Network RUS: Alternative Solutions
Scoping Document
February 2012

NetworkRail

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Foreword

I am pleased to present this scoping document for consultation of the Network Route Utilisation Strategy: Alternative Solutions. It is the latest element of the Network RUS and also the last of the first generation of Route Utilisation Strategies (RUSs) which have been led and produced by Network Rail.

The railway industry faces a constant challenge to deliver value for money, and not just in straitened economic times. It is only by rising to that challenge that the industry can continue to play a significant role in transporting people and goods across the nation in an efficient, sustainable and environmentally friendly way.

This scoping document is different from all of the previous RUS consultation documents because it considers a range of solutions which may go beyond the current rail network. It also considers solutions from other industries and contexts which may still be in development. For this reason the first element of this RUS to be published and consulted upon is this scoping document. The consultation seeks the views of the rail industry and its stakeholders on the solutions that have been analysed so far and the responses will inform the work that is undertaken to develop the full draft strategy. The second consultation stage on the draft strategy will be in the same manner as the RUS drafts for consultation that have published before and it will be followed by the publication of the final strategy.

This scoping document has examined three areas in which different ways of doing things (the 'alternative solutions'):

- can the application of tram and tram train technologies deliver savings in capital, operating and maintenance costs, whilst simultaneously improving the offering to the travelling customer?
- are there cheaper and more innovative ways of replacing diesel traction with electrically powered trains?
- to what extent can the further development of community rail initiatives provide locally applicable opportunities for adding value to railway operations?

The key conclusion from examining these solutions is a description of the circumstances in which they would be most likely to be able to contribute to delivering value for money. The aim of identifying the areas in which these solutions might contribute is to focus the resources of the rail industry and its stakeholders.

No organisation has a monopoly on good ideas. Indeed, we believe that there may be other areas where alternative approaches or technologies have the potential to drive costs down. For that reason, I invite all our stakeholders (customers, suppliers, funders, or anyone with an interest in the sustainable future of Britain's railway network) to contribute their own ideas. Details of how to do so can be found in **Chapter 8** of this document.

We will consider all responses received and these will inform the RUS draft for consultation to be published later this year.

May I thank you for your interest and participation in this RUS.

Paul Plummer
Group Strategy Director

Executive summary

Introduction

The Network Route Utilisation Strategy (RUS) considers planning issues which are network-wide and four of these (Electrification, Passenger Rolling Stock, Scenarios and Long Distance Forecasts, and Stations) have already been established. This latest workstream (Alternative Solutions) commenced in September 2010. The RUS is developed in conjunction with a range of stakeholders who also have a network-wide perspective. It is overseen by a Stakeholder Management Group consisting of representatives from:

- Association of Train Operating Companies (ATOC)
- Department for Transport (DfT)
- Freight Operating Companies (FOCs)
- Freight Transport Association (FTA)
- London TravelWatch
- Office of Rail Regulation (ORR) – in the capacity of observer
- Passenger Focus
- Passenger Transport Executive Group (PTEG)
- Rail Industry Association (RIA)
- Rail Freight Group (RFG)
- Rolling Stock Companies (ROSCOs)
- Transport for London (TfL)
- Transport Scotland (TS)
- Welsh Government (WG).

A subset of these organisations is represented on the Alternative Solutions Working Group in order to supply more detailed input and expertise to development of the RUS.

This RUS is unique amongst the Network RUS workstreams both because of its subject matter but also because Network Rail is proposing a two stage consultation process with this scoping document forming the first part of the consultation. The consultation responses to the scoping document and its emerging conclusions will shape the work that is undertaken to develop the full draft strategy. This will be the second document to be consulted upon prior to the publication of the final strategy.

Scope and policy context

The objective of this RUS is to develop a strategy which presents alternative solutions to cater for future rail passenger demand in a cost effective manner. The work undertaken examines both the range of alternative solutions and their potential contribution to increasing value for money. This document follows the established RUS process of baselining, identifying gaps and options before describing the circumstances in which solutions are most likely to be able to contribute. The RUS takes into account relevant findings from other workstreams, notably the tram train pilot between Rotherham and Sheffield and the Technical Strategy Leadership Group's (TSLG) work on electrification and energy storage.

The RUS scoping document has considered only three alternative solutions from a potentially almost limitless field. The RUS has focused upon a balance of technical and operational solutions to address the strategic network planning of the regional, lighter trafficked and rural passenger network. These solutions have been selected on the basis of their ability to contribute to the issues being faced and also because they have not or are not planned to be considered as part of the existing railway industry planning process.

The gaps and options considered by this scoping document are likely to have a strong local focus. Local Transport Plans are likely to be the source to identify the transport problem and the potential solution. In particular the RUS has sought to address the gaps identified from the perspective of heavy rail and the RUS notes that both the gaps to be solved and the benefits to be gained from the solutions proposed are in many respects much wider than this. Network Rail acknowledges that it is does not necessarily have direct experience of all of the solutions considered and this RUS is intended to facilitate rather than dictate solutions by focusing resources to where they may be most valuably employed.

Baseline and drivers of change

Governments have continued to stress the importance of rail in delivering economic and environmental benefits. There are a number of drivers of change which could potentially encourage the use of alternative solutions on the network given the objectives of the rail industry's stakeholders. These objectives include the need to reduce industry costs, to accommodate passenger growth efficiently, to improve the product offered to passengers, with the associated revenue benefits, to enable the local railway to respond more fully to local needs, to provide a more environmentally friendly product, to be less reliant on potentially insecure energy sources and to comply with environmental legislation.

In May 2011 the study by Sir Roy McNulty 'Realising the Potential of GB Rail, Final Independent Report of the Rail Value for Money Study', was published and considers in section 19 the 'Lower Cost Regional Railway'. The options that are being considered in this strategy complement these objectives and various alternative solutions have been proposed which have the theoretical potential to reduce the whole life whole industry cost of

the railway by either reducing capital, or operating and maintenance costs.
Industry forecasts and the geographic suite of Route Utilisation Strategies point to a railway which will see considerable growth in passenger and freight traffic. Indeed for many of the lower traffic density lines considerable growth has been experienced in the last ten years and in many instances further growth is forecast. However, because of the low yield per passenger and high subsidy requirements of parts of the existing railway, it can in some circumstances be hard to justify the cost of investment to increase capacity. Alternative solutions to conventional rail, in these circumstances, would be desirable as the current solutions to increasing capacity on these routes may not always represent value for money or be affordable.

The identified alternative solutions potentially may also be a more affordable means of improving rail's product offering to its passengers.

The three alternative solutions considered in the scoping document are:

1. tram and tram train conversion of heavy rail infrastructure or services
2. alternative methods of delivering electric traction on lower traffic density routes
3. community rail.

Tram and tram train conversion

Tram systems have enjoyed a resurgence over the last 20 years and there are now a number of systems operating in Great Britain's cities. Many of these systems make use of or have been converted from former heavy rail alignments and in a number of cases have been introduced as a result of a requirement for renewal of both the former heavy rail infrastructure and the rolling stock that operated on it. In Croydon and Manchester services formerly operated by heavy rail rolling stock have been converted to segregated tramways. Tram systems include an element of on street running and it is this characteristic that has opened up new markets and increased ridership.

The RUS scoping document has considered a number of scenarios of conversion of heavy rail infrastructure and services to either tram or tram train. These conversion scenarios range from extending an existing urban tramway to creating a segregated service on rural routes with no on street operations. The RUS has individually tested the proposed areas where the solutions might be able to contribute to be able to draw conclusions about the circumstances where tram or tram train are able to be most valuably employed on the rail network.

The identification of the need to address transport problems which by their definition cross modal boundaries and are local in nature is likely to come from Local Transport Plans. As with new tram schemes the identification, promotion and execution of such schemes is also likely to be undertaken locally by bodies such as Passenger Transport Executives. There is the potential that this local role may be further enhanced by the Localism Act and the DfT's planned consultation on devolution of rail powers in England. Network Rail has undertaken changes to its own structure to make it a more devolved and locally focused organisation and will be a key party where heavy rail infrastructure is involved in a tram or tram train scheme.

Tram trains are not currently in operation in Great Britain although they are used in a number of cities in Europe. Tram trains are capable of operating on both the on street sections of tramways and on the heavy rail network. The rolling stock used is complex as it has two different systems on board to enable operation in the two environments.

Trams and tram trains are high density rolling stock with a low ratio of seating to standing passengers. This internal layout configuration is appropriate for the kind of services on which they operate with frequent stops, with passengers travelling for a relatively short time. High percentages of standing passengers are appropriate in this context in a way in which it would not be for a long distance service. Trams and tram trains do not typically have toilet facilities. This means they are optimised for services with frequent stops and relatively short passenger journeys.

Both trams and tram trains are characterised by their high acceleration rates which is particularly beneficial where there are frequent stops in order to reduce overall journey time. The difference in acceleration rate is most stark when compared with heavy rail Diesel Multiple Units (DMUs).

Conversion of an existing heavy rail service to tram operation has the potential to reduce the cost of enhancements and operating costs where routes can be fully segregated. There are also additional costs associated with conversion - for example creation of a depot may be necessary and for low floor trams all existing heavy rail platforms need to be lowered. Trams are not likely to be an option where on street running is not utilised as they are expensive rolling stock which require electrification or if diesel are more complex and likely to be more costly than a light weight Diesel Multiple Unit (DMU).

The construction costs of a tram train scheme comprise the cost of converting the existing infrastructure and the cost of connecting to an existing tramway along with the cost of the rolling stock itself. In order for tram trains to operate on the existing heavy rail network, investment will be required in track (as tram trains have different wheel profiles to heavy rail rolling stock) and in stations (particularly where low floor tram trains are proposed to operate). The RUS has concluded that electrification of the heavy rail network where tram trains are to operate is likely to be required as the affordability of diesel powered tram trains is uncertain. Costs associated with connection to the existing tramway system vary depending on the complexity of the connection to the on street part of the system.

Network Rail in conjunction with South Yorkshire Passenger Transport Executive (SYPTE), Stagecoach Supertram, Northern Rail and the DfT, is currently planning a pilot to introduce tram trains between Rotherham and the existing tramway system in Sheffield. The pilot plans to address the technical challenges in introducing the concept and test a number of the cost drivers associated with conversion.

Alternative methods of delivery of electric traction on lower traffic density routes

The RUS scoping document considers three alternative methods of delivery of electric traction on lower traffic density routes: coasting, discontinuous electrification and discrete electrification.

Coasting, whereby electrically powered services coast through a neutral section in the overhead line up to a distance of around 50 metres, is already used in Great Britain where it would be necessary to undertake substantial works to obtain sufficient clearances under structures. It is restricted in its application because in order to be safely and reliably implemented the neutral section must not be in a location where a train would be likely to come to a standstill, and therefore be stranded unable to move because of the lack of power.

A discontinuous electrification scheme would involve gaps in the overhead line electrification system from around 50 metres to two kilometres. The rationale for this approach would be to reduce electrification and civil engineering costs by not wiring through complex junctions, tunnels or bridges.

To have a discontinuous section in the electrification infrastructure, the overhead line needs to be terminated at both ends of the discontinuity. Specifically designed rolling stock would be required with the ability to raise and lower pantographs frequently and on the move. It would also require installed energy storage to bridge the gap in the overhead line electrification (OLE) if coasting was not feasible because of the length of gap or the risks of a train becoming stranded. Electrical continuity of the overhead line needs to be maintained across the gap in the OLE and this will require high voltage cables for each electrical section, cable terminations at both ends of the cable, and cable routes to mechanically protect the cable.

Energy storage devices will require time and the means to recharge the stored energy automatically in order to traverse all of the discontinuities in a route. There are currently no examples of discontinuous electrification worldwide.

Discrete electrification differs from discontinuous electrification in that it involves a considerably greater distance (from two kilometres to 30 kilometres or more) of self powered operation away from the OLE using energy storage for traction power. Whilst conventional overhead electrification should remain the starting point when considering the case for electrifying a route, it is best suited to busier routes where the high infrastructure costs can be offset by the lower costs of running electric rolling stock (compared to diesels). Discrete electrification could be a way to replace diesel traction on sections of the network that would otherwise not have a business case for conventional electrification. As the electrification programme progresses there will still be areas of the network where diesel trains will be operating. At the same time the Diesel Multiple Units (DMUs) operating these routes will become progressively older and will eventually need to be replaced. Any potential application of discrete electrification would relate to this point when there is not necessarily a viable electrification case or new replacement diesel rolling stock available.

It is not thought that discrete electrification is likely to be feasible for high speed passenger or freight trains because of the high stored energy requirements. The applicability of this solution is therefore likely to be best suited to lower speed passenger routes. Currently discrete electrification is used in a number of tram networks across Europe to bridge small gaps of hundreds of metres, however, there is no current usage in a heavy rail context. The energy storage technology is still in development and its capability and price are uncertain. The RUS has therefore considered price and capability which the railway industry would need from energy storage to be able to contribute. This is not to suggest that the capability or price that appears in the RUS analysis is possible today, but rather to act as a guide to potential suppliers of the potential size of market and the rail industry's requirements.

Community rail

Community Rail is a concept which emerged in the 1990s as a response to concerns about the future of rural and local rail services. The idea has been implemented in a range of forms from DfT designated community rail lines and services through to more informal groups such as station adopters. A number of partnerships were formed (early adopters included the Penistone Line Partnership and the Devon and Cornwall Rail Partnership) which demonstrated strong local commitment to 'their' railway lines and which had some early successes in increasing passenger numbers. The focus on community rail complements the McNulty report findings suggesting the benefits of increased local engagement in the regional railway. Community rail seeks to be a locally appropriate way to address the challenges that the routes face in delivering value for money whilst also providing a socially useful transport service.

There are a wide variety of community rail lines but they are typically local or rural routes which have a single passenger operator and limited freight. Community Rail Partnerships (CRP) are generally not-for-profit organisations which are formed from a range of local groups and rail industry organisations.

Each partnership has individual objectives which relate to the specific circumstances of the locality in which the CRP route or service operates. CRPs are a means of bringing the local community and the railway industry together. By providing a focus for involving local people they can potentially make the most effective use of available resources to meet local needs and identify opportunities for improvement at marginal cost. The activities undertaken by CRPs vary considerably because of their local circumstances, needs, and objectives and resources. However, in general terms they carry out a range of actions such as:

- promotion and marketing of the line to increase ridership and revenue
- initiatives to promote ridership through fares changes and initiatives to increase revenue collection
- providing a framework to secure third party funding
- station adoption and other voluntary initiatives
- linking the railway with local regeneration projects and initiatives
- linking the railway with cultural and heritage projects.

Gaps and options

The RUS has followed the established process of gap identification followed by rigorous appraisal to develop options to bridge those gaps. Each of the three types of alternative solution has been considered in turn. The approach that has been adopted is to test the circumstances which have been proposed in which the alternative solutions could contribute. In the case of tram or tram train conversion from heavy rail there are three gaps that have been suggested:

- gaps in heavy rail city centre major station capacity and or capacity on inner suburban routes
- connectivity with city centres and their suburbs to create new journey opportunities, access new markets, and opportunities for new stations
- cost effective ways of delivering services or new journey opportunities, access new markets, and opportunities for new stations.

The RUS, as a rail industry strategy, has started with the heavy rail gaps. In reality a scheme would be likely to be formed of a package of measures contributing to addressing a range of gaps. However, the gaps have been tested individually in order to analyse the circumstance in which the solution would be most valuable. The options proposed consider in a high level manner a range of conversion scenarios.

A number of geographic RUSs have considered whether tram train conversion may provide a solution to increasingly scarce capacity at major city heavy rail terminals. This RUS has sought to develop this concept further by looking at Leeds as an example to see whether this heavy rail gap can be addressed by diverting some services away from the city centre terminus and on to an on street tramway as a potentially less costly alternative to the solution of providing more heavy rail infrastructure at the city centre terminal itself.

The RUS then broadens its outlook to consider whether tram or tram train conversion can contribute to the wider transport agenda not just providing solutions to heavy rail gaps. In particular the RUS considers the potential for increased city centre penetration, the ability to generate new markets or provide new stations by linking heavy rail services to existing city centre tramways through a tram train solution before finally looking at the potential for tram conversion of existing heavy rail services or new routes to provide a more cost effective whole life solution.

The gaps for the alternative methods of delivery of electric traction on lower density routes have been based upon two of the established Electrification Strategy gaps:

- where electrification may enable more efficient operation of passenger services
- where electrification could enable a new service to operate.

Coasting and discontinuous electrification have firstly been considered as an option to avoid expensive reconstruction of challenging structures where there is insufficient space to provide conventional electrification systems, and secondly, as a more cost effective way of delivering electric services. The options considered have been illustrated by case studies demonstrating the strengths and weaknesses of the technologies.

Discrete electrification options have considered the potential market for the conversion of DMU operated services based on the price and capability of energy storage technology. The assessment considered where existing DMU operated services crossed electrified infrastructure and the potential for their conversion.

Two gaps have been identified where community rail can potentially provide a solution:

- the potential role of community rail in obtaining value for money in the local railway
- the potential role of community rail in encouraging greater involvement of the local community in the local railway.

A toolkit of potential options has been considered to increase the value for money in the local railway including:

- additional community engagement
- wider adoption of community rail techniques particularly in respect of ticketing, retailing and marketing.

In respect of the potential role of community rail in encouraging greater involvement of the local community in the local railway the RUS has considered where community rail has enabled decisions to be made about social rail services with community engagement and where stakeholder engagement in the specification process on regional lines could permit improved timetables that meet the community needs.

Emerging conclusions

The RUS in its emerging conclusion describes the circumstances in which tram or tram train could be used most valuably to address transport gaps. This is not an absolute conclusion but rather a tool to focus resources on those circumstances in which the solutions are most likely to be beneficial. Tram or tram train conversion are not cheap solutions to heavy rail gaps in terms of capital cost investment. They do, however, offer the prospect of cheaper capital and operational costs in certain settings. Of the gaps considered, tram or tram train technology could solve conventional heavy rail capacity gaps at city centre terminals but it is unlikely to form the sole justification for conversion. Moreover, the benefits of this technology are more readily achieved through their application to address wider urban transport gaps. The technology enables better city centre penetration, reduced end to end journey times and has the potential to exploit new markets by providing both new stations and new through journey opportunities. All of the tramways constructed since 1990, with the exception of Edinburgh, converted either parts of heavy rail infrastructure or heavy rail infrastructure and services.

On rural routes the business case for electrification probably means that due to the lower traffic density, they are not candidates for electric tram or tram train conversion. Where on street running is not made use of the bi-mode or self powered tram or tram train might be more expensive than an equivalent DMU.

The RUS concludes that tram or tram train conversion of heavy rail infrastructure are most likely to be able to contribute in an urban area with a tramway where diesel operated heavy rail routes can be simply and cheaply converted, electrified, and connected to the tramway. The option to convert heavy rail infrastructure or services would need to be tested against a full range of heavy rail options and those involving other modes of public transport such as bus and guided bus.

For a route to be selected for conversion needs to have a market with relatively short but frequent journeys where urban transport gaps exist that could be solved by conversion to a tram or tram train. The size of the flow needs to be large enough in order to generate sufficient user benefits but within a volume that is appropriate for a tram style vehicle.

For new or reopened routes it is clear that tram or tram train could be lower cost options as the vehicles are potentially of a light weight and require less complex train control systems. Routes have been reopened using trams such as the Midland Metro between Birmingham Snow Hill and Wolverhampton via Wednesbury. However, the key factor in whether routes are appropriate is if the market served is suitable for a tram style vehicle which means relatively low top speeds, frequent stops and shorter journeys. In deciding that tram or tram train is the appropriate option it would have to be compared against other options including bus to establish that it provided the best value for money. Tram and tram train in absolute terms are still expensive options and appropriate transport gaps and sufficient benefits must be present for these options to be viable.

The RUS has considered a number of options for providing electric traction on lower traffic density routes. These focus on reducing the cost of fixed infrastructure and progressively shifting the balance of spending to the rolling stock to reduce the whole life cost of the railway system. Three options have been considered which consider progressively longer gaps in the OLE.

Coasting of some tens of metres through the use of neutral sections in the OLE is already in use on the UK system primarily in locations where excessive cost would be incurred through the reconstruction of structures. The RUS notes the limitations of this technology, in particular that it cannot be applied in locations where trains are likely to be brought to a stand, but nevertheless recognises the cost saving benefits that this approach can deliver.

Discontinuous electrification is not currently in use in the UK and the case study used to understand the costs and benefits of this technology suggests that it would be difficult to justify in economic terms. This is because the cost of energy storage and increased complexity of rolling stock does not necessarily outweigh the avoided cost of infrastructure. Secondly, the complexity of operating a route with large numbers of small gaps in the OLE is challenging and may, above a certain number, not be operationally feasible.

The RUS has considered the challenges and opportunities presented by the developing future prospect of discrete electrification. By its very nature, discrete electrification requires a considerable amount of energy storage on trains beyond the capability of anything in service today. Energy storage would also add weight to a train at a time when the rail industry is trying to reduce vehicle mass in order to reduce energy consumption and track maintenance costs. The current cost and technological capability of train borne energy storage has a large range and the analysis has considered the effect of both cost and capability on the potential market size for new vehicles. The RUS has found that as well as capability and cost, a critical factor to enable successful implementation of this solution is the ability to swap conventional diesel rolling stock on a one for one basis, with no additional unit requirements to enable delivery of the train service. The recharge time of the energy storage device or the ability to replace it quickly is therefore critical.

The industry will need to monitor how the costs and capabilities of different energy storage technologies improve over time due to developments driven by other sectors. In particular, the automotive sector is investing heavily in the battery technologies to support the development of electric and hybrid vehicles. This is expected, over the thirty year time horizon of this RUS, to deliver a substantial reduction in unit costs and a substantial improvement in energy density. The market considered by the RUS therefore allows margins for improvement in price and capability, it does not suggest that these values could be obtained today.

Since its inception community rail has introduced new ways of increasing ridership and economic benefit to local communities. Options have been considered for the potential role of community rail in obtaining value for money and encouraging greater involvement of the local community in the local railway. These options recognise that the history of community rail's achievement focuses on means to increase ridership and revenue. There have also been successful examples of involvement in developing rail routes and services.

These outcomes are to be welcomed and have been expanding with four new Department for Transport (DfT) designated routes in 2011 alone. The objectives of community rail are endorsed by the rail industry and its funders who would therefore wish them to be extended. However, the railway industry cannot impose partnership so its main role is to facilitate and work with those groups and partnerships that do emerge.

This RUS has analysed three very different alternative solutions in tram or tram train, innovative electrification and community rail. It has sought to express what circumstances these solutions can contribute to addressing heavy rail gaps. In general terms the RUS has found that each of the proposed solutions can address gaps in certain circumstances. None of the proposed solutions are a panacea for all transport problems and in this respect they are no different to many heavy rail solutions. The RUS concludes that each of the proposed solutions has merit and can be applied to certain circumstances and that they are all therefore worthy of further consideration and development.

Consultation and next steps

As has been emphasised, uniquely for the Network RUS, Network Rail is proposing a two stage consultation process for the Network RUS: Alternative Solutions. The first consultation on this scoping document poses an emerging conclusion to which consultation responses are welcomed both in general and to some specific questions. The responses from the rail industry and its stakeholders will inform the work that is undertaken to develop the full draft strategy that will form the second phase of consultation.

The two stage consultation is being undertaken both because of the range of potential solutions that could be considered and also because it is recognised that many of the alternative solutions analysed in this RUS are in part outwith Network Rail's direct experience. In considering alternative solutions there may be a wide range of views and experience from other industries and contexts which may be relevant to the issues that are addressed, and it is therefore essential that this scoping document for consultation is presented to the widest possible audience for comment.

The specific questions consultees are invited to respond to are:

1. Have the appropriate options been considered to address the gaps raised in this document and if not what other or different options to address those gaps would you consider to be appropriate and why?
2. Has the analysis of the options considered the appropriate factors? If there are further factors that should be considered please provide evidence where possible.
3. Do you agree with the emerging conclusions that have been reached on the basis of analysis of the options?

Details of how to respond can be found in **Chapter 8**.

Following a 60 day consultation period, the responses will be considered and further analysis will be undertaken as appropriate to develop the full draft for consultation. This will be consulted upon in the same manner as other workstreams that have formed the Network RUS.

1 Background

1.1 Context

Following the Rail Review in 2004 and the Railways Act 2005, the Office of Rail Regulation (ORR) modified Network Rail's Licence in June 2005 (as further amended, in April 2009) to require the establishment of Route Utilisation Strategies (RUSs) across the network. Simultaneously, the ORR published guidelines on RUSs. A RUS is defined in Condition 1 of the revised licence, in respect of the network or part of the network, as a strategy which will promote the route utilisation objective.

The route utilisation objective is defined as:

> 'the efficient and effective use and development of the capacity available, consistent with funding that is, or is likely to become, available.'
>
> ***Extract from ORR guidelines on Route Utilisation Strategies, April 2009***

The ORR guidelines explain how Network Rail should consider the position of the railway funding authorities, their statements, key outputs and any options they would wish to see tested. Such strategies should:

> 'enable Network Rail and persons providing services relating to railways to better plan their businesses, and funders better plan their activities.'
>
> ***Extract from ORR guidelines on Route Utilisation Strategies, April 2009***

The process is designed to be inclusive. Joint work is encouraged between industry parties, who share ownership of each RUS through its industry Stakeholder Management Group.

RUSs occupy a particular place in the planning activity for the rail industry. They use available input from Government Policy documents such as the Department for Transport's Rail White Papers and Rail Technical Strategy, the Wales Rail Planning Assessment, and Transport Scotland's Scottish Planning Assessment. The recommendations of a RUS, and the evidence revealed in the work to reach them, in turn form an input to decisions made by industry funders and suppliers on issues such as franchise specifications, investment plans or the High Level Output Specifications (HLOS). HLOS sets strategic outputs that Governments want the railway to deliver for the public funds they have made available.

Network Rail will take account of the recommendations from RUSs when carrying out its activities and the ORR will take account of established RUSs when exercising its functions.

1.2 Document structure

This scoping document starts by outlining in **Chapter 2** the role of the Network RUS. It summarises the scope of the Network RUS: Alternative Solutions workstream. This includes the key issues which will be considered and the time horizon that it examines. It outlines the policy context and the relationship between the RUS and related policy issues which are being considered by industry funders.

Chapter 3 presents the baseline for the study. The chapter defines each of the alternative solutions considered in the RUS scoping document which are:

- consideration of tram and tram train conversion
- alternative methods of delivery of electric traction on lower traffic density routes
- community rail.

The baseline describes each of these solutions, identifies today's usage, and the costs and characteristics associated with both the solution and its conventional alternative.

In **Chapter 4** the drivers of change are outlined. These are the factors which could potentially drive a move to alternative solutions on the network, given the objectives of the railway industry's stakeholders.

Chapter 5 outlines the key gaps which have been identified in relation to today's railway and a future railway which could exploit the benefits of alternative solutions as highlighted in **Chapter 4**. For clarity, a RUS gap is a gap between current system capability (supply) and what it is required to do (demand). These are summarised within the chapter, for each of the alternative solutions.

Chapter 6 outlines the options which are proposed by the RUS to bridge the gaps identified. **Chapter 7** outlines the emerging conclusions for each of the alternative solutions.

Finally, **Chapter 8** outlines the consultation process. It also describes the next steps that will be undertaken following the publication of this scoping document.

2 Scope and policy context

2.1 The role of the Network Route Utilisation Strategy

The Network Route Utilisation Strategy (RUS) considers issues which affect the entire rail network of Great Britain. Its network-wide perspective is supported by a stakeholder group with wide expertise which enables the development of a consistent approach on a number of key strategic issues which underpin the future development of the network.

