

Tram-train principles and guidance

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A snapshot of our current knowledge and experience



Introduction

Tram-train is the operation of a rail vehicle on both tramway and heavy rail infrastructure, offering seamless journeys for passengers to the heart of city centres. It blends together the challenges of both railway and tramway into one project, but offers benefits that neither form of transport alone can offer. This document has been developed to give guidance to promoters who may be interested in developing tram-train schemes in England, Scotland and Wales. It also provides guidance for organisations, such as existing tramway operators, who may become operators of tram-train services. It is not intended to be a comprehensive design or development guide, but to share some of our current knowledge and experience of the subject of tram-train.

Mott MacDonald is a global engineering, management and development consultancy focused on guiding our clients through many of the planet's most intricate challenges. A core aim is to make a sustainable difference to the world we live in. Through relentless curiosity and creativity we seek ways to enhance connectivity in sustainable ways, while making the best possible use of resources.

It is our view that the concept of tramtrain has an important part to play in our transport systems, connecting urban light rail systems to our inter-urban, regional and national rail networks. Tram-train also offers potential for lower cost re-opening of former railway lines. Achieving this represents a technical, regulatory and governance challenge on a level rarely seen in modern infrastructure projects. Because of this, we have sought to share some of our knowledge and experience to date with others in the industry through this document. Mott MacDonald has extensive experience in delivering projects for all UK light railways, as well as heavy rail. We have also been involved with the successful delivery of the UK Tram-Train Pilot project between Sheffield and Rotherham.

This document provides an overview of the benefits and challenges of tram-train. If you would like to discuss your project further, please contact us at <u>tram-train@mottmac.com</u>.

What is tram-train?

The concept of tram-train is a light rail vehicle that operates as a tram on a tramway or non-mainline railway, and as a train on heavy rail mainline railway infrastructure, offering a seamless journey to the passenger from the suburbs into the heart of cities.

The first tram-train is believed to have been developed in Karlsruhe, Germany, entering service in the early 1990s, with several other cities worldwide having introduced them since. The first commercial service in the UK commenced operation in October 2018 between Rotherham (Parkgate) and Sheffield (Cathedral).





Benefits

A tram-train service offers the opportunity for passengers to travel between a suburban rail station and a city centre tram stop in a single journey. This relieves capacity at mainline stations and takes the passengers where they want to go, opening up new travel opportunities and offering improved connectivity. A tramtrain vehicle should perform like a tram on a tramway and a train on railway infrastructure. With the appropriate signalling, control and telecommunications technology in place, tramtrains are able to operate alongside conventional heavy rail rolling stock, including freight trains, without introducing operational restrictions. The benefits of tram-trains are:

- Seamless and direct connectivity between suburbs and city centres, with no need to change between train and tram/metro.
- Increased capacity at city railway stations by relocating local services onto new or existing non-mainline railway systems, such as tramway networks. This creates more space and platform capacity for longer distance and commuter services.
- Extending the reach and capacity of tram systems through the use of existing heavy rail infrastructure.
- Reduced project costs through the use of existing infrastructure for new services.

- Improved sustainability and reduced environmental impact due to minimal new infrastructure required.
- Increased frequency of services and reduced overall journey times, by providing direct services to passengers' intended destination.
- Lower cost of re-opening disused railway lines by using tramway technology. Tramway and highways signalling can be used for road crossing, where reopening level crossings is difficult.
- Tram-trains' capability for steep gradients and sharp curves can be used to avoid sections where the track bed has been built on. This includes the use of existing highway corridors.

- On-street extension of railway lines to provide a better service directly into the centre of towns and cities.
- Improved accessibility for pedestrians and road users alike thanks to the open nature of tram systems with no barriers or fencing.
- Lower operational and maintenance costs for individual operators, who can share the costs of shared infrastructure.
- Higher levels of passenger satisfaction compared to heavy rail services.

Application of this guidance

The business case for the UK Tram-Train Pilot project was partly driven by the learning that the project could provide to reduce the costs for future tram-train schemes. Project learning is being managed by Network Rail, who have a web-based repository of information (South Yorkshire Tram Train Pilot Learning Legacy). Access can be requested by emailing tramtrainlearning@networkrail.co.uk.

