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DIGITAL RAILWAY

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- David Waboso reveals next steps for DR
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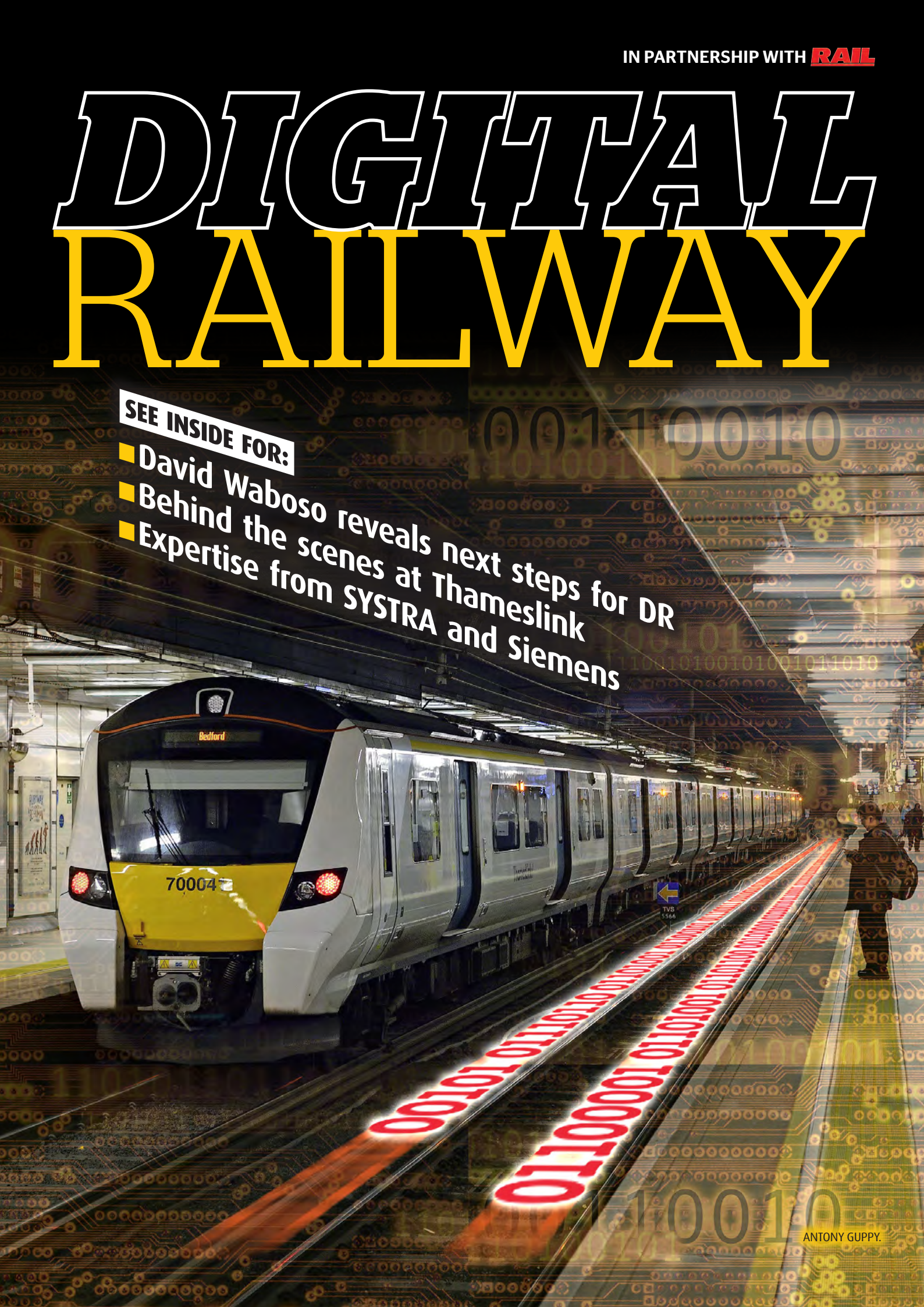

ANTONY GUPPY.

Digital Railway's next moves...

Govia Thameslink Railway 700037 meets classmate 700027 at St Pancras International on February 15. The former has come to a stand next to an ETCS marker board installed in preparation for May, when these trains will begin running under the control of Automatic Train Operation and ETCS at this station. ANTONY GUPPY.

As first phase schemes including Thameslink and Crossrail move closer to completion later this year, Network Rail's Managing Director for Digital Railway **DAVID WABOSO** outlines his vision to **PAUL STEPHEN** for where the DR programme rollout will go next

2018 is shaping up to be a historic year for NR's fledgling Digital Railway programme, as it nears its two most significant milestones to date.

The first will occur in May, when up to 18 Thameslink services per hour will commence running through central London under the control of European Train Control System (ETCS) Level 2 and Automatic Train Operation (ATO) technology. It will then rise to 24 trains per hour in December 2019.

Also in May, Crossrail services are currently scheduled to start operating under the supervision of ETCS between Heathrow terminals and Heathrow Junction. They will eventually run through to Paddington using ETCS by December 2019, although delays in the testing of signalling equipment on-board Crossrail's fleet of Class 345 Aventras are likely to affect this timetable (*RAIL* 846).

The term Digital Railway (DR) was first coined in 2015, and therefore several years after Crossrail and the Thameslink Upgrade programmes were first conceived. Even so, equipping sections of these main lines with ETCS (the signalling component of European Rail Traffic Management System, ERTMS) will mark the first large-scale deployments of digital signalling technologies in the UK away from metro systems such as London Underground, where ATO and in-cab signalling first appeared as long ago as 1968.

They will therefore both be claimed as early victories for DR's Managing Director David Waboso, who made clear to *RAIL* 12 months ago that supporting these independently governed schemes would be the first step in a carefully considered and incremental migration of DR principles to the rest of the network (*RAIL* 819).

Having been appointed to the role in June 2016, Waboso had quickly dismissed any notion of a more rapid 'big bang' mass rollout, in favour of this more sensible 'bottom-up' approach.

