood-plain, it can change its mood in a matter of hours to a raging torrent, surging through the channel, pushing debris downstream and subtly changing course with every flood event.

The single track, but well-used, passenger branch line between Exeter and Barnstaple is one of the country's scenic routes. Although it passes through attractive farmland for the whole journey, it also has the dubious privilege of sharing the River Taw's valley, interacting with the river at no less than 11 underbridges and 12 embankment locations.

Aerial view of new channel layout with cross-section markers.

This railway route is known as "The Tarka Line", named after the well-known modern classic, "Tarka the Otter" by Henry Williamson, published in 1927 and set in this area of North Devon. Here is a quotation from the book, which clearly illustrates the river/railway relationship, though it was still a double track line in those days:

Twin burnished lines were set by the river, touching its banks, straitly leaving it to its windings, and crossing it on stone bridges topped by tarred iron girders. Under the girders, jackdaws were building their nests of sticks and sheep's wool and paper picked up in the early mornings from cottage gardens. The rolling thunder over their heads did not bother them, for, like the otters, they had grown to the noise of the trains in the valley.

A critical element of the inspection and maintenance regime for this route is the early warning of, and rapid response to, potential underwater scour and lineside erosion threats.

Wall failure

At Colleton Mills, halfway along the route, the River Taw was causing a new concern with regard to the integrity of the railway support zone. In this area, the railway is carried on a shallow embankment. When originally constructed by the North Devon Railway in 1854, the river flowed innocuously past the site some 100 metres away at its closest point.

This is a dynamic river, however, and, over the passage of time since the opening of the railway, a large meander has formed, taking the main river channel alongside the railway embankment over a length of approximately 45 metres. Aerial photography of the site clearly shows the remains of the old watercourse abandoned by the river.

Because of this, partway through the life of the railway, a mass concrete wall was provided to prevent erosion of the foot of the embankment as the meander developed and approached.

Recently, inspections had noted the progressive undermining and structural failure of this wall to the point where urgent remedial work became essential.

Initial proposals

In May 2017 Network Rail let a contract to Construction Marine Ltd (CML) to carry out remedial work before the next winter. Will Johnson, contracts manager for CML, told Rail Engineer that the proposal was originally to demolish the old wall and install a new protective wall over a 30-metre extent using "Redi-Rock", a proprietary retaining wall system using a menu of precast units.

Because of environmental constraints, the work had to be completed within a very restricted eight-week period. This had to be after both the end of the lamprey spawning season at the end of July and the completion of sand martin nesting, and before the upstream migration of salmon and other fish species from the beginning of October.

It was apparent that this was going to be a challenging piece of work. Initial plans were to install a temporary cofferdam and then remove and replace the retaining wall. However, pre-start surveys identified that the scour-related problem was deeper than expected, and affected an increased length of the railway embankment.

As a result of this latest information, CML proposed to Network Rail that a temporary diversion of the river away from its natural watercourse would give much improved access for construction of the replacement wall.

Network Rail called in its consultant, WSP, to review the geomorphological and environmental implications of this proposal. This is where the story starts in earnest.

Collapsed wall before diversion.

Collapsed wall after diversion.

Scheme development

WSP and CML get the credit for the innovative nature of the scheme that was developed. Hamish Hall of WSP said that, following evaluation of the CML proposal to temporarily divert the river and also the evidence of the river's original course, the question that emerged was: "If we are going to the trouble and expense of creating a temporary channel, then why not instead put the river back where it was two hundred years ago?" »

By this time, there were only a few weeks remaining before the start of the available eight-week period during which interventions to the river regime were permitted. Between the end of June and the beginning of August, if the new proposal was to go ahead, then a full scheme had to be designed. Environmental and geomorphological implications needed assessment and approval by all the relevant authorities.

Hamish reckoned that, under normal circumstances, an 18-month timescale would be realistic to carry out scheme design, environmentally assess and gain approval. Waiting this long would have resulted in a full collapse of the wall and closure of the line.

At this point in time then, there existed neither site survey nor environmental assessment. The Environment Agency (EA) was rapidly brought up to speed with the new proposals. Four separate departments within the EA had to be involved in developing the scheme: Environment Officer, Flood Risk Officer, Geomorphological Officer and Fisheries Officer. For its part, WSP assembled a team that, at times, involved 39 staff.

Design and environmental assessment

In order to design the new channel, its physical layout, cross-sectional properties, longitudinal gradient profile and its surfacing materials needed to be understood. A topographical survey was needed, but also a good understanding of the geomorphology of the river bed upstream and downstream of the site of the new channel that was to be constructed.

Environmental assessments had to include otter surveys, bat surveys, and surveys of reptiles and freshwater pearl mussels. Kingfishers, fish species and sandmartins nesting in the river banks also had to be considered. Of particular importance amongst the many issues of ecological balance is the quality of the river bed gravels. These have to be of the correct grading and free enough of silt to ensure an acceptable and attractive habitat for lamprey, and other fish spawning. To gain approval, all parties had to be confident that, after the work, the wildlife mix and habitat diversity available would be no worse than before disturbance and preferably enhanced.

To be confident that the geomorphology of the river would be correct and in particular that it would enable the overall stability of the river, a specialist geomorphological consultant, CBEC, carried out numerical modelling of the proposed new section along with adequate lengths of the existing upstream and downstream sections remaining unaltered by the works. Working in partnership with WSP, a channel geometry was designed to be morphologically interesting.

Simon Dart, area flood risk officer for the EA, explained that, by cutting across normal timescales and by tremendous co-operation between all parties, the EA was able to issue an Environmental Permit, enabling construction work to commence at the beginning of August.

Preparing the new channel.

Catching fish. Note the silt trap at the top of the picture.

Specifications and work programme

The new section of river channel has a complicated geometry, necessitated by the geomorphological requirements, and therefore the setting-out for the earthworks was also, in turn, very complex. Cross-sections were detailed and drawn for 45 locations along the new section, roughly every five metres throughout the design length, to give close control and high accuracy for excavating and profiling the new channel.

The new reach includes two gentle meanders, each with a 'pool' area, in order to replicate as much as possible the flow and habitat conditions being replaced. Also, the most downstream end of the old river meander, which would now be abandoned, was left as a "backwater" area, would form another important element in the overall compensatory and mitigating environmental provision. The remainder of the old river channel would be filled in after diversion of the flow to the new channel.

Before any earthworks could commence, temporary 'Ecological Exclusion Zones' were identified and shown on a location plan. Also clearly identified to the contractor were all the instances of environmental mitigation being incorporated into the overall works. For example, in the residual backwater, a clean cut face is provided to replicate the lost sandmartin and kingfisher habitat.

Where it was necessary to remove certain areas favoured by reptiles, three new hibernacula (rotting log piles and stones, loosely covered with topsoil and turf) were constructed to provide an alternative habitat. Areas of the river bank thought to be used by otters were carefully monitored throughout the works.

Very few trees were removed or affected, and replacement tree planting was specified for two major areas at the top of the new channel adjacent to the two new bends. An integral part of the design of the new channel was the provision of live willow and hazel faggots, staked in to the channel sides around the normal water level. Within fourteen days of planting, these were already showing new green shoots.

The volumes of cut for the new channel and the fill required for the old channel were designed to be in balance. The only major importation of material required was limestone and granite rock armouring for the new channel bed and sides. The channel was lined with a geotextile before the placement of the rock armouring. At the top of the channel side slopes and onto the horizontal part of the banks, coir matting was lapped and pegged in.

Perhaps the most critical stage of the works was the transfer of the river flow from the old to the new channel. At each end, sheet piling had been installed to prevent inflow until the new channel was ready. There was also elaborate provision for the management of silt, with silt traps adjacent to the sheet piling at each end and a collecting area for silt in the "island" area between the old and new channels.

To avoid fish becoming stranded in the abandoned stretch of old channel, they had to be captured and relocated. This was done by 'electro fishing', a technique employed by a specialist company, Fishtek, to temporarily stun the fish for netting and transfer. 4,000 fish of all sizes and various species were caught over the three day period leading up to the river diversion, including two flounder - a long way upstream from their normal marine environment and in flagrant breach of all the wildlife surveys and appropriate provision being meticulously carried out!

A minor tributary stream also had to be accommodated. Because of relative levels across the site, this has had to be culverted through the 'island' area to rejoin the new channel at the downstream end of the new work. »

A praiseworthy success

The new channel was fully opened on 27 September, which was a tremendous achievement and in time for the salmon to migrate, with or without maps of the new layout! As the works have passed the completion phase, otters have been regularly observed moving through the 'new' river.

The Environment Agency told Rail Engineer that it was really pleased with the way that this project had been delivered. It was particularly impressed with the manner in which CML involved the local community in an understanding of the need for and the nature of the works by holding open days for the public, consulting with the local community and organising school visits to the site.

There was a real risk that, due to the severity of the scour identified, Network Rail would have needed to consider emergency works to temporarily stabilise the wall as further deterioration could have had a significant impact on the train service. Richard Edlington, programme manager for Network Rail, said that he could not praise WSP and CML enough for achieving the impossible and delivering this scheme in such a short time period. This project has not only removed a significant infrastructure risk but has also ensured the railway will not be susceptible to scour at this location in the future.

The Environment Agency also recognised the risk and enabled the project team to expedite the permitting process in order to enable the works to be completed before winter. The number of stakeholders and third parties that worked together to make this project happen against all odds was quite outstanding.

Rivers and railways - looking to the future

This story has been about rivers, and railways. However, it is possibly a foretaste of, and relevant to, things to come. The infrastructure maintenance community is now facing several challenges. Firstly, with climate change and changes in rainfall patterns, faster flash flooding events are becoming more prevalent. Secondly, there are large scale changes in morphology over shorter timescales.

Both of these lead to more challenging inspection, maintenance and renewal regimes. This is especially relevant to the railway environment. Many railways have, for very practical reasons, been built in river valleys or alongside available level coastal strips. They are therefore in prime position to be affected by any changes to the 'traditional' weather pattern.

The project at Colleton Mills has been a great example of an imaginative and innovative response to the rapidly evolving infrastructure environment. It also demonstrates the value of delivering more than one benefit. The original project was simply to protect the railway line from the threat of undermining erosion by the river. What was finally achieved is the creation of some ecological improvements and the reduction of long-term risk to the railway.

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CLIVE KESSELL

Cornwall's Capacity Challenge

Travelling down the Great Western Railway to the West Country is an interesting experience. Immediately out from Paddington, the railway is the most modern in Britain, with new electrification, ERTMS being introduced from Airport junction to Heathrow, new signalling from the Didcot ROC and a superb grade separation at Reading.

Then 1980s technology takes us through Westbury and Exeter power box areas and on into Plymouth with its 1960/70s colour light signals.

Cross the Tamar into Cornwall over the magnificently restored Brunel's Royal Albert Bridge and suddenly things become very different. With traditional signal boxes, lower quadrant semaphore signals, long block sections and some quaint branch lines, one could almost be forgiven for thinking this was a heritage railway. Yet Cornwall is seen as a growth area, especially for its long summer season holiday traffic as a result of Brexit and the weak pound.

Something has to be done to improve the capacity of the main rail route down to Penzance. In British Rail days, rationalisation went a step too far with part of the main line being singled from just past St Austell to almost Truro. This caused operating chaos, with late running of long distance trains having a potential knock on effect throughout the entire UK rail network. Sense prevailed and the section has since been re-doubled, but the overall line capacity is still inadequate for emerging needs.