Given the interest in developing tram-train projects from various organisations, Mott MacDonald has written this document to provide guidance to promoters and future operators on what is needed for the successful delivery of tram-train projects. This guidance is based on Mott MacDonald's experience in developing and delivering tram, light rail, railway and tram-train schemes.

Although this guidance has been written for tram-trains, many aspects may also be relevant to the operation of other light rail vehicles on mainline infrastructure, such as the Tyne and Wear Metro to Sunderland. The guidance in this document is applicable to projects in England, Wales and Scotland. Although the guidance is likely to be relevant to projects in Northern Ireland and other countries, the legislative framework is different, and any future projects need to be discussed with the appropriate body for the country of operation.

Network Rail is used throughout the document as the heavy rail infrastructure manager. The guidance is also applicable where sections of infrastructure have been divested from Network Rail, such as the Cardiff Valley Lines network now owned and managed by Transport for Wales.

References in this document to 'tramway' include the operation of trams on both segregated rights-of-way (eg in their own corridor) and within the street. In all situations where a tramway operates on-street, it will be necessary to meet all relevant highway regulatory requirements applicable to the specific tramway.

These are typically defined by a specific light rail or tramway act or a Transport and Works Act 1993 Order. While there is significant similarity between UK systems, there are also subtle but important differences, and these must be considered on a scheme-by-scheme basis. When considering tram-train, it is important to establish whether the vehicles will be required to operate on-street as well as on heavy rail infrastructure.



Mott MacDonald

We can draw upon our knowledge of all UK light rapid transit systems, a wide portfolio of heavy rail projects, and our successful design role as part of the team that delivered the UK Tram-Train Pilot.

We've been designing railways for more than a century and have the expertise and experience that bring confidence to a project. Whether we are adapting an existing railway or designing a brand new one, our solutions address sustainability and safety as standard, using the most appropriate technology for the job.



Incorporating trams and light rail into a busy highway environment is always a challenge, but one that we have decades of knowledge and experience in delivering. When this complexity is added to by incorporating a tramway into the heavy rail environment, it can become an unfathomable challenge. While we may not have all the answers, we specialise in highly complex, multi-disciplinary solutions to everyday challenges. We work with our customers to push the boundaries, using our experience, collaborative teams and extensive knowledge.

As a multi-disciplinary firm, we work in integrated teams to understand every angle of a problem and come up with sustainable solutions; especially important when a rail project forms the centrepiece of a wider development plan. Our rail operations and rolling stock experts sit alongside our civil engineering, environmental and rail systems teams, fostering open collaboration and exchange of ideas. Working with the supply chain and stakeholders, we drive efficiency and certainty. We have an impressive track record in the delivery of rapid transit projects and are able to provide advice on all aspects of the development and integration of such schemes – from conceptual planning and application for powers through to contract preparation, construction, commissioning and subsequent operation and maintenance.

Our light rapid transit and rail systems practice stretches across the UK and many parts of the world, including Europe, Australasia, North America and Canada. With fully integrated internal systems, experts and specialists from around the world are able to work as part of a collaborative team on any project, bringing not just the widest source of technical knowledge, but cross-continental experience of what works well. We pride ourselves on quality of advice and service specific to our customers' needs. We seek to understand your objectives and help you deliver a better world for today and tomorrow.



We are proud to be at the forefront of bringing new technologies to the light rapid transit industry, pursuing technology solutions to reduce resource requirements, carbon emissions and visual impact. We are working with batteries, hydrogen and other technologies to enhance the freedom of tramways from traditional traction power solutions. All of these offer a bright and affordable future for tram-train to move people to where they want to be.

We are the recognised leader in light rail, with 11 consecutive wins at the prestigious Global Light Rail Awards. In 2020, we won Supplier of the Year and Project of the Year up to \in 50M, followed by Vision of the Year in 2021.

If you would like to get in touch with us, please email tram-train@mottmac.com.



