

# Light Rail & Metro



MIKE HADDON.

- EXCLUSIVE INTERVIEW: Post-Croydon crash safety body takes shape
- A future without wires
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## Welcome

2018-19 was a year of strong growth for England's eight light rail and tram systems, with total passenger journeys rising to a record level of 272.4 million.

However, ridership looks set to climb higher still, given the extensions to systems in Manchester, Blackpool and the West Midlands that are currently under construction, and others that have received approval in Birmingham and Edinburgh.

But with only two new systems having been built since 2000 (in Nottingham and Edinburgh), 2019 could well be best remembered as the year when a host of new UK cities embraced light rail as the key to tackling their own congestion and environmental problems.

Transport for Wales has confirmed that on-street running and tram-trains will be coming to Cardiff as part of the £738 million South Wales Metro project (see p50-51), while systems in Cambridge, Preston and Leeds are all at the early stages of development.

Several UK systems could opt to include many of the innovations taking place in the light rail industry, including Very Light Rail vehicles or the tram-trains that have been trialled in Sheffield and have been ordered for Cardiff.

In this supplement, SYSTRA examines the various options now on offer for catenary-free running, including the growing use of battery

and hydrogen power (p48-49).

Representing the light rail sector and helping to encourage new entrants is UK Tram, whose new chairman George Lowder MBE sets out what the future holds in store for the organisation and its members (p40-45).

Meanwhile, former Metrolink director Peter Cushing tells *RAIL* how one of the key recommendations of the report into the Sandilands crash of November 2016 is now being implemented following the establishment of dedicated safety body LRSSB.

Last but not least, we also cover metro operations with Siemens discussing the work being undertaken to integrate various systems on Crossrail (p46-47). ■

**PAUL STEPHEN**  
Features Editor, *RAIL*

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# The charge of the Light Brigade

Nottingham City Council has approved a £200,000 feasibility study into new routes for the Nottingham Express Transit. These could potentially connect with the planned HS2 station at Toton, as well as extensions from Clifton to a new 3,000-home development and from Phoenix Park to Eastwood. ALAMY.



As light rail and tram usage reaches record levels, **PAUL STEPHEN** gives a glimpse of what the future has in store for UK Tram and the newly formed Light Rail Safety Standards Board - and how they will both be key to the future of the industry

According to the latest statistics compiled by the Department for Transport, some 272.4 million passenger journeys were made on the eight light rail and tram systems in England (279.7 million when also including Edinburgh Trams) - representing a 1.9% increase on the previous year, and a 44% increase over the last decade.

However, the growing popularity of light rail is not just evident from these crude ridership figures, but from the increasing calls from operators, local authorities and passenger transport executives for further investment to extend existing systems, or to build entirely new ones.

Historically, the leader in this field has been Manchester Metrolink, which - with 93 stops and 62 miles of track - has expanded

to become the most extensive network in the UK since its opening in 1992.

An eight-year £1.5 billion 'big bang' expansion programme was completed with the opening of a second route (2CC) across Manchester city centre in February 2017, while a £350 million extension to Trafford Park is currently under construction and due to open in 2020-21.

With strong growth (6.1%) in patronage recorded in 2018-19, there remains a strong appetite in the region for further extensions (including a cross-city tunnel between Manchester's Piccadilly and Victoria stations) as set out by Transport for Greater Manchester's recently published 2040 Strategy.

In the more immediate future, Metrolink's mantle would appear to have been taken

on by the West Midlands Metro, which has firm plans to double the network's original mileage by 2026. Currently consisting of a single 12.7-mile route between Birmingham and Wolverhampton city centres, extensions are under way to Edgbaston in the south and Wolverhampton railway station in the north.

Meanwhile, a proposed 6.8-mile line from Wednesbury to Brierley Hill was approved in March, and an eastward extension from Bull Street to Digbeth via Birmingham's new HS2 station at Curzon Street is being considered by government.

Elsewhere, on March 14 councillors in Edinburgh voted to approve a 2.9-mile extension to Edinburgh Trams from the city centre to Newhaven and Leith, while Nottingham City Council has announced it will fund a £200,000 feasibility study into

new routes for the Nottingham Express Transit system to the planned HS2 hub at Toton, and a new 3,000-home development near Clifton.

Other systems are also continuing to grow,

with a £22m extension to the Blackpool Tramway from Blackpool North to Blackpool Pier expected to open later this year, and passengers in Sheffield continuing to benefit from the UK's first-ever tram-train services

that were launched last October to a new terminus at Rotherham Parkgate.

Recognising the success of modern tramways in becoming effective and efficient people movers wherever they have been implemented, other UK towns and cities are also now planning their own schemes - with one or two new systems now reaching advanced stages of development.

The closest to fruition is the £225m Luton DART (Direct Air Rail Transit) project, which will provide a direct connection from Luton Airport to Luton Airport Parkway station from 2022.

Close behind Luton, tram-trains are due to start running in and around Cardiff from 2022 as part of the £738m South Wales Metro project that will integrate light and heavy rail with local bus services.



“ There is plenty of optimism around light rail, given the big environmental and urbanisation factors we're all aware of. Light rail is a green mass transit mode, and so we should be seizing these opportunities. ”

George Lowder MBE, *Chairman, UK Tram*



Tram-train 399203 departs Rotherham Parkgate with a test run to Sheffield Cathedral on July 19 2018. Passengers in South Yorkshire have been the first in the UK to benefit from tram-trains, although they have now been procured for Cardiff and are being considered by several other cities including Manchester. MIKE HADDON.



Elsewhere, proposals for a metro system in Cambridge are at an early stage, while in August the West Yorkshire Combined Authority invited experts to submit ideas for a mass transit system in what is currently the largest city in Europe without one - Leeds.