The Network RUS with its broad range of stakeholders has a number of interfaces with other key strategic workstreams. As a result, the Network RUS has developed a meeting structure, industry consultation and programme to ensure that it produces key, timely and thoroughly consulted deliverables.

There are currently five working groups of the Network RUS of which four have published strategies that have been established with the Office of Rail Regulation (ORR):

- Scenarios and long distance forecasts (published and established June 2009)
- Electrification (established October 2009)
- Stations (established October 2011)
- Passenger Rolling Stock (November 2011)
- Alternative Solutions (scoping document published February 2012).

2.1.1 Network-wide perspective

The Network RUS enables strategies to be developed by the industry, its funders, users and suppliers which are underpinned by a network wide perspective of rail planning. The development of such strategies, ensure that key issues are dealt with consistently throughout the long term planning framework. The Network RUS enables strategies to be developed which by their very nature cut across geographic boundaries (for example the development of future rolling stock families and electrification strategy) and draw on best practice for different sectors of the railway.

2.1.2 Organisation: Stakeholder Management Group and Working Groups

The Network RUS is overseen by a Stakeholder Management Group (SMG). The Stakeholder Management Group is chaired by Network Rail. It draws its members from:

- Association of Train Operating Companies (ATOC)
- Department for Transport (DfT)
- Freight Operating Companies (FOCs)
- Freight Transport Association (FTA)
- London TravelWatch
- Passenger Focus
- Passenger Transport Executive Group (PTEG)
- Rail Industry Association (RIA)
- Rail Freight Group (RFG)
- Rolling Stock Companies (ROSCOs)
- Transport for London (TfL)
- Transport Scotland (TS)
- Welsh Government (WG)
- Office of Rail Regulation (ORR) – in the capacity of observer

The majority of the work and detailed stakeholder consultation, however, is carried out within working groups which have been formed to steer each of the Network RUS workstreams. The groups vary in size but are all small enough to ensure effective levels of engagement between the participants. However, given that each is composed of individuals with relevant expertise or strategic locus for the specific subject matter, they play an important role in recommending a strategy for endorsement by the SMG.

The SMG is the endorsement body for the outputs of the individual workstreams. Its agenda concentrates on key decisions – from endorsement of the working group remits to approval of key documents and ultimately the resulting strategy. If the SMG has comments or questions on papers these would be referred back to the working group which contains each of the SMG organisations' specialist representatives.

Network and Route Specifications use the strategies recommended by the established Network RUS when developing their route-based strategies.

2.1.3 Network RUS working group

The SMG identified those elements of strategy which it wished to include in the Network RUS. A working group was formed to take forward each chosen element of strategy. The Network RUS: Alternative Solutions working group consists of members of the following organisations:

- ATOC
- DfT
- Eversholt Rail
- Network Rail
- Porterbrook
- PTEG
- RIA
- Transport for Greater Manchester (TfGM)
- Transport Scotland

- Welsh Government
- ORR (in the capacity of observer).

2.2 Time horizon

The Network RUS takes a 30 year perspective. This is consistent with the long term views of transport planning taken by UK Governments in their recent strategy documents, notably the DfT's Rail White Paper (2007) and Transport Scotland's Strategic Transport Projects Review (STPR) (2008).

2.3 Scope of the Network RUS: Alternative Solutions

The objective of this RUS, as agreed by the SMG, is to develop a strategy which presents alternative solutions to catering for future rail passenger demand in a cost effective manner. The work follows the established RUS process of baselining, identifying gaps, options and making strategic recommendations.

The remit anticipated that stakeholders would identify issues which will be expected to trigger the need for an alternative solution. Possible examples may include:

- the replacement of self-powered rolling stock
- aspirations for lighter vehicles on less heavily used parts of the network
- a desire to identify innovative lower cost forms of electric traction
- aspirations to run more frequent services on routes currently limited by infrastructure constraints (e.g. single lines with passing loops)
- aspirations for greater connectivity through better city centre penetration
- increased community involvement in operating the railway.

The scope of the Network RUS: Alternative Solutions relates to the strategic network planning of the passenger network which is neither long distance high speed, London and South East or interregional. It comprises instead regional commuter, regional and rural services. The key issues concerning this area of the network is the accommodation of current and forecast growth in patronage in a cost effective and affordable manner. The objective of the RUS is to develop a strategy which presents a number of alternative solutions to carrying the future demand for rail passengers on those parts of the network more cost effectively. The RUS builds on previous geographical and Network RUSs (particularly Electrification and Passenger Rolling Stock). The RUS focuses on rail based options on the basis that this is a rail industry strategy and it is therefore seeking to respond to the specific transport challenges that this mode of transport needs to address.

The RUS examines a number of potential alternative solutions. It identifies their potential to contribute to the objective of ensuring increased value for money. This is achieved by acquiring an understanding of the issues currently facing the railway and then, using robust analysis, appraisal of the potential contribution of each solution is undertaken.

The scoping document has considered two technological solutions, tram and tram train conversion, and innovative forms of electrification involving varying lengths of gaps in the overhead line infrastructure. To balance the otherwise technological focus of the scoping document, community rail as a concept of management philosophy involving the community in the development of the railway has also been assessed. It is recognised that the alternative solutions that have been considered are only a sub-set of all the possible options. These solutions have been selected on the basis that they have not or are not planned to be considered as part of the existing railway industry planning process, along with their ability to contribute to the issues being faced.

The scoping document takes into account relevant findings from ongoing workstreams notably that of the tram train pilot between Rotherham and Sheffield and the Technical Strategy Leadership Group (TSLG). TSLG is a cross-industry body which has led the industry activity programme to take forward the Rail Technical Strategy published by the DfT in 2007, by developing a vision in each key technology area, commissioning research and technology watches and building understanding around implementation issues and their solutions.

2.4 Policy context

2.4.1 England

In January 2011 the DfT published 'Reforming Rail Franchising: Government Response to Consultation and Policy Statement'. This document outlines a range of options for the system of passenger railway service franchising, as well as a summary of responses, and the Government policy position on each theme.

In May 2011 the final report of the Rail Value for Money Study was published by Sir Roy McNulty and this poses a challenge to the rail industry to improve value for money. It includes suggestions to consider alternative solutions to provide lower whole life cost options. This accords with the initiatives that the railway industry has been undertaking and this scoping document considers some of these areas such as the potential for usage of tram and tram train as a lower cost rolling stock solution. The report also emphasised the benefits of increasing local engagement in the railway.

Community rail was the subject of a Strategic Rail Authority, Community Rail Development Strategy (2004) and this set out the concept of designated community rail routes with objectives of increasing; ridership, freight use and net revenue, managing costs down, and greater involvement of the local community in those routes. The DfT has subsequently taken the concept forward and published a review of the Community Rail Development Strategy (2007). The DfT has now designated 31 community rail services or routes, four in 2011 alone.

2.4.2 Wales

In March 2010, the Welsh Government published the 'National Transport Plan'. This document provides a transport strategy for Wales. Rail is one important element of the overarching strategy for an integrated transport system. The National Transport Plan has five key strategic objectives which are:

- "reducing greenhouse gas emissions and other environmental impacts
- integrate local transport
- improving access between key settlements and sites
- enhancing internal connectivity
- increasing safety and security."[1]

The plan aims to take these strategic priorities forward in developing an integrated transport network. These strategic priorities have a number of connections with the scope of this document particularly in the context of improving access and reducing greenhouse gas emissions.

2.4.3 Scotland

In December 2008, Transport Scotland published its STPR. The document outlines the role of a safe efficient and effective transport system as a key enabler of the development of a successful and dynamic nation. It identifies those recommendations that most effectively contribute towards increasing sustainable economic growth and supports both the National Planning Framework and the delivery of the three strategic outcomes identified in the National Transport Strategy:

- "improving journey times and connections – to tackle congestion and the lack of integration and connections in transport which impact on our high level objectives for economic growth, social inclusion, integration and safety
- reducing emissions – to tackle the issues of climate change, air quality and health improvement which impact on our high level objective for protecting the environment and improving health, and
- improving quality, accessibility and affordability – to give people a choice of public transport, where availability means better quality transport services and value for money or an alternative to the car."[2]

The Strategic Transport Projects Review (STPR) sets the Scottish Government's 29 transport investment priorities for the next 20 years. The schemes that are detailed in the document include proposals for electrification and metro or light rapid transit.

[1] Page 9, National Transport Plan, Welsh Assembly Government, March 2010

[2] Source: http://www.transportscotland.gov.uk/strategy/strategic-transport-projects-review

3 Baseline

3.1 Introduction

This baseline chapter defines each of the alternative solutions considered by this Route Utilisation Strategy (RUS) scoping document. For each alternative solution the baseline defines the concept, along with today's usage, and the costs and characteristics associated with it.

3.2 Tram and tram train conversion

3.2.1 Definition of tram and tram train conversion

3.2.1.1 Tram conversion

'Tram conversion' is the conversion of heavy rail lines to be operated as a tramway. The Office of Rail Regulation (ORR) in its Guidance on Tramways (2006) defines a 'tramway' as meaning a rail based passenger carrying mode of transport where the public have access to the vehicle and the speed of operation mean that any such vehicle is able to stop within the distance the driver can see to be clear ahead. This is known as operation by line of sight. The guidance divided tramways into three separate categories:

1. integrated on street – a tramway operated by line of sight where the rails are laid in the highway, and is capable of being used by other vehicles or by pedestrians
2. segregated on street tramways – a tramway operated by line of sight where the rails are laid within the boundaries of a highway, and may be crossed by pedestrians but other vehicles may only cross at designated crossing points
3. off street tramways – a tramway operated by line of sight or signalled, or by a combination of the two where the track is wholly segregated from any highway; and the alignment is wholly separate from any highway.[3]

A light rail or metro service might share many of the same characteristics but because of the lack of line of sight operations cannot be shared with pedestrians or highway vehicles and must be wholly separated from the highway. Converting to a tramway means that signalling equipment can be reduced (line of sight) and level crossings become tramway crossings and the responsibility of the relevant highway department.

In Green Light for Light Rail published by the Department for Transport (DfT) a tramway or light railway is defined as "a tram or light rail operation is a public transport system that uses rail-based technology and which typically operates in urban settings. Vehicles are usually relatively lightweight, run on steel rails and are propelled by power from overhead electrical wires, although there are some systems which use a third rail (such as the Docklands Light Railway) or, occasionally, diesel" [4]

There is a range of the extent of heavy rail conversion, in some instances portions of infrastructure or alignments may be converted to tram usage but not the train service. For example the Nottingham Express Transit shares an alignment with the heavy rail infrastructure with the two single lines running side-by-side on the approach to Hucknall. **Figure 3.1** shows a Nottingham Express Transit at Hucknall where the tramway shares the alignment with the parallel heavy rail line. Hucknall is an interchange station with both tram and heavy rail platforms. In other instances, such as the Croydon Tramlink between Wimbledon to West Croydon, service as well as the infrastructure can be converted to tram operation. After a line is converted from heavy rail it may, or may not retain the original infrastructure or train control system, however the route will be operated with tram vehicles. The conversion of heavy rail routes has often formed part of developing tram networks which have included on street running.

Using an existing heavy rail alignment in this way has the potential to reduce the cost of a tramway as on street sections are minimised. This avoids severe disruption on affected highways and the need for complex utility diversions which can form a considerable proportion of the capital cost of the construction of a tramway. The nature of an on street tramway with more frequent stops compared to a former heavy rail alignment means that a direct comparison may not be relevant in reality. The presence of a convertible rail line and an on street tramway proposal are not necessarily going to be serving the same markets.

Tram needs to be segregated from heavy rail services for reasons of crashworthiness. Tram vehicles are typically less able to withstand impact than their heavy rail counter parts. However, there are a range of extents of segregation to achieve this separation of light and heavy rail vehicles. In some instances it may be achieved through the signalling system, whereas in other instances the systems are physically separated from one another.

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[3] Page 3, Railway Safety Publication, Guidance on Tramways, (2006) ORR

[4] 'Green Light for Light Rail' DfT 2011, page 9

Figure 3.1 – Photograph of Nottingham Express Transit Hucknall tram and heavy rail station

In examples of light rail conversion, such as the Stourbridge Town branch, which does not have on street operation the benefits of such proposals, can potentially include reducing the operating costs of existing services. For enhancements tram may reduce the costs of infrastructure at a potentially lower capital, maintenance and operating cost than heavy rail.

3.2.1.2 Tram train

There are a number of definitions of tram train but the scoping document uses the definition from Germany where the concept originated. Under this definition, tram train operation is enabled by the linking up of tramways with conventional heavy rail networks and the operation of the resultant service by tram style vehicles on both tramway and heavy rail routes. To a passenger a tram train offers a single journey between tram stops and conventional rail stations. The vehicle that enables this seamless journey are capable of running under both systems without undue restriction. A tram train vehicle is best defined as a tramcar capable of operating on both a street tramway and heavy rail networks and is differentiated from other tramway vehicles through being equipped with technology to interface with heavy rail systems, particularly those related to signalling, power supply, control and telecommunications.

Figure 3.2 shows a tram train in Karlsruhe operating on street, on a segregated tram route and shared with heavy rail infrastructure.

The vehicle is recognisably a tram but is able to cross the interface between heavy and tram to enable greater city centre penetration, connectivity, and uses the advantages of a trams high acceleration on a heavy rail route.

Tram trains are generally lower axle weight, high density, articulated rail vehicles capable of operating over street tramways or line of sight signalled railways, as well as on a fully signalled heavy railway. Tram trains have high acceleration and braking rates and are fitted with magnetic track brakes for use in emergency situations, particularly when operating on the highway enabling them to stop in a similar distance to a bus. The vehicles are typically powered by overhead electric line, or alternate electric supply arrangements, or less frequently by diesel.

Tram train vehicles can be dual voltage to be compatible with the national heavy rail network traction power. Although diesel electric bi-mode tram trains have been used in a small number of locations, their increased maintenance cost and fuel consumption makes them potentially more costly. Diesel tram trains are also more bespoke vehicles which can make procurement more challenging and more expensive.

To ensure compatibility with tramways, stations on the heavy rail route may have to include a low height platform section as most tramways operate low floor vehicles where the platform heights are around 300-380mm. However tram stops are significantly cheaper than conventional heavy rail stations to construct and the improved vehicle performance and reduced dwell times achievable with tram style operation enable additional stops to be provided without any significant increase in journey time.

Where tram systems exist, tram trains can extend tram networks by allowing vehicles to transfer seamlessly from heavy rail tracks to urban tramways and travel to the heart of cities. They also offer the potential for new cross-city links owing to the greater transfer possible between light and heavy rail networks.

3.2.2 Existing and planned tramway in Great Britain (GB)

Tram conversion has formed a part of the creation of all of the new tram networks in England. It has also been a feature of the Docklands Light Railway, Tyne and Wear Metro and in the sense that it uses an ultra light rail vehicle (the Class 139) the Stourbridge Town branch. Examples of tram conversion have included a range of scenarios:

- full separation taking over the entire former railway formation and services – for example the Manchester Metrolink Bury line
- full separation but sharing the alignment with heavy rail – for example the parallel alignment with heavy rail between Wilkinson Street and Bulwell on Nottingham Express Transit
- segregated operating but retaining the full original connection to the heavy rail network – for example the Stourbridge Town branch.

Until 1992 when Metrolink opened in Manchester, Blackpool was the only urban tramway remaining in Great Britain and it remains the only tramway not to occupy any portion of a disused rail formation.

Table 3.1 shows the operating tram systems in Great Britain, including the tramway that is currently being constructed in Edinburgh. All of the modern tram systems have been created in part by converting heavy rail infrastructure. In Edinburgh options considered included a heavy rail alignment but these have not formed part of the scheme as it is currently being constructed. In two systems the tram conversion replaced previously heavy rail services.

There is considerable variety between the tram systems in terms of platform design, tram length, voltage, maximum gradients, and wheel profile. In recognition of this variety, ways of standardisation are being considered by the tram industry.

Figure 3.2 – Photographs of tram trains in Karlsruhe (left to right) on an on street tramway, in segregated operation, and on heavy rail

Table 3.1 – Data on existing tram systems in Great Britain[5]

	Blackpool Tramway	Manchester Metrolink	Sheffield Supertram	Midland Metro	Croydon Tramlink	Nottingham Express Transit (NET)	Edinburgh Tram
Route length (miles)	11	25 (not including Metrolink expansion and second city crossing)	18 (tram train pilot to be confirmed)	13 (to be extended into the centre of Birmingham)	17	9 (not including NET Phase 2 and 3)	8
First section opened	1885	1992	1994	1999	2000	2004	Planned 2014
Number of trams or vehicles	Variety of heritage tram with 16 new on order	26 trams to be replaced progressively by 74 new trams as part of expansion plans	25 (additional trams and tram trains to be confirmed)	16 (to be replaced by new trams as part of expansion plans)	24 (6 on order)	15 (not including Phase 2 and 3)	27 to be delivered
Tram or vehicle lengths Metres	(new trams) 32.23	29 & 28.4	34.75	24	31.1	33	42.8
Street running	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Former railway alignments	No	Yes	Yes	Yes	Yes	Yes	No
Replaced 'heavy rail' service	No	Yes	No	Reopened a former service	Yes	No	No
Platform height	Low	High	Low	Low	Low	Low	Low
Electricity supply	Converting to 600V DC overhead line	750V DC overhead line	750V DC overhead line	750V DC overhead line	750V DC overhead line	750V DC overhead line	750V DC overhead line

[5] Source: Green Light for Light Rail, Department for Transport, 2011 http://assets.dft.gov.uk/publications/light-rail/green-light-for-light-rail.pdf

It is proposed to convert the 6½ mile long Watford Junction – St Albans Abbey branch to operate using tram vehicles. The Department for Transport (DfT) is currently working with Hertfordshire County Council and Network Rail to look at the possibility of conversion from heavy to tram. The current rail service operated by London Midland consists of a train every 45 minutes in each direction. Local stakeholders have long identified the need to increase the frequency and introduce a regular half-hourly or 20 minute frequency service to this single track branch line. Local roads between these two important Hertfordshire towns are very congested at peak times and rail could provide a meaningful public transport solution to these problems, but not with an irregular 45 minute service.

Early ideas centred around using community rail principles to implement a low cost passing loop midway along the line and sourcing low cost heavy rail rolling stock from cascades elsewhere in the south east. A solution was costed via a priced option in the London Midland franchise but that proved unaffordable. With the lack of an affordable rolling stock solution and with the cost of the passing loop and station modifications at Bricket Wood the scheme faltered as it was not deemed value for money.

In order to increase service frequency, consideration is being given to converting the Abbey Line to operate tram vehicles rather than traditional heavy rail vehicles. Assessments undertaken so far indicate that it should be possible to run a more frequent 20 or 30 minute service on the Abbey Line at approximately the same cost as the current heavy rail service operation if an intermediate passing loop is provided. The proposed conversion to tram operation would take advantage of the lower operational costs of tram, compared to heavy rail.

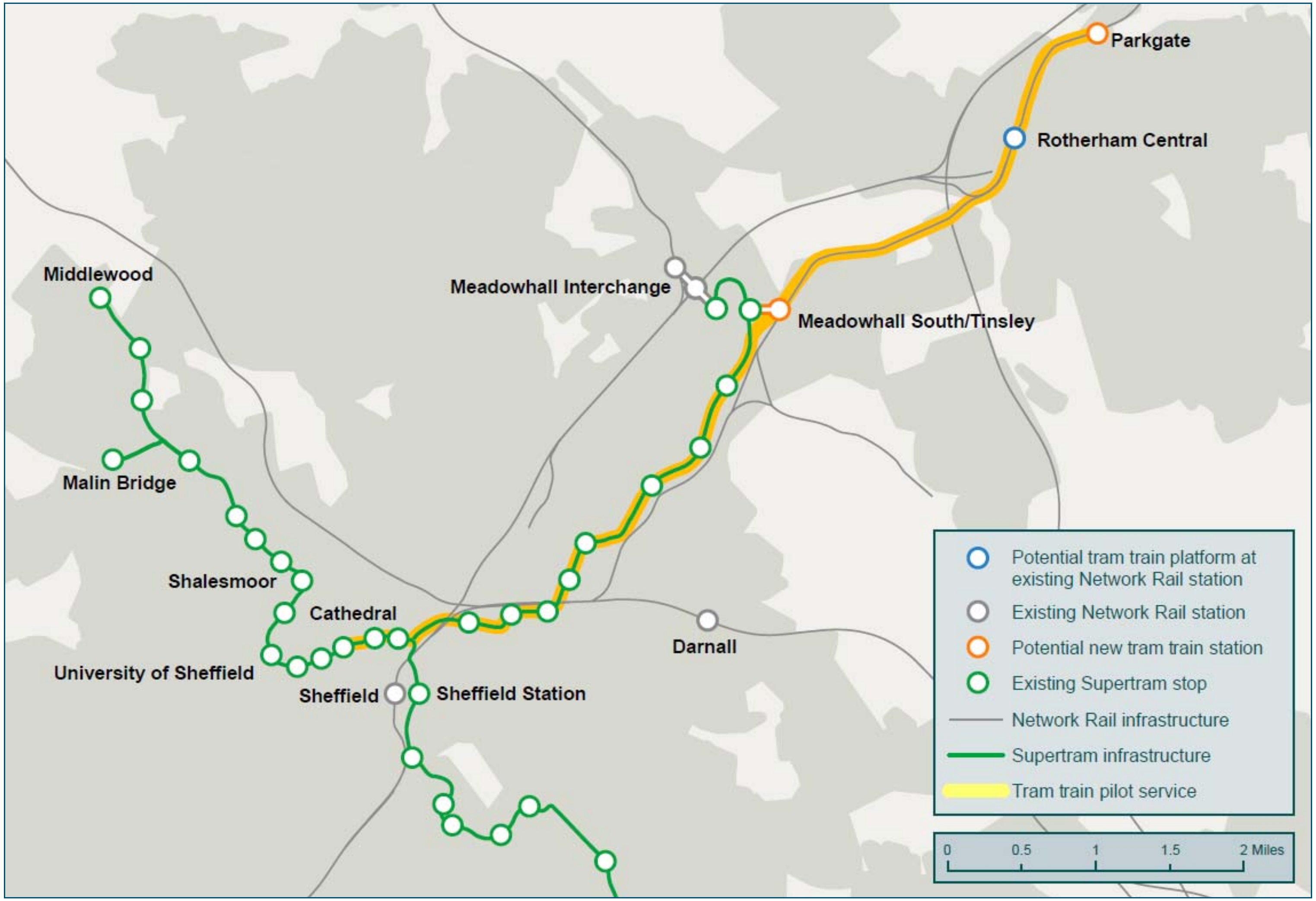
The DfT and Hertfordshire County Council consulted on these proposals at the start of 2010. The results of the consultation were made public in the autumn. Further work to develop the scheme and to resolve issues around land ownership and responsibilities for maintenance and renewal of structures and bridges is underway. A decision on the proposed scheme is expected in the near future.

3.2.3 Tram train

Currently there are no operational tram trains within Great Britain. In terms of interworking between light and heavy rail vehicles the nearest current British example to tram train is the Tyne and Wear Metro. The Tyne and Wear Metro is not a true tram train in accordance with the definition of the scoping document. It uses light rail vehicles which operate on both a dedicated alignment and the same infrastructure as heavy rail vehicles. The reason it is not considered a true tram train is that the Tyne and Wear Metro does not include any operation in an on street tramway environment. The system also relies on greater separation distances between Metro and heavy rail vehicles to provide safe train control. This reduces overall line capacity and may not be acceptable in circumstances where capacity is at a premium.

The tram train pilot between Rotherham and Sheffield is proposed to operate a service from the heavy rail station at Rotherham to Cathedral in Sheffield on the Supertram network. The route is shown in **Figure 3.**

Figure 3.3 – Map of the Sheffield to Rotherham tram train pilot



The pilot has the following objectives:

- "understand the changes to industry costs of operating a lighter weight vehicle, with track brakes, on the national rail network
- determine changes to technical standards required to allow inter running of light weight tram-type vehicles with heavy rail passenger and freight traffic and to gain the maximum cost benefit from tram train operation
- gauge passenger perception and acceptance of tram train vehicles as a replacement for existing heavy rail services
- determine the practical and operational issues of extending tram trains from the national rail network to an on street tramway."[6]

The scoping document builds upon the objectives of this pilot by considering the extent of the niche for the operation of tram train in the British market as a whole. The scoping document has therefore considered the wider market and not sought to address the specific technical issues which the pilot plans to address. Issues that the tram train pilot has considered address the key areas of:

- wheel profile and track geometry
- train protection and detection
- low platform design on the heavy rail network
- safety and engineering standards
- operating procedures.

Network Rail is also aware of a number of aspirations which are being considered for tram train schemes in:

- Cardiff
- Birmingham
- Blackpool
- Bradford
- Greater Manchester
- Leeds
- Liverpool
- Sheffield (in addition to the tram train pilot).

3.2.3.1 Origin of the tram train concept

The first tram train was introduced, on a limited basis, in Karlsruhe, Germany, in the 1960s. It involved tram vehicles operating on heavy rail infrastructure with occasional freight services. The first true tram train anywhere in the world began operation between Karlsruhe and Bretten in 1992 and had an interface with both the tram and heavy rail network, as well as being dual voltage. The aim being to allow people to get directly into the city without having to change from one mode to the other at a station a considerable distance away from the city centre. Other European cities and regions that have introduced tram train networks include Saarbrücken, Kassel, Mulhouse and The Hague.

Karlsruhe main station (Hauptbahnhof (Hbf)) is remote from the city centre. The walking distance between Karlsruhe Hbf and Karlsruhe Marktplatz is 1.7 kilometres, as illustrated in **Figure 3.4**. Before 1992 a public transport journey from Bretten to the centre of Karlsruhe at the Marktplatz involved a rail journey and an interchange with the tram network. After the tram train conversion this interchange was eliminated saving 15 minutes journey time. In addition more stations were constructed along the line of route which further decreased the generalised journey time by reducing the average distance between the nearest station passenger's place of origin or destination. Frequency on the route was increased, as was the length of the service day.

A connection between the tram network and the Deutsche Bahn (DB) heavy rail network was built with a voltage changeover. At the voltage changeover point between the 750V direct current (DC) tram network and the 15kV alternating current (AC) heavy rail electrification the tram train switches automatically on the move from DC to AC or vice versa. Having developed the first corridor in 1992 a number of additional tram train conversions have followed to the point where there are now 12 routes. The extensions to the network have followed the same principles as the first tram train line and taken it a step further and sought to link up nearby city regions.

The introduction of tram or tram train can produce benefits to the travelling public by increasing the available journey opportunities. Typically tramways serve multiple locations within a city centre, rather than solely a main railway station. In some cities it is the case that the main railway station is located some distance from areas of employment, education or leisure activities. By providing direct access to other locations the generalised cost of transport is reduced for travel and this is anticipated to increase demand.

The corridors in Karlsruhe have experience growth in patronage and modal shift following tram train introduction, however these demand changes have been driven by a number of factors:

- city centre penetration
- new stations
- new electric rolling stock replacing older diesel multiple units (DMUs)
- increases in frequency
- reduction in some fares
- increased length of the service day
- integration of public transport.

[6] Source : Network Rail, Tram Train Trial Interim Learning Report (2010)

Tram train schemes often have been associated with a package of measures. The package of measures means that it is not possible to generalise about the impact of conversion to tram train on passenger demand. This scoping document in **Chapter 6** therefore focuses on specific examples in Great Britain of proposed tram train schemes rather than generalising from the market conditions in a German city. Some of the factors which affect demand may be achievable using a heavy rail or other public transport option. In developing options for a specific scheme a range of options will need to be tested to ensure that tram train is the most appropriate and value for money option to address transport gaps.