Business case

The business case for tram-train projects needs to be developed in line with the requirements of the funding body.

This is likely to be in accordance with the requirements of WebTAG for England, WeITAG for Wales or Scot-TAG for Scotland. Guidance and assistance on developing business cases for transport projects is available from Mott MacDonald.

There are certain costs associated with tram-trains operating on the mainline which tramway owners and operators do not have: both initial capital costs during project development, and ongoing operational and maintenance costs. These costs need to be included in any business case.

Governance and project structure



Although not part of the delivery team, close co-operation will be required with a range of stakeholders.



The delivery of tram-train requires the following organisations to be involved:

- Project sponsor and funder this could be the Department for Transport (DfT), Transport Scotland, Transport for Wales (TfW), subnational transport authorities or combined authorities/Integrated Transport Authority
- Light rail infrastructure owners
- Light rail operators and maintainers
- Network Rail
- Heavy rail operators (passenger, open access and freight, etc)
- Contractors
- Consultants
- Designers
- Legal advisors
- Vehicle suppliers

An understanding of the stakeholders who need to be engaged should be carried out by all projects with a stakeholder management plan developed.

Given the number of organisations involved, each with their own priorities, it is important that a combined project management structure is put in place. The project team needs to have a clearly defined management structure with clear lines of responsibility and communication between organisations.

The project should be delivered in accordance with project management best practice. Mott MacDonald can provide further advice on how best to structure projects.

Requirements

To develop a transport system that satisfies the needs of all project partners and stakeholders, it is necessary to capture their needs or requirements at the start of the project, so that they can be taken into account in the development of the proposed solution.

It is important that the project puts in place a requirements management process that ensures all requirements are captured at the start of the development process. The requirements should drive the project development, rather than document what was delivered at the end of the process. This process should involve engagement with all the key stakeholders and where possible, confirmation or sign-off of the requirements to avoid needs being missed and only identified at a late stage, when the resulting changes can be costly and disruptive. The process should also include the validation that requirements are complete and in line with business objectives, as well as the verification that the requirement has been met by the design and implementation of the project.



Project timescales

The time required to deliver a tram-train project is highly variable and will depend on the complexity of the project. The UK Pilot Project took over 10 years from the beginning to the start of passenger service due to various delays along the way. The time required for the application and granting of a Transport and Works Act Order (TWAO) can be significant. Any promoter thinking of tram-train should contact us for further advice on the likely timescales.



Safety and legislation

In accordance with all businesses, operators and maintainers of tramtrain systems have to comply with all UK legislation, including the health and safety regulations that fall under the Health and Safety at Work Act 1974. In addition to the regulations that are applicable to all business, there are some specific regulations that are relevant for transport operators.



Railways and Other Guided Transport Systems (Safety) Regulations 2006

The Railways and Other Guided Transport Systems (Safety) Regulations (ROGS) 2006, as amended, sets out the framework for the management of safety for 'transport systems' in the UK.

The Office of Rail and Road (ORR) has determined that the operation of tram-train vehicles on Network Rail infrastructure is excluded from the mainline requirements of ROGS and has included all tram-train vehicles on its approved **list of exclusions**.

The key difference for a tram-train operator compared to a tram operator is the requirement for a non-mainline safety certificate and safety authorisations. These only need to cover the aspects related to operation on heavy rail and do not need to include operation on the tramway.

Railways Act 1993

The Railways Act 1993, as amended, sets out how the UK railway industry is regulated with the requirement for railway assets to be operated by bodies with a licence, as well as for services to be franchised. For a tram-train operator, licence and track access agreements are required.



Railways Interoperability Regulations 2011

Where new infrastructure or vehicles are introduced on Network Rail infrastructure, they are required to comply with the Railways (Interoperability) Regulations (RIR) 2011, as amended, unless they have been exempted by the Secretary of State for Transport. The DfT has excluded tram-train vehicles from interoperability as long as they operate on a tramway, and any infrastructure provided especially for tram-train use.