His justification for setting a more cautious policy direction was rooted not only in the considerable experience he was able to call upon from delivering complex digital resignalling projects for LU's Jubilee, Victoria and Northern lines (see panel, page 52), but also having to make his decision against a backdrop of limited funding. Meanwhile, he had inherited a DR programme beset by delays, false starts and failed commitments - for example, the planned installation of more experimental ETCS Level 3 moving block technology on the Wherry Lines by 2019, which was eventually shelved in August 2016.

Crucially, Waboso also wanted to substantially de-risk an enterprise which has many implementation challenges - not least integrating new technology with existing systems, the limited delivery experience of ETCS in the UK, and the complex logistics of fitting rolling stock with on-board equipment.

Now able to pause and reflect a full year later, Waboso still stands by that early judgement call, adding: "I think we had to instil a sense of pragmatism, and that's been the ambition. We need to try and see where the needs and capacity challenges on the railway can be solved by this technology, while aligning it to a business case-driven point of view.

"This will allow us to build on first phase schemes and get a solid foundation from those this year and early next year, before engaging on a plan for Control Period 6 [NR's next five-year spending period between April 2019-March 2024] and beyond. But we have to think about how we can do this in a sustainable way.

"The technology base is largely there as, quite frankly, this is not cutting-edge stuff and train control technology is nearly 40 years old. It's just that the logistics [of transferring it to main line railways] are pretty large."

Waboso and his team are currently engaged in devising a final implementation strategy for DR in CP6 that is fully aligned to NR's *Strategic Business Plan* (SBP). Published on February 13 (*RAIL* 847), the SBP confidently predicts that CP6 will herald "the end of analogue signalling" renewals and "the real start of Digital Railway".

It also provides some clues as to what Waboso's final DR strategy will look like, although whether sufficient funding can be secured for his proposals remains subject to both internal and external review before the Office of Rail and Road publishes its Final Determination on the SBP in October.

Nevertheless, the document reveals that much of the DR focus until 2024 will be on the extensive deployment of traffic management (TM) systems and Connected Driver Advisory Systems (C-DAS).

By providing real-time running information to drivers (or on-board ATO equipment if it is installed), and instructions to optimise performance, these systems can either complement ETCS or be used in isolation to combat any delays arising from the extra services that ETCS enables (or at any other times during disruption).

Waboso says this will provide a quick and cost-effective way to 'front load' many of the performance benefits offered by DR, until business cases can be approved for full in-cab signalling and all the new onboard and trackside equipment that it requires.

He explains: "At the moment, drivers get very little information except an aspect and a radio. This will help de-conflict the timetable by telling the driver to speed up, dwell, or whatever else.

"The other great thing you can do for the train operating companies with TM and C-DAS is to link it to crew and stock management. Perturbation puts them all in the wrong place, so having a computer to link it to will give you the best solution.

"Generally speaking, the business case for TM and C-DAS tends to be shorter and much shallower than ETCS. And because it's less intrusive on the existing signalling system, it can be done relatively cheaply and quickly."

Waboso says that a handful of targeted ETCS schemes will still go ahead in CP6, however, with business cases being prepared for where its deployment is most cost-effective.

This will be where it can be most closely aligned with major signalling renewals already due to take place, and where the considerable cost of retrofitting trains with on-board equipment can be avoided.

The potential expense associated with the latter was most clearly demonstrated in December, when NR signed a contract with Siemens worth up to £150 million to equip 750 'first in class' freight locomotives with ETCS equipment and software (*RAIL* 843).

A much more cost-effective option is to wait until new trains are ordered, and to specify the inclusion of this equipment by the manufacturer (as was the case with Thameslink's Class 700s). Alternatively, most new fleets are now delivered 'ETCS compatible' - equipment can be fitted far less intrusively at a later date than is the case with older stock that has no such provision, although this is still more expensive than fully fitting ETCS from the outset. ➤

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>
> **David Waboso,**
> ***Managing Director for Digital Railway, Network Rail***

➤ Says Waboso: "Until now, it's been OK to procure trains and infrastructure separately, because provided things such as EMC [Electro Magnetic Compatibility] and other standards are met, they're not really interlinked.

"ETCS essentially brings them both together, so you have to look at where you have new trains that can be fitted and where you have resignalling going on, to give you the best business case.

"Your worst business case is where you have to bring forward signalling and throw things away you've already invested in, or where you have to retrofit a huge number of trains - which is why we're keen to fit them in the factory. It's almost an act of vandalism to take a brand new fleet and then take them apart to fit this stuff. We therefore want to avoid that at all costs, because it's expensive, disruptive, and [train] performance is never quite the same afterwards."

According to the SBP, the ETCS schemes that are likely to be given the go-ahead for digital resignalling in CP6 include the trans-Pennine route between Manchester and Leeds, and the southern portion of the East Coast Main Line between King's Cross, Moorgate and Peterborough.

The Feltham Resignalling Project, the Great Eastern and South Western Main Lines, and Crewe's interface with HS2 are also being considered. These could potentially be paid for from sources including NR's £4.5 billion CP6 signalling renewals fund, the National Productivity Investment Fund, enhancement funding from the Department for Transport, contributions from HS2, or third-party funding.

DR schemes in CP6 will most likely comprise ETCS Level 2 overlaid onto conventional signalling systems (which will have to be retained or renewed to accommodate the large numbers of trains in service that will remain unequipped for in-cab signalling).

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Because of this, a second wave of CP6 renewals schemes are also currently being identified to be made 'DR-ready'. Although they will not be equipped with 'live' ETCS equipment, they will be relatively simple to upgrade at a later date once more trains have been fitted with in-cab signaling (or older trains are retrofitted).

Only then will NR have the realistic choice of either replacing existing signalling like-for-like, or removing fixed lineside signals and upgrading to ETCS Level 3 full moving block signalling.

Waboso predicts that this point will be reached in CP7 (2024-29), when more than 7,000 new carriages will have entered service (according to Rail Delivery Group figures), and up to 63% of NR's 64,000 signalling equivalent units (SEUs) will have had to be renewed.

These two factors will give Waboso much of the alignment he needs to produce robust business cases for DR, potentially resulting in a surge of digital-only projects.