Given this increased focus and renewed interest in light rail, the DfT issued a call for evidence in February to seek views on the potential for new schemes, and how best to address the issues that are currently holding them back - particularly high capital costs and a lack of standardisation.

Government is currently considering its findings, although prior to the closure of the consultation on May 19, lengthy submissions were made by network operators, local authorities, transport executives and the trade body UK Tram - whose members include all of the aforementioned, plus infrastructure and rolling stock maintenance organisations.

Chairman of UK Tram and Chief Executive of Transport for Edinburgh George Lowder MBE tells RAIL: "I welcome the consultation, and I think there is plenty of optimism around light rail, given the big environmental and urbanisation factors that we're all aware of. Light rail is a green mass transit mode, and so we should be seizing these opportunities."

"There is a confluence of different issues all coinciding helpfully at the same time, including urbanisation, congestion, the environment and reducing car ownership. Heavy rail is a more expensive solution to light rail, so wherever there is a coincidence of these issues, there is an opportunity - and

one of the obvious answers has to be light rail."

As Chief Executive of TfE, Lowder has witnessed at close quarters some of the various barriers to light rail adoption, but also how, ultimately, these systems are embraced by the populations they serve owing to their ability to significantly improve connectivity, increase socio-economic mobility, cut congestion and

improve air quality.

In January, Edinburgh Trams reported that 7.3 million journeys were made in 2018 (an increase of 10% on the previous year), despite the scheme being heavily criticised in 2014 for opening three years later than planned and £400m over budget.

Originally planned for Phase 1 but cut back amid the delays and spiralling costs, a 2.4-mile extension to Newhaven has now been approved by city leaders and is due to open by February 2023.

Lowder is hoping to bring to bear his first-hand experience of "achieving a successful operation after the huff and negativity of the original build" in his new role at UK Tram, which started on August 1. He will also continue to fulfil his predecessor Geoff Inskip's ambition to reconfigure the organisation in order to maximise the value it offers its members - by not just representing its interests in terms of safety, standards and legislative changes, but also in terms of providing a powerful forum to discuss best practice, and directional and policy guidance.

With a board meeting, annual general meeting and a light rail summit all scheduled this month (September), Lowder is clear he is in 'listening mode' for the time being before deciding how the organisation should deliver against its members' wishes.

"During the course of those three meetings I expect to hear more from

members about what they specifically would like in terms of deliverables," says Lowder.

"My role is to capture that and listen carefully to what they are telling us about various elements of UK Tram, and then provide oversight on what we are delivering."

"UK Tram should be adding value to its members and already is, and it comes down to sharing best practice, understanding what everybody else is up to, and not reinventing the wheel if another operator has tried something that works well."

One area where UK Tram is likely to increase its activities is in supporting the vibrant innovation landscape that has emerged in light rail, in order to keep the sector a cost-effective and continually improving transport mode.

By nurturing and sharing knowledge of new technological developments such as the tram-train trial in Sheffield, and the construction of the UK's first stretch of catenary-free on-street running in Birmingham, UK Tram can play a lead role in driving this innovation and technical excellence which will, ultimately, encourage further expansion of tramways across the UK.

Lowder says this will not just benefit existing members, it will also help position UK Tram as a 'one stop shop' for new entrants in the sector.

He adds: "There's also a softer issue here about providing a degree of support to new

## Croydon: there must be no repeat

Fourteen months after the tram crash that killed seven passengers, ANDY COWARD looks back at the accident and analyses the safety recommendations made by the Rail Accident Investigation Branch



14 Following the Sandilands accident, Tram 2851 was removed to a secure RAIL facility, where it has been tested and examined in detail, to learn as much as possible about what went wrong on that November morning just over a year ago. 77

companies, operators and authorities that are starting out. They should be able to come to an organisation that is well placed to provide - with a degree or authority, expertise, industry input and legal support - all of those things that someone taking on or considering taking early steps needs to know.

"UK Tram needs to be somewhere that they will feel comfortable that they're getting good guidance and information, and that they can lean on us for the softer support as well as more practical things."

Another key role for Lowder over the coming months will be to help oversee the development of the Light Rail Safety Standards Board (LRSSB), which was established in February as a dedicated safety body for the light rail sector.

Backed by £1.5m of Government funding, its creation as an independent subsidiary of UK Tram was one of 15 recommendations made by the Rail Accident Investigation

The team involved in the accident was led by the Rail Accident Investigation Branch (RAIB) and the Rail Safety and Standards Board (RSSB). The investigation was completed in February 2017 and the findings were published in a report in May 2017. The report identified several safety issues that need to be addressed to prevent a similar accident from happening again.

The investigation found that the driver was not aware of the tram's position on the tracks. This was due to a combination of factors, including the design of the tram and the way it was operated. The report also identified several other safety issues that need to be addressed, such as the need for better communication between the driver and the tram's systems.

Branch (RAIB) report into the fatal tram crash at Sandilands Junction, Croydon, on November 9 2016. Until that point the tram industry had enjoyed an exemplary safety record with no passengers killed in an accident on board a UK tram since 1959.

But with seven passengers killed by the overturning tram at Sandilands and 51 requiring hospital treatment, the Office of Rail and Road was called upon to co-operate with UK Tram to build on the work already done by UK Tram's safety board, to develop a body to manage standards and safety, and to provide authoritative impartial advice.

LRSSB Chief Executive and former Metrolink director Peter Cushing explains: "The establishment of LRSSB came out of the RAIB report, but what people should remember is that there wasn't an absence of standards before that, they just weren't all in one place."

"Previous to that people were working



Construction continues apace for West Midlands Metro on a large site occupying Paradise Circus in Birmingham City Centre. The tram route will snake its way from outside Birmingham Town Hall in the background and into Centenary Square, to the right of the white lorry, and will include the UK's first stretch of catenary-free running. MIKE HADDON.