The Rail Vehicle Accessibility (Non-Interoperable Rail System) Regulations 2011

From 1 January 2020, all rolling stock in use in the UK is required by law to be accessible for all passengers. For rolling stock operating on the mainline subject to the Railway Interoperability Regulations 2011, then they are required to comply with the Person of Reduced Mobility National Technical Specification Notice (PRM-NTSN).

Non-mainline rolling stock, including trams, are required to comply with Rail Vehicle Accessibility (Non-Interoperable Rail System) Regulations (RVAR) 2011. Tram-trains are required to comply with RVAR, this however can be through compliance with PRM-NTSN.

Project approvals

The approval process for tramways and railways are different. Tram-trains have to be approved as safe to operate on both.

Under ROGS all non-mainline and tramway duty holders introducing new or altered rolling stock or infrastructure are required to carry out safety verification (SV) if the changes meet the following criteria:

- The change is significantly different to what is already in use
- The change could increase the risk of the system

The requirement for safety verification for the mainline railway was replaced with the requirement to carry out the common safety method for risk evaluation and assessment (CSM-RA). For tram-train operators, depending on the project, it is likely that they will be required to undertake SV for introduction of the vehicles on the tramway and for the connection between heavy rail and tramway. There will also be a need to undertake CSM-RA for the introduction of the vehicle on Network Rail infrastructure.

Given the significant interface with mainline duty holders, Network Rail (or other infrastructure owners) will also need to undertake CSM-RA for the same connection. With agreement from the Office of Rail and Road (ORR) the UK Pilot Project combined SV and CSM-RA into one process that should be applicable to all future tram-train projects, saving both time and complexity.



Tram-train

 Common safety method – risk evaluation and assessment (CSM-RA) and safety verification (SV)
 AsBo incorporating ICP



Timetabling

A capacity assessment of both the heavy rail network and tramway along the proposed tram-train route needs to be carried out at the early stage of development of a project.

This needs to assess what capacity is available, the types of trains operating, and whether it is possible to introduce the new service at the desired times and frequency. Changes to both the heavy rail and tramway timetables are likely to be required to accommodate the service. It may not be possible to introduce the desired service, frequency or headway between services, and therefore a compromise solution will often be required between all parties. This is best informed by undertaking operational modelling. This modelling should be undertaken as a whole system, rather than the railway and tramway separately. We have undertaken such modelling for several proposed tram-train systems.

Rolling stock

A tram-train vehicle is one that is able to safely operate on both heavy rail and on a tramway. The technical specification should be written so that it captures both the tramway and heavy rail requirements within the contract with the vehicle manufacturer.



Tramway requirements

The essential requirements for trams in the UK is the Light Rail Safety and Standards Board LRG 1.0 Tramway Principles and Guidance (TPG). Although this is a guidance document and not a standard, it has sufficient standing to demonstrate industry best practice, and should be followed in relation to the operation of tramtrains on tramways. As part of the approvals process, a clause-by-clause assessment of the vehicle should be carried out of the relevant parts. RVAR is required to be followed for tramtrain vehicles and the interface with platforms to ensure that transport is accessible for all users.

Heavy rail requirements

Detailed guidance on introducing non-mainline vehicles on the mainline railway is provided by the Rail Safety and Standards Board (RSSB).

Where a vehicle is exempt from RIR2011, including tram-trains, there is a requirement for the vehicle to be compliant with all Railway Group Standards and Rail Industry Standards. The standards that are required to be followed are only those that are applicable to the operation. A review of all standards should be carried out to determine which are applicable so that they can be included in the vehicle specification. Where it is not possible to meet the exact requirement of a Railway Group Standard then it is possible to seek a deviation.



Vehicle design considerations

A rail vehicle that is fully compliant with heavy rail standards would not be safe to operate in street environments. A tram may also be unsafe when operating on heavy rail environments. Therefore, a tram-train has to be a compromise between the requirements for both systems while ensuring that it remains safe at all times. There will be overlapping and potentially conflicting requirements for tramway and heavy rail. The overarching concept should be that a tram-train is a light rail vehicle suitably modified to operate on the heavy rail system. Where there is conflict between the two systems, then the risks should be assessed to determine the most appropriate course of action.