"We think there are three or four areas where there is pretty good alignment, like trans-Pennine where new trains for Northern [currently on order from CAF] will be fitted or enabled and the line is due a big upgrade anyway. Interestingly, you also have the Crewe resignalling and the introduction of new trains for HS2 towards the back end of CP6, and so there's a big opportunity to create additional capacity for these trains to travel through to Manchester.

"We have the East Coast Main Line, where a huge resignalling is due and you'll have a lot of trains already fitted (or compatible) for ETCS like Thameslink's Class 700s and Virgin Trains East Coast's Azumas. But then the big opportunity will be in CP7.

"DR-ready means that when we come back to do the final DR, no more cost or closures are needed. It's the equivalent of digging up a road twice so you put all the cabling in, hardware, power supply and trackside connections so that when you come back, it's just about installing that final software and flicking a switch and running some tests.

"The big opportunity is in CP7, when the bow wave of signalling renewal projects really hits because people have been deferring resignalling until DR comes in. But in CP6 you start to get an industry base and some capability, expertise and products, and then we'll have this massive introduction of trains.

"I think the big prize is in CP7, to not go and replicate infrastructure with lineside signals and ETCS. But because I don't have all the trains fitted, in CP6 there will be a need to have a degree of infrastructure for non-fitted trains. Once they are fitted, subsequent resignalling can then be all digital, which starts to give you the big OPEX [operating expense] savings."

He adds: "The opportunity exists because of these two emerging facts - a huge number of trains to be fitted in the factory, and this huge amount of resignalling. Those are two historically significant facts for the rail industry and if it doesn't get its head around that, then in my view DR will not happen for another 30 or 40 years, when the next cycle comes along with this volume of resignalling."

A failure to grasp this opportunity to modernise its asset base would also increase the threat posed to rail by other modes of transport, says Waboso. He points to the number of autonomous road vehicles that are reaching increasingly advanced stages of production.

There is also a financial imperative for NR to realise the cost savings associated with DR as soon as possible, by reducing the amount of trackside infrastructure required and moving to a new remote condition-based maintenance regime. This can only be realised by reaching ETCS Level 3, which will enable DR to fully dispense with asset-heavy analogue signalling and the more labour-intensive and disruptive maintenance it requires. ➤

Network Rail 313121 passes Bowes Park reversing siding on February 15, with a test train from Willesden TMD to Watton-at-Stone. The train is used to test in-cab signalling and ETCS on the Hertford Loop, from its base at the Digital Railway-owned ETCS National Integration Facility at Hitchin. ANTONY GUPPY.

Northern 323228 approaches Crewe with the 0904 local stopping service from Manchester Piccadilly on October 7 2017, while Virgin West Coast 221105 and 221106 approach forming the 0652 Edinburgh-London Euston. The area is due to be resignalled by 2024, and is in contention to become a Digital Railway Phase 2 scheme. JOHN STRETTON.

EUROPEAN TRAIN CONTROL SYSTEM

ETCS is a signalling system that relies on central interlocking issuing movement authorities (MAs) to drivers of trains via either trackside balises (in Level 1, which usually also features signals) or via radio (in Levels 2 or 3).

The MA tells the driver how far he can travel, in the same way that a yellow aspect tells a driver he can only proceed as far as the next signal.

On-train equipment calculates how fast the train can go according to how long its MA is. Calculating the speed depends on factors such as gradient, train weight and braking performance.

In Level 2, trackside detection equipment such as track circuits or axle counters tells the central interlocking where the train is. In Level 3, this is removed and the train calculates and broadcasts its own position. This can be by using odometers to measure distance travelled and balises placed on sleepers to provide fixed reference points. Attention is turning to the use of systems such as GPS to determine position.

Radio links come courtesy of GSM-R, but more advanced systems are being investigated to overcome its limited capacity.

According to European definitions, when ETCS is linked with GSM-R it become ERTMS (European Rail Traffic Management System). Today's traffic management software allows better real-time train planning to cope with short-notice needs or disruption.

Ideally, as part of the Digital Railway, such software would allow train operators to run short-notice relief trains or extra trains to cope with major events, by having a more accurate understanding of a line's real capacity. It could allow more flexible timetables, perhaps to cope with school holidays or other yearly changes in demand.

➤ This is likely to result in considerable changes to current working practices, although Waboso is keen to stress that greater automation is not a ruse to reduce the size of the workforce.

"Nothing I've spoken about is a threat to anyone's job, and this has never been about job-cutting - it's quite the reverse. This has been about creating more capacity and making the industry more competitive for the next generations, so it is very much a vote of confidence in the future of the industry. If anything, this will increase the number of jobs and skills across the industry.

"But if this doesn't happen, then we are essentially continuing to use all these Victorian principles. We have colour lights now, but fundamentally nothing has changed [from semaphore signalling]. You can drop a track circuit in here and a light bulb there, but the driver is still looking at it.

"What I've learned in this job is that you have to really explain the principles first to everyone, because although it seems obvious at the end it's about joining lots of previously disparate things. And so the railway community - government, funders, train operators, routes and the Department - must start with an understanding that the industry has to remain competitive.

"You will be seeing metro technology shamelessly adopted by cars, which is all basic moving block technology. You have drones and platooning of freight vehicles and coaches, so other things will start to look and feel more like trains in mass transit, but at a fraction of the cost of our stuff.

"That's our competition and we have to be alive to that, and not just carry on saying: 'it's OK, it's not happening, please keep giving us the money'."

Alongside funding, the other outstanding question for Waboso is how he intends to procure the various aspects of DR.

In an Early Contractor Involvement report published in December 2016, Waboso argued that the cost of installing, maintaining and operating DR assets could be reduced by 10%-30% by fundamentally altering the nature of relationships between NR and its suppliers.

Unlike traditional procurement in signalling, the report advocated exploring alternative funding mechanisms for DR - shifting the focus of procurement towards brokering longer-term contracts that consider whole life asset costs, and rewarding suppliers for performance, innovation and collaboration.

This new approach is currently being trialled under a two-year contract signed by NR in July with Resonate, to trial its traffic management system on the Great Western Main Line.

Under the deal Resonate has paid to install and run the system, which has been designed to reduce delays by 15%. The company will then receive a percentage of the value of compensation payments that NR is able to save from reduced delays on the network.