Table 3.2 presents the capacities of a range of trams, tram train and heavy rail vehicles. What this shows is that a two-car heavy rail train has approximately the same capacity as a tram or tram train. However, because heavy rail vehicles can potentially operate in multiples of greater than two, and can be configured in higher density interior layouts, heavy rail vehicles have a greater range of capacities. Trams and tram trains are high density rolling stock with a low ratio of seating to standing passengers. This internal layout configuration is appropriate for the kind of services on which they operate with frequent stops, with passengers travelling for a relatively short time.

A high percentage of standing passengers is appropriate in this context in a way in which it would not be for a long distance service. Trams and tram trains also do not generally have toilet facilities.

This means that the vehicles are optimised for services with frequent stops and relatively short passenger journeys. Installation of an accessible toilet would take up more passenger space than on a heavy rail train because there is less room in a low floor tram style vehicle to accommodate an accessible controlled emissions toilet.

3.2.4 Tram and tram train capabilities

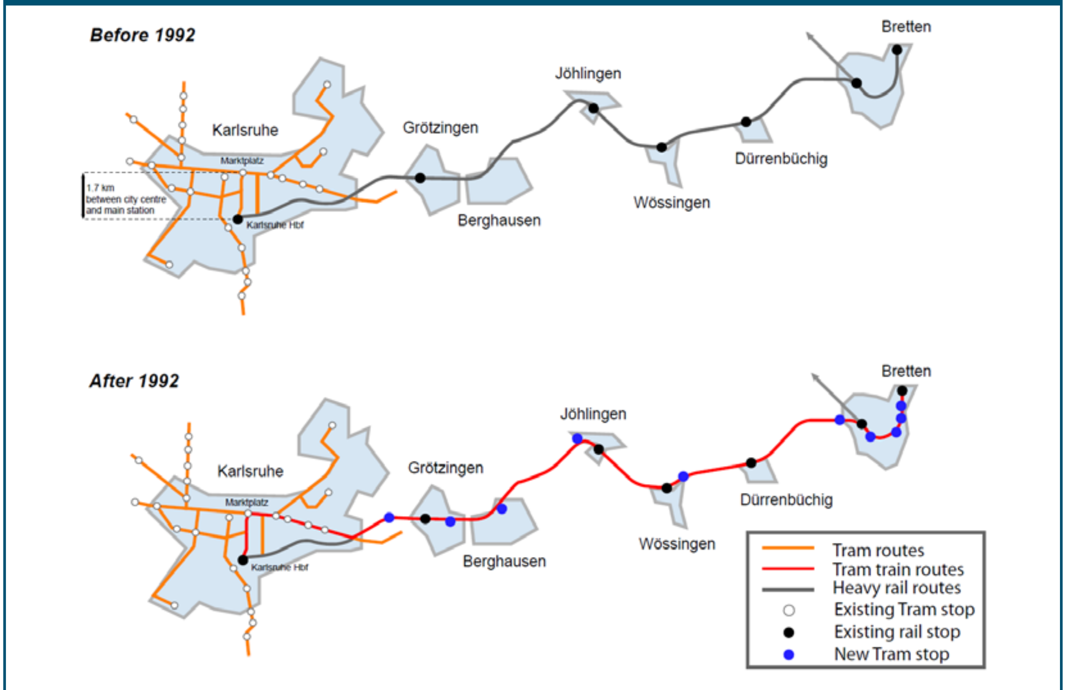
3.2.4.1 Rolling stock capacity

The maximum number of passengers that can be carried on a given service is a function of two basic factors:

- train capacity – maximum numbers of passengers per train
- service frequency – maximum numbers of services in a given direction on a given route.

This is in contrast with heavy rail vehicles which can be configured for a range of markets from long distance high speed to inner suburban. An inner suburban vehicle has a high proportion of standing allowance and no toilet facilities. A Class 376 inner suburban Electrical Multiple Unit (EMU) for example has both a similar ratio of seated to standing passengers and passengers per metre of unit length as a tram or tram train. Allowances for standing for a certain period of time are specified in Great Britain by funders through franchise agreements with train operators.

Figure 3.4 – Karlsruhe to Bretten before and after tram train introduction in 1992[7]



[7] Source: TransportTechnologie-Consult Karlsruhe GmbH (TTK)

Table 3.2 – Rolling stock seating and standing capacity[8]

Vehicle type	Vehicle type	Unit length (metres)	Total number of seats	Total passenger capacity including standing allowance	Total passenger per metre of rolling stock unit length
Heavy rail DMU (1-car)	Class 153/1	23.21	73	98	4.2
Midland Metro tram	Ansaldo T69	24	56	152	6.3
Nottingham Express Transit tram	Bombardier Incentro	33	54	183	5.5
Manchester Metrolink tram	Bombardier B5000	28.4 (two trams =56.8)	82	206 (two trams =412)	7.3
Croydon Tramlink tram	Bombardier C4000	30.1	70	208	6.9
Heavy rail DMU (2-car)	Class 170/2	47.22	122	210	4.4
Karlsruhe tram train	Vossloh Citylink	37.2(two tram trains =74.4)	104	224 (two tram trains =448)	6.0
Mulhouse tram train	Seimens Avantro	36.68	85	231	6.3
Sheffield Supertram	Siemens	34.75	88	243	7.0
Heavy rail Electric Multiple Unit (EMU) (3-car)	Class 375/3	60.79	176	291	4.8
Heavy rail DMU (3-car)	Class 170/3	70.86	196	325	4.6
Heavy rail EMU (4-car)	Class 377/4	80.78	253	398	4.9
Heavy rail EMU (5-car)	Class 376/0	100.68	226	642	6.4

[8] Source: Passengers in excess of capacity figures for heavy rail rolling stock and various for tram vehicles

As most passengers using a tram style vehicle are making short urban journeys they are configured as high density rolling stock with a small proportion of seated passengers. Heavy rail rolling stock is usually designed to cater for a wider number of markets and therefore for passengers making longer journeys where a seat is required.

Trams and tram trains can be operated in multiple on certain systems however the requirements of on street running typically limit the maximum length effectively to two trams. Only on Manchester Metrolink in Great Britain are trams operated in multiple. Frequency of tram or tram train routes may also be constrained by the density of traffic on core on street sections as well as wider track capacity. The maximum length of trams and tram trains is constrained by the need to operate on street. Although some tram systems do have longer systems for most tramways, two 40 metre trams represent the upper limit. **Figure 3.5** illustrates the impact of two tram trains operating in multiple on the occupation of road junctions.

The conclusion is therefore that tram and tram train sit at the lower end of the capacity spectrum because while service frequency can be very high, the limited capacity of the rolling stock means that the range of maximum passengers per hour in one service direction is less than that of heavy rail and metro services. Tram and tram train are therefore likely to be appropriate where the passenger flows fall within these capacity boundaries. Too low and there is an excess of capacity provision which is unlikely to be an efficient use of resources. Too high a volume and the frequency required is likely to be unfeasible because of the available track capacity.

The Network RUS: Passenger Rolling Stock found that 59 per cent of Diesel Multiple Units (DMUs) were two-car units and 69 per cent of EMUs were four-car units. Depending on seating density a 12-car EMU can accommodate between 1,200 to 1,900 passengers per train. Electrification has also occurred on routes with high traffic density. This means that electrified inner suburban routes are likely to have some of the densest numbers of trains and also be longer than DMU operated equivalents.

It is not possible to give an absolute range of the passenger flows for which tram or tram train would be appropriate in comparison with other modes of transport because it is dependent on circumstances. Tram and tram train sit in a spectrum of public transport systems which range from the bus, to bus rapid transit and guided busways, to tram to heavy rail and then to metro. The way in which the demand is catered for needs to be appropriate for the volume and type of journeys. Tram and tram trains are lower capacity rolling stock tailored to providing a high frequency service, with frequent stops and shorter journeys where a higher percentage of standing passengers is appropriate.

Figure 3.5 – Photograph of a tram train service in Karlsruhe

Table 3.3 illustrates the range of maximum numbers of passengers conveyed in a single direction for different frequencies by heavy and tram rolling stock. It has been assumed (both seated and standing capacity) for this illustrative presentation that a heavy rail vehicle carries a maximum of 100 passengers, a 30 metre tram carries 200 passengers and a 40 metre tram train carries 250 passengers. What this shows is that there is a wide range of the maximum number of passengers that can be carried on a given route using heavy rail vehicles ranging from single car DMUs to 12-car EMUs. Tram and tram train cater for a narrower band of passengers per hour. The table does not suggest that it would be possible to have a 12-car service on all routes but rather it illustrates the likely flow of passengers and the frequency of services required to carry that volume of passengers for differing capacities of rolling stock. There is a trade off between train capacity and service frequency which would determine the maximum number of passengers that can be carried on a given route.

Table 3.3 – Illustrative maximum passengers per hour in one direction for differing rolling stock and service frequencies

Rolling Stock	Maximum passenger capacity (approximate total seating and standing) services per hour											
	1	2	3	4	5	6	7	8	9	10	11	12
1-car DMU	100	200	300	400	500	600	700	800	900	1000	1100	1200
Tram (30 metres)	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400
2-car DMU	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400
Tram train (40 metres)	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
3-car EMU	300	600	900	1200	1500	1800	2100	2400	2700	3000	3300	3600
Tram (2-units)	400	800	1200	1600	2000	2400	2800	3200	3600	4000	4400	4800
4-car EMU	400	800	1200	1600	2000	2400	2800	3200	3600	4000	4400	4800
Tram Train (2-units)	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000
6-car EMU	600	1200	1800	2400	3000	3600	4200	4800	5400	6000	6600	7200
8-car EMU	800	1600	2400	3200	4000	4800	5600	6400	7200	8000	8800	9600
12-car EMU	1200	2400	3600	4800	6000	7200	8400	9600	10800	12000	13200	14400

3.2.4.2 Rolling stock acceleration

The benefits of the superior acceleration of tram style vehicles are illustrated in **Graph 3.1** and **Table 3.4**. **Graph 3.1** compares the performance of a Class 350 EMU, a Class 150 DMU and a Sheffield Supertram on a line with a maximum line speed of 120 kmh. The graph demonstrates that up until 1.6 kilometres (km) the tram's acceleration means that although it has a lower top speed (80kmh) it is faster than both DMU and EMU. The DMU's higher top speed means that after 3.12 km it would overtake the tram. It should be noted that tram trains while likely to have similar acceleration and braking as a tram can have a higher top speed of 100 kmh which would affect the point at which it was overtaken by the heavy rail rolling stock.

Table 4 shows a more pronounced advantage of tram style rolling stock which is able to use more rapid acceleration and braking to be able to maintain a higher average speed than either a DMU or an EMU where stops are close together. The results of the rolling stock modelling show for a line with a top speed of 120 kmh comparing a Class 350, Class 150 and Supertram that the time taken for a tram from start to stop is faster than both EMU and DMU at distances between stops of below three km. At distances below six km between stops the tram is faster than a DMU.

Graph 3.1 – Rolling stock speed and acceleration (EMU, DMU and Tram) on a line with a 120km speed limit (source: Network Rail)

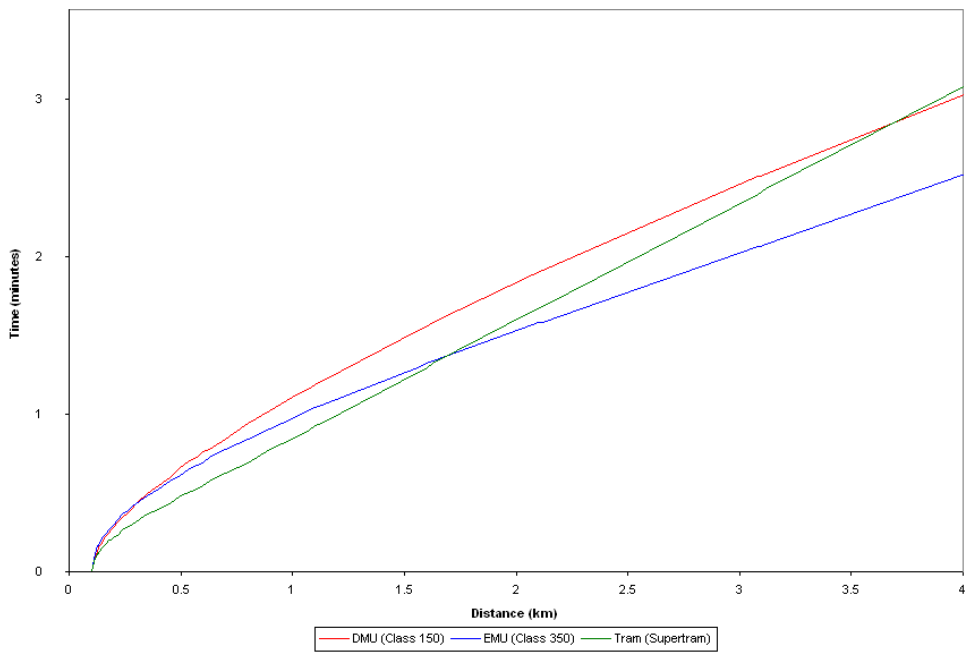


Table 3.4 – Comparison of start to stop times for an EMU, a DMU and a Tram for varying distances between stops on a line with a 120km speed limit (source: Network Rail)

Rolling Stock	Distance between stops							
	500 metres (m)	1000m	1500m	2000m	3000m	4000m	5000m	6000m
Tram (Super-Tram)	00:44	01:07	01:29	01:52	02:37	03:22	04:08	04:52
Class 350 (EMU)	00:55	01:19	01:39	01:56	02:27	02:57	03:27	03:56
Class 150 (DMU)	01:03	01:34	01:59	02:22	03:03	03:39	04:15	04:46

3.2.4.3 Characteristics of European tram train routes

There are a wide variety of tram train routes in operation in Europe some of which follow the principles set out in the Karlsruhe example. Others operate as express tramways (up to 100kmph) and do not interwork with heavy rail infrastructure. This section of the baseline chapter presents a number of statistics about the tram train routes currently in operation. It illustrates that the characteristics of tram rolling stock as outlined in **sections 3.2.4.1** and **3.2.4.2** is reflected in its application in Europe.

Graph 3.2 shows the lengths of radial corridors from city centres or where routes do not cross the city centre for the length of the total route. While there are exceptions such as the Karlsruhe-Freudenstad route which is over 80 km from Karlsruhe, 73 per cent of routes are less than 40 km in length. Even for those longer routes it is unlikely that large numbers of passengers make the total journey. Instead they link a number of centres with passengers making shorter journeys along the route.

The average distance between stops for the tram train routes in operation in Europe is approximately 2.1 km[9] which indicates that they have a dense stopping pattern consistent with the operating characteristics of a tram. However, the average distance between stops is higher than a typical street tramway reflecting in part the longer routes and higher average speeds of tram trains on heavy rail infrastructure.

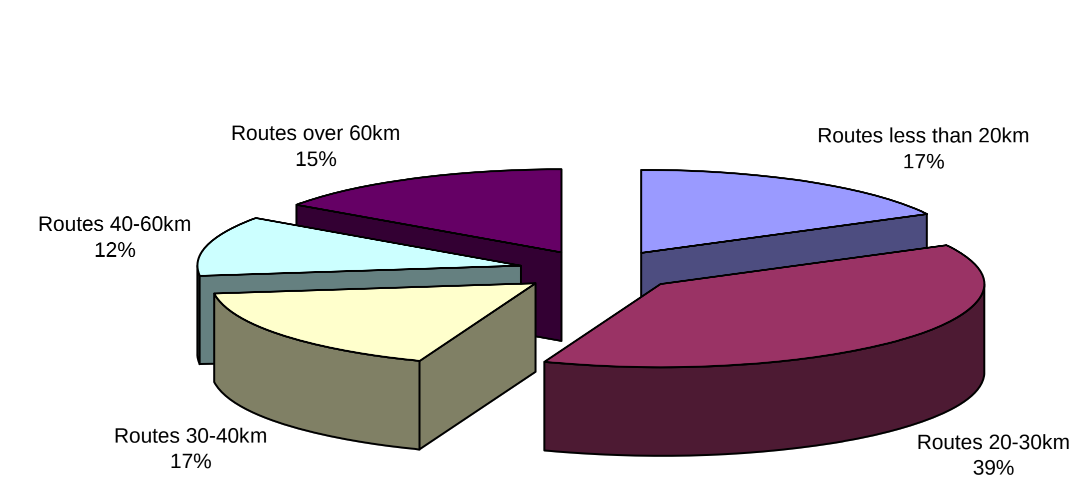
3.2.5 Capital costs

There is a difference in the way in which tram and therefore potentially tram train schemes are funded in comparison with heavy rail. Typically for the creation of a new tram system a central Government capital grant is provided to cover a large portion of the cost of creating the infrastructure and purchasing the rolling stock. Tram systems are then planned to generate revenue to cover the cost of operations and potentially a portion of the capital funding. However, they do not cover all of their capital costs and do not necessarily have provision for life cycle renewals. At the stage when a large scale renewal is required of either infrastructure or rolling stock then further central Government funding is required. The funding of the tram scheme is justified on the basis of the wider economic benefits that they will generate. A Passenger Transport Executive (PTE) for example is looking to achieve the most appropriate transport solution for a given need in the most cost effective manner. Ways are being considered for a greater portion of local funding but some central government involvement is likely. The approach is different to the franchise system for heavy rail passenger services and to Network Rail's five year control period funding to deliver the High Level Output Statement.

3.2.5.1 Tram train

The capital costs of construction of a tram train scheme consist of two elements both of which are being investigated in detail by the tram train pilot in Sheffield. These two elements are the cost of conversion of the existing infrastructure and the cost of connection to an existing tramway. The extent of these two cost components may be a determining factor in the viability of any scheme.

Graph 3.2 – Length of radial corridors and routes[9]



[9] Source: Axel Kühn 2012

The cost of connection could be quite high in particular if it is not straightforward to connect to the tramway without substantial new infrastructure, particularly on street, this is less likely to favour tram train conversion. Equally the extent of new infrastructure required to convert a section of heavy route may form a barrier to a business case for conversion. In addition to any conversion cost, there may also be enhancement costs to provide additional stations or loops which would provide capacity and facilities for enhanced service provision.

1 Conversion costs

Conversion costs comprise those capital works required to permit the operation of tram trains on existing heavy rail infrastructure. It is important to understand that there is a range of conversion costs which depend on the extent of any infrastructure modification or enhancement which is required. Some items of conversion may not be applicable in all circumstances but they are likely to comprise the following items:

Electrification costs if the route is not already electrified

All British tramways are electrified with lower voltage direct current (DC) overhead line electrification (OLE) to enable electric traction and on street running. DC OLE may be cheaper per single track kilometre because it is a lighter system with smaller electrical clearances. However, there may be two reasons that a 25kV alternating current (AC) OLE is selected for heavy rail infrastructure which is currently unelectrified:

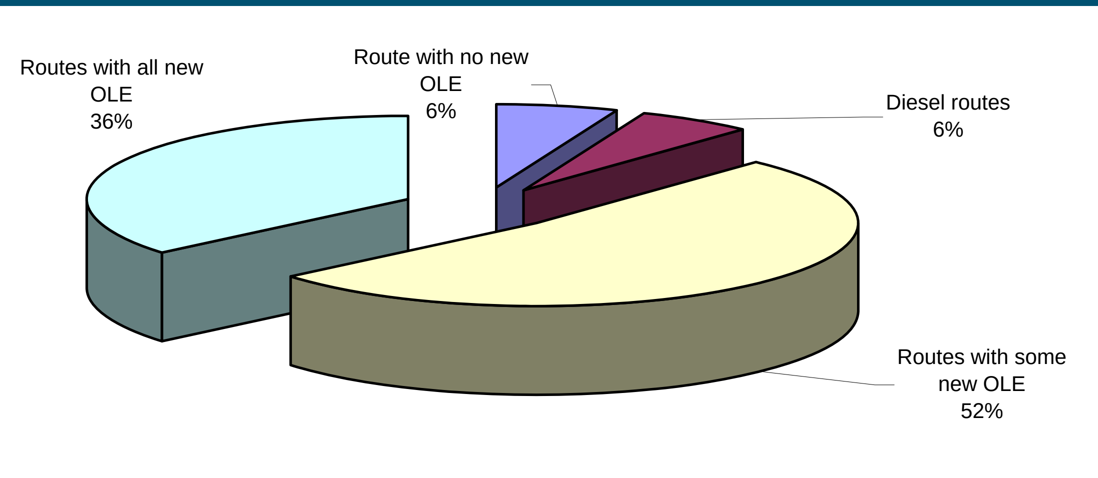
1. strategically it may be necessary to have 25kV AC electrification in order to be compatible with heavy rail electrification plans
2. over a longer distance or higher speed the inherent inefficiency of DC because of transmission losses gives the requirement for additional substations and means that it may be of higher cost.

However, there are also additional costs for dual voltage systems in terms of the provision of more complex rolling stock and infrastructure. Dual voltage tram trains require a transformer and rectifier which increase the weight of the rolling stock reducing potential operating and maintenance cost savings in comparison with tram. The decision on electrification type would be a balance of strategic requirements of the heavy rail network and the most cost effective system in the circumstances of the route.

25kV AC trolley wire as discussed in **section 3.3.2.5** may be of lower cost than equivalent OLE where operating speeds of below 60 mph permit its use. The extent of these savings has not been fully established and will be route specific to some degree. While not fully quantified there may be savings associated with tram style electrification in comparison with 25kV AC however, these savings need to be balanced against the circumstances of the route. The conclusion is that while there might be savings, the costs of electrification are still likely to be substantial and that where required will form a substantial component of the cost of conversion. There is some suggestion that because tram schemes in Great Britain has tended to draw on heavy rail experience there may be higher costs of tramway electrification than might otherwise be expected.

Graph 3.3 illustrates that the majority (88 per cent) of EU tram train projects have involved some degree of electrification. In 36 per cent of cases the entire length of the route required electrification.

Graph 3.3 – Percentage of European tram train routes by the extent of new or existing electrification and diesel operation[10]



[10] Source: Axel Kühn 2012

Platforms – there may be a cost to provide low floor platforms at existing stations in order to permit the usage of low floor trams

This cost only applies to low floor trams, however, in Great Britain high floor trams are only found in Manchester. The potential for reduced station cost relates only to new, or substantially renewed stations, and not for existing stations. The lower costs for new stations relate only to the enhancement of the rail system and not to its conversion. For conversion of a route to tram train with low floor there would be a cost to provide low floor platform arrangements.

Signalling – greater protection of tram trains

Tram trains do not have the same level of crashworthiness as heavy rail vehicles. To maintain safety levels this may need to be balanced by greater protection from the train control system. On lines where capacity is not an issue, for example with only very limited heavy rail traffic, solutions which increase separation and reduce capacity may be appropriate mitigation. In areas where capacity is at a premium more sophisticated signalling solutions may be required. These solutions will have a range of capital costs.

Where the remaining heavy rail service is infrequent, for example only overnight freight traffic, it might be possible to avoid the need for tram train and use tram vehicles but ensuring that freight trains operate only after the last

Figure 3.6 shows the separate low platform extension required to accommodate a tram train at a station in the Netherlands. This requires newly constructed low platforms, ramps to access the platform and fencing to ensure the safety of passengers. Where low floor tram trains operate in conjunction with heavy rail vehicles or at former heavy rail stations, these kinds of solutions will be needed and represent a cost of conversion. Conversely a high floor city centre tramway will have higher tram stop costs than a low floor tramway. The issues of low floor rolling stock on the heavy rail network are being considered by the tram train pilot.

tram or before the first daytime service. This method of working would need to be developed to take account of specific circumstances to ensure it was an appropriate train control solution taking into account the safety risks that were introduced. The inherent inflexibility of this arrangement whereby heavy rail services could only be operated at night, thus removing the routes ability to serve as a diversionary route during the day would need to be fully considered. If appropriate this method of working could mean that the need for the cost and complexity of a full tram train approach could be avoided and a simpler tram solution might be possible.

Track

Modifications are required to the track to enable the tram train wheel profile to operate across switches and crossings. This is likely to involve the installation of raised check rails to

Figure 3.6 – Photograph of a low platform extension to accommodate a low floor tram train

compensate for the more tram like wheel profile. Equally modifications may be required to the tramway in order to accept the tram train wheel profile. Modifications will be required in all circumstances where existing infrastructure is made use of and where new segregated track is built it would be likely to be optimised to the tram train wheel profile.

The quality of track may need to be improved on the heavy rail route in order to maintain ride quality for the tram train. This is because as a lighter rail vehicle it may have less tolerance to lower maintenance standards of track. This is likely to be of particular relevance where tram trains convert freight only routes or secondary routes.

2 Connection costs

The tram train pilot connects to the tram network in Sheffield at a location where the heavy and tram lines run in parallel. This represents a simple and relatively straight forward connection. While it is difficult to generalise as circumstances will drive costs in such instances the cost for connection will be on the lower end of the scale.

In contrast a connection that required substantial new on street running and where no available land was present for straightforward connection to the tramway would mean that the cost of connection could be extremely high. In these circumstances where technical challenges, geographic obstacles or sheer distance make connection expensive the routes at this end of the scale may find the cost of connection is prohibitive.

As with conversion costs, connection costs will form a range depending upon the specific circumstances of the route assessed for conversion. This cost range will be dependent upon the complexity of the connection and the technical and geographic challenges that need to be overcome to link a tramway with the railway.

3.2.5.2 Tram

Tram conversion results in similar considerations with the exception that the interface is not maintained with the heavy rail network, and through running does not occur in passenger operation. There is therefore no duplication of systems. The connection can be physically severed, but this may have considerable costs as signalling and power supplies, as well as track may need to be modified. However, tram conversion means that simplified train control can be implemented potentially reducing costs further than is possible for those sections on which a tram train operates alongside heavy rail trains.

Tram vehicles are by definition lighter and there may be associated cost savings. Segregation where heavy rail traffic is limited may effectively be achieved through modification to the signalling system or by potentially only operating freight services at times when passenger services are not in operation. The extent of the arrangements to ensure segregation will be dependent entirely on the circumstances and frequency of any retained heavy rail services.

Conversion of heavy rail routes might, if it is a comparable option, be lower cost than the construction of on street tramways.

As with the Class 139 operating on the Stourbridge Town branch it is likely that a tram conversion or tram train system away from an existing tramway network would require a specific depot. The Passenger Rolling Stock Depots Guidance Document provides information and guidance on the construction of new rolling stock depots. The guidance is available on Network Rail’s website at www.networkrail.co.uk.

3.2.5.3 New route

Tram has been used as an option to open new routes, for example the Midland Metro. However, the appropriateness of the route for tram is dependent upon whether a tram style vehicle would be appropriate for the market served. Similar cost issues would exist as for a conversion except that the infrastructure can be tailored to the characteristics of the vehicles and is less constrained by existing assets.

The cost breakdown for an example heavy rail reopening, Airdrie to Bathgate are shown **Table 3.5**. A commentary has been provided to illustrate what some of the potential impacts using trams might have. This is not to suggest that Airdrie to Bathgate would have been appropriate for tram, as the route is an interurban route and does not have the appropriate market type. Airdrie to Bathgate links to existing railway routes, so tram vehicles would have been inappropriate in the wider network context. However, it does illustrate the range of costs for each component of a reopening.

It is likely that cost savings would be possible using tram instead of heavy rail in a number of the areas which comprise the cost of a new railway. These cost savings relate to the lower axle load of the vehicles and to the savings associated with being able to drive on line of sight. Lower axle weight means that the track and formation can be designed to cater for lower weight vehicles reducing capital costs. Over the whole life of the track assets renewals and maintenance may also be lower. The ability of trams to stop using magnetic track brakes in a similar distance to a bus means that the train control system is not a full signalling system but relies on the driver and braking system rather than the signalling system alone. Standards which apply to heavy rail routes that ensure safety where trains are not driven on line of sight are not applicable. This potentially reduces the cost of stations as for example footbridges and lifts may not need to be provided. The extent of savings is likely to be most significant in terms of new stations, track, signalling and civil engineering and structures. However, the cost and requirement for electrification would remain, albeit at a potentially reduced cost.