Existing signalling and operation

The Plymouth signal box area provides colour light signalling as far as St Germans, then there is a long section to Liskeard, which is the Plymouth fringe box. Liskeard retains its mechanical signal box, with levers working the station area and the junction to Looe.

The next section is to Largin, which is controlled from Lostwithiel signal box covering the short single-line section over two viaducts. The section continues to Bodmin and thence on to Lostwithiel, which has a lever frame for the station

Par June 2015. PHOTO: TONY MARSDEN

Goonbarrow Junction signal box, and below handing over the token. PHOTO: NATHAN STOCKMAN

PHOTO: NATHAN STOCKMAN

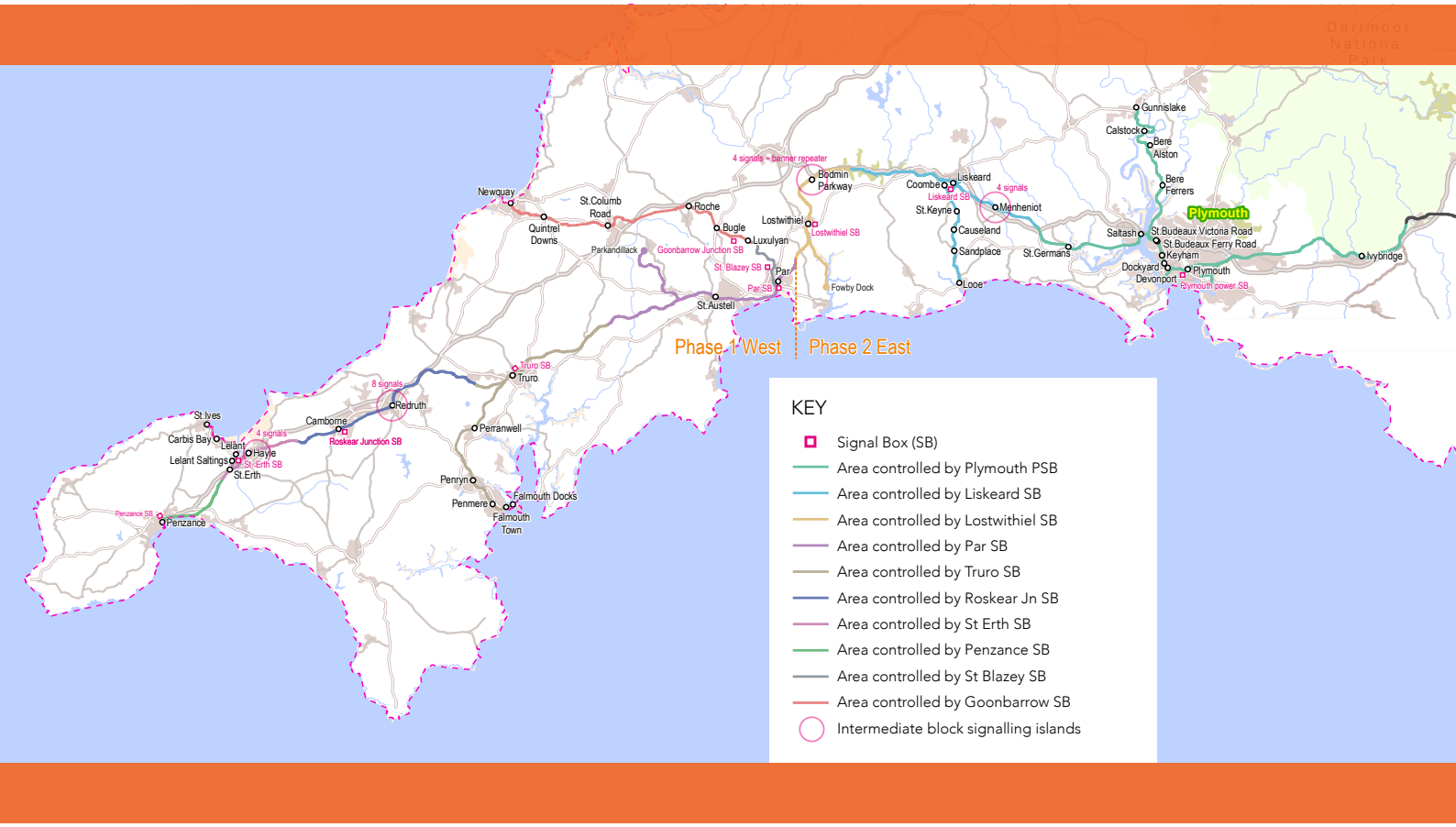
area signals and points, including the junction for the Fowey freight line, plus a small NX panel linked, remotely to a solid state interlocking at Par, for control of the sections between Liskeard and Lostwithiel.

The signalling between St Germans and Lostwithiel is by track circuit block (but using axle counters). From Lostwithiel to Penzance it is absolute block with traditional block instruments and bells.

At Par, where the Newquay branch line diverges, mechanical signalling is retained for the station area but with a panel to control the onward section to Truro where intermediate signal sections are provided at St Austell, Burngullow and Probus when this section was re-doubled in 2005.

(Fixed Telecom Network) fibre-optic cable and associated digital transmission is provided right through to Penzance.

Train services are a mixture. DMUs provide a local service to and from Plymouth and on all the branches. Long distance trains operate to London by GWR Class 43 HSTs, roughly every two hours, and through services run to the Midlands, the North and Scotland as part of the CrossCountry franchise. There is also the nightly sleeper train to and from London, and even a through London to Newquay service during the summer season. Freight services are confined to the cement traffic to Moorswater (near Liskeard) from Aberthaw in South Wales, and clay traffic between Fowey port and workings around St Austell.



Truro is the next signal box, again with a mechanical lever frame and semaphore signals but also controlling the branch line to Falmouth including a recently installed passing loop at Penryn to permit a half hour service. The loop is controlled by levers in Truro box via a TDM system to a remote relay room at Penryn, with cabling being provided for the power operated points and colour light signals.

Onwards to Roskear signal box (the London side of Camborne), which has colour light signals controlled from switches on the block shelf, and thence to St Erth, with its traditional signal box and semaphore signals to control the junction for St Ives, ever immortalised by the Flanders and Swann song on branch line Britain. The final block section is to Penzance, where power signalling controls entry to the train maintenance depot and also a short section of single line that provides a single lead into the station throat, the result of a previous rationalisation. This irritation will remain for the time being, but can cause operating delays if trains are running late.

Whilst semaphore signals remain in station areas, distant signals are all colour light and the few intermediate block sections that exist are two-aspect distant and home signals. Lineside cables provide the inter-box communication and the Network Rail FTN

Altogether, there are a mixture of services but, with long block sections, a regular clock-face timetable is not possible and the desire to provide a half hour service means that a capacity enhancement is essential.

The upgrade project

Whilst the plan to re-signal the whole of Cornwall and control it from Exeter PSB has been officially 'paused', a smaller enhancement project has commenced to improve the line capacity that will meet the franchise agreement with Great Western Trains for the December 2018 timetable change. The ensuing positive result has attracted funding not only from Network Rail but also Cornwall Council and the EU Regional Development Fund.

The project is split into two halves. Amey was awarded the Eastern section and Atkins the West, with a number of new intermediate signal sections being provided plus some renewals of existing signalling equipment.

The Amey contract covers from the Plymouth power box fringe at St Germans to Lostwithiel. A new signal section will be introduced at Menheniot between St Germans and Liskeard comprising a home and distant signal on both lines, controlled from Plymouth »

box. This involves making alterations to the existing western style 'turn - push' NX panel with new 'dominoes' and additional signal control switches and buttons being provided by Henry Williams. Another intermediate signal section will be introduced at Bodmin Parkway, roughly half way between Largin and Lostwithiel, with up and down signals either side of the station. These will be controlled from a new push - push NX panel in Lostwithiel box as the present panel has insufficient capacity. At Bodmin Parkway station, two 'Off' indicators will be provided for train despatch and on the down line, a white and green banner signal will be included to improve signal sighting.

Control of the new signals at Menheniot will be from a Siemens 'Westplex' vital transmission system, with train detection provided by new Thales AzLM K-type axle counters, which also sees replacement of some axle counters of an earlier design. This will ensure a consistent product for the maintenance teams. Around 50km of new cable is being laid and use will also be made of the FTN fibre network to give digital access to some lineside locations.

The Atkins contract covers from Par to St Erth. Since the Par to Truro section already has sufficient intermediate signal sections, no additional capacity is needed. However, from Truro to St Erth, three new signal sections will be provided at Chacewater, Redruth and Gwinear Road, the latter originally being the junction for the long-closed Helston branch. Home and distant signals on both up and down lines will be provided at all three locations, all of which will be controlled from a new 'One Switch Control' panel in Roskear box, which will have its 'western' style E10K relay interlocking upgraded. The existing signals at Roskear will transfer to the new panel. No changes to the St Erth - Penzance section are needed.

The new signal sections at Chacewater and Redruth will see the section from Truro to St Erth converted from absolute block to track circuit block but with axle counters. Again, a Siemens 'Westplex' vital transmission system will control the new signal sections and axle counters using the FTN digital access plus local cabling.

Permanent way and level crossings

No track alterations are needed for this capacity enhancements scheme, so the existing control of the branch line junctions will remain the same.

Level crossing upgrades are required with six User Worked Crossings being upgraded to Miniature Stop Light, to give additional protection to users. These will employ the VaMoS Schweizer equipment triggered from dedicated Frauscher axle counter sections. The AHB crossing at Dolcoath (approximately one mile north of Camborne) will be changed to a four-barrier MCB Obstacle Detection crossing, allowing continued automatic operation but protected by the new section signals. The existing four-barrier crossing at Camborne, controlled by CCTV from Roskear, remains unchanged.

PHOTO: TONY MARSDEN

Truro April 2016.

The Equipment Providers

Both Amey and Atkins have engaged specialist subcontractors for the supply of signalling hardware and some software provision. These are:

Signals - the Collis lightweight structure with a hinged post and including the Collis LED aspects with separate units within the head for red/green or yellow/green;

Axle Counters - Thales AzLM-K type;

Transmission - Siemens for the Westplex vital TDM system data and hardware;

Equipment Buildings and Fitment - MGB Signalling (based in Plymouth) who provide all the combined REB/PSP (power supply) units with integrated UPS and batteries (from AEG) and the external signalling location cases;

Power - MGB Signalling for the power Distribution Network Operator (DNO) cubicles;

SSI Data - OSL Rail for the Liskeard to Lostwithiel part of the Amey works;

New Panel at Lostwithiel - Henry Williams.

Signalling design work has been carried out by Amey from its Bristol office and by Atkins in Swindon, Birmingham and Bangalore (India). Amey has established a depot at Menheniot, with Atkins having a depot at Redruth. Testing is part of their respective contracts.

Network Rail Telecoms (NRT) has done the FTN design and Network Rail staff will carry out the final signalling acceptance. Progress meetings between all three main parties take place on a regular basis, with a formal periodic review every four weeks.

Access to the sites is not always easy but, at Bodmin Parkway, the assistance of the Bodmin and Wenford Heritage line was given to transport the REB and its fitments to the site in the vee of the main and heritage lines.

Commissioning and timetable change

The new timetable is planned for December 2018, so the upgrade work has to be completed by then. The Eastern section will be a three-stage commissioning, with the Plymouth panel alterations scheduled for February 2018 followed by re-control of the Bodmin area in March and the remainder in April 2018.