Waboso says that NR has yet to finalise its signalling procurement strategy and continues to explore its options, but he is acutely aware that decisions must be made sooner rather than later to enable the supply chain to fully mobilise and effectively engage.

"Infrastructure is difficult because it's complex, safety-critical, intrusive, requires closures, and is expensive. So, in CP6 we're arguing that we should take a chunk of the money that's in the SBP and allocate it to DR.

"We're assembling the bare bones of a plan for CP6, and we're talking to funders, stakeholders, operators, infrastructure managers and the supply chain so that people can at least begin to align themselves behind it. But the main thing for CP6 is that we've really got to start going to market this side of April 2019, which is all subject to getting finance in place.

"We think there is a large amount of market appetite to provide TMS [to NR] in more of a service way, as shown by the Resonate trial, and that they [suppliers] will take payment based on performance.

"Whether you can buy ETCS as a service or whether it has to be procured like a conventional bit of kit, we're still exploring. We need to work through that in terms of details and logistics, but one thing we certainly want to do is build on the ECI workshops and buy it through this new way of doing business.

"The supply chain has told us very clearly that they want to work on whole life, route-based, outcome-based procurement with payment for performance, and we're a fair way down the runway on working all of this out."

For rolling stock that is privately owned, financed and operated, Waboso concedes that NR will potentially have to fund the fitting of in-cab signalling in older trains that lack any equipment and in 'ETCS compatible' fleets, if it wants them to start running using ETCS. Private asset finance might also be considered.

For new trains, it should be possible to include it in specifications issued by rolling stock companies, operators or the DfT at little or no cost to NR.

How quickly fitment can be completed will dictate the overall pace that ETCS Level 3 can be reached, and so Waboso is calling for a sizeable portion of the £4.5bn CP6 signalling fund to be dedicated to this purpose.

"We have 64,000 SEUs on the network and 40,000 that need renewing in the next ten to 15 years, and if you multiply that by a notional unit cost, you quickly get to several billion. For me, the big picture that's emerging is that ideally, we need to spend our money fitting the trains. That way, when you do this huge amount of resignalling, it's so much cheaper.

"It's chalk and cheese because colour light signals, bases and gantries - that's where all the money goes. Tomorrow's signalling needs much less trackside infrastructure and is all software-based, so it's almost a different gig.

"This is a strategically important decision for us. If we do it, we can probably do it within existing funding anyway, because the cost of resignalling will more than pay for fitment. And then all the benefits we talk about - faster line speeds, increased capacity and performance - we'd get for free."

Finally, *RAIL* puts to Waboso that NR will lose one of its greatest DR advocates when NR Chief Executive Mark Carne retires later this year.

Carne is a staunch personal champion of the programme, but Waboso does not feel that his departure will affect the strong momentum that DR has established, nor prevent any further progress.

He concludes: "He [Carne] created this programme and gave me my job, but the trick with these things is to make it independent of whoever's in charge. Initially you need individuals to push and prod, but I think we've got enough momentum now to see it through, and so his legacy will live on." ■

Further reading

■ *A level-headed approach - RAIL 819.*

DAVID WABOSO CBE

David Waboso joined Network Rail in June 2016, and is an engineer and project manager who has worked for engineering and consultancy firms on infrastructure programmes.

He led the upgrade of the Docklands Light Railway and the completion of the trains and signalling system for the Jubilee Line Extension. He worked on Thameslink and train safety programmes, led cross-industry programmes on ERTMS at the Strategic Rail Authority, and from 2005-16 he was the engineering director (then capital programmes director) at London Underground, leading a £10 billion upgrade programme.

Waboso is a chartered engineer and a fellow of the Royal Academy of Engineering, the Institution of Civil Engineers, the Institution of Railway Signal Engineers and the Association for Project Management. He was made a CBE for services to transport in London.

Direct Rail Services 66431 passes Nuneaton on January 22, at the head of the 1047 Daventry-Wentloog intermodal service. 750 'first in class' freight locomotives will be retrofitted with ETCS in-cab equipment under NR's Digital Railway programme. GRAHAM NUTTALL.

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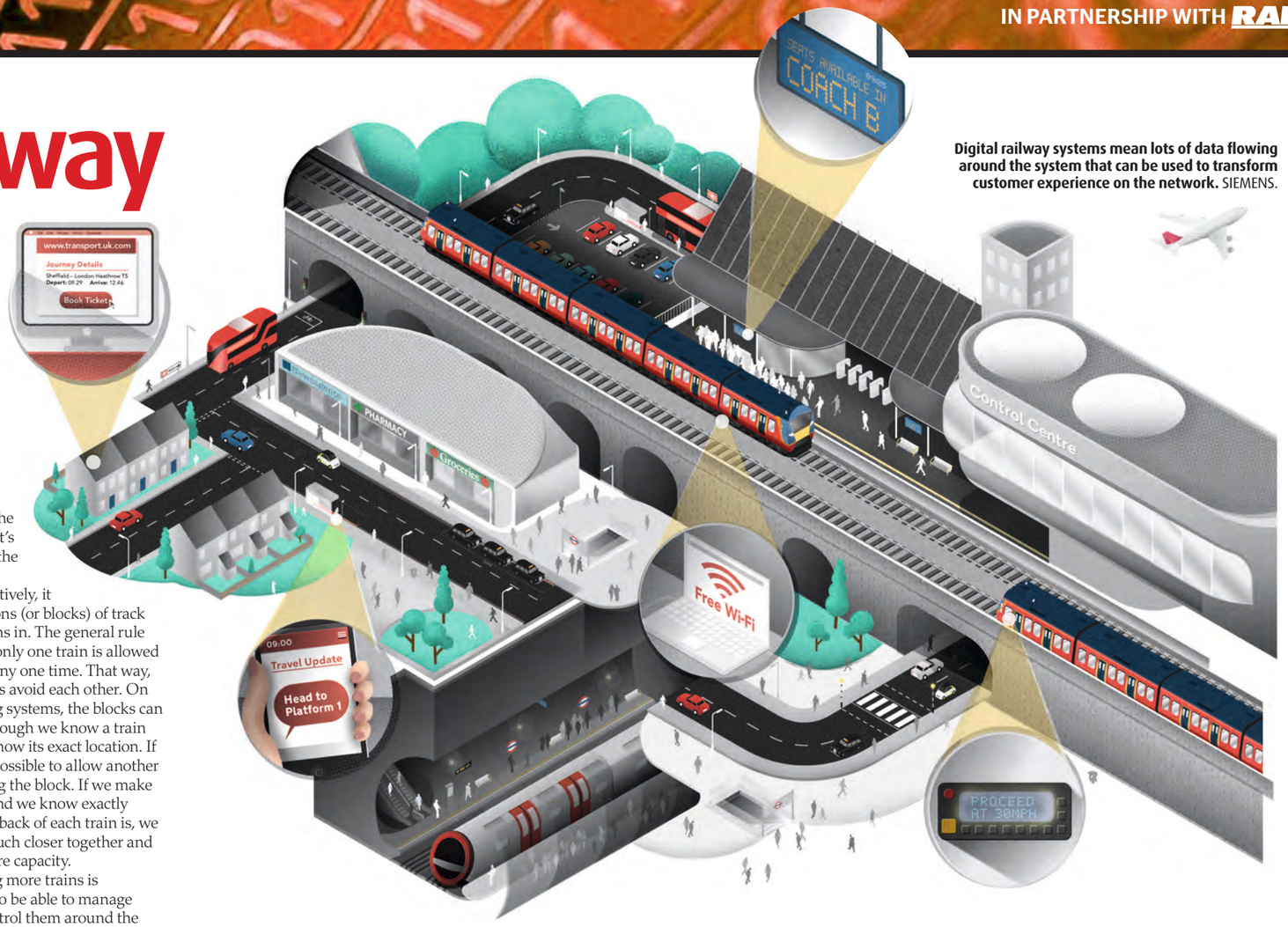
A vision for the railway of tomorrow