If ultra light rail vehicles such as the Class 139 were used the extent of savings might be greater than for a heavier dual voltage tram train.The extent of any savings would be dependent on circumstances. A key difference in cost might be the use of a self powered ultra light rail vehicle avoiding the cost of electrification infrastructure. However, any such decision on traction and rolling stock would need to be made considering the whole life whole industry cost of self power versus electrification on a whole life cost basis.

There may be additional costs of a depot and other facilities such as a control room which might not be required for a new line connected to a heavy rail system which could use or adapt existing facilities. The additional costs therefore relate to the standalone nature of a light rail line.

The key question in terms of feasibility is whether the market conditions exist such that a tram style vehicle is appropriate and whether the market can be served without the substantial disadvantage of a segregated system.

Table 3.5 – Airdrie to Bathgate capital costs range by type of asset (source: Network Rail)

Cost component	Lower range of total scheme cost	Upper range of total scheme cost
Depot	0%	10%
Electrification	10%	20%
Signalling & telecommunications	10%	20%
Stations	10%	20%
Track	10%	20%
Civils and structures	30%	40%

3.2.6 Operating cost

Currently there are no operational tram trains in Great Britain and the tram train pilot seeks to understand the impact of tram train on operating costs. It is however assumed based on the experience of tram operators and the cost estimates of the tram train pilot that operating costs may be affected as follows:

- lower track maintenance cost possible but dependent on circumstances
- electric tram train lower energy consumption
- staff cost savings.

For trams operating cost saving categories would be similar to tram train, but potentially greater as all heavy rail is eliminated. This depends on circumstances as the lower tram costs stem from the lack of duplication of systems, and the greater savings from the lighter weight vehicles.

It is important to note in both tram and tram train cases that fleet utilisation of smaller fleets and other economies of scale might counter some of the lower operating costs.
This scoping document has not at this stage sought to draw detailed conclusions about operating costs as generalisations are difficult and the assumptions vary depending on the specific characteristics of each route and service.

The tram train pilot will investigate the detailed operational cost impact of tram train and any tram conversion will make an assessment of these issues on a case by case basis. This scoping document has considered in detail the impact on rolling stock cost and the traction choice between electric and self powered vehicles.

3.2.6.1 Rolling stock costs

The established industry strategy, the Network RUS: Passenger Rolling Stock, asked the Rail Industry Association (RIA) two specific questions about passenger rolling stock procurement costs which are related to this strategy. RIA represents UK-based railway suppliers, and its rolling stock manufacturing members are Bombardier Transportation, Alstom and Siemens. The questions were:

1. what is the variation in vehicle cost with order volume?
2. what is the cost of discontinuous rolling stock procurement?

A significant amount of non recurring cost investment, such as research and development, is required to produce a new type of rolling stock. This work is typically unique to each rolling stock fleet and there are few synergies between the research and development activities undertaken for different types of rolling stock. It is estimated by RIA that the cost of this work is, 'rarely less than £10 million, even for repeat orders of trains, and can reach as much as £100 million for substantially or completely new train specifications'.

Information provided by RIA suggests that a reduction in the number of variants, and an increase in the number of vehicles of each variant, would reduce both the one-off research and development share of the total cost per vehicle and the average cost per vehicle. This reduction in costs would occur at a diminishing marginal rate with the additional total cost saving reducing as the number of vehicles per variant increases.

RIA has consulted with some of the vehicle manufacturers and has estimated that this increases the cost of building rolling stock for the British market by approximately 20 per cent over what would have been possible against a scenario of continuous production. This figure is exclusive of any costs incurred in the bid process.

Both continuity of production and order size are likely to be difficult to optimise for tram and tram train orders because the fleets for each individual scheme are small and there is no current mechanism to have a programme of tram or tram train schemes. The highly bespoke nature of tram trains combined with a likely lack of continuity of orders means that the unit price for such rolling stock may be high in comparison with conventional heavy rail rolling stock where procurement economies of scale and continuity of orders can potentially be exploited. Tram and tram trains orders may be able to be linked to European orders in a way in which is generally more difficult for conventional heavy rail rolling stock because of the difference in platform height and gauge. This could be a means of achieving a more optimum order size to generate a lower unit cost.

There is a difference in the way in which heavy rail and tram rolling stock is purchased. For tram schemes rolling stock is typically purchased as part of a capital grant to build the tramway or renew the tramway. Heavy rail vehicles are for the most part leased from Rolling Stock Companies (ROSCOs) and this also reflects the wider market for heavy rail vehicles in Great Britain and consequently the possibility of reuse and therefore residual value as a leased asset.

This can make cost comparison less straight forward and therefore the scoping document has assumed the following cost assumptions in **Figure 3.7** based on the relative price comparison and the increasing capital cost with the complexity of the rolling stock.

3.2.6.2 Diesel tram trains

The first phase of the tram train trial planned to introduce diesel powered tram trains between Huddersfield and Sheffield. The route had been chosen, against a large number of other routes, using comprehensive criteria. A significant assumption in the choice of this route (or any other potential route that was not electrified) was that diesel powered tram trains would be available for use on the route. The project had observed the operation of diesel electric hybrid tram trains in Kassel and had received encouraging signs from potential manufacturers which had suggested that a suitable product would be available for the tram train trial. **Figure 3.8** shows a bi-mode tram train in Kassel operating in diesel mode.

Figure 3.7 – Cost of rolling stock assumptions

Capital costs range from slightly cheaper than two EMU vehicles to similar cost	More complex than equivalent tram	More expensive than a single voltage tram train	More expensive still and potentially higher cost than equivalent two-car DMU as a result of complexity

Increasing complexity = increasing £

EMU vehicle lease per annum	DMU vehicle lease per annum
£90,000*	£110,000*

*Source: Network RUS: Electrification (2009)

Figure 3.8 - Photograph of a bi-mode tram train in Kassel

Subsequently, Northern Rail received one bid for the supply of diesel tram train vehicles and it transpired that the existing diesel electric tram train product was no longer available in its current form without the redesign of a number of elements. Included within the list of issues was that a suitable EU Stage IIIB compliant diesel engine (as was required from 2012) was not yet available for tram train vehicles.

The very small order of vehicles required for the tram train trial placed a disproportionally high percentage of design and development costs onto the single order – there being no other market for diesel tram trains at that time. The resultant unit price made the vehicles unaffordable. The project had already identified a second phase that would involve through running on the South Yorkshire Supertram network using electric tram trains and in 2009 it was decided to put on hold the first phase of the project and commence work on the second phase on the basis of using an electric only tram train vehicle.

The tram train pilot understands that there may now be bi-mode tram train products which are under development. The question of order size is likely to be an issue for any purchase of tram train vehicles as they are individually unlikely to be of a sufficient size to realise economies of scale or continuity of production.
However, diesel tram trains represent only a percentage of an already small global market for tram train rolling stock. This strategy has therefore assumed because of the experience of the tram train pilot and the highly bespoke nature of the diesel tram train product that electric tram trains are the most likely option. Electric tram trains have therefore formed the starting point of the analysis.

The capital cost of a diesel bi-mode tram train may be higher than an equivalent capacity DMU. This means that a diesel tram train is unlikely to be a lower cost rolling stock option than a new DMU.

3.2.6.3 Ultra light rail

The term ultra light rail refers to a number of differing solutions. The common features that these proposals share is the use of a lighter weight vehicle, with potentially lower capacity and hence cost. The concept proposes relatively limited changes to existing infrastructure and may or may not be self powered. For new infrastructure it is contended by those promoting such schemes that substantially reduced costs might be seen. The concept may also be linked to personal rapid transit but the scoping document has not chosen to consider the latter as the application has most relevance in the context of issues such as airport people movers similar to those in use at London Heathrow Airport Terminal 5.

Some of these solutions have been trialled but the only commercially operating service of this kind uses a Class 139 vehicle (see **Figure 3.9**) in segregated operation from the main line between Stourbridge Town and Stourbridge Junction. This service has been operated since 2009 and two Class 139s are required to operate the service.

The branch is unique on the railway network in that it is only around ¾ mile long. The service is subcontracted from the London Midland franchise and the vehicles are owned by Porterbrook Leasing. Prior to 2009 a test service had operated on the line. The two Class 139 vehicles replaced one heavy rail single car Class 153 DMU.

Figure 3.9 – Photograph of Class 139 approaching Stourbridge Junction

The Class 139 is segregated from heavy rail trains and operates a ten minute frequency service with only one vehicle in service at any one time.

The Class 139 is a light weight vehicle with a tare weight of 10.5 tonnes, two axles and a total capacity for 60 passengers. This compares to approximately 100 passengers per equivalent heavy rail 20 metre DMU vehicle. The vehicle has a flywheel energy storage system in order to recover braking energy and reduce peak power requirements from the liquefied petroleum gas powered internal combustion engine which has the effect of reducing fuel consumption. Given the length of the branch line the speed of the vehicle is necessarily low, but the vehicle is designed for operating at up to 40 miles per hour.

The operation of the service has required the installation of a small maintenance facility and the addition of a new buffer stop design at Stourbridge Town. Works were required to the infrastructure to address ride quality as a result of the vehicles' tolerance to the track conditions. On Network Rail's infrastructure the Class 139 has been approved for operation only on the Stourbridge Town branch. Operation on the Stourbridge Town branch in this way is acceptable due to the self contained nature of the branch and the one train method of operation.

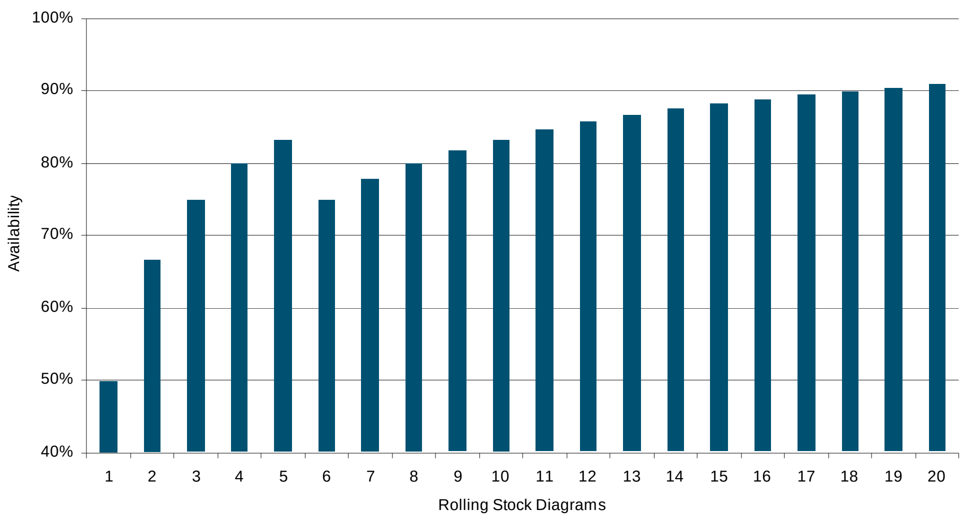
The Class 139 vehicle is not compliant to Railway Group Standards for compatibility with other Network Rail infrastructure and is not compliant with standards for interoperability with other heavy rail vehicles. The personnel who operate the service are not required to have national network competence requirements.

3.2.6.4 Fleet utilisation

For all alternative solutions which are likely to be employed on a small scale in any location fleet utilisation is a significant issue. **Graph 3.4** demonstrates that for a fleet size of less than 20 units it is difficult to achieve the optimum balance of availability of rolling stock.

This is because with a larger fleet economies of scale mean that a smaller number of units are required to cover maintenance spares.
If an alternative solution results in moving to a substantially smaller fleet that this may increase the total number of units required to operate the service. This conclusion applies to tram and tram train, as well as across the heavy rail industry.

Graph 3.4 – Typical fleet availability by number of rolling stock diagrams in a fleet



3.3 Alternative methods of delivery of electric traction on lower traffic density routes

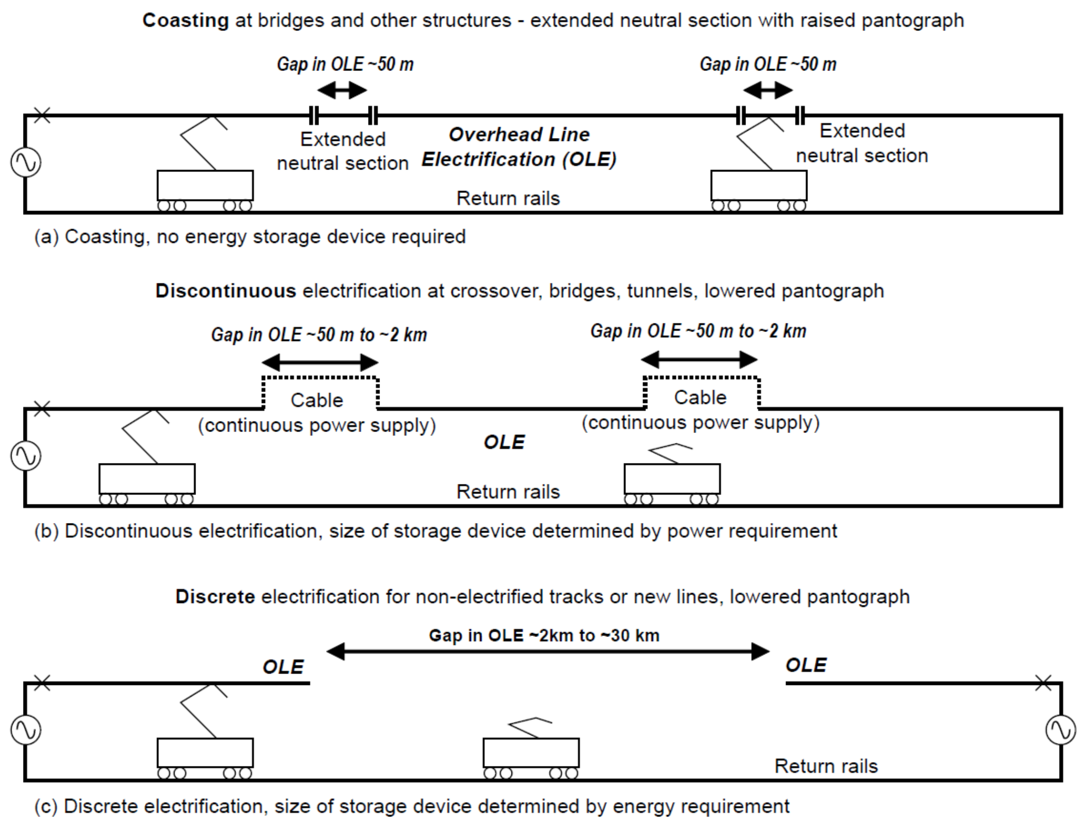
3.3.1 Definitions of the alternative solution

To date a number of alternative solutions have been proposed which potentially could contribute to reducing the infrastructure cost of electric traction. The solutions which have been considered by this scoping document are described as follows in **Figure 3.10**.

There are two aspects to the alternative forms of electrification. Firstly, the shorter gaps are aimed at reducing the cost of gauge clearing challenging structures. Secondly, the longer gaps aim to remove all of the additional OLE infrastructure capital and maintenance costs of providing electric traction transferring some of those costs to energy storage onboard the rolling stock.

From the analysis in the Network RUS: Electrification the cost of gauge clearing structures and tunnels, depending on the route, accounts for between 30 to 40 per cent of the capital cost of an electrification scheme. An example of a challenging structure to electrify is the Farnworth Tunnels which are part of the North Western Electrification scheme between Manchester and Blackpool North. **Figure 3.11** below shows a Class 185 emerging from one of the tunnels and illustrates the very constrained tunnel size making electrical clearance challenging. There is a conventional solution which is being developed for the electrification project, but the diameter of the right hand tunnel bore illustrates some of the challenges that can be faced to electrify a route.

Figure 3.10 – Coasting, discontinuous and discrete electrification[11]



[11] Source: RSSB, T777, Research Programme Engineering, Understanding the effect of 'gaps' in electrical continuity of the traction contact system Gaps in electrical conductivity of the overhead line AC traction system (2010)

Figure 3.11 – Farnworth Tunnels part of the North West electrification project between Farnworth and Kearsley

The alternative solutions to conventional electrification considered in this strategy are coasting, discontinuous, and discrete electrification which are described as follows:

3.3.1.1 Coasting

This concept involves extended neutral sections in overhead line electrification (OLE) of a few tens of metres through which a train can coast in order to avoid gauge clearance of complex structures. Gaps of this distance could be introduced without any train borne energy storage device. Where sufficient physical clearance exists but there is insufficient electrical clearance a neutral contact wire used through the extended neutral section. This is a solution which is in established use in three locations across the network. In locations with insufficient physical and electrical clearance an as yet undeveloped automated means of raising the pantograph could be used through a gap in the OLE. While there might be gaps in the OLE, the gap would be bridged by cables meaning that the power supply was continuous.

3.3.1.2 Discontinuous electrification

Discontinuous electrification is a route electrified with gaps in the OLE of distances in the order of a few hundreds of metres where an appropriate train borne energy storage device, for example super capacitor, can be used to provide power for short durations through discontinuities in the OLE. This could be implemented to avoid the electrification of complex areas or structures, such as stations or tunnels. As with coasting, the power supply would be continuous.

3.3.1.3 Discrete electrification

Discrete electrification is an unelectrified route, or section of route, where a train borne energy storage device is used to power a train for a distance in the order of several kilometres. In this instance there would be a complete gap in the electrification infrastructure and each side of the gap would have entirely separate power supplies. Electrification or an external source of traction power would be required to charge the energy storage device both at some point in the trains journey and at the rolling stock depot.

3.3.2 Existing and planned usage of the solutions

3.3.2.1 Coasting

There are three examples in Great Britain of extended neutral sections of gaps of tens of metres to avoid areas of insufficient gauge clearance for installation of 25kV AC OLE, these sites are:

- Romford - Upminster Bridge No. 9: Brentwood Road
- Romford - Upminster Bridge No. 10: Heath Park Road
- Ayr – Bridge 45 "Tam's Brig" on the A79.[12]

Coasting, while not widely used, is therefore a conventional tool for avoiding the need to undertake substantial works to obtain sufficient clearances under structures. It is restricted in its application because of the following factors:

- in order to be safely implemented the neutral section must be in a location where it is neither likely nor appropriate that a train would become stationary and therefore stranded by the lack of power, this precludes locations such as:
  - junctions
  - near stop signals
  - stations
  - steep gradients.

The proposed electrification of the Paisley Canal branch between Corkerhill and Paisley Canal in Glasgow is being developed as a scheme to consider the potential option for using neutral sections of conductor wire under bridges which would be prohibitively expensive to modify to allow sufficient clearance for live OLE.

The key technical issue is the suitability of the location for having an extended neutral section. The clear risk is of a train becoming stranded in the neutral section and being unable to move. The location choice for neutral sections needs therefore to ensure that there are no signals, crossovers, level crossings, occupational crossings, speed restrictions, stations, significant gradients or tunnels in the section. This is to ensure that there are no features which might reduce the speed of or stop the traction unit traversing the gap. The use of EMUs formed of multiple sets would reduce the risk of becoming stranded because of there being pantographs on each unit. Clearly these characteristics will exist on significant sections of the network.

Future technical solutions might include the installation of a second pantograph on the train to avoid 'gapping' with sophisticated controls to raise and lower the pantograph(s). However, these represent far more complex technical solutions which are not currently in use and are likely to import significant costs to rolling stock as well as affect the flexibility of rolling stock deployment.

3.3.2.2 Discontinuous electrification

There are currently no examples in Great Britain, or the rest of the world, of discontinuous electrification in heavy rail usage. There are a number of technical and operational issues which would need to be overcome in order to implement the solutions.

To have a discontinuous section in the infrastructure the overhead line needs to be terminated at both ends of the discontinuity. This will require extra balance weights, anchor foundations and ties at both ends. Specifically designed rolling stock would be required with the ability to automatically raise and lower their pantographs on the move and to have installed energy storage to bridge the gap in the OLE.

Electrical continuity of the overhead line needs to be maintained across the gap in the OLE and this will require high voltage cables for each electrical section, cable terminations at both ends of the cable, and cable routes to mechanically protect the cable.

A means of opening the circuit breaker on the traction unit and automatically lowering the pantograph before the discontinuity will also be required. The opposite process is required as the train rejoins the OLE. Whilst there is currently no method in operation for the traction unit to lower and raise its pantograph automatically at the required locations the control signal could be provided through lineside balises or Automatic Power Control (APC) magnets. The automatic means to raise and lower a pantograph very frequently, as would be required for discontinuous electrification, is of a different order of magnitude to current operations requiring a pantograph to be raised or lowered. Examples of more conventional requirements include voltage change over or bi-modes, both of which might only lower the pantograph once in a journey whereas discontinuities could in theory be far more frequent. There is also a technical challenge in switching between an internal and external power supply on the move.

Energy storage devices will require time and the means to recharge the stored energy automatically in order to traverse the discontinuities along a route.

As a result of the peak energy requirements it is not thought that it is currently feasible for high speed and freight trains to make use of energy storage. The applicability of this solution is therefore likely to be limited to lower speed passenger routes.

[12] Source: RSSB, 'Potential to reduce the cost for electrifying GB railways' (2011)

3.3.2.3 Discrete electrification

There are currently no examples in Great Britain or the rest of the world of discrete electrification in heavy rail in commercial service using energy storage (such as batteries, flywheels or fuel cells).

There are battery powered trains for use in specific circumstances, for example London Underground infrastructure trains that operate underground when the power system is isolated. Class 73 electro-diesel locomotives are able to operate from either the 3rd rail DC power supply or under the power of a diesel engine, and the Intercity Express Programme is developing a hybrid electric diesel variant of a long distance high speed train. Heavy rail vehicles have been hybridised but the energy storage is not the sole prime mover. For example the Class 139 vehicles have a steel flywheel which acts as an energy store to provide power for acceleration. The liquefied petroleum gas (LPG) engine is used once initial acceleration has been completed to maintain speed, and while stationary in order to 'charge' the flywheel. More recently developments have been proposed to enable 25kV AC powered locomotives to have a bi-mode capability to travel the 'last mile' to an unelectrified freight terminal.

There are a number of examples in Europe in which urban tram systems have trialled energy storage devices (batteries, flywheels and super capacitors) to allow self powered operation through the centre of cities. This removes the need for overhead line electrification to be provided over relatively short sections in order to protect the visual impact of architecturally sensitive and historic streetscapes. Nice tramway line 1 is operated in commercial service with battery storage and a number of other lines are planned for example in Seville, and Seattle. The alternative is to use an under street electrification system which is potentially very expensive to construct particularly as it must never expose a street user to a live power supply.

Tram line 1 in Nice uses nickel metal hydride batteries to go through some of the central sections of the city under its own power avoiding the more expensive under street electrification and preserving an uncluttered visual environment. The Alstom Citadis trams use batteries in day-to-day operations entering commercial service in 2007. **Figure 3.12** shows two trams operating under battery power through one of the two gaps in the OLE. The gaps are a couple of hundred metres in length and the trams operate at 30kmh.

The reasons for implementing energy storage in the on street tram context are very different from those in the heavy rail arena. For heavy rail the main aim is to minimise infrastructure costs for the implementation of OLE. In a tram on street context, aesthetics of the urban streetscape and the cost of utility diversions are the primary drivers.

All of the points for discontinuous electrification apply to discrete electrification with the exception of the issues around maintaining continuity of power supply. As a result of the longer gap in the electrical supply, issues about change over between internal and external power may be simpler as they can be aligned to station stops.

With greater length of gaps in the OLE, reinforcing of existing power supply points might be required to allow trains to charge up either on the move, or when stationary in a depot or platform. If new electrification infrastructure is needed to make gaps feasible for the range of energy storage powered trains, these may be remote from existing OLE and power supply adding to cost and complexity.

Figure 3.12 – Photograph of Nice line 1 trams in battery mode

In comparison with the shorter discontinuous gaps, the increased distance of the gap in OLE for discrete electrification will require a larger amount of energy storage to traverse the gap. In turn this will impact on unit weight and therefore track maintenance. It may also reduce the available space for passengers if there is insufficient space underneath individual vehicles to install the energy storage systems. The number of stations at which a service calls, as well as overall line speed and gradient will have a considerable impact on the size of the required energy storage device.

Similarly to discontinuous electrification, as a result of the peak energy requirements, it is not thought that it is currently feasible for high speed passenger and freight trains to make use of energy storage. The applicability of this solution is therefore likely to be limited to lower speed passenger routes.

3.3.2.4 Energy storage

The energy storage technology to allow operation in a heavy rail context in the way described has not yet been employed in commercial operation. The use of batteries in Nice tram line 1 is for hundreds of metres rather than tens of kilometres.

For this reason the scoping document proposes to focus on the potential specification of suitable energy storage devices for the long term view of the RUS up to 30 years in the future. Energy storage technologies that have been considered include (not an exhaustive list):

- batteries
  - lead acid batteries
  - nickel metal hydride and nickel cadmium batteries
  - lithium ion batteries
  - lithium ferrous phosphate batteries
  - sodium salt batteries
- electrical
  - super capacitor
- mechanical
  - flywheels
  - range extenders where a gas turbine or internal combustion engine charges an energy store thereby reducing the peak power demand on the motive power source.

Conventional electric trains have batteries to provide backup power in the event of OLE or 3^{rd} rail power failure. This energy storage provides onboard power for a period of time to the onboard auxiliary systems for the train's non traction electrical systems such as lighting and heating.

Energy storage may also have other applications which are not directly being considered by this strategy.

These might include:

- hybridising diesel trains to reduce fuel consumption by capturing and storing energy from braking
- storing energy onboard the train or beside the track to reduce the peak power consumption avoiding the need for power supply strengthening
- reducing the peak load of an internal combustion engine or enabling that engine to be "down sized" by charging an energy store which is used for peak power consumption. An example is the Class 139 flywheel vehicle.

However, the focus for this scoping document is on the potential for energy storage in its application to reduce the need for fixed infrastructure rather than these broader applications.

Based on previous studies **Table 3.6** shows a high level comparison of the three main types of energy storage that have been proposed. What this illustrates is that each have areas in which they have both strengths and weaknesses when compared to diesel internal combustion engines. In the analysis that has been conducted to develop this scoping document batteries have been assumed to be the most viable technology for discrete electrification. This is because while they are slower to charge than flywheels or super capacitors and are not able to provide the same specific power for acceleration, batteries may have the specific energy range to power a train through a gap of kilometres in distance.

This is not to suggest that batteries are appropriate for all circumstances and for shorter gaps associated with discontinuous electrification the acceleration and rapid charging of super capacitors or flywheels may be more applicable. No energy storage technology currently available matches diesel fuel and an internal combustion engine for its combination of range, acceleration, and charging time. The storage technologies have different niches and are appropriate for different circumstances.

Hydrogen fuel cells have not been considered because of two factors. The first of these is the lack of a hydrogen distribution network and the energy cost associated with its production. The second is that rail is unlikely to lead the development of hydrogen fuel cell technology but instead is more likely to draw on developments in the automotive sector. The Rail Safety and Standards Board (RSSB) is considering this subject with the potential for trialling the technology if and when it becomes viable for use in a heavy rail context.

Energy storage has also been used to hybridise for energy efficiency reasons a number of types of heavy rail vehicles to improve energy efficiency:

- flywheel:
  - Class 139 – LPG powered internal combustion engine hybridised with a flywheel
- batteries:
  - Japanese Railways East diesel-lithium ion battery hybrid diesel multiple unit (DMU) trial
  - Class 43 “Hayabusa” trial undertaken in order to test the energy efficiency gains of installation of lithium ion battery storage on a diesel train
  - there have been a number of trials in Europe, Japan and North America of hybrid diesel freight and shunting locomotives.