► to ORR, BSI and European standards, plus some that came from RSSB and were adopted or adapted to light rail. Clearly, it's a different playing field in light rail [compared with heavy rail] as there isn't a single infrastructure owner or one method of operation, but nevertheless it was necessary to put standards in one place as it probably wasn't as controlled for light rail as much as it should have been."

According to Cushing, LRSSB has been given a headstart by UK Tram, as much of its current remit was already being worked on prior to Sandilands in terms of risk management and reporting of safety incidents.

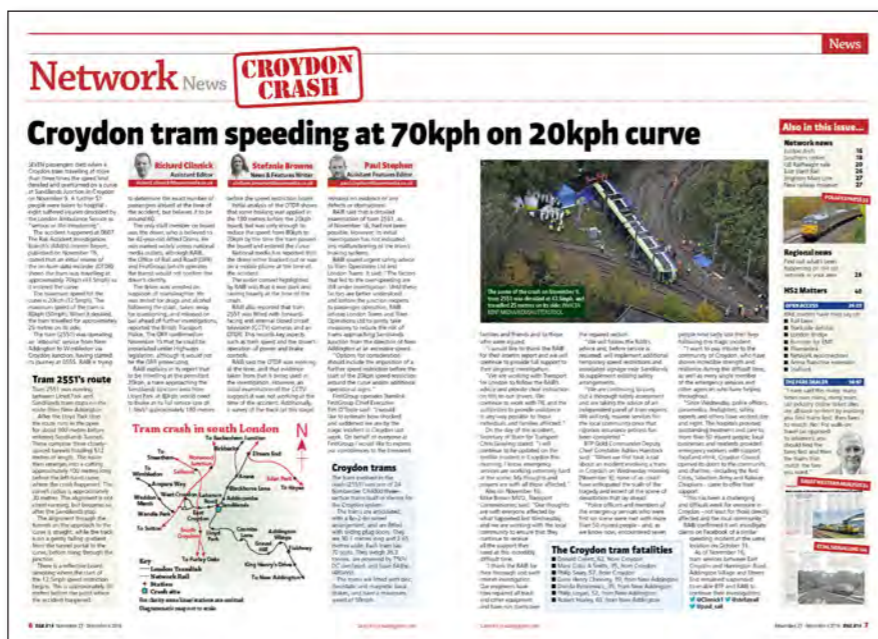
UK Tram is also in a position to share knowledge, expertise and resources with LRSSB, making the decision to create it as a subsidiary organisation a sensible one.

He says: "Some of the systems LRSSB is using and the risk models and database we're using for standards were already developed by UK Tram, so there was already a move towards this anyway. Sandilands was just the catalyst that increased the speed of it, frankly."

"LRSSB is a subsidiary of UK Tram, but is a completely separate body and has its own board and constitution. But it was obviously easier to set it up this way and to carry on as much as possible as before, instead of establishing something completely independent."

"We also have limited funding, which we're trying to spend on developing what we need rather than having a big administrative back office."

The LRSSB only has the equivalent of two full-time employees with one full-time administrator of the database, and a



part-time safety and standards manager. He shares his time with UK Tram and then there's Cushing himself, as a part-time CEO.

"That's the limit of LRSSB, but we obviously work with UK Tram's Heads of Safety Group (comprising safety members from each operating group and standards body) when we're trying to establish a standard, and we're also able to pull time from the Engineering and Operators Group."

Cushing adds that it is the LRSSB's job to put the documentation for a standard to these groups and then ask the ORR for any comments.

"ORR can't sign off on any standards, but they can give us comments and we take those into account, write it up, clear it with the Heads of Safety Group, and then it's

signed off and notified as a standard on the LRSSB database," he says.

The LRSSB database is available to every member to access with a password. Cushing says it not only includes standards, but is also being used a messaging system - for example, when there is an indication from RSSB that there has been an incident in Europe or perhaps in heavy rail in the UK.

Any learning points relevant for light rail can then be put into the database, with members also able to interact with LRSSB or other members if any action needs to be taken. As LRSSB continues to develop, the database will also be used for reporting accidents and incidents including near misses, which will allow LRSSB to produce an industry view on safety as well as an

individual network view.

Members will be able to see how they compare across the industry, giving the database a unique benchmarking capability.

"We're using a piece of software that has been developed in heavy rail called RM3 [Risk Maturity model 3]," says Cushing. "It's been updated to be friendlier to light rail so members can use their incident and near miss data, work through RM3 and then be able to show their level of risk maturity within the industry."

"We'll also do peer reviews so we can learn as a sector. And if there's a particular area where one network appears to be weak, they can speak to someone who has an apparent strength in that area to learn from it."

Obviously, all this has taken some time to set up and the process is ongoing, but the benefits should be seen over the course of the next two or three years. Once the whole industry is working on a common risk platform it can share data on risks not just in the UK but across Europe, giving a really clear view on what risks are held within networks and as an industry as a whole.

According to Cushing, the creation of LRSSB has already garnered much interest from operators in Europe and further afield which, lacking their own similar body, might wish to become overseas members and to feed into the common risk platform.

Clearly LRSSB will not be able to regulate or apply standards to international members, but they will be able to use its risk management model and monitor their own risk maturity, while providing another valuable source of information to the database.