Compatibility

One of the fundamental requirements for the safety of a rail system is to ensure that vehicles are compatible with the infrastructure on which they operate and vice versa. A major part of ensuring compatibility is to manage the interfaces between the vehicle and the infrastructure. The interfaces between the tram-train vehicle and other tram, railway and road vehicles also need to be understood and managed.



Tramway to railway connection



When operating on the tramway, a tram-train will operate as a tram under lineof-sight rules. When operating on Network Rail, a tram-train will operate as a train under control of the signalling system. A method needs to be derived to accommodate the changeover in operational rules and control centres between the two modes.

From an operational perspective, it is not desirable to be in a position where a tram-train vehicle imports a delay on one network due to an issue on the other – therefore this needs to be addressed by the system design at the interface.

Operational and maintenance boundaries

In general, all heavy rail type infrastructure that is under the control and operation of Network Rail should be maintained by Network Rail. Conversely all tramway type infrastructure under the control of the tramway duty holder should be maintained by them. The management of assets that crossover the interface needs to be agreed upon. Agreement should also be reached on the safety systems and procedures required for staff to have safe access to all assets for maintenance.

Operations

It is important to understand how the system will operate, even during the early stages of project development.



Concept of operations

One approach is the development of a 'concept of operations' (ConOps) document that allows the high-level operational requirements to be captured within the design of infrastructure and vehicles. The concept of operations for tram-train should include:

- Services to be operated
- Operational management
- Operational systems
- Transition between tram and train operation
- Modes of operation: normal, degraded and abnormal
- Emergency/recovery situations
- Staff, recruitment and training
- Rolling stock
- Introduction to service

As a project develops, the concept of operations needs to be developed into a detailed plan that sets out how the scheme will be delivered. This will eventually be incorporated in the operator's and infrastructure manager's safety management systems.



Rulebook and other operational standards

When operating on the tramway, the tram-train will operate as a tram. The rules and operating procedures for the tramway are to be followed at all times.

When operating as a train on Network Rail infrastructure, the heavy rail rulebook will need to be followed. However, not all parts of the rulebook will be relevant for tram-train operations. Staff should only be trained on those parts that are. It is therefore important as part of the development of the operational plan to review the rulebook and the other operational heavy rail standards to determine which parts/standards are relevant to the operation. This review needs to be conducted by people with knowledge of the project, tramway operation and heavy rail operation. It is therefore best conducted by a panel of experts.

Development of a tram-train scheme



We are one of the few companies who have a fulltime, permanent team of light rapid transit staff with specialists available in almost every area including:

- Accessibility
- Active modes interaction (cyclists, pedestrians, micro-electric vehicles)
- All elements of heavy and light civil engineering
- Business case development (from strategic and initial case to full busines case)
- Climate change resilience
 assessment and mitigation
- Control centres
- Demand (patronage) forecasting
- Depot facilities
- Environmental and sustainability assessment

- Fire risk, evacuation, management and infrastructure
- Highway design for tramways
- Infrastructure resilience assessment (including climate and threat risks)
- Interface definition and management
- Integration management
- Light rail vehicles
- Onboard Energy Storage Systems (OESS)
- Operations and operational modelling both on heavy rail, on-street and combined
- Overhead line equipment
- Park and ride facilities
- Passenger information systems

- Passenger modelling and management
- Rail technology, track form and materials engineering
- Requirements definition and management
- Risk assessment (CSM-RA, CDM)
- Signalling for heavy rail, light rail and road signal integration
- Telecommunications including LAN, WAN, Mesh Radio
- Traction power
- Tram stops
- Vehicle detection
- Wayfinding

Case studies



Tyne and Wear Metro



The Tyne and Wear Metro transformed underutilised heavy rail routes by introducing a modern and frequent electrified service from 1980.

Originally, the route only served Tyneside, despite its name. In 2002 the system owner Nexus opened an extension from Pelaw to South Hylton, passing through Sunderland. This however was not just a simple extension of the route: it required it to operate on Network Rail infrastructure.