The Western section will be achieved as a single changeover planned over a three-day period 13-15 October 2018. Thus, some of the benefits will be available for next summer even before the timetable change. The full project should enable a headway of less than 10 minutes to be achieved throughout the Cornish main line.

The scheme is seen as an important 'stepping stone', enabling half-hourly services ahead of a larger resignalling scheme that will follow at some future date. The chances are semaphore signals will still be in use for a few more years yet.

Thanks to Paul Munday and Spencer Hobbs from Network Rail, Andy Cobb and Dave Helliwell from Amey and Jon Leach and Stephen Mills from Atkins for explaining the complexities of this project.

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Improving the Vehicle Track Interface

MALCOLM DOBELL

On 17 October 2000, a train derailed at Hatfield, Hertfordshire when the running rail catastrophically fractured caused by rolling contact fatigue (RCF). Four people were killed and more than 70 injured.

If good can come from such tragic events, it is that the lessons are learned and applied to improve safety. The Vehicle/Track System Interface Committee (V/T SIC) is a product of the Hatfield tragedy. The seeds of cooperative research and development were sown with the creation of the independent Wheel Rail Interface Systems Authority in May 2001, which morphed into V/T SIC, sponsored by RSSB, in 2004. It was, and still is chaired by Network Rail's Andy Doherty.

In the early days, there was a view that "the trains were causing all this RCF". At one level, of course, this was true - if no trains ran there would be no RCF - but it didn't help solve the problem. Eventually independent engineers started to explain the engineering reasons for RCF, which was a precursor for solutions.

This started the process that V/T SIC has employed very successfully; carry out enough research and development to be confident an improvement can be made, give advice for implementing the findings, whilst continuing R&D to further improve knowledge. The introduction of grinding as a preventive maintenance/ life extension activity was one of WRISA and V/T SIC's early successes.

Making progress

Each year, there is a seminar to report on progress made with the various programmes being managed. The 2017 seminar was held on 4 December and was attended by over 70 delegates from across the industry.

Andy Doherty introduced the session by reviewing what has been achieved since the Hatfield crash. There is strong competence in the wheel rail interface across the industry, with clear and competent standards for track and rolling stock asset management. There has been a reduction in fundamental energy and damage in the wheel-rail interface (WRI) leading to a reduction in defects in both rail and wheel leading to a significant reduction in broken rails.

Engineers now have the ability to model the WRI using tools such as Track-Ex (identify risk of RCF and propose corrective action) and the Vehicle Track Interaction Strategic Model that enables engineers to be ahead of the defects. The variable track access charge has provided the financial incentive to the industry

These are good achievements, but there is more to do, particularly as traffic is growing and slots to access the railway are shrinking. Andy's target list for further improvement included:

- Rail Management
- Reduce broken rails below 50 per annum;
- Reduction in squats and reduced maintenance costs;
- Managing out rail foot corrosion defects.
- Adhesion and autumn
- Braking systems that do not rely entirely on adhesion such as magnetic track brakes (MTB);
- Fully integrated brake control including electric brake and MTB.
- Wheelset Management
- Further wheel life extension;

- Additive wheel repair.
- Infrastructure
- Reduction in whole life cost;
- Truly low-cost track for regional and light railways.

Research funding

At this year's seminar, Andy delivered the first talk himself, about the opportunities to obtain funding for research under the Horizon 2020 and Shift2Rail EU programmes. He reminded everyone that UK had been a powerful influence in structuring Shift2Rail using the Rail Technical Strategy (RTS) to help set the agenda.

Much good work has been done and, for 2018, Network Rail has €9 million to spend and is working with its supply base to try innovations with a high Technical Readiness Level. This is part of a €30 million programme being led by Network Rail, and Andy highlighted several initiatives: a scanning tool to "look" behind tunnel linings, the ability to lift brick-arch bridges (issue 146, December 2016), induction welding and the development of an automated squat defect repair method.

Andy then introduced the remainder of the seminar, which was a mixture of progress reports on research projects and feedback from the implementation of previous research.

Dr Gareth Tucker.

Wear limits

Dr Gareth Tucker from Huddersfield University sought to answer three questions. Can flange height and thickness limits be changed to allow more wear? Is there a benefit? And what additional controls might be required if flange wear limits relaxed?

Gareth used the wear limits defined in Railway Group Standard GMRT2466 on Railway Wheelsets, compared them with those in the Locomotive & Passenger and the Wagon TSIs (Technical Specifications for Interoperability), and sought to understand what hazards are controlled by flange wear limits such as negotiation of obtuse crossings.

GMRT 2466 defines nine wheel profiles with minimum flange thickness of 21mm (P9 profile) to 27 mm (P5, P10). Maximum flange height varies between 33mm (P5, P10) and 36.5mm (all except P5, P10, P11).

Gareth analysed the impact if all profiles were to have a minimum width 24mm and maximum height 36.5mm by assessing, or modelling, the performance of various thicknesses against the following hazards:

1. Flange back strikes open switch;
2. Flange back makes contact with check rail before checkrail entry point;
3. Flange back makes contact with wing rail before wing rail entry point;
4. Flange hits the end of a closed switch;
5. Flange makes contact with a closed worn switch blade with a low contact angle (relative to horizontal);
6. Wheel with high tread wear makes contact with a fish plate on rail at maximum head wear

V/T SIC aims to manage out rail foot corrosion defects. This rail is only three months old!

V/T SIC exists to:

- Define the geometry condition of the wheel/rail interface;
- Set out permitted track geometry, including curve radius, installed cant, vertical curvature for the various types or track;
- Set out allowable wheelset parameters, such as gauge, conicity, profile, axle load, for the trains that operate on the network;
- Set requirements to maintain the wheel/rail interface within the prescribed limits and ensure safety of the railway;
- Implement processes to ensure sustainability of the railway;
- Ensure systems exist for seasonal maintenance activities and revised to account for seasonal variation;
- Utilise systems to monitor the condition at the wheel/rail interface and to analyse and distribute data collected by these systems to the appropriate party for the monitoring of performance and programme rectification activities.

It currently has three sub groups:

- Adhesion Research Group;
- Vehicle/Track Technical Advisory Group;
- Wheelset Management Group;
- Plus an infrastructure sub-group to be added in 2018.

allowance;

7. High angle of attack in curves due to thin flanges;
8. Allowing wheels to run longer between turning cycles could lead to low or high conicity;
9. Flange strikes obtuse crossing nose.

The results to date indicate that the flange height limit for P5, P10 and P11 could be increased to 36.5 mm and, pending review of worn switch monitoring, it may be possible to introduce 24 mm flange width for P5 and P10. Gareth also highlighted that TSI flange width limits should only be used in combination with full TSI wheelset dimension controls.

Gareth noted that allowing thinner flanges might only be of any value on the final "life" of the wheel before scrapping because allowing wheels to wear to the thin flange limit generally means more metal has to be turned off to restore the correct profile, thus reducing overall life.

Brian Whitney, Network Rail's Engineering Expert (Track and Lineside) gave his annual update on rail management - he presents the trend in broken rails for Network Rail each year.

In the 40 years from 1962 to 2002 there was an average of 750 broken rails a year, with an absolute peak in 1980. In 2000 there were 919, but the number has declined rapidly with less than 100 forecast for the whole of 2017 - ten of which occurred between Ferrybridge and Llangerrech on 30 October 2017 following the passage of a heavily laden freight train with very severe flats on one axle!

This reduction is all the more remarkable given that tonnage has increased by approximately 50 per cent and access time to conduct repairs and maintenance has been reduced.

Brian's work is now focussed on identifying the pre-cursors of broken rail to give track maintainers the tools to identify track defects that, if ignored, might lead to a rail break. This is easy to say, but to identify individual unsupported sleepers, small plain line non-actionable dip angles (say, 10 to 15 milliradians) or wet spots (especially at bridge transition) on rails with high cumulative tonnage is not easy. Brian illustrated these factors with examples from previous broken rail investigations.

The challenge is to find a tool that can identify wet spots from aerial photographs, pick up the small plain-line non-actionable dip angles and integrate this with the cumulative tonnage, age of rail, supervisors' inspections to deliver a rail health index/risk ranking.

Brian also talked about the benefits of tools that will help to identify pre-cursers, including Sperry B-Scan, train mounted eddy current testing and fitting deflection sensors to the measurement train on both the locos and the passenger cars to understand whether different loads cause variation in deflection and hence point to inadequate support.

Whilst good progress has been made on rail management, more needs to be done to design out switch and crossing (S&C) failure modes and to detect faults before failure. Brian made the rather

Mark Burston.

pointed remark that the same S&C designs have been used for over 50 years.

He concluded his talk by saying that tools are increasingly available to improve decision-making. His task is to provide guidance on their use so that:

- Wider use is made of premium rail steels in key locations;
- Tensile residual stress in the rail foot is reduced to minimise foot defects and breaks;
- Rail grinding and milling are used optimally to reduce surface damage and the need for extensive re-railing;
- Pre-cursor conditions are proactively sought out; today's geometry fault maybe tomorrow's rail defect or break;
- Design cant and cant deficiency in curves for the dominant traffic is considered - high tonnage low speed freight vs low tonnage higher speed passenger service;
- Track support - stiffness and resilience - is maintained and improved ways of repairing the track support are developed.

Line speed differentials

Mark Burstow, principal vehicle track dynamics engineer at Network Rail, gave two presentations. The first concerned line speed improvements. For many years, 'Sprinter' vehicles have been permitted to operate at higher speeds than other traffic on some secondary routes. Over the years there had been some 'drift' in what constituted a Sprinter, and research project T996 recommended characteristics to define Sprinters. The work did not address the reasons for Sprinter differentials.

V/T SIC requested a "bottom-up approach to determine the design speed profile for the current infrastructure", or, as Mark put it, to determine if current differentials on infrastructure are appropriate.

Andy Doherty.

The original reason for the application of differential is often not clear and, following renewals or enhancement, the original reason for the differential may no longer exist. Indeed, it might be acceptable to raise line speed to the Sprinter speed for all traffic in some cases.

The York - Scarborough line (YSL), which has Sprinter differentials applied, was chosen for the study. It is a candidate for operating a wider range of vehicles whilst maintaining or improving current timings; for example, Class 185 trains (not classed as Sprinters) which are currently restricted to lower speeds.

The factors that impact on line speed, and therefore need to be assessed, are curvature, switches and crossings, level crossings, structures and signals (spacing and sighting). Mark said that jointed track would lead to restricted speed, but most of this had been replaced by CWR (continuous welded rail) since the differential speed was first adopted.

Mark explained that the assessment had used the principles in Network Rail's standard for Design and Construction of Track, gauging, structures' RA ratings and the output of T996, and had assumed that the track category would not be altered. Work undertaken to date suggests that there may be a good case for raising line speeds.

Premium rail grade selection

In his second presentation, Mark Burstow provided practical advice and guidance to track engineers and designers on when to use the various grade of rail available. He said that current guidance is only slightly helpful: "Premium hardened steel may be used on one or both rails where rail life is reduced due to surface damage such as RCF or there is a high rate of side wear, a significant flattening of the low rail, or corrugation" (NR/L2/TRK/2102).

This advice pre-dates the most recent developments in rail steels and before the development of the tools now used to predict rail damage. Mark presented evidence to show that harder rail is not a panacea for all ills. He showed a number of scenarios where the use of premium grade rail will indeed reduce wear but will also increase RCF.