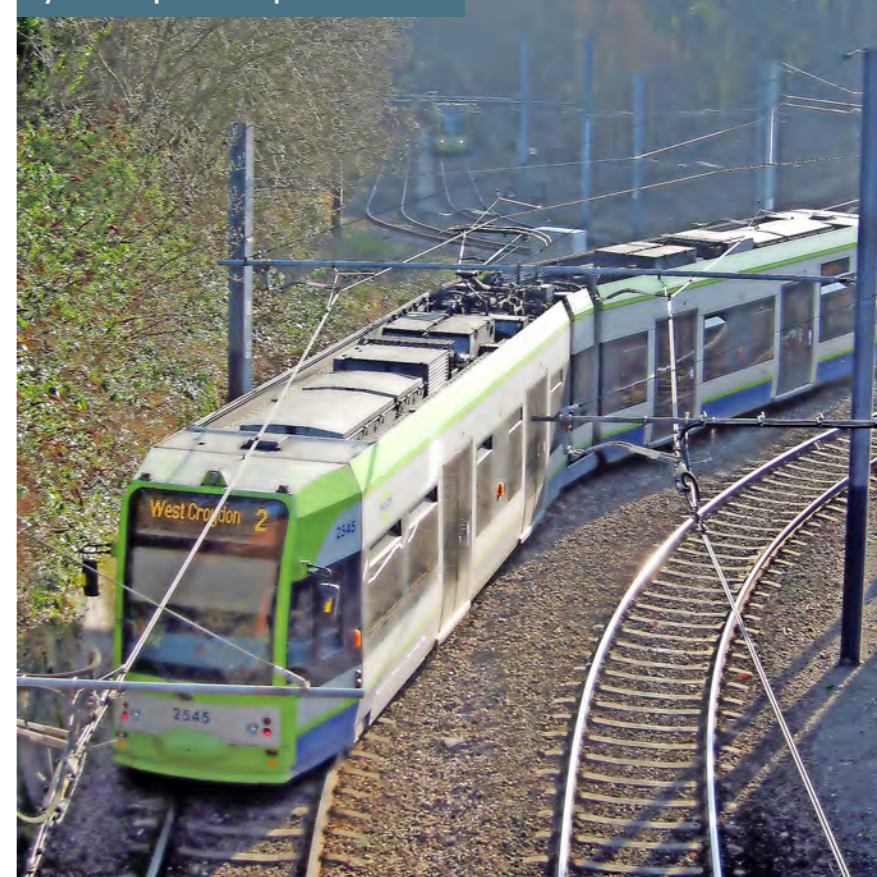
Looking ahead, Cushing and the team will need to persuade the DfT or another source to provide long term funding to LRSSB once the initial tranche of £1.5m is used up in under three years' time.

He is confident, however, that it will prove its worthiness to become a permanent body once members start to feel the benefits provided by the database, and being part of the common risk platform.

"We're not going to need mountains of funding, and we don't expect this to be a massive organisation," he says.

"The way we work with members is that we get a lot done for what is effectively not a lot of money, and we will continue to focus on doing it in the best way possible and

On March 12 2012, Tram 2545 approaches the junction near Sandilands, Croydon, where the UK's first fatal tram accident since 1959 occurred on November 9 2016. The LRSSB was established earlier this year to satisfy one of the 15 recommendations made by the subsequent RAIB report. NEIL PULLING.



not overspending.

"Right now, we're pretty much on track and where we expected to be. We need to get the risk model and database working across all the networks and then get some meaningful data from it in terms of reporting, which we should be able to do from early next year when we've got everybody on board."

"For me, it's about what we do in year one and two in terms of expanding our reach, not only in rewriting standards but in making sure everything else in the database stays current. It's not just about producing standards, but also helping operators get the best out of their networks in terms of being aware of the risks and making them as safe as possible."

In addition to the eventual publication of the Government's light rail consultation, Cushing believes that LRSSB will also play a key role in unlocking several of the barriers to entry for towns and cities looking to build their own networks. He argues that a more structured approach to regulation and standardisation will make it easier to replicate existing solutions in other places, and will potentially reduce the cost and time that might have been spent in designing, engineering and then operating an entirely bespoke solution.

He concludes: "One of the reasons why this should encourage new entrants is because when you look at establishing a light rail network, in the past they've had to look across a much broader aspect to be able to find the standards they need to develop and what they need to do."

"There's a lot of learning for a city that wants to establish a new tram network, and what we can do is to give people a template that says 'these are the standards you need to work to, this is what you need to adhere to, this is how it is regulated, and this is the process you'll be able to work through'."

"There's no reason why someone couldn't become a member of LRSSB or UK Tram very early on in the development and design process, and they absolutely don't need to wait until they've got something to operate." ■



“There isn't a single infrastructure owner or one method of operation, but it was necessary to put standards in one place as it probably wasn't as controlled for light rail as much as it should have been.”

Peter Cushing, Chief Executive, Light Rail Safety Standards Board





# Testing times

**ADRIAN STUBBS, Siemens Mobility's Operations Director for Crossrail, describes the work now being undertaken to integrate the various systems for Crossrail**

For much of the last decade, the £17 billion-plus Crossrail programme has been Europe's largest infrastructure project.

With 13 miles of twin tunnels stretching from east to west beneath central London, it also promises to transform travel in the capital by delivering quicker, easier and more accessible journeys.

The full length of Crossrail - which will officially be known as the Elizabeth Line - is 73 miles from Reading and Heathrow at one end to Abbey Wood and Shenfield at the other.

With ten new stations being built in the central section, it will also make new direct connections possible - including between Heathrow, the West End, the City and Canary Wharf.

Meanwhile, a new fleet of 70 nine-car Class 345 trains will run at frequencies of up to 24 trains per hour in peak between Paddington and Whitechapel, helping to provide a 10% increase in central London's rail capacity, cut journey times and support regeneration across the capital.

Among the Tier 1 contractors working to deliver the Elizabeth Line is Siemens Mobility, which was awarded two key contracts to design, test, install and commission key communications and control systems within the central section.

These systems include CCTV and public address systems at stations, customer information displays, staff and emergency services radio systems, and the data networks that will carry information to and from the route control centre.

Siemens Mobility is also providing its radio Communications-Based Train Control (CBTC) system in the central section and on board the fleet of Bombardier Class 345s, to enable high-frequency running on this section of the line.