To date, energy storage has been used in heavy rail to improve energy efficiency by recovering energy from braking or for restricted environments such as the London Underground tunnels. It has not primarily been used in order to bridge gaps in electrification. In commercial service only in a tram context have energy storage devices been used to bridge gaps in OLE. However, the reason for its use in these contexts has been to avoid OLE having to be erected in historic city centre locations. The alternative is to use an under street electrification system which is an expensive and complex technology. In this context energy storage may be a lower cost alternative to allow a small area of a city centre to be wire free. These considerations do not usually apply to the heavy rail market as issues of aesthetics of visual intrusion are generally not so relevant except in specific historic locations.

Table 3.6 – Indicative capability of batteries, high-tec h flywheels and super capacitors[13]

	Batteries	**High tech flywheels**	**Super capacitors**
Specific energy (range)	Good	Ok	Poor
Specific power (acceleration)	Good	Very good	Very good
Useful life	~2-5 yrs	~10 yrs	~20yrs
Maintenance	Little maintenance	Some maintenance	Maintenance free
Environmental impact	Depends on type some use scares materials and are difficult to recycle	Good – readily available materials	Uses scarce materials
Safety	Low risk but dependent on type	Uncertain	Possible risk of electrical discharge
Reliability	Very reliable	Uncertain	Very reliable
Electrical efficiency	~90%	>95%	>90%
Charging & discharging time	Reasonable	Fast	Very fast
Self discharge	Days	Minutes	Hours

[13] Source: RSSB, T779, Energy storage systems for railway applications (2010)

Energy storage is being developed for a number of market uses most significantly for renewable power generation, uninterruptable power sources for telecommunications and data centres, and in the automotive industry. In terms of automotive uses, hybrid technology is most widely in use in cars and in the bus industry. This is designed to capture the energy of braking to reduce fuel consumption used for acceleration, to reduce emissions, and particularly in the case of buses to reduce noise. The rail industry in comparison with these other markets is relatively small. However, the rail industry may be able to make use of the lower unit cost and longer asset life which potentially may develop as a result of deployment of energy storage in the automotive, power, and telecoms sectors.

3.3.2.5 Initiatives to reduce the whole life cost of conventional electrification

There are a number of initiatives that the railway industry is considering which may reduce the cost of conventional electrification on some routes. The two main developments are the consideration of trolley wire on routes with an operating speed below 60mph. The second is the potential to convert existing 3rd rail DC electrification to 25kV AC OLE. The scoping document notes both of these issues as ways in which the conventional cost base may reduce costs on some routes. This will need to be factored into the options appraisal of any alternative solution.

Following on from an initial study by the Technical Strategy Leadership Group (TSLG) the findings of which were published in 'Investigating the economics of the 3rd rail DC system compared to other electrification systems, T950 - August 2011', Network Rail is currently developing a study to consider the potential for a business case to convert elements of the 3rd rail network to 25kV AC. As this strategy is being developed already the scoping document does not propose to consider this subject further. However, the base 3rd rail electrification may, depending on the findings of the study, be found to be more cost effective in whole-life terms if it were converted to 25kV AC.

Trolley wire OLE provides a lower cost overhead line arrangement by eliminating the catenary wire. One or two contact wires are suspended from OLE masts without a supporting catenary wire. This reduces the weight of the overhead wires and reduces the required strength and height of masts. It offers the potential for lower installation and material costs when compared to a conventional OLE system. However, it is only suitable for line speeds up to 60mph owing to limitations on the ability for current collection to be maintained at higher speeds. In addition if the route has tight radius curves this solution might be more advantageous as the longer span lengths possible with conventional OLE would not be feasible. On straight track the extra masts required by trolley wire might negate the costs of simpler wire. Masts have a significant per mast cost, regardless of size. The major potential benefit is a reduced requirement for physical clearances when compared to a conventional OLE system because of the lack of the catenary wire and size of the mast construction.

3.3.2.6 Bi-mode (electro diesel) trains

This scoping document is considering the potential for energy storage technology to bridge gaps in OLE of varying lengths. It is acknowledged by the strategy that bi-mode diesel electric trains are already in service and may offer a comparable technology. Bi-mode trains exist in Great Britain in the form of the Class 73 locomotive, and form part of the Intercity Express Programme (IEP). In France EMUs are in service which have a bi-mode capability. However, these technologies are not considered further by the scoping document because the case is being considered elsewhere as part of the IEP and conventional electrification schemes.

3.3.3 Discrete electrification energy storage assumptions

The energy storage technology to allow operation in a heavy rail context in the way described has not yet been developed in commercial operation or even tested in a trial for the size of gaps that have been considered. The RUS has a 30 year view and therefore has taken a more aggressive capability in order to establish the market if the supply industry is able to develop these capabilities and the price at which it would be affordable. For this reason the scoping document proposes to focus on the potential specification of suitable energy storage devices. Discussion of energy storage technologies is the primary focus of the scoping document rather the capabilities and that would be needed for it to be able to be economically useful to the rail industry.

This scoping document uses the values and costs for electrification in the Network RUS: Electrification **Table 3.7** and presents the costs for DMU, EMU and EMU with battery storage operation. Assumptions have then been made based on discussions with suppliers, previous research and engineering advice about the impact on these values that using battery storage potentially would have. The key assumptions are as follows:

- electricity consumption is assumed to be 20 per cent higher over its total journey than an EMU due to the inefficiency of the

battery and the additional weight of the vehicle as a result of the battery
- variable track access charge (VTAC) was estimated based on increased battery weight added to an EMU which is explained in **Table 3.8**
- maintenance per vehicle mile is assumed to be the same as an EMU at this stage, but this assumption would need to be confirmed in operation
- capital costs for discrete electrification have not been included at this stage, but there are potential costs for power supply strengthening or for example wiring bay platforms
- the battery cost is based on a 300 kWh requirement per vehicle which is explained in **Table 3.8**. Due to the uncertainty about cost per kWh and battery life a range of costs have been used. This cost would implicitly also need to cover the cost of additional electrical and pantograph control equipment
- journey time savings of EMUs compared to DMUs may still be possible with discrete electrification, but acceleration consumes energy which reduces battery range.

For the basis of this analysis the costs have been kept at a high level and have not included the costs of additional complexity of rolling stock such as the additional systems relating to the battery. In effect it has been assumed that these would be included as part of the fixed cost of the battery. **Table 3.8** sets out the assumptions that underpin the battery specific figures in **Table 3.7** and the selection of routes for analysis for the potential use of energy storage vehicles.

The key issue for the economics of the solution is the capital cost and life expectancy of energy storage devices and any ongoing maintenance. Life expectancy depends on the specific technology and its duty cycles. Batteries over a period of time become less efficient and for an application in which they form the prime form of power the point at which they fail is more critical than for circumstances in which they are used as a hybrid to reduce fuel consumption because they are not the prime mover. The battery life obviously affects the periodicity of the replacement cost which has a critical impact on whole life costs.

The cost per kWh of battery has a very wide range of current and future cost estimates. For this reason the wide range has been used in order to establish the sensitivity of the market to price. The range has also been used because there is uncertainty about battery life affecting the whole life costs. The range therefore has been expressed as a range of costs per annum which addresses the uncertainty about both factors.
Ranges of batteries are not an easy issue to summarise. This is because range depends upon a number of dynamic factors described in **Table 3.8**. This scoping document in its analysis has therefore tested a range of capabilities for the distance that a battery can power a train away from the OLE. This more straight forward assessment of the network and the services operated has been done on the basis that a given range can be achieved with a charging time which allows the current timetable to be operated with the same number of trains. A more complex expression of the capabilities of a battery requires modelling of both battery and rolling stock to establish the energy required and the charging and discharging cycle for each route. The 75 mile range has been used not because this is technically possible today, but to understand the impact of increased range on the number of routes on which it might be applicable as the technology develops over the 30 year life of the strategy.

Table 3.7 – Assumptions of cost differential between, DMUs, EMUs and battery storage

	Diesel (£)	Electric (£)	Battery storage (£)
Fuel or electricity – per vehicle mile	0.47	0.26	0.31
VTAC – per vehicle mile	0.10	0.085	0.094
Maintenance – per vehicle mile	0.60	0.40	0.40
Variable cost per vehicle mile	1.22	0.76	0.82
Vehicle leasing per year	110,000	90,000	90,000
Capital expenditure per single track km	-	Capital expenditure for OLE and financing costs	Potential additional capital costs
Vehicle energy storage per annum	-	-	26,000 to 281,000

Table 3.8 – Specific assumptions about batteries	
Factor	
Batteries per vehicle	300 kWh central estimate: could vary according to service
Cost per battery kWh	£400 - £2,500
Battery life	3 – 5 years (a mid point of 4 years has therefore been assumed)
Financing costs	2.1% – 6% per annum
Installation costs	Unknown
Additional maintenance	Unknown
Disposal costs	Unknown but particularly for some kinds of batteries (for example Lithium Ion) there is currently not a recycling market
Other operation	Unknown
Battery mass per vehicle	~3 tonnes and ~1 tonne casing
Voltage	AC & DC
Efficiency	~+20% electricity consumption
Range (mileage)	Up to 75 miles depending upon the following:
Charge to discharge ratio	Ratio of OLE exposure time to total route distance is key
Speed (mph)	Speed increases power consumption and reduces range
Number of stops	Each station stop reduces range
Acceleration (m/s)	Match normal EMU, will consume more energy reduces range
Gradient (+%)	Gradients add to power consumption decreases range
Unit mass (tonnes)	Greater mass increases power consumption reduces range
Auxiliary power (kw)	Heating, ventilation, air conditioning and other auxiliary systems power reduces range

3.4 Community rail

3.4.1 Definition of community rail

Community rail involves people in the development and promotion of their local rail routes, services and stations. Since its inception community rail has encouraged the community to get directly involved in improving the railway environment through use of redundant buildings, provision of additional services and the improvement of railway land. It has also introduced new ways of increasing patronage and economic benefit to local communities. Community rail introduces a flexibility to local routes and services that would be difficult to achieve through other rail industry mechanisms, and it enables local communities both to influence and directly provide the service that meets their priorities.

There are a range of expressions of the concept of community rail, from the DfT formal designation of community rail lines and services, station adoptions, to more informal partnerships and interest groups. The Association of Community Rail Partnerships (ACoRP) represents a wide range of these community rail groups.

Some of the effect of community rail type initiatives can be achieved by other means, for example in the devolution of powers to more local bodies such as Passenger Transport Executives. Train operators may be able to achieve similar outcomes to community rail without necessarily actually entering into a partnership with a community. An example of a non-community rail initiative which achieves similar outcomes to community rail, but on a larger scale and without an explicit partnership, is Southern's Safer Travel Team which seeks to combat low level crime affecting passengers across its franchise. However, the unique factor relating to community rail is the involvement of the local community in partnership with the railway.

In this scoping document, community refers to a reasonably cohesive geographic area such that interest can be represented within a partnership. A community rail initiative along the whole length of a main line, or where routes cross multiple boundaries is unlikely to be sufficiently self contained to allow genuine partnership. It is also important to emphasise that by its very nature a partnership cannot be imposed upon a community by the rail industry or its funders.

The DfT's definition of community rail starts from the premise that route closure is not a policy option and that conventional means of reducing costs or improving the sustainability of local railways are not possible. Community rail seeks to be a locally appropriate way forward to address the challenges that the routes face in delivering value for money whilst also providing a socially useful transport service. The term 'community rail' relates to the involvement of the local community and the rail industry in partnership.

3.4.2 Community Rail Partnerships and Station Adoption

3.4.2.1 Community Rail Partnerships

Seeing the potential benefits of the approach, the former Strategic Rail Authority (SRA) developed its Community Rail Development Strategy (November 2004). The strategy was subsequently adopted by the Department for Transport (DfT) when it succeeded the SRA. The key aim of this strategy was to "improve the financial performance, value-for-money and social value of local and rural railways" (Community Rail Development Strategy, SRA 2004).

The strategy stated that "the objectives of this approach to the development of community railways are based on providing a strategic framework for local routes, services and stations, within which they can develop and be put on a sustainable basis:

- increasing patronage, freight use and net revenue
- managing costs down; and
- greater involvement of the local community." [14]

The DfT subsequently added a fourth objective:

- enabling local rail to play a larger role in economic and social regeneration.

At the time of publication 31 routes in England have been granted DfT designated community rail status by the DfT. Service designation relates only to the train services and not to the infrastructure, line designation applies to both infrastructure and train services. **Figure 3.13** shows the lines and services which have been designated in England.

Table 3.9 details the 31 Community Rail Partnerships (CRPs) in England along with their branded names and geographic extent. The numbering of the route corresponds to the map of the CRPs. There are no designated community rail lines and services in Scotland or Wales. However, in both instances there are groups which represent the concept without having lines of designated status. In Wales there are six community rail partnerships:

- The Heart of Wales Line Community Rail Partnership – Swansea to Shrewsbury

[14] Source: page 5, Community Rail Development Strategy, 2004

- The South West Wales Line Community Rail Partnership – Swansea to Fishguard, Milford Haven and Pembroke Dock
- The Cambrian railways - Shrewsbury to Aberystwyth and Machynlleth to Pwllheli
- Conwy valley line – Llandudno to Blaenau Ffestiniog
- The Borderlands line – Wrexham to Bidston
- Chester Shrewsbury.

A consultation into the future of rail passenger services in Scotland was launched on 15 November 2011 and closed on 20 February 2012. The consultation will inform the Scottish Ministers' decisions in relation to the future of the ScotRail passenger franchise from 2014 and the High Level Output Specification for Control Period 5.

The consultation covered a wide range of issues including:

- Achieving reliability, performance and service quality
- Train service provision
- Rail fares
- Location and management of stations
- Cross-border services
- Rolling stock requirements
- Passenger requirements
- Sleeper services
- Environmental issues

There is a strong theme of community engagement, and questions are asked about how to develop and enhance community involvement in the Scottish rail network.

There are two levels of DfT designation. Where a service operates over a line exclusively and over part of the wider network, the exclusive part may carry a 'line designation', the rest a 'service designation'.

There are a wide variety of community rail lines but they are typically local or rural routes which have a single passenger operator and limited freight. Community Rail Partnerships are generally not for profit organisations working in partnership with the rail industry. They are formed of a range of local groups such as:

- local authorities
- community groups
- rail user groups.

DfT criteria state that Community Rail lines are typically:

- low speed – less than 75 mph, single or double track (not multiple track)
- one train operator providing most services
- do not provide major conurbations with commuter services, have no major freight flows, are not part of Trans European Networks (TENs).

Each partnership has individual objectives which relate to the specific circumstances of the locality in which the CRP route or service operates.

CRPs are a means of bringing the local community and the railway industry together. By being able to provide a focus for involving local people they can potentially make the most effective use of available resources to meet local needs and identify opportunities for improvement at marginal cost.

Figure 3.13 – Map of DfT community rail designated lines and services in England

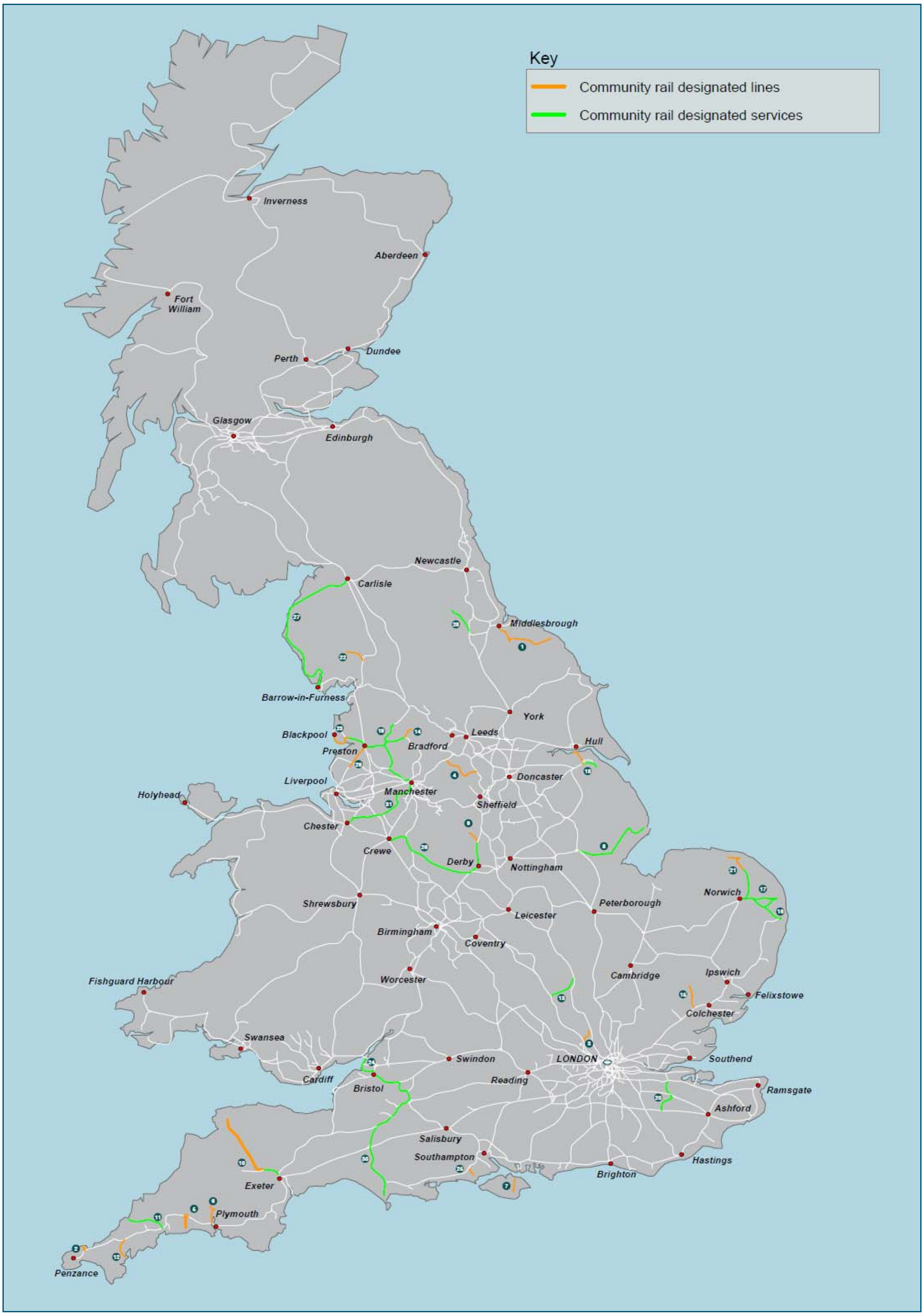


Table 3.9 – DfT designated community rail lines and services in England			
Number	**DfT designated – community rail lines and services**	**Designation**	**Date**
1	Esk Valley Line: Whitby to Middlesbrough	Line	Jul-05
2	St Ives Bay: St Ives to St Erth	Line	Jul-05
3	Abbey Line: St Albans Abbey to Watford Junction	Line	Jul-05
4	Penistone Line: Barnsley to Huddersfield	Line	Sep-05
5	Looe Valley Line: Looe to Liskeard	Line	Sep-05
6	Tamar Valley Line: Gunnislake to Plymouth	Line and service	Sep-05
7	Island Line: Ryde Pier Head to Shanklin	Line	Mar-06
8	Poacher Line: Skegness to Grantham	Service	Jul-06
9	Derwent Valley Line: Matlock to Derby	Line and service	Jul-06
10	Tarka Line: Exeter St Davids to Barnstaple	Line and service	Sep-06
11	Atlantic Coast Line: Newquay to Par	Service	Sep-06
12	Maritime Line: Falmouth to Truro	Line	Sep-06
13	Marston Vale Line: Bedford to Bletchley	Service	Nov-06
14	East Lancashire Line: Preston to Colne	Line	Nov-06
15	Gainsborough Line: Sudbury to Marks Tey	Line	Nov-06
16	Wherry Line: Norwich to Lowestoft	Service	Feb-07
17	Wherry Line: Norwich to Great Yarmouth	Service	Feb-07
18	Barton Line: Barton-on-Humber to Cleethorpes	Line and service	Feb-07
19	Clitheroe Line: Clitheroe to Manchester Victoria (via Blackburn)	Service	Mar-07
20	Medway Valley: Paddock Wood to Strood	Service	Sep-07
21	Bittern Line: Norwich to Sheringham	Line and service	Sep-07
22	Lakes Line: Oxenholme (Lake District) to Windermere	Line	Apr-08
23	South Fylde Line: Blackpool South to Preston	Line and service	Apr-08
24	Severn Beach Line: Bristol Temple Meads to Severn Beach	Service	Apr-08
25	Lymington Line: Lymington Pier to Brockenhurst	Line	Jul-08
26	North Staffordshire Line: Crewe to Derby via Stoke-on-Trent	Service	Nov-08
27	Cumbrian Coast Line: Carlisle to Barrow-in-Furness	Service	Jun-09
28	Bishop Line: Darlington to Bishop Auckland	Service	Jan-11
29	Preston to Ormskirk	Line and service	Sept-11
30	Heart of Wessex – Bristol Temple Meads to Weymouth	Service	Oct-11
31	Mid Cheshire Line – Chester and Manchester via Northwich	Service	Jan-12

3.4.2.2 Station adoption

Station adoption often involves the local community or a specific local community group. Such groups often develop out of wider rail user groups or community rail partnerships that cover a whole line or group of lines. Adoption is most common in Britain among small and medium sized stations.

Stations can act as a focal point within communities and help with local regeneration such as in Lancashire where the engagement of local communities has helped to bring buildings back into reuse for a variety of purposes. Such activity brings life to the station and may have a mutual benefit for the local economy. Property income of community rail routes can be increased with scope for community use of empty or derelict buildings. In some cases buildings could be provided for a rent free period in exchange for renovation. The reuse of buildings would both benefit the local community and the railway by improving the station environment, providing a presence at the station thus deterring trespass and vandalism and potentially attracting more passengers to visit the facility provided. For example, at Lostock Hall – CCTV has recently been installed using Designated Community Rail Development Fund (DCRDF)[15] funding. This has seen an almost instant decline in anti-social behaviour at the station. Station adoption can include volunteers cleaning, installing flower tubs and the like. Train operators have supported repainting and return to 'heritage' colour schemes and signage.

There are 55 ongoing 'long-term' Community Schemes on Network Rail managed land, involving some 400 regular volunteers, plus another 100 or so helping out occasionally.

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[15] Designated Community Rail Development Fund (DCRDF),fund established by the Department for Transport, Network Rail and ACoRP to support designated CRPs

Most have been established since the scheme began three years ago, but three were 'informal' schemes which have existed for far longer.

In the past 12 months there have been 11 'one-off' short-term community schemes, where work usually takes place just for a day, supervised by Network Rail. Two of these have involved cosmetic painting – of railings in Hungerford, Berkshire, and a footbridge in Levenmouth, Fife.

Community groups involved are widely varying in nature – from District and Town Councils, Students Unions and Rail Partnerships, through to groups of two to three local residents. **Figure 3.14** shows Plymouth University students volunteering at Looe station.
The website of the Association of Community Rail Partnerships (ACoRP) lists 126 Station Adoption groups, all of which look after train operating company leased land (some also have Network Rail Community Schemes). This number is almost certainly an underestimate, both because many groups are not members of ACoRP and because new Station Adopters are starting up all the time and would not necessarily have been recorded.

In Scotland there is the First ScotRail Adopt a Station scheme that finds community or start-up uses for vacant buildings at stations. Examples of adopters include Pitlochry Station Bookshop and a community meeting room at Maxwell Park (Pollokshields Heritage).[16] The railway contribution is to provide the space rent free but the adopters may need to find the funds to make the space habitable for their purposes.

3.4.2.3 Other forms of community rail

There are a wide range of other groups, many represented by ACoRP, who embody the concept of community rail. These groups range from community rail partnerships which are on undesignated lines, to rail user groups, and local authorities. All of these bodies may be involved in a partnership with the railway.

Figure 3.14 – Photograph of Plymouth University students volunteering at Looe station

[16] http://www.scotrail.co.uk/content/adopt-station

3.4.3 Impact of Community Rail

The activities undertaken by community rail groups vary considerably because of their local circumstances, needs, objectives, and resources and by definition each group is bespoke to its local needs. Community rail groups do not operate passenger services instead they undertake activities designed principally to attract additional patronage to the rail services and increase community involvement. The main ways this has been achieved are through:

1. ticketing
2. marketing
3. retailing
4. setting local funding priorities
5. engaging volunteers.

3.4.3.1 Ticketing

DfT community rail designation allows flexibility in fares. As a result of community rail designation train operating companies with the community are able to set locally appropriate prices, and have the freedom to make changes outside of the normal rail industry timescales. There have been a number of examples where fares levels have been changed or the ticketing structure simplified as a result of CRPs. A number of examples are detailed in the case study of the Devon and Cornwall Community Rail Partnership.

CRPs have also been active in taking initiatives to increase revenue collection. Simplification of the fares structure can be one way in which to promote revenue collection in order to make the transaction time shorter thereby allowing the on train staff to collect the revenue more effectively when services are busy.

In Scotland the Highland Railcard which is an annual railcard for Highland residents which entitles holders to 50 per cent off local rail travel arose out of a desire to provide rail services relevant to the local community.

3.4.3.2 Marketing

Community Rail plays a significant role in setting the marketing priorities of local services. Community rail by its nature is locally based and as a result can have a greater understanding of the local market and the opportunities for growth that are available. A primary focus of any marketing activity is to provide information which in itself serves to promote awareness of options thus allowing potential travellers a more informed choice. Most CRPs manage websites covering the details of their routes, the services on the route including on train events such as music and Christmas trains, other tourist attractions, and ticket offers. These websites provide a variety of useful information including details of ways to get involved and volunteering with the aim of increasing patronage and community involvement.

Community Rail Partnerships can actively work with their partners to develop a range of information distribution outlets, including libraries, tourist information offices, community outreach centres and retail outlets. An example is direct marketing in the pubs featured in “Rail Ale” guides, such as on the Penistone Line. During the blockade to upgrade the line the CRP provided information to the local community and passengers.

Beyond signage and leafleting, potential resources available to Community Rail Partnerships include:

- rolling stock vinyl route promoting branding, see example from the Settle and Carlisle line in **Figure 3.15**
- station information boards
- local authority information offices
- on train posters
- websites and social media.

Tourism partnerships can be particularly helpful in both encouraging rail use and in increasing visitor numbers to the tourist attraction in question. Operators of visitor attractions and other tourism bodies such as national park authorities, are likely to have shared interests in encouraging more visitors to an area by sustainable modes, but may not have the necessary focus or remit to concentrate on the rail service which the Community Rail Partnership has. Successful examples include the provision of cycle hire at Windermere and Brockenhurst stations.

3.4.3.3 Retailing

Ticket sales at local shops are a means to provide face-to-face ticket sales and pre-paid authority to travel arrangements. Residents railcards can also be introduced, such as cards which have been introduced on the Esk Valley Line, which for a relatively small cost, offer discounts on ordinary tickets on the route with the aim of encouraging greater use of the route once the railcard has been bought.

3.4.3.4 Setting local funding priorities

Community rail using local partnerships can provide direction to the railway to focus the deployment of funding and resources. Examples include First Great Western who approached the Heart of Wessex CRP to help prioritise the franchise commitment spending on stations along the route.

On the Barnstaple branch which has seen a progressive increase in train services over recent years, funding for additional services has been sought from and granted by the Local Authority and other agencies.