Siemens Operations Director for Digital Railway MARK FERRER tells STEFANIE FOSTER why digital technology will transform the network in the UK and beyond



Digital railway systems mean lots of data flowing around the system that can be used to transform customer experience on the network. SIEMENS.

The technologies and principles that we apply to today's railway are fundamentally the same as those we applied back in the 1960s. Advancements have been made, but the rules remain the same. When you consider the transformations in other parts of our everyday lives, the railway seems like a dinosaur. Look at the telephone. Back in the 1960s, owning one was a luxury and you dialled numbers by spinning a wheel with your finger. Fifty years later and much of the population is walking around with a smartphone in their pocket, connected to the rest of the world all the time.

"The railway needs to move into that modern age," says Mark Ferrer, Siemens Rail Automation's operations director for Digital Railway. "We can improve capacity on the railway by the application of appropriate technologies. I say appropriate because it's not a one-size-fits-all answer. We don't necessarily need to go and put high-technology, high-complexity systems in everywhere."

Digital railway technology and principles are not new. They have existed in the world of metro railways for years, but Ferrer says they now need porting across to the main line, which is something Siemens is doing as part of the circa-£7 billion Government-sponsored Thameslink programme.

"Thameslink is a digital railway. It encompasses every part of the digital railway concept that we would need but, importantly, we have lots and lots of data flowing around that can be used to bring new benefits."

In future, data capture and subsequent analytics could help transform the customer experience - the ability to inform passengers better as to what is going to happen on the railway during their journey or just before their journey, as opposed to them turning up and finding out that trains aren't running, or that there has been a failure.

Ferrer explains: "We will be able to start predicting what is going to happen on a digital railway through all the data we will gather from trains and trackside infrastructure, provided that we capture that data and run analytics on it. So, we will start to spot trends in what led up to an incident, such as a delay or cancellation. By using those trends in the future, we can predict that something is going to happen and take pre-emptive action. On Thameslink, we have equipped all of the trackside infrastructure with remote diagnostics, enabling Network Rail to monitor the performance of the assets and start to identify trends."

That use of Remote Condition Monitoring (RCM) on Thameslink will allow for predictive maintenance of the infrastructure. Rather than a 'fail and fix' methodology, the systems can predict that something is going to fail, so that it can be maintained or replaced before it does.

With increasing levels of traffic, the potential for disruption and the impact caused by the failure of an asset becomes greater than ever. Therefore, the remote condition monitoring of assets, for example trains, signalling equipment, civil structures, communication systems and the track becomes an essential tool, with the added benefit that information gained from one system can be useful in finding out about the status of other systems - for example, on-board systems can give an indication of the track condition.

The fundamental principle behind the Digital Railway and its deployment on Thameslink is an increase in capacity through the deployment of Automatic Train Operation (ATO) over ETCS (European Train Control System), which exists at different levels - in the case of Thameslink it's Level 2, overlaid on the existing system.

Says Ferrer: "Effectively, it provides more sections (or blocks) of track that we can run trains in. The general rule of signalling is that only one train is allowed in any one block at any one time. That way, the trains will always avoid each other. On traditional signalling systems, the blocks can be quite big and although we know a train is in one, we don't know its exact location. If we did, it might be possible to allow another train to start entering the block. If we make the blocks smaller and we know exactly where the front and back of each train is, we can get the trains much closer together and so start to create more capacity.

"Of course, adding more trains is great, but you have to be able to manage those trains and control them around the infrastructure so they are at the right place at the right time and don't have to slow down, or stop and wait. That is all about timetable management, and that's where traffic management comes in."

On Thameslink, NR is deploying traffic management using Hitachi's Tranista product, with Siemens providing the enabling technology to control the trains in the central core. There are, though, a number of other technologies that can be deployed on a digitised railway to further increase capacity, of which ATO is an obvious candidate.

"ATO is really about getting systems to control trains, so we start to remove variations in the way trains are driven," says Ferrer. "Different drivers may have slightly different driving styles, so with ATO, we're making sure that trains are being driven at the optimum speed at each location along the track.

Other countries are watching what we are doing in the UK in terms of the deployment of new technologies.

Mark Ferrer, ***Operations Director - Digital Railway, Siemens Rail Automation UK***

"This enables operators to increase the accuracy of prediction, because if they know the performance of the train, the speed-distance profile it will follow and its exact position, all of a sudden the capacity increases which provides the opportunity to add more trains onto the network."