A connection between the metro system and Network Rail was built at Pelaw Junction with 1500V DC overhead provided along the route. The Tyne and Wear Automatic Train Protection (ATP) system was fitted along the route for use by Metrocars, with Network Rail's train protection and warning system (TPWS) also fitted for heavy rail trains.

The introduction of the Metro through Sunderland restricted the speed and operation of freight trains, and required additional space between them and the Metrocars (sometimes referred to as 'double block').

In 2020, Nexus announced that a fleet of new vehicles designed for dual operation would be built by Stadler. We provided technical support for the specification of the new rolling stock and have continued to support Nexus through the procurement and construction process.

This support included traction power modelling, including a feasibility assessment for the provision of an onboard energy storage system (OESS). We also provided technical support for the redevelopment of the depot. Nexus also received permission to undertake the Metro Flow project, which will introduce further shared running with freight trains between Pelaw and Bede.

The operation of Tyne and Wear Metro through Sunderland has many similarities with tramtrain. However, the Metro is a fully signalled system and does not operate on-street, so there is no need for drivers to change between line-of-sight and signalled operation.

UK Tram-Train Pilot

The UK Pilot Tram-Train project was funded by the DfT to operate between Sheffield city centre and Parkgate retail park via Rotherham Central from autumn 2018.

Operation is on the Supertram network and on Network Rail, with a connection between networks at Tinsley/Meadowhall South. It was a joint project between Network Rail, Northern, South Yorkshire Passenger Transport Executive (SYPTE) and Stagecoach Supertram. The key achievements of the project were:

- First deployment of tram-train within the UK
- Approval for seven dual voltage Stadler Citylink tram-train vehicles for use on tramway and on heavy rail lines. Deviations against Railway Group Standards for various aspects were granted
- A tramway operator became a heavy rail operator with the required safety certificate,
- operator licence and track access agreements
- Safe integration of tramway and heavy rail signalling to allow the vehicle to operate seamlessly

- Tram drivers trained to be able to safely operate on Network Rail infrastructure with a changeover between line-ofsight and signalled operation
- Introduction of low floor platforms on heavy rail infrastructure, with the safety case developed and successfully demonstrated for safe operation
- First use of CSM-RA combined with SV for approval of vehicles on tramway and Network Rail
- More than 1M passengers in the first year and 100% passenger satisfaction, according to Transport Focus

Although the delivery of the project was challenging, with significant cost overruns and programme delays, it has demonstrated that tram-train can safely be introduced in the UK.

Our contribution to the project was undertaking initial design for Network Rail. We also designed and undertook the approval process for the 750V DC overhead that was installed along the Network Rail route. This is future-proofed to allow for changes to the standard 25kV AC.



South Wales Metro

The railway network to the north of Cardiff was built to take coal from the Heads of the Valleys to the docks. Although the amount of coal carried has reduced dramatically, there are still coal trains operating alongside heavy rail passenger trains.

The Welsh Government and Transport for Wales have built a business case to transform these lines into a modern transport network providing easy access to the heart of the Welsh capital.

The project is underway for delivery in 2023. The approach is to transform the lines from Treherbert, Aberdare and Merthyr Tydfil to Cardiff Bay, and the City line via Ninian Park and Cardiff Central through the introduction of bi-mode Stadler Citylink tram-train vehicles. Line-of-sight tramway operation will be introduced between Cardiff Queen Street and Cardiff Bay, with the aim of future tramway extensions. The lines to Rhymney and Coryton through Cardiff Central to Barry and Penarth will be operated by a new fleet of tri-mode heavy rail Stadler Flirts, which will work alongside the tram-trains.

Electrification of the South Wales Metro will be at 25kV. This is also known as 'smart electrification' as it involves unwired sections and the use of permanently earthed sections (PES) in complex areas and through tunnels and bridges to reduce the amount of reconstruction work and minimise costs. The vehicles will be fitted with batteries to ensure they can operate through these areas.



Opening opportunities with connected thinking.

Talk to us.

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