Community Rail Partnerships can actively bring partner organisations together from a wide range of backgrounds. Partner organisations may have very different objectives in working with the Community Rail Partnership from those which the rail industry may have initially expected. It may be that the availability of a redundant station building could be the start of the development of a project, the primary aim of which may be to deliver educational, economic, or regenerative outcomes, rather than having the direct aim of meeting the rail industry objective of increasing patronage, or even the Local Authority transport objectives. The desired rail industry outcomes may then become part of the outcomes identified as part of the overall development project as the local partnership proceeds.

3.4.3.5 Volunteering

Community Rail also helps enable volunteering. It is estimated by ACoRP that 4,000 volunteers contributing in excess of 1.2 million hours of work in a year. They have estimated the value of this contribution at between £7.3 million and £27.5 million[17] per annum. ACoRP suggests that volunteering is both valued by the rail industry for the positive contribution it makes and gives a sense of achievement and giving to the volunteers themselves. The outcome for the volunteer is particularly important given that people are giving their time freely to community rail related activities.

Voluntary support has had considerable impact in improving areas such as the station environment on community rail routes and also as part of specific station adoption schemes.

This has benefited a wide range of stations and in some cases using very innovative sources of labour. On the Severn Beach Line the CRP, working with the Probation Service, has facilitated people with Community Service Orders to undertake work at stations along the line.

Examples of successful volunteering include Southminster in Essex where the train operator leases the station building at a peppercorn rent to the Essex Community Rail Partnership and the local volunteer group Right Tracks. The station house has been renovated as a Healthy Living Centre, incorporating a café, meeting room and citizen's advice bureau.

3.4.4 Infrastructure and rolling stock

The community rail concept also includes achieving cost reductions in infrastructure and train operation. As has been discussed most community rail activity on the network to date has focused on the revenue generation and community involvement and not to such a degree on cost savings.

Separately from this scoping document Network Rail and the Technical Strategy Leadership Group (TSLG) are considering the potential for the reduction of cost of infrastructure whole life costs on lesser used parts of the network.

This scoping document does not seek to explore further the potential for community rail to affect the cost of infrastructure. Instead this will be pursued separately and the other alternative solutions under consideration in this strategy, namely tram train, tram conversion and energy storage, all have the potential to contribute directly or indirectly to the rolling stock and infrastructure cost of community rail routes. As part of this strategy these aspects are being considered in parallel with the concept of community rail.

Figure 3.15 – Northern Rail Settle and Carlisle Class 156 livery

Source: Northern Rail

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[17] ACoRP, 'Making a difference – the value of community rail volunteering report', July 2009

3.4.5 Passenger demand on community rail lines

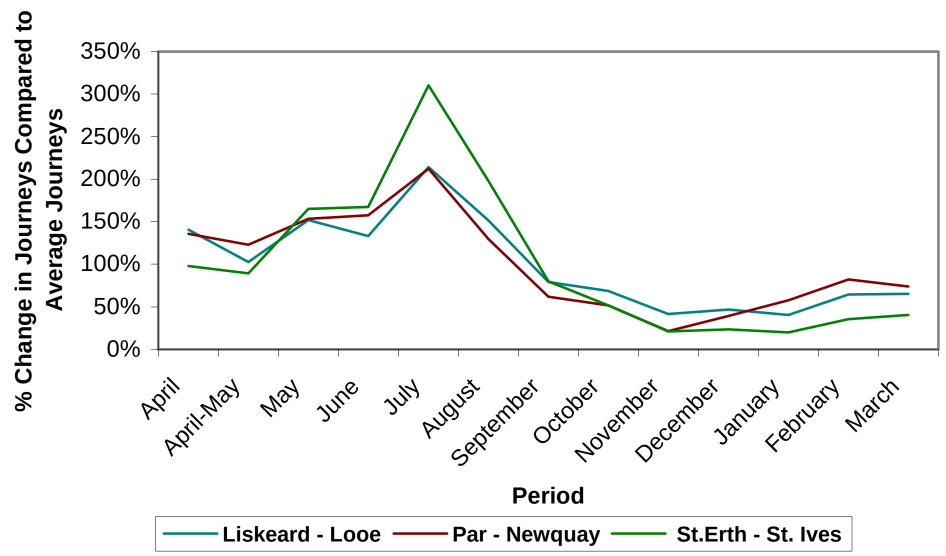
The designated community lines are diverse in their location and train service specification. Reflecting DfTs community rail criteria, they cover the more local train services, which can have low service frequencies and comparatively slower journey times than other routes. Travel on the designated community rail lines represents approximately two per cent of the national network. With many of the journeys undertaken concentrated in the South West, North West and East of England as shown in **Table 3.10**. The community rail lines also tend to have a lower share of season tickets than the national average of 35 per cent, as shown in **Table 3.10**. This suggests that the majority of journeys are taken for leisure journeys, rather than commuting.

As much of the community rail market is for leisure purposes it can be highly seasonal. This is reflective of many of the locations served by community rail lines having stations in holiday locations. For example a number of the lines in Devon and Cornwall have substantial seasonal demand as a result of serving a tourist market which leads to demand being concentrated in the summer months, as shown in **Graph 3.5**. The corresponding low numbers of season ticket sales for these lines further emphasises the seasonal nature of the demand they experience and the market in which they operate.

Table 3.10 – Usage of DfT designated community rail lines by area in England[18]

CRP by region	Total CRP journeys 2010-11 (000s)	Season ticket % (2010-11)
East Midlands	1045	17.2%
East of England	2185	13.4%
North East	185	10.0%
North West	2834	17.4%
South East	1879	24.1%
South West	2805	17.2%
West Midlands	539	15.8%
Yorkshire And The Humber	1350	10.7%
East Midlands	1045	17.2%

Graph 3.5 – CRP seasonal fluctuations in passenger journeys (2010-11) on three routes (source: First Great Western)



[18] Source: RIFF database, Heart of Wessex and Mid-Cheshire lines not included

Passenger demand has grown strongly over the past six years as shown in **Graph 3.6**. The lines have over the period grown at different rates over the period. A more granular analysis shows that the individual lines grew at different rates over the period 2004-05 to 2010-11. The different growth rate is shown in **Graph 3.7**, where growth is plotted against the percentage of journeys undertaken on season tickets. As a group the lines have grown faster than the national average, nevertheless there is substantial deviation in the performance. The community rail lines that have a high proportion of season ticket travellers have experienced lower growth, only three have above the national average. These lines with a high season ticket percentage also have grown slower than the average. The lines that have fewer season tickets have grown relatively faster.

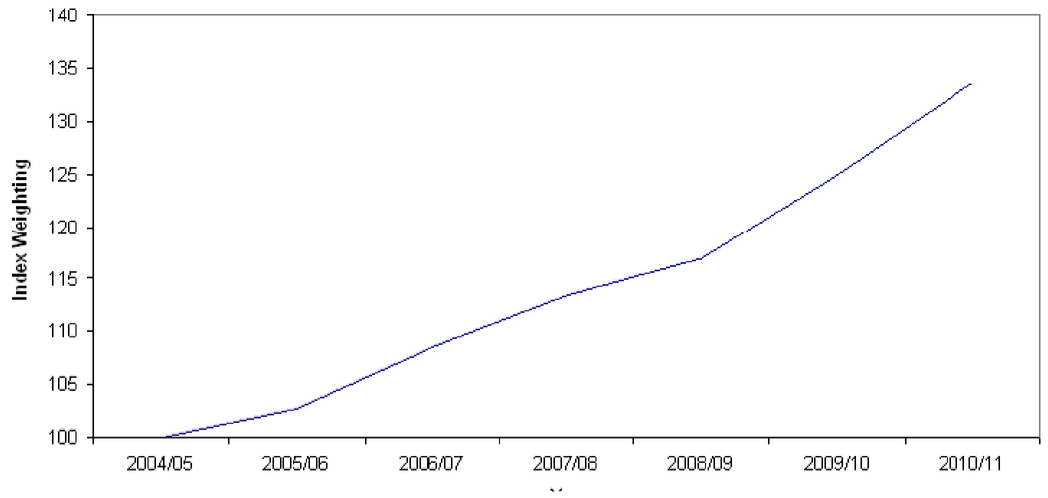
The percentage of season tickets has been plotted in **Graph 3.7** to make a high level assessment of the predominance of commuter markets on each route. It has been assumed that for those lines with lower percentages of season ticket sales that they are serving primarily a leisure market. Leisure markets have different characteristics and demand drivers to those of business or commuter markets and have a greater level of discretionary travel which means that marketing may be more effective in influencing demand on such routes.

There have been five lines, the dots on the right of **Graph 3.7**, that have grown very rapidly over the period. These routes have had growth over the period in excess of 80 per cent and have all experienced major changes to the service provision to increase frequencies. These are the:

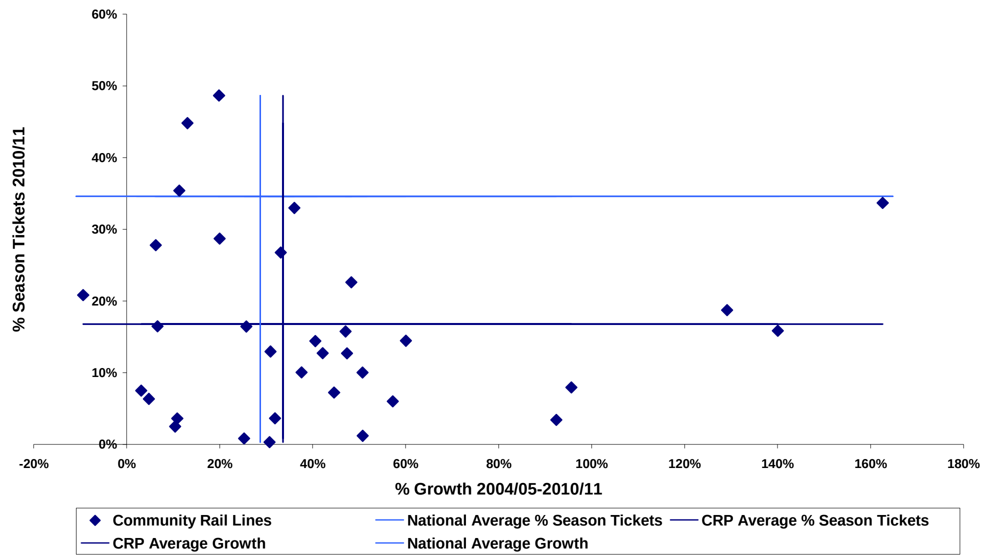
1. Severn Beach line
2. North Staffordshire line
3. Maritime line
4. Tarka Valley line
5. Matlock to Derby.

Therefore, some of the growth for the lines should be attributed to the changes in service provision.

Graph 3.6 – Growth in CRP passenger journeys 2004-5 to 2010-11, indexed to 100 at 2004-5



Graph 3.7 – Growth in CRP passenger journeys plotted against season ticket sales as a percentage of total sales



A top down approach to drawing conclusions on the impact of CRP and community involvement on each of the lines is difficult given the nature of much of the community involvement in the railways. Also changes such as to marketing and local awareness are hard to isolate from other changes as such increased passenger services and macro economic changes. Instead the impact of the railways is examined by using a case study of the Devon and Cornwall Community Rail Partnership.

3.4.6 Devon and Cornwall Community Rail Partnership case study

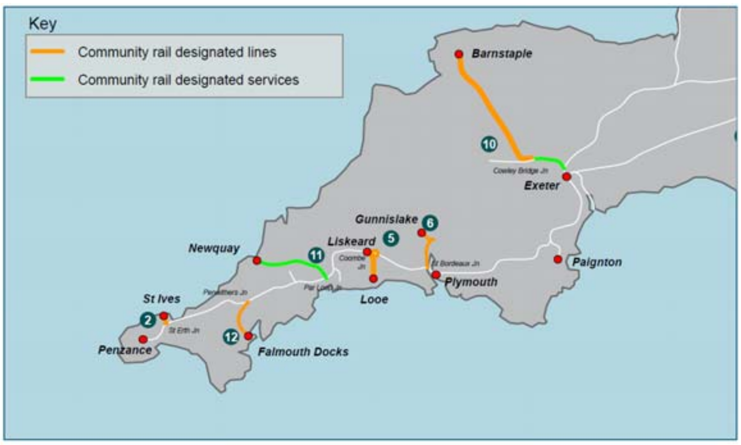
The Devon and Cornwall CRP consists of six community rail lines, all of which were granted designated status by the DfT by September 2006.

The CRP has existed in Devon and Cornwall since 1991. Its remit covers six routes across both counties:

- 'The Tarka Line' Exeter to Barnstaple
- 'The Tamar Valley Line' Plymouth to Gunnislake
- 'The Looe Valley Line' Liskeard to Looe
- 'The Atlantic Coast Line' Par to Newquay
- 'The Maritime Line' Truro to Falmouth
- 'The St Ives Bay Line' Penzance to St Ives.

The six lines can be seen in **Figure 3.16**, which shows those designated community rail lines and services that form the wider CRP

Figure 3.16 - Map of the Devon and Cornwall CRP routes



*the numbers relate to the national order in which lines and services were designated by the DfT.

The Partnership comprises the two counties, the train operator First Great Western, local government and the University of Plymouth. The CRP has a small team with two full time staff, one part time member of staff and volunteers, and is funded by the franchisee. The aims of the Devon and Cornwall CRP include:

- increase passenger numbers
- seek improvements to the railway
- boost the local economy
- link the community to the railway.

3.4.6.1 Devon and Cornwall Community Rail Partnership activities

In order to achieve its aims the CRP has undertaken activities which have focused on the following areas:

- marketing
- fares and retailing
- service development
- volunteering.

The partnership is actively marketing the routes that it covers through promotion including a website, leafleting and advertising aimed at local residents, visitors to the area and the tourist industry. Marketing has been targeted on specific lines to reach target audiences.

The Devon and Cornwall CRP has been particularly active in the area of ticketing and retailing. In 2004 “Ranger” rickets were introduced at St Ives, St Erth and Lelant Saltings with a standard £4 fare for all local journeys. In 2005 the partnership introduced the concept of “Carnets” where tickets are sold as a group of single tickets in advance from local shops in the community. This was introduced on the Tamar Valley Line and the Tarka lines in response to the falling passenger numbers. The CRP found that this concept was particularly useful in areas where the local station has no ticket office and 20 per cent of all journeys on the Tamar Valley line are undertaken using carnet tickets. The Devon and Cornwall CRP has been active in introducing new ticket and retailing opportunities on the lines under their stewardship. The partnership has also helped provide ticketing services on the Looe Valley line in the height of summer. In order to increase the attractiveness of rail as a mode of transport the CRP has worked to improve car parking facilities at six stations across all the lines.

The Partnership has also been involved in developing train services. This has happened on the Barnstaple branch where the CRP undertook research and concluded that the local community’s wish for journey time improvement was greater than the need to call all services at all stations on the branch. Services at the lightly used Portsmouth Arms station were reduced from seven to five a day from 2004 and the time saved by not calling at this station has been reflected in journey time savings between Exeter St Davids and Barnstaple. The CRP also in consultation with the community and the train operator, was able to negotiate an increase in ticket prices in order to fund improved services.

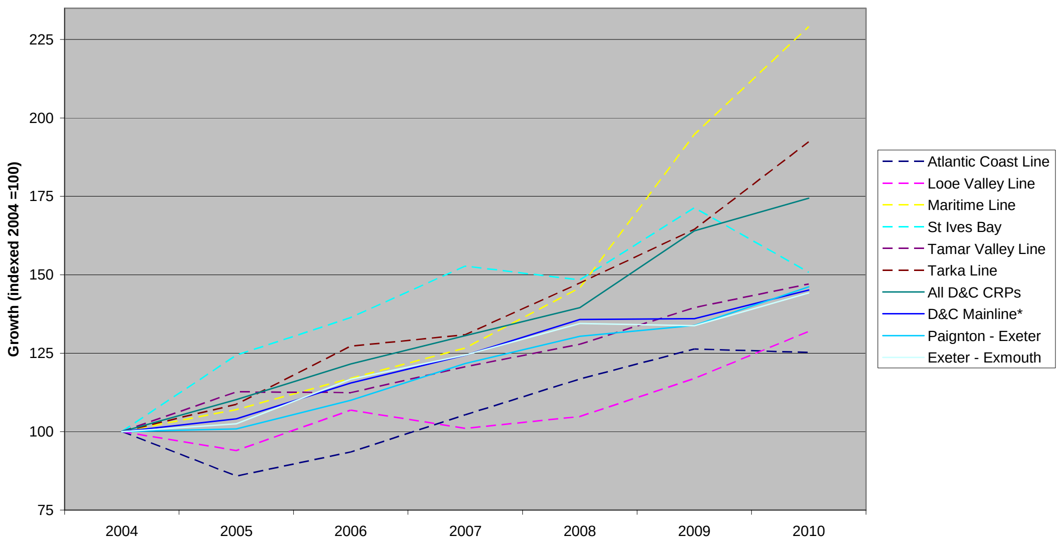
The CRP has also facilitated station adoptions and encouraged volunteering on the lines. All stations on the Tarka line have volunteer groups, and 12 other stations are regularly maintained by the local community. Students from local universities also regularly visit other stations to volunteer. This has resulted in the environments at a number of stations being improved significantly.

3.4.6.2 Devon and Cornwall Community Rail Partnership changes in passenger demand

The CRP’s remit specifically aims to increase passenger numbers. Since 2004 the Devon and Cornwall community rail lines in total have grown faster than the non-community rail lines in the region. Overall four of the six lines have over the period outperformed the mainline and other regional branch lines in terms of growth. The relative growth in rail passenger demand is shown in **Graph 3.8**.

A key driver of the strong CRP growth has been the increase in demand on the Maritime and the Tarka lines the two busiest lines. Both of these lines have had improved train services over the period presented by the graph. The St Ives branch has also had service improvements on it. The community partnership has been directly involved in many of these changes.

Graph 3.8 – Devon and Cornwall Community Rail Partnership line specific growth 2004-5 to 2010-11 (indexed to 2004-5)[19]



*D&C Mainline – Devon and Cornwall Mainline services Penzance to Exeter and onwards to Bristol and London

Graph 3.8 – Devon and Cornwall Community Rail Partnership line specific growth 2004-5 to 2010-11 (indexed to 2004-5)[19]

Since the introduction of the Carnet tickets the decline in growth on the Tamar line has been reversed and demand is growing at a similar rate to the other lines in the region. Research suggests that passengers value the ability to buy tickets before travel from retail facilities and, therefore, it is reasonable to assume that these activities would have contributed to growth. The tickets are now used by 17.6 per cent of travellers on the line despite no longer being sold at a discount to season tickets.

The impact of the additional marketing and station improvements are ongoing activities and would not present themselves clearly in this data.

3.4.7 Northern Rail – community rail case study

Northern Rail won their operating franchise in 2004, since that time they have worked to encourage the development of Community Rail Partnerships within their operating area. Northern Rail currently have 18 formal Community Rail organisations on their network across the North of England, as well as a number of informal partnerships, which in some cases are working towards formal Community Rail designation of lines or services.

Many of the 'Community Rail' organisations Northern Rail work with are not confined to Community Rail routes or services as the principles that have been developed have been applied across the Northern Rail network. This includes the development of 'station adoption', a station, rather than line of route, form of Community Rail activity, which takes place at varying levels as follows:

- 1st level – Station Adopter who will review and report back on the condition of the station waiting facilities, notice boards, etc and whether any repairs are required, in return for which they receive travel benefits from Northern Rail;
- 2nd level – More formal Station Adoption by community groups to develop and look after station facilities, notice boards, planters, gardens etc, beyond that which would normally be provided by the rail industry.
- 3rd Level – Corporate adoption of station facilities by local companies.

There are a large number of level 1 and 2 station adoptions across the network, whilst take up of the 3rd level has yet to develop. Level 2 station adoptions are particularly strong around Greater Manchester where support has been forthcoming from Transport for Greater Manchester. This level of support for the stations provides the opportunity for Northern Rail to monitor the condition of assets and respond quickly where required, and at a higher level enables Northern Rail to work much more closely with the community to improve the quality of the waiting environment for passengers using the rail network.

A large number of Community Rail routes exist across the Northern Rail network. These groups have prospered since the Strategic Rail Authority set up the initiative, regularly holding

[19] Source: Devon and Cornwall CRP

community events and promoting attractions to encourage passengers to use the services on their lines and providing the impetus for collaborative planning and development of the rail network on the Community Rail routes concerned. They have worked to enhance station environments with extensive planting and ideas such as promoting local rail walks and places to eat that are accessible from local stations.

3.4.7.1 Mid Cheshire Community Rail Partnership

A good example of the work of Community Rail groups in the North is the Mid Cheshire Community Rail Partnership. The partnership was formed in 2004 and is made up of local authorities on the route, Transport for Greater Manchester, town and parish councils, Mid Cheshire Rail Users Association and the Forestry Commission. The services on the line were 'designated' as a Community Rail Service on 18th Jaunary 2012, and this has already unlocked grant funding for the line for a booklet to promote group travel.

The Partnership has four key aims, to work with the member organisations to improve the service, to promote and market the line, to improve stations, and to increase levels of community involvement. In order to achieve these aims there are a very large number of activities which have, and are, being undertaken to encourage people to use the Mid Cheshire Line. For example promoting Mid Cheshire attractions accessible by train through the rail walks booklet and Scenic Britain by Train publications, awareness raising exercises at community events, the preparation of digital publicity material including social media such as YouTube, on train events such as the family ghost train, the heritage train and music trains.

The Partnership is also working with a number of local companies to, where possible, use the time available through medium and large sized corporate social responsibility programmes to complete station garden and renovation projects. This has led to staff from Barclays Bank completing work on the Mid Cheshire line, and a little further afield at Ellesmere Port, staff from Veolia Environmental Services, carrying out repainting and planting works at the stations creating a better station environment, a productive use of company time in the local community, and positive news in the local press. As well as this work at stations the Partnership works closely with Northern Rail to report and monitor progress of station repairs, encourages communities, schools and residents to get involved at stations and is looking to create an outdoor art gallery at each of the 16 stations on the line.

Part of the value of CRPs is that they act as a catalyst – bringing in extra resources, both financial and in kind – and enabling positive partnerships between local organisations, communities and the rail industry. This contribution can be quantified through external funding brought in and the number of volunteer hours given. The Mid Cheshire Community Rail Partnership estimates that as a minimum 600 volunteer hours are given every quarter, roughly equivalent to an additional 1½ posts working to promote the line and help develop the service every day.

3.4.7.2 Crewe to Manchester Community Rail Partnership

On the Crewe-Manchester via Stockport and Manchester Airport rail lines, a partnership was established in 2007 to promote use of services on these lines. The line or service is not formally designated, nor does the CRP have current plans to seek designation. This partnership was set up to address a drop in patronage on the local services between Crewe and Manchester whilst extensive engineering works unavoidably disrupted the local service whilst the West Coast Main Line Route Modernisation programme was underway.

Since the group was established, it has implemented garden development projects at Chelford, Goostrey, Holmes Chapel, Sandbach and Wilmslow to improve the appearance of the stations, promote tourist opportunities at each of the locations. This was originally started in conjunction with the county wide Cheshire Year of Gardens 2008 and was carried out by local volunteers and businesses. The Partnership is committed to building on the hard work of stakeholders at stations on the line, and plans continuous investment in garden projects that will improve the attractiveness of the stations for passengers. Recently further work has begun to improve the appearance of Heaton Chapel Station, undertaken by the newly formed friends group.

The Partnership works closely with the British Transport Police, schools and the local community to tackle antisocial behaviour at stations on the line. It worked closely with local County and Parish Councils towards obtaining funding and the implementation of CCTV at Sandbach and Alderley Edge stations. The Partnership is working with a variety of local schools along the line to develop a scheme that promotes the use of the railway to visit attractions along the Crewe to Manchester line. In recent months, a number of local schools have taken advantage of the scheme to visit attractions along the line.

The Partnership continues to work with volunteers providing timetables, arranging leaflet drops, and development of travel plan initiatives to promote the service. This work continues, and illustrates the value of the partnership and the focus it can bring by bringing together the operator, local government and volunteers to develop a route, despite not being formally designated as a Community Rail service or line.

3.4.7.3 Manchester - Clitheroe fares changes

The Clitheroe Line Community Rail Partnership was established in December 2006 and was the successor body to the Clitheroe Line Development Group (CLDG). The CLDG was formed in 2002 to market the additional services introduced in June of that year following a successful bid to the Strategic Rail Authority (SRA) for funding to provide a year round hourly Sunday service between Manchester and Clitheroe, along with other minor service improvements.

The SRA funding continued for three years and at the end of this the members of the CLDG were able to secure funding to continue the services for a further year in 2006 and following that made a bid for funding from the North Western Regional Development Agency's Market Town Initiative (MTI) to cover operation in 2007. It was evident that this was not a sustainable way to fund the services and there was a real prospect that the services would cease once the MTI funding ran out.

The opportunity to seek an innovative way to secure the services came with the formal designation of the Manchester to Clitheroe route as a Community Rail Service by the DfT on the 27th March, 2007. The designation covers the service operated between Manchester Victoria and Clitheroe and the stations from Hall i' th' Wood to Clitheroe inclusive. Designation allowed the CRP to look at new ways to develop the service and to experiment with initiatives that would be difficult to achieve within the normal railway industry framework.

The first major challenge for the CRP was to look for a way to secure the future of the Sunday services. Surveys were carried out which showed they were very popular and seen as an integral part of the overall service package. Their loss would impact on usage of the service on other days of the week.

The issue was discussed with Northern Rail and a possible way forward was to see if revisions to the fare package could generate sufficient additional revenue to provide the support required for the Sunday service. Further work was commissioned to carry out a fare yield analysis and this showed that by a series of fare adjustments sufficient revenue would be generated to support the Sunday services, as long as the full amount was predicated to the service.

To implement changes of this nature required agreement from the DfT and this is where the Community Rail line designation was invaluable. For the additional revenue to be predicated to the service required derogation from the incremental revenue share agreement contained in Northern Rail's Franchise Agreement. Through this Northern Rail is required to pay 40 per cent of additional revenues over a specified threshold to the DfT. However, the DfT accepted that in this case a fare adjustment was an innovative way to secure the Sunday services and agreed to the predication of all the additional fare revenue for this purpose.

The final package agreed with Northern Rail was as follows:

- from May 2007 fares on the line were increased by one per cent with the one per cent being predicated to cover the funding gap for the Sunday services for the remainder of the Northern Rail franchise
- other fare adjustments were made including the ending of most Cheap Day Returns and Cheap Evening Returns on the line. Although minor they also had the benefit of simplifying the fare structure as the difference between Standard Day and Cheap Day single and return tickets was minimal
- to ensure that the full additional revenue was predicated to fund the Sunday services the CRP and Northern Rail obtained agreement from the DfT to derogation from the Incremental Revenue share arrangements in the Franchise Agreement.

3.4.7.4 Esk Valley passenger information

Northern Rail operates trains across a large part of the network, which uses a variety of often old systems to disseminate passenger information. Northern Rail wished to improve passenger information and approached the Esk Valley Rail Development Company with a plan to use the Esk Valley line as a pilot for using GPS satellite and 3G mobile phone technology to deliver passenger information to stations on the route. The Esk Valley Railway Development Company (EVRDC) was set up in 2003 to promote the Esk Valley Railway, and is structured slightly differently as a not for profit company, rather than the local Authority model used in the examples above. The EVRDC have given financial support to contribute towards some of the costs of implementing the new technology.

The GPS and 3G technology has proved to be a very reliable way of providing information all year round to passengers, in particular when the ticket office is closed, or when there is a disruption to the services, and for general reassurance of the service pattern. It also provides information on the timetabled arrival and departures of the heritage services on the route operated by the North Yorkshire Moors Railway.