The knock-on effect of that predictability is that passengers are more confident in their train service. But ATO is not appropriate or cost-effective for every railway, so there is a secondary option for where trains are still being driven manually.

Says Ferrer: "With these digital technologies, we can inform the driver of the speed at which to drive the train for them to reach a given point on the railway at exactly the right time. That's where a Connected Driver Advisory System also comes into play, by transmitting information to the driver to slow down or speed up, or to advise them about events elsewhere on the railway that may affect their service.

"That has the potential to remove congestion and delays, which then increases the capacity of the infrastructure. The deployment of a digital railway using all these technologies removes the need to put signals trackside. We aren't there yet, certainly not in the UK, but some European networks are. On High Speed 2 the trains will be going so fast that the driver won't be able to see the signals, so that information has to be transmitted to the cab."

There are significant benefits to removing infrastructure from the trackside. No signals means no need to dig holes, fill them with concrete or maintain them, reducing costs and making for a safer workforce because there is less requirement for staff track-time. Reducing the infrastructure also means fewer bits of kit to go wrong, so the reliability improves.

Combining the best of available and future technology brings abundant benefits to the railway - increased capacity, reduced cost and improved reliability. But, as Ferrer explains, the secondary benefit is huge amounts of data. The key will be making use of it.

"There will be a point where it's possible to predict what tomorrow is going to look like and how the rail service is connected with other modes of transport, so as a nation, we will end up with a connected mobility strategy whereby everything becomes connected and congestion is removed. That can only be a good thing for the UK economy.

"But it also enables us to export that capability to other countries, with many of them in exactly the same situation as us, facing the same challenges of rapidly increasing demand. From a Siemens perspective, I see that lots of other countries are watching what we are doing in the UK in terms of the deployment of new technologies and they are starting to follow our lead. It is important for the UK to maintain that leading role in forward-thinking technologies and the application of them to solve transport problems because, if we don't, other countries will start to copy and overtake us." ■

Opened on time and to budget in July 2017, SYSTRA undertook the design and engineering of France's 7.5 billion euro high-speed SEA project between Tours and Bordeaux. The company's technical responsibilities included design of the line's digital signalling system using techniques which will now be applied in the UK. PASCAL LE DOARE 2018/SYSTRA.

Digital infrastructure

SYSTRA's Technical Head of Systems and Signalling DOMINIC TAYLOR talks to PAUL STEPHEN about the hidden challenges of railway data management

The digital modernisation of Britain's largely-Victorian railway network will reach two major milestones later this year.

From May, up to 16 trains per hour will be able to drive automatically through the Thameslink 'core' between Blackfriars and St Pancras International using a combination of European Train Control System (ETCS) Level 2 and Automatic Train Operation (ATO), before rising to 24tph by December 2019.

Meanwhile, from December 2018, Elizabeth Line services will be signalled using an ETCS/ATO combination and also a Communication Based Train Control (CBTC) system when travelling on different sections of the Crossrail route.

SYSTRA has been at the forefront of designing, testing and commissioning the digital signalling technologies that will underpin both of these projects for more than 15 years.

The international transport consultancy and engineering services provider has provided its extensive digital rail expertise to clients in eight different countries, and in a diverse range of contexts.

These range from overlaying ETCS, ATO and Traffic Management Systems onto busy urban routes like Thameslink, to its installation on new-build high-speed railways such as the 300km (187-mile) Southern Europe Atlantic (SEA) line that opened between Tours and Bordeaux in July 2017.

In the UK, the company has also delivered projects on rural lines, having been appointed by Network Rail in October 2006 to design and oversee, on the Cambrian Line, the delivery of NR's first ever deployment of in-cab signalling.

Where SYSTRA has emerged as a market leader, however, is in its deep understanding not only of the need for sophisticated discrete Digital Railway products from individual suppliers, but of the need to carefully manage the large amounts of configuration data upon which these systems depend to integrate with one another and act as a single system.

To design and test the complex interfaces between the different data feeds that individual components of in-cab and trackside equipment generate, SYSTRA has therefore pioneered the use of established virtual design tools such as BIM (Building Information Modelling) and the use of Infrastructure Digital Replicas for the first time in digital signalling projects.

SYSTRA's Technical Head of Systems and Signalling Dominic Taylor explains: "The challenges of data management are not always very obvious until you actually come to deliver a project, but we know that Digital Railway has a huge capacity for data consumption - and generation.

"With ETCS and in-cab signalling, there is a huge increase in the need for data accuracy when compared to conventional signalling, so that trains don't receive redundant information and end up stopping in the wrong place.

"But the big advantage of DR is that you can build the signalling system and test it for some time without installing it on a real railway. That digital infrastructure can be performance-tested off-site, as we've done for both Crossrail and Thameslink in order to limit the risks [of failure] when deployed."

According to Taylor, the use of BIM and Infrastructure Digital Replicas is especially important in the UK, where retrofitting digital technologies to existing infrastructure can be more complex than if building it from new, and where the opportunities for testing in situ are more limited.

He adds: "A lot of the current network runs through brownfield sites where there would be less time to integrate the new systems. Getting it wrong and causing operational disruption can be extremely costly and time-consuming to put right.

"We bring experience from across the globe of using our system engineering and BIM capabilities to help eliminate that risk, however. Having traditionally been applied to the construction sector, these are proven techniques that we're now applying to Crossrail and HS2. We've worked extremely hard for the last couple of years to bring these methods into the world of railway signalling."

SYSTRA's specialisms in Digital Railway technologies are not just limited to signalling, however, but also extend into the allied areas of asset data management, mobility as a service and timetable and capacity planning.

The company has therefore developed a suite of tools to help ensure projects deliver not only the headline benefits of DR in terms of increasing capacity and improving traffic management, but in Remote Conditioning Monitoring and enhancing the passenger experience from the diagnostic data being generated.

Once again, SYSTRA has been able to draw on its consultancy and engineering experience in other sectors to pioneer the use of innovative techniques that are new to rail.