Adrian Stubbs, Siemens Mobility's Operations Director for Crossrail, explains: "Siemens Mobility is very proud to be involved in what is still the largest infrastructure project in Europe. To be able to say that you played a significant part in creating the phenomenal legacy Crossrail will leave is a proud moment in anyone's career."

He adds: "We have two direct contracts on the project, on which we currently have deployed a workforce of over 500 employees in the UK and more in Germany and beyond. They are involved in a huge cross-section of activities, including the software development and advanced systems integration work being undertaken at our Rail Automation and Crossrail Integration Facility in Chippenham."

Initially due to open in December 2018, a new delivery date for the opening of the Elizabeth Line is now being targeted by the new leadership team for between October 2020 and March 2021 to allow for outstanding work to be completed.

Stubbs says: "There is now a focus on system integration and recognition of both the technical and organisational complexities of this programme. As an example, Crossrail has established a Plateau team comprising technical leads from Crossrail, Siemens Mobility, Bombardier and the operator, to support system integration and promote



Siemens Mobility's Crossrail Integration Facility. SIEMENS MOBILITY.

collaboration which is proving beneficial."

This includes the dynamic testing of train and signalling systems with both Siemens Mobility and Bombardier working closely together in order to integrate and increase the reliability of all associated software.

The CBTC system not only needs to be integrated between train and track, but also where it will interface between the two different signalling and train control systems in operation on other parts of the route.

These are not being provided by Siemens Mobility so integrating the different systems is a complex, but essential, task.

ETCS Level 2 signalling is being installed on the western section from Paddington to Heathrow and Reading, while Train Protection Warning System (TPWS) is in operation on MTR Crossrail's eastern branch to Shenfield.

This integration must be completed before intensive trials can begin in 2020 to simulate the full 24tph service, although a major milestone was reached on June 8 when close-headway multi-train testing commenced in the central section.

Meanwhile, extensive off-site work is

being undertaken by Bombardier in Derby, and by Siemens Mobility at its Chippenham Crossrail Integration Facility, and elsewhere internationally.

Stubbs explains: "The Crossrail Integration Facility is an advanced system test facility that combines key target hardware and software elements - for example, train, signalling, communications and platform screen doors, with simulation. The facility was built as a key part of the system integration strategy. It enables early testing of configurations before they are tested on the actual railway. The testing is led by Crossrail and fully supported by both Siemens Mobility and Bombardier."

The challenge with a complex project such as Crossrail is always in the integration with other systems, such as the software on board the train.

Says Stubbs: "The core TrainGuard Mass Transit CBTC system we are deploying is proven and already in operational service elsewhere - for example, in Copenhagen. However, there are unique functions required for Crossrail, and the complexity of this railway having three signalling systems

means we must go through an extremely comprehensive testing programme to ensure a safe and reliable railway.

"We are able to bring the systems together in our R&D and system test centres in Germany to have confidence in its functionality, but ultimately it's only when you integrate it with the train and the wider infrastructure that you can become aware of all the issues and then solve them."

He adds: "Getting the close-headway multi-train testing under way is a big step forward in the programme and the delivery of the Elizabeth Line."

By the end of the year dynamic testing should be in its final stages, enabling trial running to commence in the first quarter of 2020.

Stubbs and Siemens Mobility recognise the importance: "All of our reputations rest on the successful delivery of the Elizabeth Line for London. We have a fully committed team and it is an absolute priority for the wider Siemens Mobility business. Working collaboratively with our partners, I look forward to delivering the Elizabeth Line - a project we can all be extremely proud of." ■

**“ All of our reputations rest on the successful delivery of the Elizabeth Line for London. ”**

**Adrian Stubbs, Operations Director for Crossrail, Siemens Mobility**





# Reducing the overheads

**T**ramways and light rail systems have historically sourced much of their power from overhead line equipment (OLE). However, over the last two decades, catenary-free operations have rapidly grown in popularity. They avoid the need for visually obtrusive OLE equipment in city centres, allowing historical features to remain visible to residents and visitors.

There are other advantages to catenary-free running, including reduced cost and time associated with design and approval of the system, expedited stakeholder acceptance, enhanced climate resilience, and more flexibility for rolling stock design as headroom is not limited by OLE equipment.

There are several technology options for catenary-free operation. The choice for a given tramway is influenced by the length over which catenary-free running is required and the characteristics of the section on which the catenary-free solution will be rolled out. The solutions can broadly be split into two categories: systems based on a **continuous power source** delivered through a contact line embedded in the trackbed; and vehicles equipped with **on-board energy storage** from batteries, supercapacitors and hydrogen fuel cells.

For continuous ground-level power supply systems, power is provided by physical contact or by induction. SYSTRA selected the Alstom APS supply system for the pioneering catenary free system installed in Bordeaux in 2003. This system has been

## Do away with overhead line equipment and urban tramways become a much more attractive proposition, says SYSTRA

extremely successful and has been adopted in other areas of France including Reims, Angers, Orleans and Tours.

APS has been adopted around the world - it was installed on the Dubai Tram which, upon opening in 2014, became the first tramway in the world to feature a ground-based power supply system along its entire length. SYSTRA managed the design of the first phase of the Dubai Tram and is in the process of undertaking preliminary design for its second and third phases, in association with AECOM.

System Engineering Manager at SYSTRA, Mathieu Melenchon reflects: "We are very proud that SYSTRA has played an instrumental part in making this innovative technology real. The challenge now is to find a way to make the costs comparable with traditional systems. This is something we are working on."

There are three principal ways of providing on-board energy storage - batteries, supercapacitors and hydrogen fuel cells. The first, battery storage, is applicable closer to home, with Midland Metro set to become the first system in the country featuring sections without OLE, and relying on battery power in carefully selected areas of the region.