Mark's preference is for wear rather than RCF, as the former can be more easily managed, for example by lubrication.

In summary, adopting current grades of premium steels for all curves of radius less than 2,500 metres is not optimal; it is of little benefit on curves with cant deficiency and there is significant disbenefit on tight radius curves.

There were also presentations about the RSSB-sponsored enhanced sanding trials given by Steve Mills (issue 157, November 2017) and the development of rail steels from Jay Jaiswal and Adam Bevan of the University of Huddersfield.

Following a final panel session, chaired by Virgin Trains' Keith Mack, Andy Doherty gave some final thoughts on the work of the V/T SIC, thanked everyone for attending and looked forward to the next meeting.

PAUL
DARLINGTON

Network Rail Telecom
Enabler of the Digital Railway

In most railway organisations, the telecommunications function is one of the smallest when compared to other engineering disciplines. However, from the earliest days of railways, telecoms services have always been very important, both for normal and emergency working purposes.

Today, with digital rail, traffic management, in-cab signalling, big data, customer information, the remote monitoring of assets and passengers requiring to be always connected via Wi-Fi, the railway telecoms network is, strategically, more important than ever.

Rail Engineer recently met up with Simon Atterwell, director of Network Rail Telecom (NRT), to hear of the progress being made to improve the GSM-R radio system. He also discussed ways in which the rail telecoms network could be used to benefit wider society.

Organisation

NRT is part of Network Rail's Group Digital Railway organisation and operates across all of the devolved routes. This is because the relatively few telecoms specialists are more effectively deployed across the rail network, and telecoms assets do not fit easily into the geographical layout of the routes. For example, there is a single telecoms network control centre for all of Network Rail, and the mesh network of fibre cables and data routers is best managed as a single, unified network.

The data routed through the fixed telecom and GSM-R networks will underpin and connect all of the digital rail systems. These include the European Train Control System (ETCS), which will allow trains to run closer together and to travel at their best speeds whilst maintaining safe braking distances. Connected Driver Advisory Systems (CDAS) and Automatic Train Operation (ATO) will provide decision support to drivers in the cab, so that they have the information they need at the right time to boost performance and safety, while Traffic Management (TM) will maximise performance as trains flow across the network by optimising the use of existing track.

All of these systems will adapt in real-time via the telecoms network as conditions change to aid rapid recovery.

Simon confirmed that a new top team is now in place, which includes some of the best telecoms specialists available in the industry. The organisation also contains experienced railway telecoms engineers, who understand the twin requirements of safety and performance.

In addition, apprentices and graduates are being developed with the right skills to support the network, both now and in the future.

Paddington Platform 4A.

Security

One of these key skills is cyber security, a subject very important to a data-rich operational network. A specialist telecom security operations team, under the direction of chief information security officer Darren Hepburn, manages the security measures which, as well as logical and physical security, include business continuity, disaster-recovery processes and risk management.


Manchester Piccadilly.

These measures, which include threat detection and vulnerability analysis as well as incident management, are some of the best available and the rail industry has learnt from enterprise networks, and other control system industries, in order to adopt best practice.

The details of the measures must remain confidential, for obvious reasons, but it is a subject that is under constant review and updated as threats develop and change.

GSM-R interference

Phased into service across the rail network between 2007 and 2014, GSM-R is a major achievement, with the renewal of the entire lineside fibre network and the installation of over 2,500 radio masts. The system, which allows drivers to speak securely to signallers and receive broadcast calls in an emergency, is now in daily use to assist the safe operation of the rail network. It has been very well received by both train drivers and signallers alike, and future enhancements to the system will include upgrades to support the rollout of ETCS beyond the rural Cambrian route.

The initial rollout of the GSM-R System led to a number of issues that impacted on operational performance. Some of these were caused by interference from nearby public cellular mobile radio sites and registration issues, such as locations where drivers could not see the information required to register and 'set up' the cab radio on the network. These all led to train delay incidents, so Project Artemis was formed and, working closely with train operators, it led to a number of initiatives in response to the issues. This included an upgrade of the in-cab radio software and other modifications to radio sites and processes. »

Paddington Platform 2.


Train driver using his GSM-R radio.

The problems included poor visibility of signals at platforms. Quite often, due to the varying length of trains, drivers could not see the relevant signal number and had been either relying on pocket reminders, memory or using a 'wildcard' system to register the in-cab radios. In some locations, new small blue and white signs have been provided on platforms, to advise of the signal number ahead.

Other locations suffered from short-term interference from nearby public mobile operator radio masts. It was found that cab radios affected by the interference did not automatically regain the GSM-R network when the interference subsided, and were left in a state displaying "Searching for Networks" on the driver's control panel. This was particularly common for radios in the rear cab of a train, being discovered when the service terminated and the driver changed ends for the return journey. A process has been developed to recover the radio by the driver simply keying in a reset procedure.

GSM-R registrations were also failing due, in part, to the in-cab radios attaching to an incorrect radio cell. These registration rejections were resolved by a reduction of the transmitted radio power from the interfering public mobile network operators' sites, along with physical changes to the serving GSM-R mast antenna orientation and modifications to the configurable parameters of the radio site.

The Artemis project has been a great success and routes have reported a dramatic improvement in performance, with far fewer train delay incidents caused by GSM-R registration failures.

Improving telecoms for society

Over the years, there have always been various proposals to sell off and commercialise the railway telecoms assets. Fundamentally, though, the assets are there to support the safe and secure operational requirements of the railway, and Simon was clear that ownership, control and management of the network will remain with Network Rail. However, his team are involved with a number of trials to support telecoms services outside of the operational arena.

In issue 151 (May 2017), Rail Engineer reported on the Government's Digital Strategy for the UK. This strategy included the comment that publicly owned or funded networks, such as the Network Rail telecoms network, offer the potential to increase fibre connectivity. As a result, these would be investigated to see how they could be opened up to provide vital 'backhaul' infrastructure, which could help to increase business and residential connectivity in hard-to-reach areas. They might also provide connections for the emergency services network (ESN), which will provide the next generation integrated critical voice and broadband data services for the three emergency services (police, fire and rescue, and ambulance) and other public safety users.

This is now starting to happen and NRT is involved in a trial with Broadband Delivery UK (BDUK), part of the Department for Digital, Culture, Media & Sport, in delivering superfast broadband to rural areas of Cumbria using the railway fibre network. A trial is also underway to provide services for ESN in such locations as the Severn Tunnel.

It is important that any connections to other networks are made safely and with no interference or capacity implications to the operational railway, which is why NRT has to be involved whenever a third-party telecoms operator connects to, or operates on, the rail network.

NRT is also involved in assisting mobile network operators to tackle public radio 'not spots', where there is poor coverage near to the railway. The plan is to provide cellular mobile operators with the ability to access and connect to 'neutral host capability' radio sites on Network Rail land. This will help to remove poor coverage areas for rail customers, lineside neighbours and rail maintenance teams, together with improving Wi-Fi access on trains where this is provided via public cellular radio systems.

The interference that has been experienced by GSM-R from third-party sites can be managed better with NRT being able to influence the design with filtering and antenna configuration, and it also allows the NRT engineers to gain experience with 4G radio, which is likely to be used for the next generation of rail radio to replace GSM-R, unless the industry waits for the introduction of 5G in a few years' time.

Another scheme to improve Wi-Fi on trains is the Project SWIFT (Superfast Wi-Fi For Trains) trial, currently taking place on the Edinburgh-Glasgow route. The pilot scheme is being funded by Innovate UK and RSSB and is being undertaken on behalf of the entire rail industry. It is aimed at fully understanding how today's on-train Wi-Fi can be taken to the next level.

This proof-of-concept trial is being delivered to ScotRail. Cisco is leading the trial using Fluidmesh technology and NRT is providing the backhaul links. The Edinburgh-Glasgow route is typical of the UK rail network in terms of current mobile coverage. Cellular mobile networks provide good connections in the two main cities and within the confines of the towns that the rail route runs through. However, coverage becomes patchy as the trains cross open country or are in deep cuttings along the 79km route.

The project will use the trackside NRT fibre to backhaul data from the existing trackside GSM-R infrastructure and newly installed infill masts. The masts will access the unlicensed 5GHz Wi-Fi spectrum to connect trains to the NRT fibre network. Indications are that an average 350Mbps, with peaks at 500Mbps, may be achieved with seamless handover between the radio sites, and with no packet loss during the handover.

The not-for-profit structure of Network Rail allows NRT to provide the backhaul connections required for the innovative schemes at cost, maximising the benefit to society.

These interesting trials, along with other NRT innovations, will be covered in more detail in future editions of Rail Engineer.

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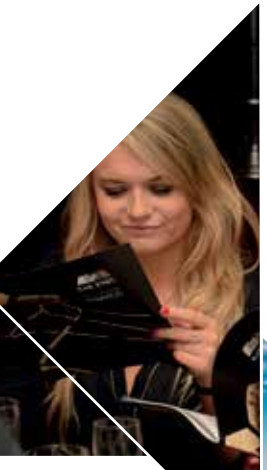

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EGIP's Millerhill milestone

DAVID SHIRRES

Like any major infrastructure programme, the Edinburgh to Glasgow Improvement Programme (EGIP) must achieve many milestones to meet its end goal, in this case running faster electric trains between Edinburgh and Glasgow that are two coaches longer than the current service. On 10 December, the project delivered three milestones in one day, of which one, not visible to passengers, was Millerhill depot.

Initially, the depot will service a small number of trains. However, when fully operational, it will be one of ScotRail's main stabling points, with many of its 70 new class 385 Hitachi EMUs serviced there overnight. At the depot, trains will be washed, cleaned, toilet tanks emptied, sanders filled, and screen washers topped up and there are also facilities for maintenance staff who may be called to the depot to repair minor faults.

Old yard transformed

Issues raised during the depot's planning application were the requirement for a sustainable urban drainage system (SUDS) and that the site is within a development high-risk area with identified coal mining features. Once mitigation for these issues was confirmed, planning permission was relatively straightforward as the depot is on a site that has been in railway use since Scotland's largest marshalling yard opened there in 1962. This had around a hundred sidings and, at its peak, handled 4,000 wagons a day, both from the Midlothian coalfields and for freight trains over the Waverley route to Carlisle, which passed through the yard and closed in 1969.

Class 385 at Millerhill depot.

With the reduction in wagonload traffic, the west-side yard closed in 1983. As the remaining facility handled ever-decreasing freight traffic, some of its sidings were mothballed with the remainder becoming an engineer's yard and a freight locomotive servicing and fuelling point. The main through line is electrified and leaves the new Borders Railway just south of Newcraighall station and connects with the East Coast main line at Monktonhall via a line built when the marshalling yard first opened.

Planning permission was granted for the depot in April 2013. However, this was for the construction of a heavy maintenance depot to maintain the electric trains that had to be procured by the holder of the new ScotRail franchise - due to be awarded in October 2014. Prior to this, plans for the depot needed to be well advanced, even though no-one knew where these trains would come from, or how they would be maintained.

As it turned out, the franchise was awarded to Abellio which bought AT200 series EMUs from Hitachi, now designated Class 385. These have many similarities to Virgin's Class 800/801 IEP trains, derived from AT300 series units, and, as part of the supply contract, both will be maintained by Hitachi. Hence, it was decided to maintain both classes at the nearby Craigentinny depot, so a maintenance depot at Millerhill was no longer needed. It was therefore

repurposed as a servicing facility to stable the trains to be used on EGIP and other stock.