Taylor says: "In terms of traffic management and timetable planning, we now have the capability to run advanced simulations to trial new service patterns intensively before we deploy them, and to study the implications of changes to existing services. This is helpful not just for planning new timetables but for re-planning services in real time in order to optimise how they respond to anomalies, which is a very exciting development of Digital Railway.

"You can also do a lot to replicate where assets are and collate information to get better management asset profiles. There's lots we can learn from other industries such as aviation about mitigating failures and ensuring higher availability of assets. We see lots of opportunity in this area, and it's something we're working on.

"Finally, offering mobility as a service and providing passengers with a more comprehensive product for their complete end-to-end journey is also an area where digital technologies can be very powerful. Rather than just selling a train ticket, diagnostic and real-time performance data can help connect rail services to other modes of transport, such as buses or taxis, to offer people more seamless and predictable travel, which reduces congestion and has environmental benefits." ■

> "The big advantage of DR is that you can build the signalling system and test it for some time without installing it on a real railway."

Dominic Taylor,
Technical Head of Systems and Signalling, SYSTRA

Core project

PAUL STEPHEN goes behind the scenes at Network Rail's Thameslink Programme, where final preparations are being made to switch from conventional to in-cab signalling on its central section in May

On May 20, the introduction of higher frequency Thameslink services through central London will commence to serve a wider range of destinations, including Peterborough, Ashford and Cambridge.

The timetable change will result in up to 18 trains per hour travelling in each direction at peak times through the Thameslink 'core', between St Pancras International and Blackfriars, which will rise incrementally to 24tph by December 2019.

This core section of Thameslink is a short two-track stretch of railway where routes from three different directions in the south and two directions in the north converge. The key to achieving a central core frequency of 24tph has therefore been to install ETCS (European Train Control System) Level 2 and ATO (Automatic Train Operation) digital in-cab signalling technology.

ETCS Level 2 is a step below full Level 3 moving block signalling, but nevertheless increases the number of available train paths compared to conventional signalling by having much shorter track circuit block sections. This reduces headways by enabling trains to run much closer together.

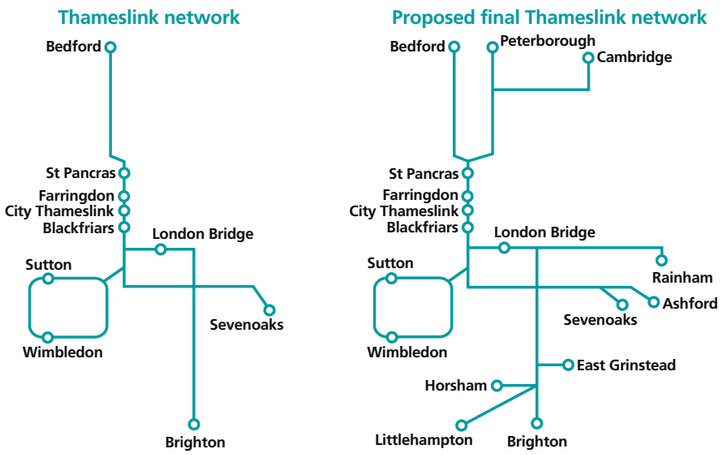
Alongside ETCS, existing lineside signals are being retained throughout the core for non-ETCS-fitted trains, while also providing a useful backup should it fail.

A traffic management (TM) system will also operate within a wider area of the core (broadly covering 20 minutes' travel time in all directions) from later this year to help keep performance as close as possible to the timetabled path of each train, and to mitigate the risk of late-running services.

Linking TM to Automatic Route Setting software will also help signallers based at Three Bridges Rail Operating Centre (TBROC) to recover the timetable in case of disruption.

Opened in January 2014, Three Bridges ROC controls signalling through Thameslink's central core, and is one of 12 Network Rail rail operating centres that will eventually control the entire network across the UK. NETWORK RAIL.

Changes to the Thameslink network from May 2018



The task of delivering this infrastructure falls to Network Rail's Thameslink Programme High Capacity Infrastructure (HCI) team, led by project director Martin Chatfield.

Based near Blackfriars station at James Forbes House (JFH), HCI began its journey in 2012 to extensively test and commission the digital signalling technology, both hardware and software, before it is pressed into full service in May.

The team's challenge is unique within NR. ETCS has never before been deployed on this scale on a UK main line. Another team is also working to install ETCS on Crossrail's western section, but ETCS Level 2 has never been overlaid onto existing systems in combination with ATO, as is the case with Thameslink.

Elevating its status even further, Thameslink is of great interest to NR's Digital Railway team. Thameslink is an entirely independently governed programme from DR, but it will act as a benchmark for the migration of ETCS to other parts of the network in Control Period 6 (April 2019-March 2024) and beyond.

Chatfield explains: "Getting to this point hasn't just happened overnight and the software wasn't suddenly just switched on. Until 2019 the industry will be continuing to work incrementally to get up to 24tph. We are also providing the tools to allow TOCs to manage the PPM (Public Performance Measure) for up to 700 daily Thameslink services.

"Since 2012 we've been working hard on three work packages: deploying the ATO and ETCS to create reliable 24tph capability, managing the necessary signalling re-controls and traffic management introduction, and carrying out a number of station enhancements to help reduce dwell times."

Chatfield is keen to stress the importance of the last point, as high frequencies cannot be maintained through the core without reducing dwell times at stations from their current two-three minutes, to less than 60 seconds.

To help achieve this, mobility ramps have been installed mid-platform at all core stations to expedite wheelchair access, while passenger information screens will be improved and station signage increased.

He adds: "It's not just been about providing a system to run 24tph, but having a whole-system approach in order to change passenger behavior.

"We're trying to concentrate on talking up the benefits of this, as Thameslink passengers will be getting a metro-style railway like the London Underground - but with much better views.

"That means that trains will be pulling into stations as the tail lights of the one in front are still disappearing from view, which I don't think all Thameslink passengers will be used to.

"New and improved signage and information screens will help with that [transition], and help maintain performance throughout the core."

> "Thameslink passengers will be getting a metro-style railway like the London Underground - but with much better views."
>
> **Martin Chatfield,** ***Project Director, Network Rail***

Testing of ETCS and ATO commenced in 2013, following the opening of a purpose-built lab at JFH containing an exact replica of a Class 700 cab.