Midland Metro's fleet of 21 Urbos 3 trams is currently being retrofitted by CAF with lithium-ion cells, so that OLE can be dispensed with on four planned sections of the network - including through Birmingham's central Victoria Square and in Wolverhampton City Centre.

The batteries will be fitted to the roofs of the trams and recharged by OLE on other sections of the route. Recharging is also possible through a ground-level power supply in stations.

Fitting out the entire 21-tram fleet is estimated to cost £15.5 million, and further costs will be incurred to replace the batteries once they are life-expired.

However, according to Midland Metro owner the West Midlands Combined Authority, the decision will save more than £9m in infrastructure capital costs while also protecting architecturally sensitive areas of both Wolverhampton and Birmingham. The metro system continues to provide an effective alternative to the private car, helping to ease congestion and support economic growth.

Research and development in batteries is also being supported by the automotive sector, which could help yield significant

improvements such as distance between charging points and the time between upgrades and replacement.

Supercapacitors are an alternative way of providing onboard energy storage, and can be charged much more quickly than batteries. However, they have less capacity to hold charge, meaning they are more suited to lines with short distances between stations where charging points can be located.

CAF Urbos 3 trams use this technology to run on catenary-free sections of the tram networks in the Spanish cities of Zaragoza, Seville and Cadiz.

Lifecycle costs for supercapacitor systems tend to be higher, owing to the need for larger substations.

Hydrogen fuel cells produce power from hydrogen and air using electrolysis. The 'emission' from this process is pure, drinkable water, making it a non-polluting power source. An additional advantage over battery-power is the speed of charging - a few minutes (roughly the same as a petrol car) in comparison to several hours for a battery.

In addition to the onboard equipment, hydrogen refuelling stations are required

and (potentially) a hydrogen production facility, which further increases overall system lifecycle costs. The lack of hydrogen distribution infrastructure makes this the most costly solution compared to classic OLE systems, but economies of scale could be achieved if a local transport authority also chose to migrate its bus fleets to hydrogen fuel cells. Furthermore, the UK commitment to achieve 'net zero' greenhouse gases by 2050 means cost is not the only factor to be considered.

Currently, across the globe, only the Chinese company Sifang is developing a hydrogen-powered tram which will have a top speed of 70kph (43.5mph) and will be able to carry 380 passengers. The tram is being designed to take three minutes to refuel and will have a range of 100km.

SYSTRA says it watches all these technology developments very carefully, which are being increasingly applied to heavy rail systems before their eventual migration to light rail.

Alstom has already introduced hydrogen trains onto regional services in Germany, while in the UK there are partnerships

between the University of Birmingham and Porterbrook and between Alstom and Eversholt which are in the process of constructing standard gauge hydrogen-powered trains.

Other rolling stock owning companies and manufacturers are offering hybrid units that can operate using a combination of diesel, electrical and battery power.

Derek Small, from SYSTRA, adds: "There is no definitive answer to the catenary-free question. It comes down to careful consideration of many factors to determine which of these solutions is most appropriate - client drivers location, route, demand, environmental impact must all be considered, and you can't treat any one of them in isolation. It's a bit of a balancing act but simply looking at cost is probably the wrong thing to do for a whole transport solution. The 'net zero' greenhouse gases by 2050 emissions target is a bit of a game changer for the industry, but at SYSTRA we have been developing this technology for over a decade."

He adds: "Battery power is seen as experimental in the UK, but it has been readily available on light rail in China for the last five or six years, and we're starting to see much more of it on the heavy rail side.

"The same goes for hydrogen, which is emerging in heavy rail and looks set to make its debut in light rail in China. The more you produce, the more the costs come down, so while there are obvious cost implications for whichever system you go for, these promising technologies will help to solve many of the environmental and planning problems we face." ■



The nine-mile Dubai Tram is the first tramway in the world to feature a ground-based power supply system throughout its length. HYWELL WATERS/SYSTRA.



The 41-mile Bordeaux tramway utilises a ground-based supply system to reduce visual intrusion in the city's UNESCO Heritage Listed centre. SYSTRA.

A SYSTRA-led consortium project managed the Bordeaux tramway (Communauté Urbaine de Bordeaux) which opened in 2003, and which will carry more than 430,000 passenger per day on completion of Phase 3. System Engineering Manager at SYSTRA Mathieu Melenchon explains:

"Part of the Bordeaux system in the city centre uses APS, where electric power to the tram is supplied by a centre rail that automatically switches on and off when a tram passes over it. This prevents any risk of electrocution to pedestrians or other road users. "This solution is most appropriate for

sections of line with large distances between stations and where speeds can be considered high (greater than 50kph, or 31mph)." Costs can be higher than classic catenary systems but the catenary-free approach offers several advantages. "In Bordeaux, a UNESCO World Heritage-listed city, the Mayor didn't want people to see unsightly wires. He was a strong believer that a traditional system would meet with stakeholder resistance and that a catenary-free system could be more acceptable, smoothing the way for planning permission. He was right - the scheme was implemented without objection and demand in Bordeaux has exceeded all predictions.

"We can say that APS has played a key role in unlocking that market, improving the environment and helping reduce congestion whilst maintaining the historical integrity of this proud city."



**“ We are very proud that SYSTRA has played an instrumental part in making this innovative technology real. ”**

**Mathieu Melenchon, System Engineering Manager, SYSTRA**





An artist's impression of a Tri-mode unit built by Stadler in operation on the Rhymney Line. 24 of the trains - which can be powered by diesel, batteries or 25kV overhead wires - are on order for Tfw Rail. TRANSPORT FOR WALES.



# Tfw's holistic approach

Wales is on the cusp of a transport revolution with some £5 billion worth of investment due to be pumped into its ageing rail infrastructure and rolling stock under the terms of the new 15-year Wales & Borders franchise that commenced in October 2018.