EGIP alliance contractor Morgan Sindall started work on the £30 million depot construction work early in 2016. An early problem was the decommissioning of the contaminated locomotive fuelling point. The new roads and walkways in the depot were constructed by resurfacing contractor CPR, which also worked on the depot drainage system by building the separation tank and five-metre deep, 38-metre diameter SUDS pond.

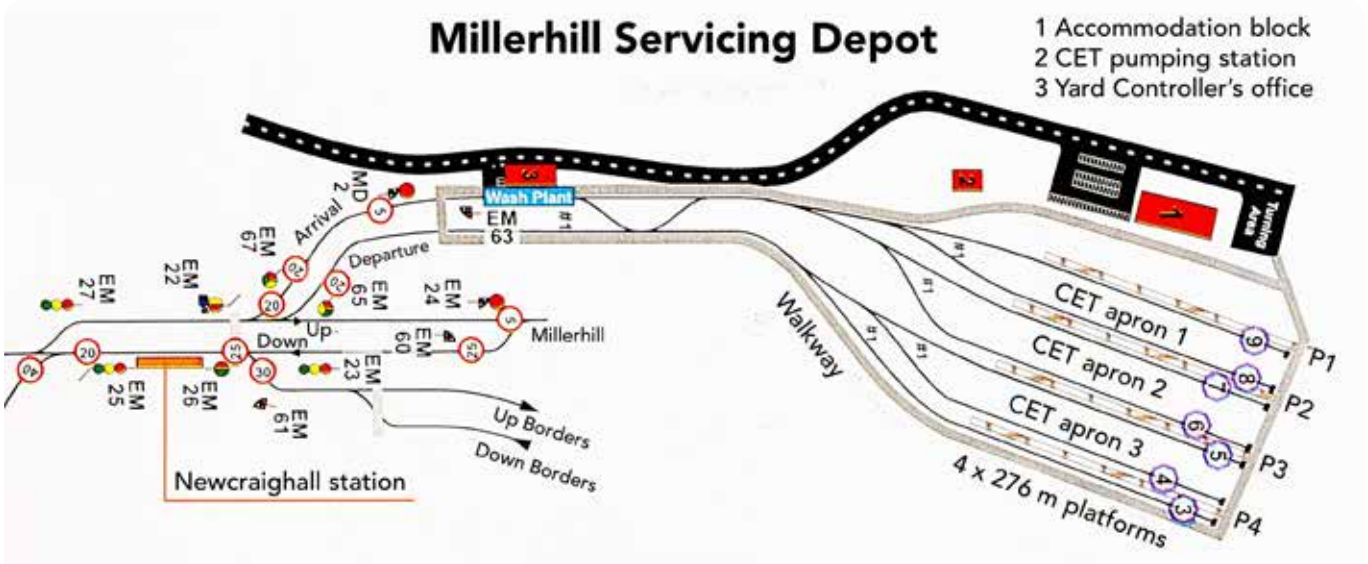
Road and rail access to the new depot is from the northern end of the Millerhill complex, with its servicing facilities, half a mile to the south, built on top of the redundant east-side yard. There remain some sidings east of the depot for engineering trains. These are connected to the main line at the south of the yard.

For resilience of operations, both entrance roads are bi-directional and have their own connection to the Up line at Millerhill. Normally, these lines are operated as distinct arrival road and departure roads.

MRX condition monitoring station.

Remote condition monitoring

On entering the depot, all trains through the arrival road pass through a condition monitoring station supplied by MRX technologies. For the Hitachi class 385 units, this records pantograph wear, wheel profile, brake and disc pad »



Class 385 at Millerhill, note CET stations in foreground.

Platform 12 extension on 4 December.

wear. As Millerhill is a stabling facility, this station is visited by individual units on an almost-daily basis, allowing the team at Craigentinny to use the resulting information for maintenance planning. This is not a new arrangement for Hitachi, which has had ten years' experience of using data from a similar MRX station installed at its Ashford depot.

Immediately after the MRX station is the train washing plant. This is next to the office of the yard controller, who liaises with signallers to accept trains and control movements in the depot. This includes setting the manually operated points between the washing plant and the depot's seven servicing roads, which are actually numbered three to nine as the depot has been constructed with passive provision for two more roads between it and the main line.

These seven 305-metre-long roads can accommodate 12-car units. Each has a 276-metre-long platform on one side with water and power points. On the other side, each road, except for number 3, has an apron with controlled emission toilet (CET) emptying stations.

The 48-metre by 12-metre accommodation building provides changing facilities, locker rooms and a mess area for vehicle presentation staff, as well as carriage cleaning and maintenance stores. The accommodation block is large enough to provide facilities for drivers if Millerhill were to become a signing-on point.

At the Glasgow end of the line, Eastfield depot is being modified to service electric trains. In 2004, a depot to service DMUs was built on the site of the traction maintenance depot that closed in early 1992. Four additional sidings were added in 2017 and the depot was electrified so that it can also service EMUs.

Milestones two and three

The escalators that were installed a few years ago to connect Platform 11 to the mezzanine footbridge at Edinburgh Waverley had to be temporarily removed from the beginning of September to permit construction of another essential part of EGIP, the lengthening of Platform 12. Although the station has several long platforms that can accommodate EGIP's longer trains, the station's berthing plan frequently requires platforms to have two trains so, without this longer platform, it would not be possible to run longer trains between Edinburgh and Glasgow.

This work required the demolition of a redundant office building and extension of the overhead lines. Platform 12 re-opened on 10 December. With its new length of 204 metres, it can now accommodate eight-car trains. The escalators from the mezzanine footbridge will be relocated closer to the centre of the main concourse and will re-open in the spring.

The most newsworthy of the 10 December milestones was the introduction of the first electric trains to carry passengers on the Edinburgh to Glasgow line through Falkirk. With Class 385 production delays, these

Graphic of completed Platform 12 extension.

Class 380 EMU at Linlithgow on 10 December.

trains will be seven-car trains formed from four and three-car Class 380 EMUs. Two such trains are now working, about one in four of the trains on the line. This will provide some extra capacity as the maximum train length was previously only six-cars.

Still to come

Whilst it's good to see the pieces of EGIP falling into place, both EGIP and Hitachi's train delivery schedule are a year behind schedule. In its invitation to tender document for the ScotRail franchise, issued in November 2013, Transport Scotland's specified milestones were:

- December 2016: one seven-car EMU running between Edinburgh and Glasgow;
- December 2017: trains between Edinburgh and Glasgow to be seven-car EMUs in peak periods;
- December 2018: eight-car EMUs to be introduced between Edinburgh and Glasgow with a 42-minute journey time; Stirling, Alloa electrified with all services operated by class 385 units; Queen Street station development complete.

It is expected that, as Hitachi ramps up Class 385 production at its Newton Aycliffe plant, the original December 2017 milestone for a full service of seven-car EMUs on the Edinburgh to Glasgow service is likely to be achieved in the next few months. No date has been set for this, however, and ScotRail Alliance's managing director Alex Hynes has stated that he does not want to jeopardise the line's current good punctuality and passenger satisfaction by introducing the trains before sufficient numbers are fully tested.

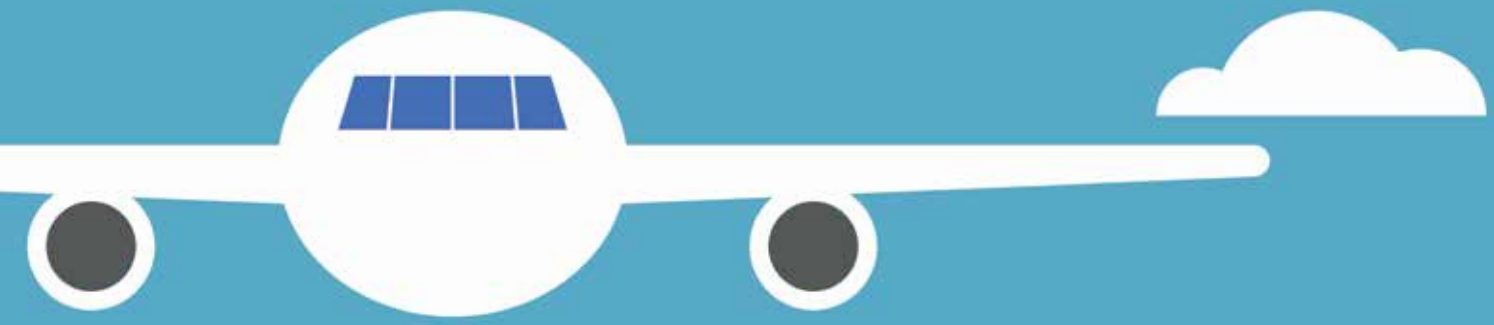
The December 2018 milestone of a 42-minute Edinburgh to Glasgow service requires the Stirling Alloa electrification scheme to be completed by then. This is because faster electric Edinburgh to Glasgow services are not possible if EMUs must follow DMUs from Glasgow and Edinburgh to Stirling, particularly on the climb up Queen Street tunnel.

One of the original December 2018 milestones that has been delayed a year is the introduction of eight-car services, as these require the platform extensions that are part of the Glasgow Queen Street station development. The Queen Street work was originally programmed to start in January 2017. However, with the required Transport and Works Act order taking much longer to obtain than anticipated, work could not start until August. As a result, it will be 2020 before the station work is completed, although it is expected that the platform extensions will be completed by December 2019.

Once longer and faster trains are available, EGIP and Hitachi will have provided significantly improved passenger journeys, not just between Edinburgh and Glasgow, but also to Stirling, Shotts and other locations in central Scotland. With the delays to the programme, and inevitable disruption to services for major work such as Winchburgh and Queen Street tunnels, the electrification work has not been without its frustration. However, once all the milestones have been met, Edinburgh to Glasgow passengers will have 33 per cent more seats during the peak, faster and more reliable trains that are more efficient and environmentally friendly.

Let's hope that the line's passengers think it was all worth it. ●


Class 380 EMU crosses Avon viaduct, west of Linlithgow.



Out by Plane, Back by Train

Each year, the Railway Division of the Institution of Mechanical Engineers organises a technical study tour for its members. It is an opportunity to see how others design, build and operate railways, and it often builds career lasting relationships amongst delegates on what is, effectively, a seven-day engineering networking event.

MALCOLM DOBELL

Members young and old work together to explain the familiar and understand the unfamiliar with the help of hosts who generously show off their facilities or factories. This was the writer's ninth tour, and on each one there has been learning that could be brought back to the workplace and implemented.

Early in November 2017, twenty engineers met in Porto, northern Portugal, and travelled to Paris in stages by train, visiting the metros of Porto Lisbon and Bilbao, train manufacturers Talgo and CAF, and the trams of Porto, Lisbon, Vitoria/Gasteiz, Bilbao, and Bordeaux, as well as the newest SNCF Ligne à Grand Vitesse, along the way.

The tour was led by Birmingham University's Dr Felix Schmid and RSSB's Bridget Eickhoff, albeit in their personal capacities. The participant mix was almost 50:50 young members and 'old hares', with representation from Angel Trains, Atkins, Birmingham University, Bombardier, DB ESG, Eversholt Rail, Montreux Oberland Bernois Railway (Switzerland), Porterbrook Leasing, RSSB, TfL, Transport Scotland and Unipart Rail, in addition to some individual members.