Dynamic testing then began at Network Rail's ETCS National Integration Facility (ENIF) at Hitchin approximately a year later using NR's Class 313 ERTMS test train on a specially designated section of the Hertford Loop line.

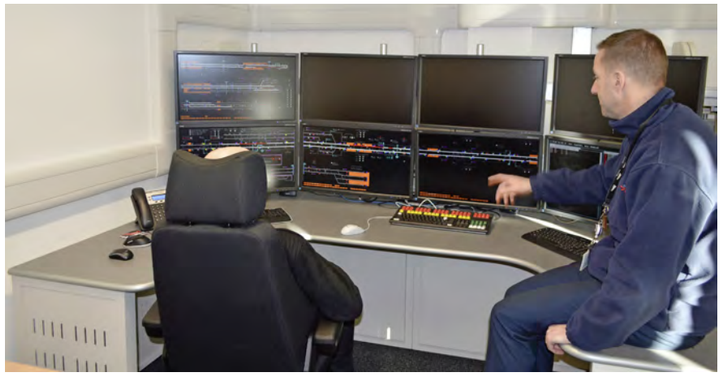
The HCI team then switched to overnight testing on the core itself, in April 2016, using a Class 700 train specifically provided for this purpose by Siemens.

Chatfield adds: "We used ENIF for a couple of years and the '313' while we awaited our own Class 700, which we tested there before taking it into the core. I guess that means we must be one of the only NR projects to have ever been given our own train."

RAIL was invited to tour the lab at JFH on February 19, where it is given a tour and demonstration of the simulator by senior programme engineer David Harris.

As the only facility of its type in the UK, Harris says that two or three requests are received every month to visit the lab by ➤

ETCS technology incorporated by Thameslink was tested at the ETCS National Integration Facility at Hitchin and on the Hertford Loop line near Watton at Stone, where ETCS marker blocks can clearly be seen. NETWORK RAIL.



All 24 signallers at Three Bridges have received three days of training and assessment in ETCS and ATO in the rail operating centre's ground floor simulator room. A further four to five days training is provided for traffic management. PAUL STEPHEN.

Left and adove: HCI's system integration laboratory at James Forbes House in Southwark enables the offline testing of ETCS and ATO equipment using real equipment and a Class 700 simulator. PAUL STEPHEN.

➤ a range of suppliers, operators and other industry bodies.

This offline testing centre contains at least one sample of each component needed to run ETCS and ATO. This includes a dummy balise (ETCS transponder), a balise reader, AWS and TPWS (which would provide train protection if ETCS fails), GSM-R connection, all on-board equipment, plus real trackside interlockings and a radio block controller.

The laboratory has the capacity to simulate 60 trains and to operate any one of them in order to replicate the connection that trains will have with other equipped trains in the core.

It will remain in use with HCI until at least November when a further use will be found for it.

"All of this is real kit," adds Chatfield. "There are balises, interlockings and a doppler radar downstairs, so we've got an entire railway in a double-storey Portakabin.

"We'll try and find a purchaser for it when we're finished, perhaps within NR, or offer it as a maintenance facility to the routes or equipment maintainers."

RAIL then heads almost 30 miles south to Three Bridges Rail Operating Centre (TBROC), where control and signalling of the Thameslink network is being consolidated into a single site.

On the first floor, new workstations have been installed and are fully operational for the Thameslink core's north and central sections, having already been re-controlled from West Hampstead and Victoria.

Elsewhere in the room, there are workstations for London Bridge, Charing Cross and Cannon Street A and B. Work has also begun to accommodate panels from Lewisham and Grove Park in May. There will also be a screen for the traffic management system that will be run in shadow mode and then become fully operational in early 2019, when it will become interfaced with signallers' workstations via Automatic Route Setting.

Meanwhile, on the ground floor, full training for ETCS, ATO and TM is being delivered in a simulator room for the 24 signallers based at TBROC. Not only will they have to be able to work with the new systems, but they must be able to signal trains in the conventional fashion and switch back to lineside signalling in the event of ETCS failure.

Left and adove: The Thameslink core central workstation at TBROC is pictured left, alongside a wider view of the operations room on February 19. PAUL STEPHEN.

GTR 700041 passes an ETCS track block marker as it departs City Thameslink with a Three Bridges-Bedford service on February 15. These services will remain conventionally signalled until May when the '700s' will switch to in-cab signaling and ATO. ANTONY GUPPY.

Looking ahead, and Chatfield says that the existing infrastructure could support the introduction of 24tph by the end of 2018 as originally envisaged.

In fact, it could potentially support 30tph, although this would be reserved for times of extreme disruption-only as some services would be required to run non-stop, undoubtedly inconveniencing some passengers.

The industry has agreed that it would be beneficial to passengers to introduce the timetable in four phases, to enable experience to be embedded between stages.

As for Chatfield and his approximately 35-strong HCI team, they have been incorporated into NR's Infrastructure Projects signalling team and seconded back to Thameslink, so that its digital signalling capabilities are not lost at the end of the programme next year.

They may then be deployed to the possible future Digital Railway projects which were outlined in NR's CP6 *Strategic Business Plan*, published on February 13, such as resignalling schemes at Feltham or on the southern portion of the East Coast Main Line into King's Cross and Moorgate.

Chatfield welcomes the opportunity to continue the pioneering work of Thameslink, and to cultivate more talented young engineers.

> "We must be one of the only NR projects to have ever been given our own train."
>
> **Martin Chatfield, *Project Director, Network Rail***

"There's a very collaborative team here with our technology suppliers Siemens and Hitachi Rail Europe. ETCS engineers weren't exactly growing on trees in 2012, and they still aren't, so it has been a very open process with suppliers, which will be carried through to the next schemes.

"The amount of staff development here during testing has been phenomenal, however, and we've had three or four graduate engineers move on to highly skilled jobs abroad and elsewhere in the supply chain, and that cycle continues.

"Upskilling has always been very important to me and keeping hold of people has been quite difficult, but we have been very successful at providing career paths and hopefully we will now provide the industry with lots of future capability." ■