With almost £2 billion of that funding coming from a new franchise operator run by KeolisAmey, and called Tfw Rail, a complete fleet replacement has already started with 148 new trains on order from manufacturers CAF and Stadler, and refurbished Class 170s, '230s' and locomotive-hauled Mk 4 sets all due to arrive by the end of the year.

Meanwhile, £194 million is being spent on improving all 247 stations in Wales, and by December 2023 there will be an extra 285 services running each weekday and an additional 294 on Sundays. In total, there will be a 60% increase in capacity.

But perhaps the most eye-catching major change within the franchise is the plan to build a £738m South Wales Metro which will integrate heavy and light rail as well as local bus services, around the hub of Cardiff Central.

Thirty-six three-car Stadler Citylink Metro

## Tfw Chief Executive JAMES PRICE explains why a less prescriptive approach was taken to improving transport in Wales

vehicles - using electric and battery power - will run between Cardiff and Treherbert, Aberdare and Merthyr Tydfil via existing rail links.

172km of the Valley Lines will be electrified to accommodate these services, although the vehicles' use of batteries will enable a 'smart' electrification programme to be rolled out requiring only limited modification to bridges and other structures.

These tram-trains will also be capable of on-street running on the short branch being built from Cardiff Queen Street to Cardiff Bay, where they will call at new stations at Loudoun Square, Crwys Road, Gabalfa and Flourish.

Stadler will also supply 24 tri-mode trains to operate to Rhymney, Coryton and lines to the south of Cardiff where diesel power is required, while a further 11 DEMUs will be used on diesel-only services such as the Ebbw Vale line.

Since the franchise commenced in October

2018 it has been managed by Transport for Wales (TFW) - an 'arm's length' company created by the Welsh Government to implement policy and bring a more coherent approach to road and rail planning.

TFW was also placed in charge of the franchise procurement process, which was won by a KeolisAmey joint venture that now operates under the Tfw Rail brand.

TFW Chief Executive James Price says: "We are a wholly owned company charged with driving forward integrated transport in Wales. Our first big projects happen to be in rail and the South Wales Metro, but our remit will quickly expand into other modes such as buses, and more policy statements will be made in due course."

"Rail is part of an integrated picture. We don't want to run standalone modes that can often compete with each other. We aim to become outcome-focused instead, rather than being too wedded to specific inputs or individual technologies."

This integrated approach was clearly demonstrated during the franchise procurement process in which shortlisted bidders were invited to submit their own proposals for South Wales Metro, rather than tendering to operate a preconceived solution specified by Tfw.

Enabling bidders to make proposals based on only outline requirements from the client is known in the public sector as 'competitive dialogue', and has been previously applied to build infrastructure such as roads and



**“ This is about a collaborative approach to the integration of track and train to ensure customers get the best out of their rail experience. ”**

Kevin Thomas, Chief Executive, KeolisAmey Wales

hospitals but never in the rail industry.

Price explains: "We believe there is a risk in over-specifying projects on an input basis, so our approach was to leave it to the provider and leave the industry to innovate. Certain groups of people had argued that South Wales Metro should be exclusively light rail or exclusively heavy rail, so we deliberately allowed parties to bid whatever they wanted, based on outputs around delivering passenger benefits and transforming the economy."

"We received three fully compliant bids that encompassed light rail, heavy rail and hybrid systems - which is what we ended up with - so that demonstrates the industry's ability to think differently and innovate."

He adds: "I think it's definitely paid off as we will be getting an incredibly good solution with on-street running by 2023, a minimum of 4tph on parts of the Metro by December 2023 and up to 14tph in certain places. There will be lots of other features too, such as level boarding, improved air and noise quality, and journey time reductions."

With the rolling stock ordered Tfw is now in a position to agree the final price of the scheme and then begin construction.

Ownership of the core Valley Lines is due

to be transferred from Network Rail to Tfw by the end of the year, while a £135,000 study is under way to consider reviving the 12-mile disused line from Cardiff-Llantrisant as part of the Metro project to offer links between the city centre and Talbot Green, Creigiau, and Pontyclun, with a potential spur to Beddau.

In another break with conventional franchising, Tfw Rail operator KeolisAmey will be responsible for the delivery of South Wales Metro and managing the infrastructure, in addition to operating services.

This will ensure a degree of vertical integration that has hitherto not been seen on this scale in franchising throughout the UK and could, perhaps, become a template for operating rail services and infrastructure in other urban areas of the country.

"I guess people will watch to see what happens in South Wales," says Price. "The big difference is that everything is operated and managed by the same outfit which makes it more aligned, but we still have to be successful with the ethos we're trying to instil."

"We all need to pull together in the same direction and be absolutely aligned to

deliver this scheme to the same budget and timescales, with no underlying contracts or disincentives."

While Tfw is undoubtedly a first mover in areas such as this, Price points to the recent trial of tram-train technology in Sheffield as evidence to prove that the organisation is also comfortable with adopting innovative ideas from elsewhere.

With the trial in South Yorkshire running three years late and costing more than £60m over budget, it is easy to see why he believes it to be more prudent to watch others break the mould in order to benefit from any lessons learned, and to avoid costly mistakes.

He concludes: "The big difference is that we're not going first. The product set has been seen and used elsewhere and is based on a heavy rail system, although I'm sure there will still be challenges."

"I don't think we're cutting edge globally, but we're just behind the curve so we can get all the benefits but with much lower risk. My view is that if Tfw can uniformly sit just behind the best in class, then we will - on aggregate - be the best in class."

"We don't need to take silly risks when learning from others is so important, and can potentially be so beneficial."

Kevin Thomas is chief executive of KeolisAmey Wales. He adds: "As the operator of Transport for Wales Rail Services, our partnership is about more than a train operation. This is about a collaborative approach to the integration of track and train to ensure customers get the best out of their rail experience. As part of Tfw's vision we then need to integrate with other modes to provide a seamless end-to-end mobility solution. This will enable us to connect communities and stimulate economic growth." ■

## THE SOUTH WALES METRO



TRANSPORT FOR WALES.