As well as the engineering, it is important to develop an understanding of the context and culture of the countries visited and learn something about the circumstances and different requirements that have led to the current situation of the rail networks, systems, installations and companies visited. Even simple activities, such as buying a ticket, can provide interesting experiences! Language can be a considerable barrier, but our leader was multi-lingual, and we were fortunate that English is widely spoken, both in Portugal and by the suppliers.

Bilbao tram.

The City of Porto

Porto (with the definite article "o Porto" in Portuguese, hence Oporto in English) has a population of approximately 250,000 in the city itself and around 2.4 million in the metropolitan area. The airport is served by line E of the metro, which is heavily used, even mid-morning on a Saturday.

The visits to the transport installations in Porto were led by Porto native and light rail engineer Rui Costa, currently working in Bergen, Norway. The first visit was to the Museu do Carro Eléctrico, Sociedade de Transportes Colectivos do Porto. This museum tells the story of the development of the tram system and much of the history of the electric traction, from both the rolling stock and supply perspectives. Exhibits included horse trams from the 1870s and electric trams from the birth of electrification to the 1930s. Many early vehicles were made in England while later vehicles were built in Porto.

Delegates were able to see how electric traction had developed from simple, four-wheeled vehicles to trams with maximum


Porto Eurotram motor bogie.

traction bogies (one driving axle with large wheels and one non-driving axle with smaller wheels - the bogie pivot is located off-centre, so more than half the mass rests on the driving wheels). In general, the construction of the vehicles featured an underframe of iron or steel and a wooden body.

An unusual feature of the museum is the display of historic power station and sub-station equipment, some of which is about 100 years old: rotary converters, mercury arc rectifiers, 1950s transformers and ancient switchgear, all located in the former power station building.

Many of the exhibits are used on historic tram tours of the city and participants were shown around the renovation workshop, which illustrated that quite different skills are required to renovate historic vehicles compared with todays' products. Interestingly, even the oldest trams are being fitted with laminated glass windows to improve the chance of survival in an accident.

The museum visit ended with a vintage tram ride over most of the old on-street network where the latest technology was demonstrated: the tram driver support system using GPS-enabled tablets had been introduced three days before - a sort of Driver Advisory System. It shows the historic tram network and issues conflict avoidance messages to the driver that become increasingly urgent as trams approach each other on the single-track sections. The guide and driver demonstrated the use of rheostatic braking on the 10 per cent (1 in 10) gradients that are common in Porto.

Today's tram network, Metro Porto, is a low-floor light-rail system. It has 81 stations on 67km of standard gauge (1,435mm) double track. Most of the system is at ground level, some is elevated, and 8km are underground. Most of the metro features automatic train protection (ATP), although there are some street-running outer sections with line of sight operation.

Metro Porto uses vehicles best described as high-performance trams. There are 72 seven-section Bombardier Eurotrams from around 2004 and 32 three-section Bombardier Flexity Swift trams from 2010.

The visit to the depot included its stabling yard, workshop, control centre and a modern sub-station - it was interesting to compare the latter with the facility at the museum. The light rail principles of the Metro were illustrated by small-radius points and grooved rail in the sidings. Vehicles in the workshop demonstrated the design challenge of the all-low-floor Eurotrams compared with the Flexity Swift vehicles, which have low floors near the doorways but high floors in the centre section and above the bogie on each end section.

The high floors allow bogies that are largely conventional, whereas the Eurotrams bogies have independently rotating wheels with individual brake discs - while motor bogies have each wheel powered by an asynchronous three-phase motor connected via a gearbox.

Lisbon Metro and Trams

The group travelled from Porto's beautiful Sao Bento station by Comboios de Portugal (Portuguese Railways or CP) to Lisbon. CP, like Spanish Railways (Renfe), use the Iberian gauge of 1668mm. This gauge, equivalent to six Castilian feet, was chosen following an 1844 report by two Spanish road engineers, Subercase and Santa Cruz. They opined that the tough Iberian topography required more powerful locomotives than those of England and France, thus the wider gauge.

The train was a tilting Alfa Pendular - an Alstom Pendolino - which reached speeds of up to 220km/h according to the vehicles' displays. On arrival at the Calatrava-designed Lisboa Oriente station, the group was given the task of buying local area day tickets. About half discovered the hard way that the CP day ticket is not interchangeable with the Metro do Lisboa ticket.

The visit to Metro do Lisboa started with a presentation about the history and development of the metro, which had opened in 1959. The population of the city is 570,000 and Greater Lisbon has 2.8 million inhabitants. More than 60 per cent of commuting to and from Lisbon's City Centre is by public transport, split roughly equally between Metro and bus/tram.

The Metro is recovering after suffering badly during Portugal's financial difficulties following the Euro crisis. Traffic fell from approximately 170 million in 2010 to approximately 120 million in 2013. Development plans were put on hold, there were many redundancies and the remaining staff had to take a significant pay cut while working harder.

The consequences for the Metro were that it had to reduce maintenance, surveillance and cleaning operations »


Lisbon Metro historic car (1959).

and increase headways. The situation is improving, with a forecast 180 million journeys in 2017, and the Metro has been able to reinstate some of the cut activities and implement developments to improve stations and customer service.

The party's guide, Nuno Goncalves Pereira, was upbeat about the prospects for new lines, extensions and the enhancement of the existing system. Metro de Lisboa is manually driven with ATP, but is examining the installation of CBTC with automatic operation.

The group toured the depot and workshop. The standard Lisbon metro car has a stainless-steel body, air conditioning and is formed into five or six-car trains, the newest with walk-through gangways.

All trains in normal use have three-phase propulsion systems with fully suspended motors/gearboxes. Like the Porto Eurotrams, they were built by AdTranz/Bombardier in its plant at Amadora Portugal, which closed in 2005.

Metro do Lisboa has its own electronics maintenance and development facility in which highly skilled electronics engineers are developing their own GTO to IGBT conversion kits for the three-phase AC propulsion packages.

Lisbon is a hilly city, so some innovative design features have been incorporated into the Metro network. For example, Baixa-Chiado station in the city centre offers interchange between the blue and green lines. One entrance is at street level in Baixa, the other is in the Chiado district, reached via a flight of five escalators.

The hilly nature of the city also allowed members of the group to experience reliable 'steel wheel on steel rail operation' on gradients of up to 12 per cent. A small party also sampled one of the funicular railways, propelled by traction motors on the two balanced cars.

Talgo series 1 dating from 1942.

From Lisbon, the group travelled to Spain on an almost-historic Talgo hotel train. Your writer was lucky enough to have a single berth although it was located close to a wheelset (see later) and the ride was rather uncomfortable.

Patentes Talgo

After a 10-hour journey, the group arrived at Miranda de Ebro and boarded a coach to visit Talgo's factory in nearby Rivabellosa.

Talgo's Ramón Ortiz García and UK representative Jon Veitch introduced the company. Alejandro Goicoechea and José Luis Oriol founded the company in 1942 to develop their concept of a Tren Articulado Ligero Goicoechea Oriol (light articulated train of Goicoechea and Oriol), the principles of which they had patented in 1940. They tested the concept with a train of isosceles-triangle-shaped frames with independently rotating wheels at the ends of the short sides. Each triangle was then replaced with a short bodyshell, which rested on two wheels at one end and the adjacent vehicle at the other end.

The first commercial operation was in 1950. Since then, Talgo has developed trains capable of changing gauge and travelling at 250km/h, as well as high-speed trains capable of 350km/h. The company has also built hotel trains and bi-mode trains which have a locomotive, with an adjacent diesel generator car, at each end of the train.

During the visit, Talgo engineers explained how the wheels are steered and how the suspension system works. Talgo trains feature steerable two-wheel bogies without axles between the vehicles, which are typically 13.5 metres long, with a tare vehicle mass of some 15.5 t. Compared with a 26-metre bogie vehicle, this arrangement results in half the number of wheelsets and a weight saving of between five and ten tonnes per 26 metres. A rake has one more axle than there are vehicles.

Lisbon Metro fully suspended gearbox and flexible coupling.

Above the frames that link the wheels are vertical tubes connecting the bogie to the secondary suspension, located at cantrail level, which interfaces in turn with the body bolster at roof height. The adjacent vehicle is supported on struts that run from the body bolster to the adjacent vehicle's underframe. The high secondary air-suspension enables passive tilting of the vehicles to compensate some of the cant deficiency.

Longitudinal forces are reacted at an underframe level coupler. Rods and levers between adjacent bodies and the wheelset ensure that the bogie is always perpendicular to the curvature of the rails.

The group toured the works, where trailer vehicles are being manufactured. Talgo's technique is to use single-skin aluminium body extrusions, except where more

strength or rigidity is required. Body sides and roofs are single skin, reinforced by channel sections. Floors are double-skin extrusions and door portals are reinforced using sections machined from solid.

A train being tested for the Saudi Arabian high-speed line was on show and provided evidence of the high quality of the finish being achieved.

Vitoria/Gasteiz

The afternoon included a visit to the tram system of Vitoria/Gasteiz. This is an old town that 30 years ago accommodated approximately 50,000 people and has grown to 250,000 today, with most living in apartment blocks that create a public-transport-friendly population density. (The only tram system in the UK in a remotely comparable setting is that of Blackpool with its very special context. Other UK towns of 250,000 are simply too spread out).

It is a network of two lines sharing a common section, with a total length of 8.6km of double metre-gauge track and 11 trams, the peak service requiring nine vehicles. Even off-peak, the trams were busy.

The well-equipped depot allows plenty of room for the planned network expansion. The CAF-manufactured and maintained five-segment trams are similar to those operating in Bilbao but are low floor throughout.

The train back to Miranda de Ebro happened to be a Talgo 250, which had a comparatively noisy and rough ride - was it the train or the track?

Renfe middle distance multiple unit

Construcciones y Auxiliar de Ferrocarriles (CAF)

Next, the group travelled on a CAF-built regional train to Ordizia for a visit to CAF, Beasain. Hosts Xabier Perez and José Gortazar led a tour of the works.

The bogie shop was home to a variety of small and large frames and completed bogies, to be used under anything from metre-gauge trams through to Iberian-gauge articulated train sets.

Generally, CAF uses strong double-skin extrusions for car body construction. A variety of body shells for different vehicle types were in production, including tram and light rail rolling stock, UK-gauge vehicles and very large metro cars for Santiago, Chile.

The group was shown how CAF designs and integrates vehicles using Catia 3-D software, followed by a visit to the fit-out and final test areas where Caledonian Sleeper vehicles were much in evidence. This project is of great interest to UK rolling stock engineers as they are likely to be the most complex trailer coaches ever put into service in Britain. It is challenging to accommodate all that is required of a modern 'hotel train' in the UK loading gauge, especially when cabins with private toilets and showers have been specified for some of the vehicles. The members of the group were privileged to be amongst the first to see how this feat has been accomplished; an object lesson in tightly packaging all the features one would expect in a hotel room. The group also saw a club car with its extremely well-equipped kitchen. The sheer amount of equipment fitted would not disgrace the most complex power car.

For several delegates, the Talgo and CAF visits represented their first ever chance to see rolling stock being manufactured. »

Renfe rolling stock Miranda de Ebro station.


Euskotren CAF 4-car metre gauge articulated EMU.

Euskotren, Euskotram and Bilbao Metro

Thursday's visit was to Bilbao's tram and metro system. The day started at the historic Bilbao Axturi Euskotren station, with a presentation by Iñaki Uriarte about the Euskotren enterprise, the Basque country's national operator of trains, trams and buses. The rail element is a metre-gauge, largely 'all stations', network. Journey times are dependable but slow. However, the company is also in charge of one branch of the hugely ambitious Basque Y high-speed rail project, which will operate at 250km/h even though 67 per cent will be in tunnel. Once built, it will also facilitate combined transport operations from northern Europe to Spain.