For the Esk Valley Line, the information system is absolutely essential to encourage customer loyalty, the details it provides is important for all passengers and particularly so for school traffic which provides much of the source of demand for the services, particularly outside holiday periods. The EVRDC is keen for further schemes to be rolled out across the Northern network to other lines with limited service provision. Northern are interested in developing a similar scheme on the Cumbrian coast line.

3.5 Summary

This chapter has described the characteristics of each alternative solution, along with their usage, characteristics and cost comparisons. The next chapter takes these characteristics and outlines those factors which could potentially drive a move to alternative solutions on the network given the objectives of the rail industry's stakeholders. **Chapter 5** sets out the gaps based on the overarching drivers of change, and then how the characteristics of each alternative solution enable them to contribute to addressing these objectives.

4 Drivers of change

4.1 Introduction

The Governments of the UK, Scotland and Wales continue to emphasise the importance of rail in delivering economic and environmental benefits. This chapter outlines those factors which could drive a move to alternative solutions on the network given the objectives of the rail industry's stakeholders. These objectives include the need to reduce industry costs, to accommodate passenger demand efficiently, to improve the product offered to passengers, with the associated revenue benefits, to provide a more environmentally friendly product, to be less reliant on potentially insecure energy sources, to comply with environmental legislation, to make best use of technological development and to replace diesel powered rolling stock.

The chapter describes how the concepts of tram and tram train conversion, alternative methods of electric traction on lower traffic density routes, and community rail are potentially able to contribute to these objectives. These drivers of change and the potential contribution of each alternative solution will be used to identify, in **Chapter 5**, the gaps.

4.2 Reducing whole industry whole life costs

A key driver towards the alternative solutions under consideration in this document is the objective of minimising the whole industry whole life cost of railways. Whole industry whole life cost means considering the capital and operating cost of the railway system across the asset lives of the infrastructure and rolling stock. This emphasis has been reinforced by the recent publication of the McNulty 'Realising the Potential of GB Rail, Final Independent Report of the Rail Value for Money Study, Detailed Report', May 2011 which considers in section 19 the 'Lower Cost Regional Railway'. The options that are being considered in this strategy complement these objectives. Various alternative solutions have been proposed which have the potential to reduce the whole life whole industry cost of the railway by either reducing capital, or operating and maintenance costs.

4.2.1 Tram and tram train

Tram and tram train have been proposed as a means of reducing the cost of rolling stock and operating costs. The McNulty Report stated that, 'The options for the provision of lower-cost trains could include a number of solutions: […] there may be opportunities in some areas to convert from heavy rail to trams, or tram-trains'.[20] This might apply to reductions in operating costs, as well as capital cost of enhancements.

4.2.2 Alternative forms of electrification on lower traffic density lines

The Network RUS: Electrification Strategy explored the potential for 25kV AC overhead line electrification (OLE) to enable more efficient operation of passenger services. The strategy recommended options for electrification of which the routes between London Paddington and Cardiff Central, Bristol Temple Meads, Oxford and Newbury, between Manchester and Blackpool North, Liverpool Lime Street via Earlestown and between Liverpool Lime Street and Wigan North Western and between Manchester and York have committed funding for electrification. Whilst conventional overhead electrification should remain the starting point when considering the case for electrifying a route, it is best suited to busier routes where the high infrastructure costs can be offset by the lower costs of running electric rolling stock (compared to diesels). The Electrification Strategy acknowledged that lower cost forms of electrification potentially allow the use of electric traction on sections of the network that would otherwise not have a business case.

Coasting, discontinuous and discrete electrification result in infrastructure savings in capital cost of the OLE which are possible with varying lengths of gaps in the OLE. The alternative solutions offer the prospect of reduced cost of infrastructure making electric traction theoretically more affordable for lower density lines. If the form of innovative electrification requires energy storage to power the train through the gap in the OLE the infrastructure saving needs to be balanced against the cost of energy storage on the rolling stock.

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[20] Source: page 268, Realising the Potential of GB Rail, Final Independent Report of the Rail Value for Money Study, Detailed Report, May 2011

4.2.3 Community rail

There were expectations that community rail would be able to reduce whole life whole industry costs. However, for the most part these cost savings have not materialised. Other elements of this strategy such as tram conversion and energy storage on trains have more potential to impact on these costs. In terms of the maintenance and renewal of infrastructure Network Rail is separately considering these issues along with the Technical Strategy Leadership Group (TSLG). This is because the issue is far broader than community rail alone. It has not been demonstrated on a wide scale that these operations, maintenance and renewals costs have been influenced by the present application of the community rail concept.

4.3 Efficiently accommodating passenger growth

For many of the lower traffic density lines considerable growth has been experienced in the last ten years with further growth forecast. However, because of the low yield per passenger and high subsidy requirements on many of these lines, it can be hard to demonstrate a good business case for investment to increase capacity and the geographical RUSs have not always been able to find viable options to address gaps raised. Alternative, lower cost solutions to conventional rail, in these circumstances, would be desirable.. Community rail has the potential to allow greater flexibility to incorporate local priorities and develop a service offering which meets the needs of the local community, suggesting service pattern and frequency changes.

Tram and tram train have been proposed as ways to enhance capacity or frequency at a lower cost than a heavy rail option where a tram style vehicle is appropriate for the market served.

In urban areas tram and tram train may be a way of addressing capacity gaps at major city centre stations. This could be achieved by the diversion of existing heavy rail services away from congested main line stations (through tram or tram train operation on adjacent city streets) and could lead to improved network performance or release capacity for more economically valuable services. This may represent better value for money than the conventional solution of expanding the terminus. It is only beneficial to address capacity gaps in this way, if the capacity released by tram train can be used in an economically valuable manner.

4.4 Improving the passenger product

Alternative solutions may offer a more affordable means of improving rail's product offering to its passengers. Improvements could include:

- reduced journey times
- new journey opportunities
- increased connectivity
- improved city centre penetration
- elimination of modal interchange
- increased frequency
- train services tailored to local requirements
- new rolling stock.

In contrast to the two technical alternative solutions, community rail provides a community focus to a railway line and this has been used in improving the passenger product by providing a focus for volunteer engagement in local routes and services and targeted investment based on local priorities.

4.5 Bringing additional passenger revenue

Each of the factors outlined in **sections 4.3** and **4.4** combine to improve the product offer to the passenger and as such attract additional rail passengers so bringing additional revenue to the railway.

Cost per passenger kilometre can be reduced by increases in revenue through increased ridership.
This could be through a transformative system wide change such as tram conversion and its impact on ridership and revenue. Equally in other circumstances it could be achieved through community rail activities which have largely focused on increasing patronage and maximising revenue by marketing and promoting local rail services.

4.6 Contributing to the localism agenda

The Localism Act 2011 seeks to devolve certain powers from central government. It should be noted that it does not apply in Scotland. The significance for the rail industry is twofold in that it potentially gives an increase in control of local public finances and seeks to increase community involvement in decision making. This may see the increase in locally developed and funded involvement in the rail industry. This in turn might promote the usage of alternative solutions which are appropriate for local problems.

This has particular relevance to tram and tram train which is likely to develop out of local aspirations to address urban transport gaps and local multimodal transport plans may identify transport problems which can be addressed by tram or tram train conversion. The multimodal impact of tram and tram train schemes is one of the main reasons why they are likely to have their origins in local transport policy.

Community rail can facilitate funding of activities which meet local priorities and needs. In addition community rail can be a focus for community volunteer engagement. There are a wide variety of voluntary activities that have been facilitated in this way. These voluntary activities depend upon the willingness of members of the communities to provide their time to meeting their local needs. Examples of voluntary activities have included station adoption schemes where members of the local community have undertaken basic station maintenance, such as painting and gardening. This improves local facilities and gives them a unique character which would be hard for the railway industry to achieve alone.

One of the key advantages of community rail is to provide the bridge between the rail industry and the local community. For example, community rail can be instrumental in attracting local third party funding. In the current public funding environment this area of community rail becomes potentially even more significant.

Devolution of rail powers from central government may provide more opportunities to realise the full range of benefits of the community rail concept. The Department for Transport (DfT) intends to consult on the possibility of rail devolution in England early in 2012, and its possible implications are considered in more detail in **Chapter 6**.

4.7 Delivering environmental benefits

Rail transport currently accounts for approximately two per cent of carbon dioxide emissions from the UK domestic transport sector[21]. It is generally a more environmentally friendly method of travel than its major competitor (road) but it is important that it improves its environmental credentials even further in the light of government targets to cut carbon emissions and improve air quality. Other modes are improving their environmental performance at a faster rate than rail. The automotive sector in particular has delivered substantial improvements in the fuel efficiency and emissions performance of road vehicles in recent years and this is set to continue. In some circumstances alternative solutions potentially have an important role to play in achieving a downward step change in the carbon emissions of rail services.

European legislation controlling emissions from rail diesel engines came into force in two stages with the first part (Stage 3A) coming into force in 2009. The extent to which these regulations impact adversely on fuel efficiency depends on the emissions control strategy used and the application of further advances in engine technology – such as better control of the combustion process. The second part (Stage 3B) of the regulations come into force in 2012 and is likely to require some form of exhaust aftertreatment system to reduce levels of nitrogen oxides and diesel particulates. There is a general expectation that Stage 3B engines will consume more fuel than equivalent 3A engines unless further improvements are made to the engine design such as the use of higher pressure fuel injection systems. The location, size and design of some Diesel Multiple Unit (DMU) engines may make engine replacement difficult or too expensive, in particular with Stage 3B engines. Instead, operators may seek to refurbish their existing engines and modify these where cost effective to improve fuel efficiency. This issue is of particular relevance to regional and rural markets. In some circumstances an alternative solution may be able to contribute to addressing this issue.

The European emissions standards are not retrospective and owner or operator is not incentivised to consider refitting with the latest engine design, especially when it would require the engine raft to be redesigned (with the associated costs). Also the space envelope of a 3B compliant engine is larger than that of a 3A engine, this will create added complications in the Great Britain as it has the smallest space envelop in Europe underneath a vehicle.

Alternative solutions may be quieter in operation than diesel rolling stock. The difference in noise emissions between conventional electric and diesel traction are illustrated in the Rail Safety and Standards Board (RSSB) T633: Study on further electrification of Britain's railway network published in 2007.

4.8 Addressing security of energy supply

Rail transport currently accounts for approximately two percent of domestic oil consumption in the UK[22]. The White Paper on Energy (Meeting the Energy Challenge, May 2007) published by the Department of Trade

[21] Source: Low Carbon Transport Innovation Strategy, DfT May 2007

[22] Source Energy consumption in the United Kingdom: 2008 data tables, BERR

and Industry (now Business Innovation and Skills) recognises that the heavy dependence of the transport sector on oil at a time when the UK will increasingly rely on imported oil carries potential consequences for the security of energy supply. Electricity can be generated from a variety of primary sources. The greater flexibility in the sources of energy available (particularly the potential to source from within the UK) would enable electrification to contribute to fuel security, reducing the exposure to the risk of future scarcity and the volatility of oil prices. Alternative solutions may in some circumstances be able to reduce dependency on oil as an ultimate source of traction power supply.

4.9 Making best usage of technological development

Rail transport modes have the opportunity to take advantage of technological development either from within the rail industry or from other industries. Such developments if they can be made use of to improve aspects of service delivery, environmental benefits or whole life cost reductions may be a reason that an alternative solution is considered and implemented.

There are varying levels of technological maturity of the solutions considered in this scoping document. Conversion from heavy rail has formed part of most recent tramways that have been built in Great Britain. Tram train, while novel in the UK has been in operation in Europe since the early 1990s. Energy storage technology by contrast has not been employed in the heavy rail environment anywhere in the world in the way considered by this strategy. In addition to the challenges of using this new technology, the capability of energy storage is not yet at a point of development where it is capable of being used in operation. This strategy considers what would be required for the technology to achieve in terms of both price and capability in order to have the potential to be useful in contributing to the drivers of change.

4.10 Replacing diesel powered passenger rolling stock

A significant driver of alternative solutions is the requirement to provide new and additional passenger rolling stock on the network. Of the nonintercity diesel powered passenger rolling stock fleet, 66 per cent of vehicles on the network are over 20 years old. In the next few years decisions will need to be made on whether to replace them or extend their lives. This will influence the case for tram and tram train as well as alternative forms of electrification and shape the strategy for their potential implementation. The Network RUS: Passenger Rolling Stock provides more detail on this driver of change about the age profile of the current diesel powered rolling stock.

The committed electrification schemes in Great Britain will result in the cascade of DMU rolling stock which will be able to be cascaded to other locations. However, as the DMU fleet ages and as there is a progressive diminishing rate of return of DMUs displaced by subsequent electrification there is a point at which for lines without a viable electrification case or diesel rolling stock replacement that an alternative solution is potentially required. The timing of this need will depend upon the extent of future electrification as well as the extent to which it is possible to affordably life extend existing DMUs.

4.11 Summary

The desire to achieve batter value for money lies at the heart of each of the three groups of alternative solutions. The key consideration is lower cost solutions where conventional heavy rail solutions are not appropriate. This is not to suggest conventional solutions are inefficient but rather that there may be alternatives in some circumstances. **Chapter 5** goes on to develop gaps based on the drivers of change outlined in this chapter and on the baseline described in **Chapter 3**.

5 Gaps

5.1 Introduction

This chapter outlines the key gaps which can be identified between today's railway and a future railway which could exploit the benefits of the alternative solutions as outlined in **Chapter 3**.

A Route Utilisation Strategy (RUS) gap is the gap between what the system can do now (supply) and what it needs to do (demand) and the gaps are summarised for each alternative solution below.

5.2 Tram and tram train conversion

Gap A relates to gaps in capacity on the heavy rail network. Gaps B and C relate in part to the existing network but could also include wider gaps in public transport provision that might extend beyond the current network. Gap C relates specifically to potential cost savings that the solution might enable. The gaps have been considered in such a way as to test the contribution of the various elements of the benefits of tram or tram train conversion that have been proposed by previous studies.

The analysis of the gaps is not intended to suggest that these gaps would occur in isolation. As with any substantial change to the infrastructure and rolling stock it is likely that there would be a number of gaps addressed by any tram or tram train scheme. The point of the analysis is to attempt to isolate the specific circumstances in which tram or tram train is able to contribute to addressing gaps. As such they have been set out as follows:

- heavy rail gaps (Gap A)
- accessing new markets (Gap B)
- cost savings. (Gap C)

In reality it is unlikely that these gaps would exist in isolation and a tram or tram train scheme would address a range of gaps reflecting the package of changes to the whole public transport system that occur when such a service is introduced. The package of measures often includes:

- new journey opportunities
- reduced generalised journey time through improved connectivity and elimination of modal interchange
- increases in frequency
- fares changes
- changes in other public transport and to residual heavy rail services
- new stations.

The gaps have been tested in a step-by-step manner to attempt to isolate those specific factors which have been proposed as possible benefits of tram or tram train and to separate the specific contribution of the elements of the package of changes that a scheme would involve. This scoping document starts from a heavy rail perspective and for that reason considers heavy rail capacity gaps first in Gap A.

However, in Gap B it is recognised that for the extension of an urban tramway either by means of tram or tram train wider public transport gaps are likely to be key. These gaps are not necessarily the direct role of the railway to address nor are they Network Rail's core area of competency. Instead they are more likely to be relevant to local transport plans and Passenger Transport Executives (PTEs) aims to provide the most cost effective transport offering for the given transport need. Nevertheless using parts of the heavy rail network differently might be part of addressing those gaps. The gaps that would be considered in a PTE and local transport perspective are multimodal in nature and tram or tram train might be the most cost effective means of addressing those gaps in such circumstances.

Gap C relates to both the rail industry and local transport planning aspirations to provide local rail services more cost effectively and it has been proposed that trams might be one means to achieve this aim.

Gap A – city centre major station capacity and or capacity on inner suburban routes

As has been identified in the **Chapter 4** one reason for using tram or tram train conversion is in order to address major city centre station, or inner suburban route capacity. A key gap is therefore the locations in the UK where geographical RUSs have identified capacity gaps which have not been solved by conventional means and where tram or tram train conversion might be able to release capacity by diverting certain services away from the constrained infrastructure.

Tram or tram train has been proposed as an option for capacity gaps at Leeds and Glasgow Central. Tram train has been referenced in a number of other RUSs for consideration but in Leeds and Glasgow Central it was proposed for a specific gap rather than as a more general concept.

Gap B – connectivity with city centres and their suburbs to create new journey opportunities, access new markets, and opportunities for new stations

The gap relates to a number of areas where existing areas of demand are currently not well served by train services:

- current connectivity where location to location journey times by passenger services do not meet current or future needs
- journey times are not optimised as modal interchange is required to complete journeys
- new journey opportunities and markets
- opportunities for new stations.

In general these gaps relate to situations where a city centre tramway is already in existence.

Gap C – cost effective ways of delivering services or new journey opportunities, access new markets, and opportunities for new stations

This is a gap where the cost of existing operations could be provided more efficiently in whole life, whole industry cost terms if services were provided by trams or tram trains. If could also be where gaps exist in the capacity, connectivity and journey time on a particular route as identified in geographical RUSs but the capital cost of capacity increases were not found to be possible with heavy rail. This gap does not necessarily relate to where an urban tramway exists and could include conversion of routes where no such tramway exists.

5.2.1 Alternative methods of delivery of electric traction on lower traffic density routes

The gaps for the alternative methods of delivery of electric traction on lower density routes have been based upon established Network RUS: Electrification Strategy gaps. These gaps were:

- where electrification may enable more efficient operation of passenger services
- where electrification may enable more efficient operation of freight services
- where electrification could provide diversionary route capacity
- where electrification could enable a new service to operate.

However, two of the four gaps in the strategy have been excluded, namely freight and diversionary routes. This is because the energy storage requirements for freight are thought to be too large to be currently viable. For diversionary routes many related to long distance high speed services which for the same reason are not thought to be viable. Equally for diversionary routes the infrequency of usage combined with the cost of energy storage probably make them inappropriate for consideration. Accordingly the remaining two gaps have been adapted for relevance to the alternative solutions under consideration. The intention of this scoping document is to build upon the gaps in the Network RUS: Electrification Strategy by considering options for coasting, discontinuous and discrete electrification.

Gap D – coasting, discontinuous or discrete electrification may enable more efficient operation of passenger services

The Network RUS: Electrification Strategy (2009) took a threshold for conventional 25kV AC electrification to have a viable business case on the basis of greater efficiency than diesel train operation as one million passenger vehicle tonnes per annum per kilometre on single track routes. For double track routes the threshold was assumed to be two million tonnes per annum. The electrification strategy in its recommendations acknowledged that if lower cost innovative forms of electrification were developed then this threshold might be lowered. This is not to say that conventional 25kV AC OLE is not efficient but it is unlikely to have a business case on the basis of greater efficiency unless sufficient volumes of diesel train kilometres are converted to electric traction.

This strategy therefore develops the gap for the enabling of more efficient operation of passenger services from the Network RUS: Electrification Strategy, however, this strategy targets lower traffic density lines where conventional electrification may not be appropriate for achieving greater efficiency of operation of passenger services.

Two areas of Gap D have been identified. These are:

1. For avoiding reconstruction of challenging structures

This element of Gap D relates to the gaps identified in the Network RUS: Electrification Strategy where upon detailed investigation it is found that there are considerable costs of reconstruction of difficult structures. In these cases alternative solutions may be able to enable more efficient operation of passenger services.

2. Innovative low cost forms of electrification

The alternative solutions have different characteristics to conventional electrification and may mean for example through nodal electrification, areas of the network which were not considered as within the threshold for conventional electrification can be considered.

Gap E – coasting, discontinuous or discrete electrification could enable a new service to operate

These gaps include passenger routes which extend beyond a currently electrified area, and the use of energy storage would enable a corresponding extension of services at present operated by electric traction. This builds upon the gap in the Network RUS: Electrification Strategy.

While acknowledging that the Network RUS: Electrification Strategy also had a gap relating to new services, given that this is a national strategy no options have been assessed of this nature because none have been proposed. It is likely that in implementing any electrification scheme the potential for new of modified services would be considered. This scoping document does not therefore propose any options of this nature as they would be considered at the point of implementation of any scheme.

Community rail

This section outlines the two key gaps which can be identified between today's railway and a future railway which could realise the benefits outlined in the drivers of change from community rail initiatives.

The two gaps that have been identified are:

Gap F – the potential role of community rail in obtaining value for money in the local railway

Type F gaps relate to the potential ability of com munity rail initiatives to generate either additional revenue, minimise costs, target spending, improve the deployment of resources based on local priorities and secure 3rd party funding.

Gap G – the potential role of community rail in encouraging greater involvement of the local community in the local railway.

Type G gaps relate to the potential ability of community rail initiatives to encourage greater involvement in the local railway through greater local involvement either in volunteering or decision making.

Summary

This chapter has presented gaps based on the drivers of change and baseline for the three groups of alternative solutions. The gaps have aimed to capture the areas which it may be relevant options to consider. Following on from the gaps outlined in this chapter, **Chapter 6** will go on to develop options to address these gaps.

6 Options

6.1 Introduction

This chapter proposes options to address the gaps detailed in **Chapter 5**. This Route Utilisation Strategy (RUS) scoping document has considered two technological sets of options, tram and tram train conversion, and innovative forms of electrification involving varying lengths of gaps in the overhead line infrastructure. To balance the otherwise technological focus of the scoping document, community rail as a concept of management philosophy involving the community in the development of the railway has also been assessed. It is recognised that the options that have been considered are only a sub-set of all the possible solutions that are available. These options have been selected on the basis that a) they have not or are not planned to be considered as part of the existing railway industry planning process and b), their ability to contribute to the gaps being faced.

6.2 Trams and tram train conversion

The options that have been considered address each gap in turn. While each option focuses on one gap, a scheme to create or extend a tram network would be likely to address elements of all three gaps that have been identified. The reason for the approach of focusing on individual gaps is to understand the specific contribution of tram or tram train options in each area in which benefits have been proposed. In reality any tram or tram train scheme would introduce a package of changes which would be likely to address a range of gaps and deliver a wide range of benefits. In particular many of the transport gaps that the scheme related to would be outside of the direct responsibility of the railway industry and would fall primarily within local transport plans and Passenger Transport Executives areas of concern. The gaps and therefore options start from the perspective of heavy rail capacity because this RUS is a rail industry strategy but it recognises that different uses of the railway network might be able to address wider public transport gaps at the same time as making the best usage of the railway network.

Given that the scoping document is looking at the high level strategic issues relating to conversion of tram or tram train other options have not been considered. In reality any project developing a scheme would consider the range of public transport options in a particular corridor for addressing the gap in order to select the best value for money option. In addition to tram and tram train these options might include a combination of heavy rail interventions as well as other public transport modes, for example bus service changes or guided busways and bus rapid transit. These wider non-rail based options have not been considered in this scoping document because it is outside of the scope of the railway industry. It is acknowledged that in developing options for a specific scheme that these options would need to be considered at the option development and selection stage.

Gap A – city centre major station capacity and or capacity on inner suburban routes

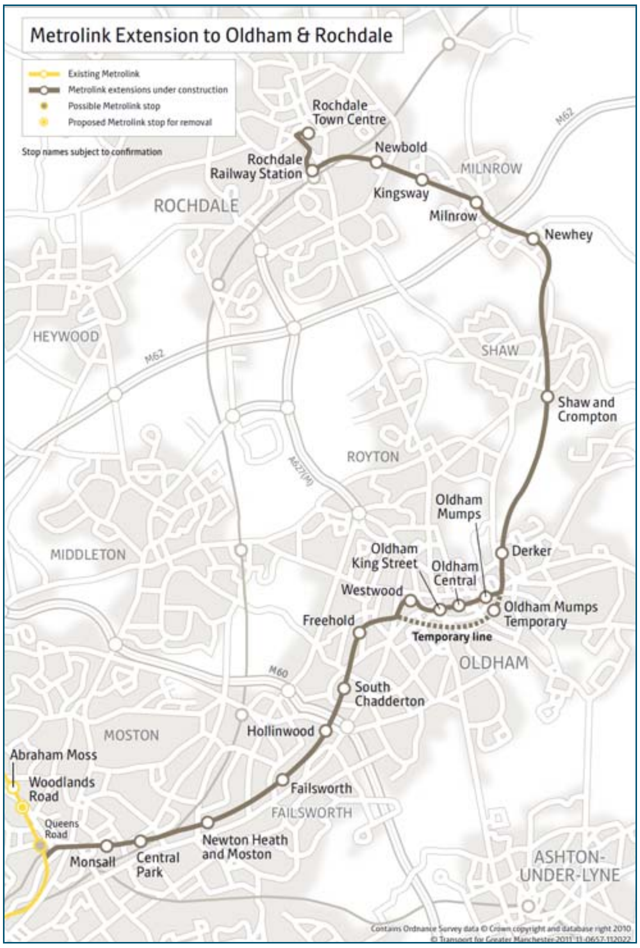
The options that will be considered in this section relate to the potential for tram or tram train to address gaps of heavy rail capacity. The range of options below considers the basic scenarios of with or without an existing tramway. The importance of considering heavy rail gaps in isolation of other impacts is to understand if there are circumstances which mainly for heavy rail reasons that services would be converted to tram or tram train in order to address current capacity gaps at heavy rail terminal stations in city centres. As has been discussed above, it is unlikely that a scheme would only contribute to heavy rail gaps, and the examples cited in both Options A.1 and A.2 would all have more substantial impacts to the wider public transport network. The conclusions to these options relates only to their impact on the heavy rail network and not their wider aims.

<table>
<tr><th colspan="2">Assessment of Option A.1 tram or tram train on some routes to take suburban services out of a heavy rail terminal where a city centre tramway exists</th></tr>
<tr><td>Concept</td><td>

Conversion of existing inner suburban train services to tram or tram train where there is an existing tramway in order to release capacity on the heavy rail network.

An example of a conversion of is the Rochdale to Manchester via the Oldham Loop services to Metrolink tram operations (see **Figure 6.1**). Capacity has been released into the city centre terminal. The conversion means that the service no longer travels between Manchester Victoria and Thorpes Bridge Junction. At Rochdale the service formerly terminated in the bay platform but once opened (planned 2012) trams will use a new stop next to the railway station. This is not to suggest that the main aim of the conversion was the release heavy rail capacity. The main aims of the scheme are to increase frequency and connectivity to both the city centre and the town centres of Oldham and Rochdale. These impacts relate primarily to Gap B, however, it has been used to illustrate the impact on Gap A.