**“ We believe there is a risk in over-specifying projects on an input basis, so our approach was to leave it to the provider and leave the industry to innovate. ”**

James Price, Chief Executive, Tfw





# Collaboration is key

**T**rams are a popular mode of transport in Europe. Making up over half the world's networks and carrying almost two thirds of annual passenger journeys, there's been a real boom in the introduction and reintroduction



**Alistair Gordon,  
Chief Executive,  
Keolis UK**

of lines since the 1990s. European nations are also some of the most prolific investors in new schemes, accounting for nearly half of all new openings globally between 2010-17.

A notable exception to this trend, however, is the UK. Development of new tram networks has been far slower here than across the rest of Europe, despite clear demand from passengers. Liverpool, for example, is discussing proposals for a new network that would link its emerging Knowledge Quarter development with Lime Street station. Both Birmingham and Sheffield have also recently announced extensions to their existing networks, boosting connections from the wider region to the city centres.

But a series of fundamental challenges will continue to restrict the UK's ability to successfully introduce new light rail networks.

The first, and one of the biggest, is the lack of integration between tram networks and buses. Typically, in the UK, when a new tram scheme opens it is forced to compete with other operators, lessening the effectiveness of a region's public transport offering and, most importantly, failing to provide the best experience for passengers.

Decisive action is required from both central and local government to champion the devolution of transport decision-making, which will be critical to overcoming this barrier. We are already starting to see positive change here - the Prime Minister, for example, has recently announced his ambition to reregulate the bus network. Greater Manchester Metro Mayor Andy Burnham is also exploring how best to take advantage of the powers available to him under the Bus Services Act (2017), to deliver his vision of an integrated, modern and accessible public transport system.

These will be key steps in stimulating discussion on how to deliver tangible, passenger-centric changes to our public transport provision, and realising the full benefits of light rail.

Tram services are popular. Our networks are experiencing rapid growth, with Manchester's Metrolink achieving a 6% increase in passenger numbers year on year, and the Nottingham Express Transit

fulfilling over 17.8 million passenger journeys last year alone.

They also achieve consistently high levels of passenger satisfaction. The results of Transport Focus' Tram Passenger Survey for 2018 (published April 2019) show 91% satisfaction overall across the four major networks in the survey, compared with 79% overall satisfaction with rail services (National Rail Passenger Survey, January 2019).

And it's easy to understand why. Trams are convenient, quick, and an easy way to boost mobility and increase passengers' access to key destinations in their region. Introducing new networks is good for cities too, helping to enhance and modernise urban spaces. By incorporating features such as landscaping and pedestrianisation of public spaces, along with re-alignment of road networks, the introduction of light rail can greatly improve the look and feel of a city, while providing the infrastructure and connectivity to attract employers and boost inward investment.

But crucially, they can help regions to enhance their existing public transport offering, restructuring networks to drive better integration and facilitate inter-modality, increasing the ability of passengers to travel in the most efficient way. The above-ground, urban nature of tram stations allows them to act as mobility hubs, offering connections between multiple transport modes from trains and buses to cycling and walking.

**“ Trams are a quick and easy way to boost mobility. ”**

One of the biggest barriers to championing this kind of integration is affordability. Introducing light rail networks is often prohibitively expensive for local authorities, compounded by logistical challenges such as the movement of utilities during the construction phase. It's well known that utility companies often capitalise on construction works to upgrade their infrastructure, which results in escalated costs and, in the worst scenarios, can halt development altogether.

With the advantages of light rail so clear, the onus is on local and central government to explore more affordable ways of delivering new schemes and move away from the norm of relying on public money. With public finances under such intense pressure, particularly at a regional level, councils must be more creative to reap the long-term benefits of integrated public transport.

The UK has a wealth of international best practice to draw on, where innovative approaches to funding see operators challenged to subsidise the costs of

construction, the purchase of rolling stock or system upgrades, such as fleet overhauls. In Australia and Canada, for example, Public-Private Partnerships (PPPs) are used regularly, with private consortiums - comprising operators, equipment manufacturers and investment funds - contributing to construction costs. This method makes it possible to transfer any construction-related risks, such as delays or underperformance, to the private sector, easing the burden on the local community.

Other examples of alternative funding models include the approach taken in France, where companies with more than 11 employees pay a transport tax. This approach funds around one third of all public transport costs. Similarly, in Germany, tram networks are financed in part by electricity suppliers, as trams are one of the biggest consumers of this energy.

Some of the UK's existing networks have already taken advantage of alternative funding models to see development through to completion. The team behind the Nottingham Express Transit (NET), for example, recognised that to wait for public funding would likely place its scheme at the back of a long queue behind Manchester and Birmingham, and instead opted for a PPP.

Nottingham also took a new approach to funding the scheme throughout its lifetime, introducing a workplace parking levy - applicable to employers with more than 11 parking spaces - which contributed 35% of the scheme's funding, alongside contributions from central government.

This is a prime example of how councils can successfully champion new schemes through creative thinking and bold political decision-making and should be used as the benchmark for the UK's collective approach to enhancing its provision of light rail.

The Government's ongoing consultation on light rail is also helping to shed light on the critical issue of affordability, and is a necessary first step in generating momentum and further boosting the viability of new schemes.

It's clear that there is an appetite for expanding the UK's light rail infrastructure, and the signals from regional and central government suggest that the conversation around how to make our public transport offering more effective is moving in the right direction. But the Government must now be ready to act on the findings of its consultation and collaborate with local authorities and transport operators to help address the fundamental challenges that currently restrict the development of new tram networks.

When they do they will find many companies - Keolis included - ready and willing to help deliver a truly integrated, sustainable and modern service for passengers across the UK. ■