The Bilbao tram system has nine three-segment vehicles. The workshop was built into the side of a hill on a very constrained site and has just one road. Whilst very compact, the depot is equipped with everything necessary to maintain the trams, such as cranes, bogie drop and a wheel lathe. Equipment is maintained off site, usually by the OEM, and there is a lift to take even major components up to street level.

The depot is separated from the tram track by the metre-gauge regional lines. To access the depot, trams must cross the main line. Both are metre gauge, but the tram is electrified at 750V DC and the main line at 1500V DC. Thus, when the trams are signalled into the depot, electrical switching is necessary to provide the correct supply for the trams.

Pedestrian access to the depot involved the group crossing the main line twice and lining up hard against the fence alongside the river to allow a tram to pass.

Next, the group visited Bilbao Metro. Bilbao is probably unique in having an architect-designed system, the concept for the stations having originated in Norman Foster's practice and they all exhibit a similar feel, making navigation easier.

The network is 49km long with 48 stations, of which 31 are underground, and 36 trains in a mixture of four and five-car formations also running on metre-gauge tracks. The cars are 18 metres long and 2.8 metres wide, making them unusually spacious for the gauge. The network is electrified at 1500V DC, like Euskotren's, and features attended automatic train operation with ATP. For the group's visit to the depot, the train driver had to switch to ATP manual to allow the train to stop at the staff halt.

In the evening, the group travelled from Bilbao to San Sebastian with 'El Topo', Euskotren's main line. The train, a four-car articulated electric set by CAF, took two and a half hours to cover 100km, was busy and the fare was only €3.80. The seat comfort, though, left something to be desired, even when compared to the much-derided UK class 387!


Bilbao Caf 3-section metre gauge tram.

From Spain to Bordeaux

The group travelled from San Sebastian to Bordeaux on Friday morning to experience the city's tram network, riding on the El Topo and an SNCF TGV, having remembered to 'compost' our tickets before boarding the French train. Bordeaux's centre has about 250,000 inhabitants, while Bordeaux Métropole, which includes suburbs, has nearly one million.

In Bordeaux, Felix Schmid delivered a specially written lecture describing the Bordeaux region and how it is regenerating itself after the loss of much of its industry, enabled in part by the modern standard-gauge tramway.

Bordeaux's city planners did not want the historic areas disfigured by electrification masts and overhead lines. Responding to the challenge, Alstom developed the APS system (Alimentation par le Sol - literally 'feeding via the ground') for Bordeaux and it is now used in Reims, Angers, Tours and Dubai (issue 98, December 2012). The principle is that there is a discontinuous conductor rail between the running rails that is energised only when covered by the tram. It then has to be proved to be de-energised whilst still under the tram, otherwise the vehicle will stop. It was possible to hear the clattering of the conductor shoes on the discontinuous rail whilst travelling. Changeover from track to catenary takes place at stations.

Today there are 62 seven-section trams, each 43.9 metres long, for lines A and B as well as 12 five-section trams, 32.8 metres long for line C, operating on the 66km network. An extension project has just got underway.

LGV Tours - Bordeaux

The tour concluded with a high-speed rail visit. In Bordeaux, Felix had presented a brief talk provided by the concessionaire of the line, LISEA, which described how the

line had been privately financed, in a very French way where virtually all the funding is guaranteed by the state.

For its last visit on Saturday, the group toured some of the infrastructure built for the Tours-Bordeaux line, which opened in July 2017. The tour included a 1500V DC to 25kV AC changeover location, new bridges and stations, as well as the simple and elegant OLE equipment capable of supporting speeds up to 300 km/h, with two pantographs. This was in great contrast with what has been provided for the Great Western electrification. The group then travelled on a 1990s single-deck, smooth-riding TGV to Paris Montparnesse, where the tour ended.

Bordeaux Place de la Bourse.

Lessons learned

These comments are typical:

Matthew Cooper from Angel Trains, one of the younger delegates, said: "The Annual Technical Tour gave me an opportunity to visit many sites that I would not have been able to visit as part of my normal role. This gave me the chance to learn how different companies are finding solutions to my day to day problems."

Bill Reeve, director of railways at Transport Scotland, a veteran of several tours, added: "It has unquestionably been a highly valuable tour - the challenging programme has ensured we have been kept intensely engaged throughout the week.

"I am convinced that such visits are essential for the development of young railway engineers and for the continued education and understanding of senior staff too. I know of no other method where I may obtain such strategic insight through benchmark visits at the same time as highly informed discussions with the deeply expert members of the technical visit group.

"Over many years now, I have found these visits to have been of great value in developing the strategy for Scotland's railways. I have no hesitation in recommending them to others, whatever the stage of their rail industry careers."

Thanks are due to the tour's sponsors, Angel Trains, Eversholt Rail and Unipart Rail, The University of Birmingham's Centre for Railway Research and Education and, especially, to Felix Schmid and Bridget Eickhoff, without whose efforts the tour could not have gone ahead. Felix also checked this text for technical accuracy and provided editorial input. Travel and hotels were organised by Ffestiniog Travel. Subject to sufficient interest from young entrants to the industry and support by experienced railway engineers, there will be a Railway Technical Tour in 2018. The provisional dates are 6 to 13 October 2018 and the Tour is expected to cover developments in northern Italy and the Swiss Alps. Expressions of interest can be sent to rail-tech-tour@talktalk.net.

ALL PHOTOS: PETER ALVEY

MALCOLM DOBELL

RRUKA Annual Conference 2017

Over 200 delegates attended the recent 2017 Rail Research UK Association (RRUKA) conference and exhibition, held at King's Place London. Luisa Moisio, RSSB R&D programme director and industry co-chair of RRUKA, reminded delegates that RRUKA exists to provide a link between the rail industry and academia through which problems can be shared and the results of work reported (issue 113, March 2014).

Trenitalia chairman and managing director Ernesto Sicilia, and the company's engineering director Marco Caposciutti, delivered the first keynote address.

Ernesto highlighted the opportunities in the UK - the most open rail market in the whole of Europe. He is delighted by the success of the c2c operation Trenitalia has bought from National Express and is looking forward to collaboration with First Group on the West Coast Partnership, bringing the experience of being the only high speed operator exposed to competition. It was also stressed that Trenitalia can draw on the experience of its infrastructure provider, also part of the FS group (Ferrovie dello Stato Italiane).

With the twin aims of improving customer satisfaction and reducing costs, Marco quoted three examples that typify Trenitalia's approach to innovation. Firstly, it has specified new high-speed trains with a capability to run at up to 360km/h, even though the current infrastructure only supports 300km/h, as it is confident that it will identify innovative ways of delivering the higher speed without building new infrastructure.

Secondly, Trenitalia is investing heavily in sensor and data solutions to enable maintenance based on condition/cycles of operation rather than time. Thirdly, solar panels are being installed on depot and workshop roofs to reduce energy costs.

Partnerships

Sharon Odetunde of RSSB and the University of Birmingham's Clive Roberts talked about academic partnerships, past, present and future. RRUKA now has a

membership of some 55 academic institutions. Sharon highlighted current research opportunities including a £500,000 research fund to identify data-driven solutions to some of the performance challenges, such as dwell time variations, reactionary delays and lack of berth availability, and so help increase capacity, improve punctuality, and reduce delays.

Clive introduced the UK Railway Research Network - UKRRIN. This has been developed in response to the Rail Technical Strategy, which called for innovations to be introduced faster with fewer of them "getting lost" between academia and commercialisation. A number of the UK's best academic research organisations have collaborated to propose centres to bring academics together to solve industry problems.

It would take a whole article to describe the process required to set them up, but there are to be four centres, supported by government funding of £28 million for capital investment, and £64 million pledged by 17 industrial partners, with support from organisations in the public sector such as Transport for London and Network Rail. The centres will be:

- Digital Systems, led by the University of Birmingham;
- Rolling Stock, led by the University of Huddersfield in collaboration with Newcastle University and Loughborough University;
- Infrastructure, led by the University of Southampton in conjunction with the University of Nottingham, the University of Sheffield, Loughborough University and Heriot Watt University, Edinburgh;
- Existing testing and trialling facilities.

A formal launch will take place early in 2018 and they are due to start operation on 1 April 2018.

It is planned that there will be a consolidation of RRUKA and UKRRIN academic institutions to deliver five core functions - the link to industry strategies, promotional activities, bridging services, capability mapping and the route to market.

The proposed structure for academic engagement will start with the UKRRIN centres stated above with partner universities supporting delivery in core areas and affiliate universities providing cross-discipline skills that are of value to the network as a whole, in areas such as human factors, economics and education. Clive pointed out a number of risks in delivering this plan, which will need careful mitigation.

Robotic servicing

Following a conference programme full of presentations and debate, it is impossible to report on everything. However, certain topics stood out as being relevant to today's (or even tomorrow's) railway.

Neil Drury from South Western Trains introduced three presentations on the theme of robotics and autonomous systems for rolling stock maintenance. All were funded through RSSB while the first two of which were also supported by Chiltern Railways.

The results of a feasibility study on the robust automated servicing of passenger train fluids were presented by Mark Atherton, Brunel University. His team has worked closely with Chiltern Railways to understand the nature of fluids that need routine attention, including windscreen washers, toilet effluent, toilet clean fluid, washbasin & catering water, and sanders together with the locations of the various fillers. Two concepts have been developed which suggested very significant savings in the cost of staff required to replenish fluids - a nasty, smelly and potentially risky job often carried out in the open.

To safely and reliably attach the robotic devices to the train, and afterwards reseal the train fillers, Brunel has used rapid prototyping to develop a number of potential devices. The concepts have attracted much interest and next steps include developing proof-of-concept for connectors and port interfaces including lab tests. They will shortly commence an InnovateUK project with TBG Solutions »

and Chiltern Railways to develop a working prototype for field tests. Mark said that industry involvement is key to getting the technology to market and that "we welcome additional partners".

The Cab-Front Cleaning Robot was introduced by Tetsuo Tomiyama of Cranfield University. The problem to be addressed is that cab front cleaning is often a manual activity, is hazardous for the staff (awkward positions, working at height, electrical supplies in the vicinity) and the result is often not very good! The latter point is also true of the automatic cab front cleaning machines on the market today. Cleaning between cars is quite rare.

Cranfield aimed to develop a proof-of-concept prototype of a semi-autonomous robotic cab front cleaner, with versions for in-between the carriages, which would be low cost, robust, and easy to use. The project included system design, mechanical arm design, cleaning head design, designing control algorithms for the arm position, and building a one-eighth scale model to demonstrate the concepts.

Tetsuo explained that the brush design was critical. The force on the brush must be high enough to provide the scrubbing action but not so high that it scratches the surface. The brush also must be controlled to remain parallel to the surface being cleaned.

The other key issue was control of the cleaning arm movement. For comparatively simple cab fronts such as that in class 168/170 Turbostar trains, the control strategy needs no pre-knowledge of the design - the system works it out from the starting point (set manually or from a visual sensor) and then scans the cab front whilst both maintaining constant force and avoiding windscreen wipers and handles.

For more complex front ends, for example trains with corridor connections, visual information must be supplemented by a CAD model of the cab front.

Tetsuo concluded that a cab front cleaning robot is realistic, is likely to be cost effective and overcome all the problems seen with today's systems. It is also capable of being expanded to clean both coupled cabs and gaps between cars. His parting remark was "on to the full-scale version!"

Reworking wheelsets

Stephen Kent, from the University of Birmingham, talked about the feasibility of the use of autonomous robotic systems for wheelset reworking, especially using laser welding to restore worn wheels.

Normally, after four or five visits to the wheel lathe, wheelsets have to be replaced as all of the machining allowance has now been used up. Whilst this can usually be planned to coincide with bogie overhauls, it is very costly - wheelset maintenance typically accounts for around 20-30 per cent of total vehicle maintenance costs for passenger vehicles. It would therefore be good if material could be added back on to avoid changing wheels.

The work was split into three phases:

- Industry consultation: wheel users and maintainers explained issues, constraints and value to the industry which indicated that a significant saving is available if wheels could last multiple bogie overhaul intervals.
- Robotic Control Development: involved developing the algorithms appropriate to the railway environment rather than the factory production line environment.
- Inspection Technology: the results indicated the best wheelset inspection approaches would be phased-array ultrasonic, and magnetic flux leakage.
- Repair Technology: the most promising additive process is laser deposition as it is highly controllable and minimises heat input.

Whilst no fundamental technical barriers to laser deposition had been identified, Stephen emphasised that repairing wheels is challenging as it is difficult reliably to obtain the correct microstructure and it is tricky to achieve the required wheel rim compression with additive processes. Even assuming these difficulties could be overcome, wheels are single point failure/safety critical items and thus the railway's approvals process would be difficult and time-consuming.

Stephen said that there are many other ways to extend wheel life and maximise fleet availability before investing in additive repair. One attractive possibility, however, is to apply a low friction material to the flange for routes with sharp curves, or look at additive rail repair, something that would be easier to achieve and arguably of higher value.

In a nutshell

Roger Goodall of Universities of Loughborough and Huddersfield introduced a number of elevator pitches - four to five minute presentations.

The University of Huddersfield has been working on a low adhesion braking dynamic optimisation for rolling stock (LABRADOR) simulation model. Hamid Alturbeh briefly described the objective as being to develop a computer simulation tool to predict the braking performance and behaviour of a range of multiple unit passenger train types in normal and low adhesion conditions. This will provide a means of investigating:

- Root causes of occasional 'very long' train slides;
- Different brake blending strategies;
- Adhesion gains that different sander placements and/or delivery rates might provide;
- The benefits of a true train speed value to assist low adhesion braking;
- Comparison of current train brake control strategies to identify best practice;
- Improved brake control strategies to improve existing trains cost-effectively.

Hamid said that a model had been built in Matlab/Simulink, integrating all the subsystems of the train and track that affect braking. LABRADOR simulates braking system configurations under varying track gradient and adhesion profiles. So far, it is developed for one to four car trains but the model can be extended to represent longer trains and model brake systems for any rolling stock.

Tingyu Xin described the University of Birmingham's research into railway pantograph dynamic behaviour measurement and fault diagnosis. Pantograph faults may cause poor current collection, loss of energy supply, reduction of system life, lower reliability, as well as increased maintenance cost and downtime.

The project proposed that it is possible to develop a pantograph dynamic behaviour measurement device that will enable condition based fault diagnosis and maintenance. Dynamic tests have allowed characterisation of critical pantograph parameters and have shown that key faults can be detected. The next phase of the research will work towards transferring the laboratory system to a depot environment.

At the University of Huddersfield, Gareth Tucker has been studying how deployment of available rail steels can reduce life cycle costs. Previous research has focused on investigating vehicle-track characteristics to reduce wheel-rail forces and less effort has been spent on increasing rail steel's resistance to the imposed forces. Rail manufacturers have recently developed new steels, such as British Steel's HP335, which provide improved resistance to wear and RCF.

Experimental testing was undertaken to understand the performance of current rail steels. A laboratory twin-disc facility has been developed for future testing of rail steels under more realistic contact conditions and further work controlled testing and microstructural assessment is proposed to cover more rail steels.

Stuart Hillmansen (left) and Alexander Knight-Percival.

Case studies

Stuart Hillmansen of the University of Birmingham and Trevor Dowens from Ricardo Rail presented the SmartDrive Project. A variety of technologies, such as automatic train operation (ATO) and driver advisory systems (DAS), have been proposed or introduced to minimise energy consumption for a given run time. The SmartDrive project is proposing a driver-centric system which would deliver savings by driver education.

Working with Edinburgh Trams, the team calculated the optimum speed-distance curves for all the inter-stop runs to deliver the run-time required and assessed where cues for drivers might be required - for example by introducing coast boards. During night-time trials, trams that were driven by drivers briefed on the new process achieved an average energy saving of around 15 per cent.

Iain Roche, head of innovation at HS2, delivered a second keynote address. Iain »

Iain Roche, head of innovation at HS2.

said, for him, innovation is about coming up with solutions to HS2's key challenges:

» Passenger experience;
» Design and aesthetics;
» Safety, health and wellbeing of staff, passengers and neighbours;
» Delivery/construction excellence;
» Logistics, with 130 million tonnes of spoil to move and, mostly, re-use;
» Robust operations;
» Sustainability.

Iain went on to describe examples of how innovation is already helping:

» BIM - to be able to demonstrate in models that HS2 can be built;
» Condition monitoring - with trains running at 300km/h, one needs to be confident the infrastructure will be working and intact;
» Sustainable materials to reduce the embedded carbon footprint;
» Remote survey using drones and satellites to identify materials and monitor progress;
» Nearly at market is an automated method for changing tunnel boring machine cutting teeth to eliminate a hazardous and unpleasant manual task;
» A new chemical technique for removing asbestos and turning it into an inert material that can be used in aggregate;
» Copied from Crossrail is the provision of extra bores to provide sources of heat free-of-charge whilst undertaking grouting operations - at little extra cost to the project but of great future benefit to neighbours.

Ian concluded by describing some of the processes being used to encourage innovation. These include hacks - use some real data, indicate desired outcomes and encourage analysts/software writers to come up with solutions - innovation forums and an innovation hub where people might post ideas. All of these are intended to break down barriers and encourage working together.

Analysing collaboration

The final presentation was from Alexander Knight-Percival, of Unipart Rail and Manchester Metropolitan University, who had just received the RRUKA Best Young Researcher Award for his work on mapping of the electromagnetic environment on the railway and condition monitoring of signalling assets. It involved using trains to monitor the performance of track circuits, which can be unreliable, but rarely fail without giving some sign of impending failure.

Alexander cited the successful installation of infrastructure-based monitoring of London Underground Victoria line track circuits, which has eliminated service-affecting failures. Alexander had decided to measure the magnetic fields created by track circuits using a very sensitive sensor on board a train. This was tested in practice with the sensor built into a housing mounted on the bogie and connected to a portable module containing a GPS system, analogue to digital converter and hard disk storage.

A vast quantity of data, some 10GB per hour, was collected and analysis showed that the concept works. Alexander showed how track circuit signal strength can be colour coded and plotted on a map of the railway, allowing easy comparisons to be made. Once areas of concern are identified, it is possible to use the base data to see exactly what is happening.

Alexander concluded that his work opens the way to bring track circuit condition monitoring to much of the network at low cost.

This was the final example of the collaboration between industry and academia.

Summing up what had been a very interesting day, the conference was closed by Stuart Hillmansen, senior lecturer in electrical energy systems at the University of Birmingham and academic co-chair of the RRUKA. He said that the day's discussions had illustrated the need for continued research and innovation in rail, and demonstrated the high level of interest and investment in the sector at present.

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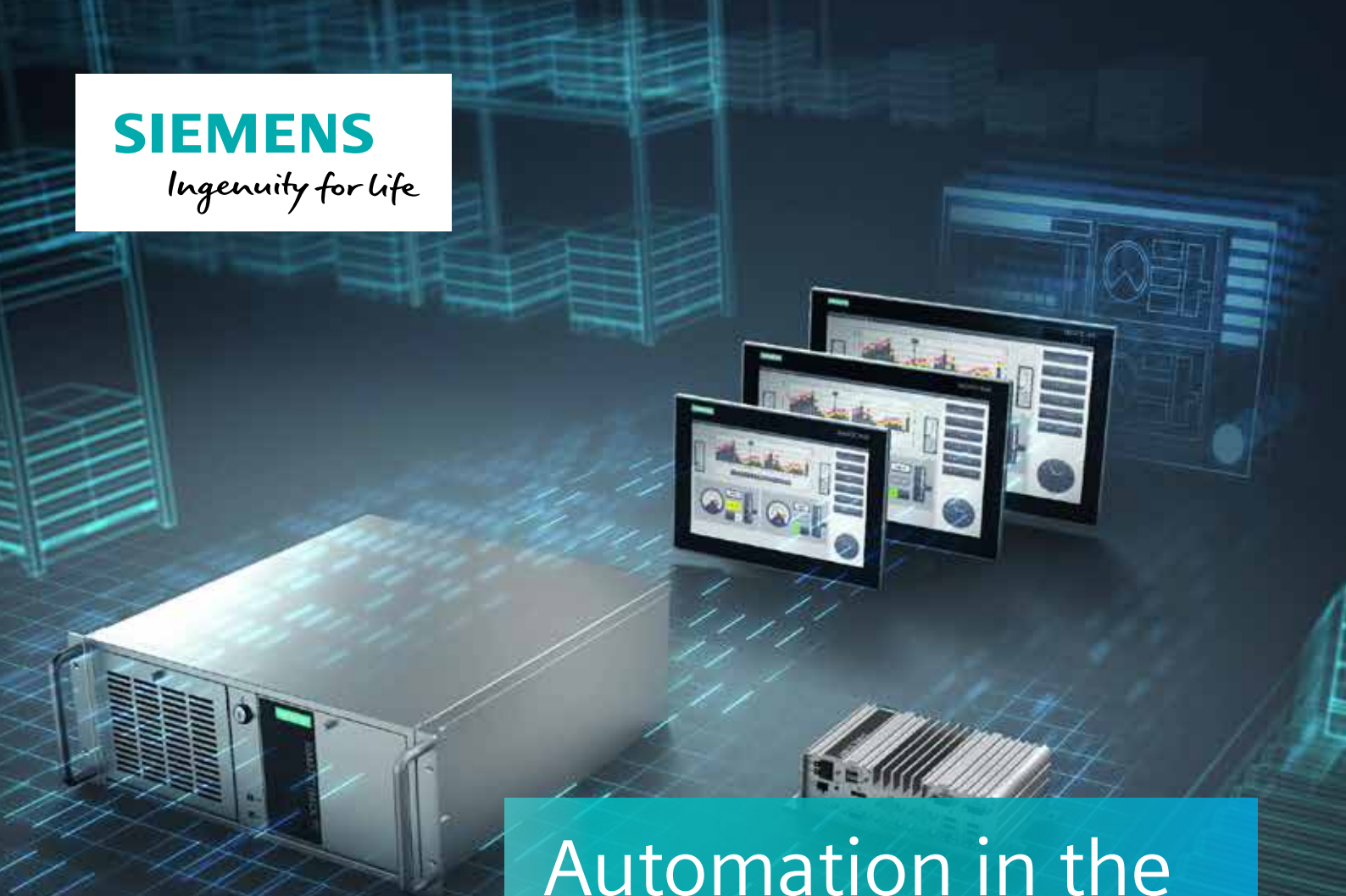

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