Figure 6.1 – Map of the Rochdale via Oldham extension of Manchester Metrolink [23]



</td></tr>
</table>

[23] Source: http://www.metrolink.co.uk/futuremetrolink/oldham-and-rochdale-line.asp

Assessment of Option A.1 tram or tram train on some routes to take suburban services out of a heavy rail terminal where a city centre tramway exists	
Infrastructure and rolling stock requirements	• segregated connection to the existing tram network • electrification to 750V DC Overhead Line Electrification (OLE) • new rolling stock trams • track renewal • revised train control • refurbished structures • refurbished stations • new stations • new street running extensions into Oldham town centre and into Rochdale town centre.
Impact	• planned increased service frequency • increased connectivity from new street running extensions and new stations • connectivity with the city centre by connecting into the existing tramway • the Diesel Multiple Unit (DMU) rolling stock released has been used to strengthen existing Northern services • the Northern Hub has proposals to increase the train service at both Manchester Victoria and Rochdale. Manchester Victoria is not currently used at full capacity, if the Northern Hub proposals are implemented this position would change and it is possible that the capacity released by the Oldham Loop services might have a performance benefit • at Rochdale access to the bay platform by the Oldham Loop services was across the station throat, a capacity constraining move but no current timetable changes take advantage of this change.
Feasibility	The key issue for this option is the existence of services which can be segregated to allow tram operation which can be connected affordably to an existing tramway. In both the case of tram train and tram the appropriate service length and market demand are needed to be present for the concept to be feasible. In the case of the Oldham - Rochdale line full segregation was possible so tram conversion is being implemented, however, if this had not been possible then tram train could have been considered.
Conclusion	Capacity benefits have and can derive from tram or tram train conversion. However, it is important to understand that capacity release is only one element of the benefits and is not the main justification for the conversion of the Oldham Loop services to tram operation. The main immediate capacity benefit has been the release of DMUs for service strengthening elsewhere. In the longer term the capacity may prove useful in terms of performance if Northern Hub proposals are implemented. However, it is not always possible to envisage what capacity will be useful for and this was illustrated by the original Metrolink conversions of the Altrincham line which has released considerable capacity through the Castlefield corridor in the centre of Manchester which has subsequently been used by interregional services. However, the extent of this benefit was not realised at the time and did not form a main objective of the scheme. The capacity released by a tram conversion may not always be usable or relevant to the actual capacity gaps on a particular route. There are relatively few cities in Great Britain with tramways (seven, including Edinburgh which is currently under construction) so the option is limited to where capacity gaps have been identified and there is an existing tramway. Where connection to the tramway is relatively straightforward this option may be viable if the capacity released can address a capacity gap. Based on the current planning horizon no examples could be found from the geographical RUSs which would be solely justified on the basis of capacity released on the heavy rail network. However, capacity release can be a benefit of conversion and there may be circumstances in the future where this formed the sole justification for a scheme if the conventional solution was too large scale to be value for money or affordable.

Assessment of Option A.2 convert some routes to tram or tram train operation to take suburban services out of a heavy rail terminal into a city centre without an existing tramway	
Concept	Geographical RUSs have identified a number of capacity gaps at major terminals in cities where no tramway currently exists, this scoping document proposes to illustrate the issues with reference to Leeds but has also considered work undertaken at other locations such as Glasgow Central. It was suggested in the Northern Generation 2 RUS that tram train conversion of service groups into Leeds station might be a means to avoid more expensive and complex options to create new lines into Leeds and/or potentially double-decking of the station. It is important to note in consideration of this option that current committed plans at Leeds station are sufficient to address performance and capacity requirements. As with Option A.1 capacity gaps are only one reason why tram train is proposed by West Yorkshire Passenger Transport Executive (WYPTE). The option only considers the capacity situation and not the wider benefits of connection to Leeds Bradford Airport or penetration and connectivity in the city centre.

<table>
<tr><th colspan="2">Assessment of Option A.2 convert some routes to tram or tram train operation to take suburban services out of a heavy rail terminal into a city centre without an existing tramway</th></tr>
<tr><td></td><td>This option is only considered in terms of its ability to address heavy rail gaps. There are two potential corridors that have been identified to address potential performance and capacity gaps at the station and these are:
1. Harrogate services
2. Knottingley services</td></tr>
<tr><td>Infrastructure and rolling stock requirements</td><td>Harrogate – electrification to support electric tram train operation from Leeds to a termination point which could be the turnback which will be implemented during Control Period 4 (CP4 2009-2014) at Horsforth or further either extending to Leeds Bradford Airport or Harrogate itself. A line to a tram stop area adjacent to Leeds station (possibly with an on street section) to remove services from the main station.

Knottingley – electrification to support electric tram train operation from Leeds to Knottingley via Castleford) and a line to a tram stop area adjacent to Leeds station (possibly with an on street section) to remove services from the main station.</td></tr>
<tr><td>Impact</td><td>Harrogate – tram trains could use the turnback to be created in CP4 at Horsforth, could be extended to Leeds Bradford Airport as has been proposed by WYPTE, or to Harrogate itself. Heavy rail services from Harrogate could then have accelerated journey times into Leeds by removing the intermediate stops between Horsforth and Leeds. Heavy rail only infrastructure solutions to gaps on the Harrogate and Leeds North West corridors combined include a new platform face at Leeds which could probably be avoided if only heavy rail services from Harrogate needed to be accommodated alongside longer trains on the Skipton and Ilkley corridor.

Knottingley – this option has the potential to provide capacity and performance benefits by enabling the removal of services from Knottingley from the E and F lines into Leeds.</td></tr>
<tr><td>Feasibility</td><td>Harrogate – it is likely that the heavy rail option to address only the heavy rail gaps on this and the Leeds – Skipton and Ilkley corridors would be possible and also less costly than a tram train solution.

Knottingley – this option might address the gap at Leeds station, but the cost and complexity of taking the Knottingley services to the tram stop site is potentially significant due to the side of the station on which it is likely to be located. This would need to be compared with the cost of the relevant heavy rail only solution.</td></tr>
<tr><td>Conclusion</td><td>Tram train options have the ability to contribute to heavy rail gaps at Leeds station, however, solely based on heavy rail benefits they are unlikely to be justified. This is for two reasons; firstly the cost of electrifying the route concerned, unless there is a business case for that already, and secondly the cost of providing a new alignment to take tram trains away from a city centre station to a tram stop site (possibly on street) which in one case may be significant in comparison with heavy rail only options. The scoping document has considered similar gaps in geographical RUSs across the network and has not found circumstances where tram train would be a viable option solely based on heavy rail gaps. The conclusion is therefore that tram train conversion may have the potential to contribute to addressing heavy rail gaps, however, it is not thought likely that this would be the sole justification.

This conclusion relates only to the assessment of the heavy rail gaps and is not a reflection on the wider potential benefits of such tram train proposals which relate to Gap B such as accessing the airport and achieving better connectivity by an on street tramway penetrating the city centre. Heavy rail capacity benefits would be one element that could be taken account of in developing a wider case for tram train in Leeds. The same also applies to other cities where heavy rail capacity gaps exist where the removal of specific services onto an on street tramway could release capacity that would cost effectively address the gap.</td></tr>
</table>

Gap B – Connectivity with city centres and their suburbs to create new journey opportunities, tap new markets, opportunities for new stations

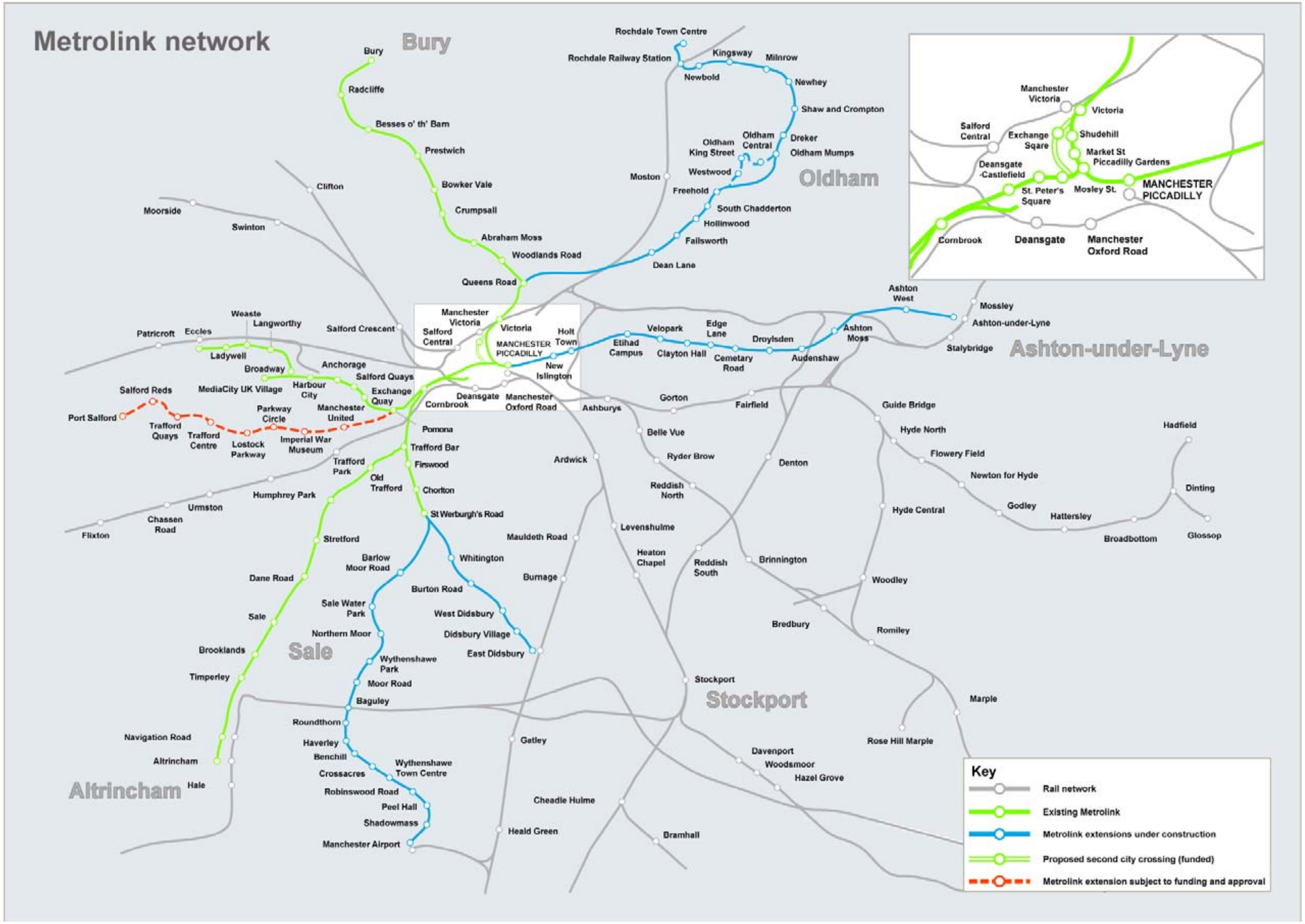
The options to address Type B gaps involve new markets and new opportunities many of which would involve extension beyond the existing network. The options consider the scenarios that are possible with or without a tramway.

<table>
<tr><th colspan="2">Assessment of Option B.1 tram train onto existing tramway system to provide connectivity with city centres and their suburbs to create new journey opportunities, tap new markets, opportunities for new stations</th></tr>
<tr><td>Concept</td><td>Connection of an existing tram system to the existing heavy rail network, for example the tram train pilot between Rotherham and Sheffield to provide connectivity with city centres and their suburbs to create new journey opportunities, tap new markets, opportunities for new stations. This option is illustrated with reference to modeling conducted by Transport for Greater Manchester (TfGM) of the proposed conversion of the Marple line in Manchester to tram train. The Manchester – Marple route is one of a number of potential tram train schemes in Greater Manchester and the relevant local planning authorities will need to consider the route along with other tram train possibilities in an appropriate strategic context.

Key aims of the proposal are to overcome the disadvantage of the location of Manchester Piccadilly station on the edge of the city centre and to facilitate higher frequencies by avoiding the congested Northern Hub rail bottleneck. Both these aims would be furthered by connecting with the Metrolink network in Manchester city centre. The map below shows the Metrolink network along with the surrounding heavy rail lines. Figure 6.2 below shows the Metrolink network along with the heavy rail network in Greater Manchester.

The TfGM modelled proposal is a tram train extension of the Metrolink Eccles to Manchester Piccadilly services to run through to Marple, at a 12 minute headway, with:
• all tram train services calling at all stations.
• the existing rail services modified as follows:
o all Manchester Piccadilly– Marple / New Mills via Bredbury services are withdrawn
o existing local services from Manchester Piccadilly – Marple Rose Hill via Guide Bridge service are retained
o existing local services from Manchester Piccadilly to Chinley and the Hope Valley (one train per hour) serving Ashburys and Maple are diverted to call at Guide Bridge and Hyde Central, continuing to Romiley, Marple, Strines, New Mills etc.</td></tr>
</table>

Figure 6.2 – Map of the Manchester Metrolink and Greater Manchester rail network



Assessment of Option B.1 tram train onto existing tramway system to provide connectivity with city centres and their suburbs to create new journey opportunities, tap new markets, opportunities for new stations	
Infrastructure and rolling stock requirements	Specific Marple line infrastructure and rolling stock includes: • tram train rolling stock • connection to the Metrolink line • electrification of Ashburys to Marple rail line for through running and track sharing by Metrolink services • new bay platform at Marple for terminating Metrolink services. The general infrastructure and rolling stock requirements which are not specific to the Marple line example are: • tram train rolling stock has to be procured because of the requirement to operate both on-street and on the heavy rail network • depending on location, the connection between the tramway and the heavy rail network may involve minor track work or considerable extension of the tramway. The cost will vary depending upon the length and complexity of the connection and what, if any, additional powers are required to build it • to provide a compatible traction system with 25kV AC OLE there needs to be a voltage change over to a lower voltage DC system for street running, or run DC throughout (which could restrict heavy rail network flexibility). The OLE system should be selected commensurate with the electrification strategy for the route. Dual, or single voltage vehicles are readily available but the more equipment that is required onboard, the greater will be the capital cost as well as the added weight per vehicle but dual voltage vehicles may be a more cost effective way of future proofing a scheme for 25KV extensions as retro fitting is more expensive • if the traction system is to be DC throughout, appropriate control and maintenance arrangements which minimise the safety interfaces are needed • wheel rail interface design that is compatible for both transport systems is needed as the increased flange back gap of tram wheels on heavy rail switches and crossings (S&C) requires special wheel profile and additional guidance measures such as raised check rails or swing nosed crossings • if the tramway has low-floor trams then existing heavy rail stations will need to be modified to allow tram trains • reduced level of crash worthiness of vehicles allowed under the relevant standards requires additional train control for crash mitigation to reduce the likelihood of a collision • effective radio communications for all the networks operated to all signallers and controllers must be provided – Network Rail is currently installing GSM-R, while tramway operators use other radio systems • consideration needs to be given to preventing wrong routeing from the railway to the tramway • track alignment and geometry on the heavy rail system may need to be improved to allow the lighter weight tram train vehicle to operate with sufficient ride quality due to the differences in car body design • the operational model for the service needs to be defined i.e. extension of tramway operation onto heavy rail network, or extension of franchised service onto tramway system, together with the creation/identification of a possibly new open access operator onto both • a new depot may be required if existing facilities are not suitable.
Impact	The Marple line tram train proposals are expected to deliver the following changes: • improved journey times and network connectivity, with the creation of direct journey opportunities from stations on the Marple line to the city centre and beyond, linking into the existing Metrolink network • extension of programmed Metrolink services running through the city centre to Manchester Piccadilly through to Marple, offering services every 12 minutes thereby delivering a net increase in trains on the route, especially at inner suburban stations. Tram train services would replace some existing heavy rail services, whilst other existing services would be modified • a more balanced pattern of demand by time of day through attracting a less work dominated range of trip purposes, in large part due to providing a much more attractive service from the inner urban area, which has a much higher trip rate to Manchester city centre for non-work purposes than the outer part of the route • Adoption of Metrolink fares and ticketing on tram train services. Modelling developed by TfGM shows the proposals would deliver a significant increase in patronage, with journeys to and from stations on the Marple line increasing by over sixty per cent. A significant proportion of this growth would be abstracted from local bus services serving the suburbs of Manchester. The increased fares revenue would reduce or eliminate the need for an ongoing subsidy and facilitate some recovery of capital costs. The distribution of revenue would need to be rebalanced with the heavy rail franchise. Other benefits include lower operating costs, and potentially less wear on the heavy rail network due to the lower axle weight of tram train vehicles.

<table>
<tr><th colspan="2">Assessment of Option B.1 tram train onto existing tramway system to provide connectivity with city centres and their suburbs to create new journey opportunities, tap new markets, opportunities for new stations</th></tr>
<tr><td></td><td>The general benefits might include:
• access to new markets
• new stops potentially at lower cost than heavy rail
• higher acceleration of tram trains compared to DMUs
• lower unit operating costs
• frequency increases may be possible but they depend on available capacity, and the additional operating and capital costs required to achieve additional frequency
• track access charges are likely to be cheaper due to the lower axle weight of tram vehicles.

The general operational and technical issues might include:
• potential delays to heavy rail services because the tramway service could be affected by road congestion
• limited possibility to reduce complexity of the signalling system unless there are to be new sections of fully-segregated operation
• if tram services operate a high frequency, they may be the busier operator than the heavy rail service and may need to take priority through appropriate timetable management
• drivers would need to be trained to operate both systems.</td></tr>
<tr><td>Feasibility</td><td>• needs a tramways with sufficient capacity to be able to connect to or a pre-existing tram service that can be extended
• analysis of tram acceleration characteristics in Chapter 4 suggests greater benefits would be likely going from a DMU to a tram train than an Electric Multiple Unit (EMU) to tram train
• analysis of inner suburban services in Chapter 4 suggests that where these are operated by EMUs the capacity provided in the high peak hour is higher than for DMU operated services, such as those presently operating the Manchester – Marple services. This is, in part, because EMUs are longer, on average, than DMUs and electrification has usually been provided on high traffic density routes. It may be likely that tram train conversion would have greater benefit on non-electrified routes
• tram trains may permit an increase in the frequency on both the tramway and heavy rail network where sufficient capacity exists. Tram train capacity is 200-250 passengers per vehicle which should be matched against current and optimum train capacity for the route using conventional vehicles. There would also be a cost for providing that additional frequency
• tram train is useful where separate running is not practical because of the need to retain other heavy rail services (freight or passenger) on the converted route
• provision must be made to integrate with other transport modes, in line with both the heavy rail and local transport strategies
• depending on the safety and performance strategies of the proposed system, the cost of construction and maintenance will affect the economics of the business case, ie. alternative technology solutions in small quantities will drive up maintenance costs, versus the inclusion of heavy rail system components, which are easier/cheaper to source, but over-engineered relative to tram systems
• if 750V DC OLE is used this will constrain future development opportunities for heavy rail infrastructure. 750V DC is only cheaper than 25kV AC for shorter distances and there is a speed/performance trade off. Even for shorter distances while 750V DC is potentially cheaper, it is not a substantial difference. This suggests that, both on cost and flexibility grounds, longer distances would be electrified to 25kV AC
• the need to renew either the infrastructure or the rolling stock of either the heavy rail or the tram systems might trigger a business case for the introduction of tram train to offset conversion costs against the renewal requirement
• small and discontinuous orders with bespoke requirements will raise the unit price of tram trains. Economies of scale should be sought as part of the procurement strategy.
• the need to renew rolling stock and/or infrastructure may be a trigger point for such conversion
• early consideration of the operational and maintenance costs of tram train specific infrastructure is needed in relation to specific tram train infrastructure features and applicable standards. Consideration needs to be given to the relative costs of maintaining ‘one off’/low population tram type components against the installation of heavy rail items for which there is an economy of scale
• because safety systems for heavy rail are more stringent than for trams there would be higher costs in integrating these features on tram vehicles. Vehicle capital or leasing costs are likely to increase with the necessity to meet heavy rail safety standards and the need to cover higher insurance premia due to higher operational risks and these need to be assessed at the start of the project. This may be mitigated through exemption by risk assessment</td></tr>
</table>

Assessment of Option B.1 tram train onto existing tramway system to provide connectivity with city centres and their suburbs to create new journey opportunities, tap new markets, opportunities for new stations	
	• stops, where required, may have to satisfy existing heavy rail station platform dimensions or new bespoke stops would need to be provided. These should be done by a risk assessment which considers the amount of passing traffic, footfall etc • tram train operational costs (including vehicle refurbishment, carriage maintenance, mechanical maintenance, staffing, cleaning and breakdown systems) may be higher than for tram system only vehicles due to the presence of additional railway safety equipment. Further investigation would need to be done at the start of the project.
Conclusion	• the factors affecting the appropriateness of the route for conversion depend upon: o the level of existing train services not to be converted – if too dense then tram trains will have insufficient capacity o if demand is too limited then tram trains will over supply the market and/or there will be insufficient demand and benefits to justify the capital costs o competition from other modes of transport o the potential benefits of city centre penetration o the potential benefits of new stops o the potential benefits of increased frequency • the principal factors driving the cost of a conversion to tram train are: o the complexity and scale of connection to the tramway o the cost of conversion of the heavy rail infrastructure which, if it requires substantial electrification, may be considerable • DMU conversion would be likely to have the most benefits because EMU acceleration is nearer to tram or tram train and EMU capacity is generally higher than DMU • whilst a whole life cost assessment would need to be undertaken for each option it is likely to involve electrification because of the capital and operating costs of bi-mode trams or tram trains.

Assessment of Option B.2 tram train onto a new city centre system to provide connectivity with city centres and their suburbs to create new journey opportunities, tap new markets, opportunities for new stations	
Concept	Construction of a new city centre tram system and successive connection to the existing heavy rail network. There are a number of examples across the Great Britain where tram train schemes have been proposed in cities that currently do not have a tramway.
Infrastructure and rolling stock requirements	As option B.1 plus: • creation of a new tramway plus associated vehicles • there could be an opportunity to align with best practice standard design • consideration needs to be made with regards to routeing of the tram e.g. how far from the heavy rail station is the city centre? Whether there is the opportunity to have a form of interchange station connected to the heavy rail station for the tram services or convert the existing heavy rail station to an interchange station to include (but not be limited to) light and heavy rail, bus and taxi services • a new depot would be required for the small fleet created.

Assessment of Option B.2 tram train onto a new city centre system to provide connectivity with city centres and their suburbs to create new journey opportunities, tap new markets, opportunities for new stations	
Impact	As option B.1 plus: • the converted element of the scheme would be similar to option B.1, however, a new tramway would also result in an impact which would need to be evaluated • significant disruption to existing transport network (eg. road network for buses and city centre deliveries, taxis, emergency services etc) during construction – not just in the city centre area, but beyond if the heavy rail network is not in close proximity to the centre. However this is unlikely to be any greater than most significant transport improvement schemes • the cost of tram train conversion of an existing or former heavy rail route may be lower than construction of on street tramways and result in less disruption to road traffic during the construction phase due to there being less utility or other developed assets to overcome and third party interfaces to manage and compensate. Conversion of operational heavy rail routes could incur maintenance possession costs at a similar level to the current heavy rail network.
Feasibility	As option B.1 plus: • the creation of a new tramway would be dependent upon the feasibility and business case which would carry a considerable financial cost • land purchase, or leasing costs will occur (no differential whether heavy rail or tram) • assuming the new tram track is to follow a previous rail corridor which has been decommissioned and removed, and that the land has been sold o track installation and signalling costs will be incurred but will be increased, as compared with tram only system due to potential requirement to comply with heavy rail safety standards although exemptions may be possible through risk assessment o signal control centre for tramway system must be budgeted for unless capacity exists within the Network Rail centre. This will require dedicated staff which may result in additional costs.
Conclusion	As option B.1 plus: • the cost of a city centre tramway would be unlikely to be justified solely on the basis of the converted elements. It is noted that the city centre infrastructure for the Manchester Metrolink was justified largely on the basis of converting the Bury and Altrincham lines. In this case however the new city centre infrastructure was a relatively short section in the city centre. Secondly, it has subsequently formed a part of the core network which has far wider benefits than the original converted lines • however, heavy rail conversion to either tram or tram train is likely to be lower cost than new on street tramways o most new tramways have made use of former railway alignments o Manchester Metrolink and Croydon Tramlink have both converted actual heavy rail services.

Assessment of Option B.3 convert to segregated tram system to provide connectivity with city centres and their suburbs to create new journey opportunities, tap new markets, opportunities for new stations	
Concept	Conversion from heavy rail to tram and successive separation from the existing heavy rail network, for example Nottingham Express Transit Phase 1 Hucknall-Nottingham City Centre. This conversion only applied to the infrastructure but conversion can also encompass converting heavy rail services as with the Croydon Tramlink's conversion of the Wimbledon to West Croydon services.
Infrastructure and rolling stock requirements	As option B.1 plus: • might be part of the creation of an entirely new tram system or as an extension to an existing tramway • tram vehicles only • change in infrastructure and train control systems to sever the new tram operation from the heavy rail network • possibility of simplification of the heavy rail signalling system • no requirement for any of the track, power, and train control interfaces with the heavy rail network.

Assessment of Option B.3 convert to segregated tram system to provide connectivity with city centres and their suburbs to create new journey opportunities, tap new markets, opportunities for new stations	
Impact	As option B.1 plus: • might be part of the creation of an entirely new tram system or as an extension to an existing tramway • tram vehicles only • change in infrastructure and train control systems to sever the new tram operation from the heavy rail network. Closure powers would be required • possibility of simplification of the heavy rail signalling system • a new depot may be required for the small fleet created
Feasibility	As option B.1 plus: • in some instances there may be a loss of passenger destination flexibility due to disaggregation from heavy rail network services leading to a requirement for a passenger interchange with onward heavy rail services, this is not always the case but may be a factor which influences the choice of service for conversion • potentially lower cost than tram train because: o trams may be cheaper than tram trains o train control systems can be simplified throughout o heavy rail vehicles are no longer present therefore infrastructure maintenance costs may be lower
Conclusion	As option B.1 plus: • tram conversion is only possible where the pattern of services and demand allows the removal of all other heavy rail services including freight. The circumstance in which this applies may be constrained by requirements to retain significant numbers of heavy rail services on a route.

Gap C – Cost effective ways of delivering services or new journey opportunities, tap new markets, opportunities for new stations

These options will be considered to inform the question of the circumstances in which tram conversion is able to reduce the cost of services and enhancements on rural routes. This could include using tram or tram train as well as ultra light rail vehicles such as the Class 139.

Option C.2 provides a high level assessment of the impact of using trams as an alternative to heavy rail when reopening a route. The Midland Metro is one such example where trams have been used to reopen a former heavy rail service using trams. The option sets out the considerations that will be needed in selecting trams as opposed to heavy rail. This could include a range of solutions from a tram to ultra light rail vehicles such as the Class 139

Assessment of Option C.2 reopening of closed routes to tram or tram train operation	
Concept	Opening or reopening a corridor for tram use as an alternative to heavy rail. A number of openings or reopenings have been proposed but the capital and operating cost of a heavy solution means that there is a high cost hurdle to be overcome. Tram or tram train might be a means to reduce the capital and operating costs of such schemes.
Infrastructure and rolling stock requirements	• the type of infrastructure and rolling stock that would be required is dependent on whether the reopening of the heavy rail corridor is planned for shared running or whether segregated rail services • the impact on infrastructure required for tram would be to potentially reduce the level of a number of cost areas. However, electrification is likely to still be required and a number of items would remain unaffected • a new depot would be required for the small fleet created
Impact	• potential for disruption to existing transport networks (e.g. road network for buses, taxis, emergency services etc) during construction – not just along the corridor and immediate area – although unlikely to be worse than any other major transport improvement project • potential for disruption of existing land uses depending on if the corridor is in a rural environment rather than in built up areas. This impact would be dependent on the extent to which new routes were required and whether the existing track bed could be utilised and how long it had been out of use.

<table>
<tr><th colspan="2">Assessment of Option C.2 reopening of closed routes to tram or tram train operation</th></tr>
<tr><td>Feasibility</td><td>provision may be needed to integrate with other modes – especially heavy rail and would require passenger interchange to be addressed
the level of demand, linespeed, overall route length, and stopping frequency would determine if tram, tram train or conventional heavy rail was appropriate for a particular route
tram would only be possible where it was acceptable not to integrate with heavy rail or limited time share operation was possible.</td></tr>
<tr><td>Conclusion</td><td>if undertaken as a tramway segregation needs to be possible, and the disbenefits of loss of network benefits needs to be acceptable.
a tram style vehicle is only appropriate depending on the:
market type
route length
passenger volumes
as with conversion of routes diesel tram vehicles are expensive and electrification has a considerable capital cost to its installation
may reduce cost hurdle of a new or reopened line but the solution will not be appropriate for all routes or markets.</td></tr>
</table>

Alternative methods of delivery of electric traction on lower traffic density routes

Gap D – coasting, discontinuous or discrete electrification may enable more efficient operation of passenger services

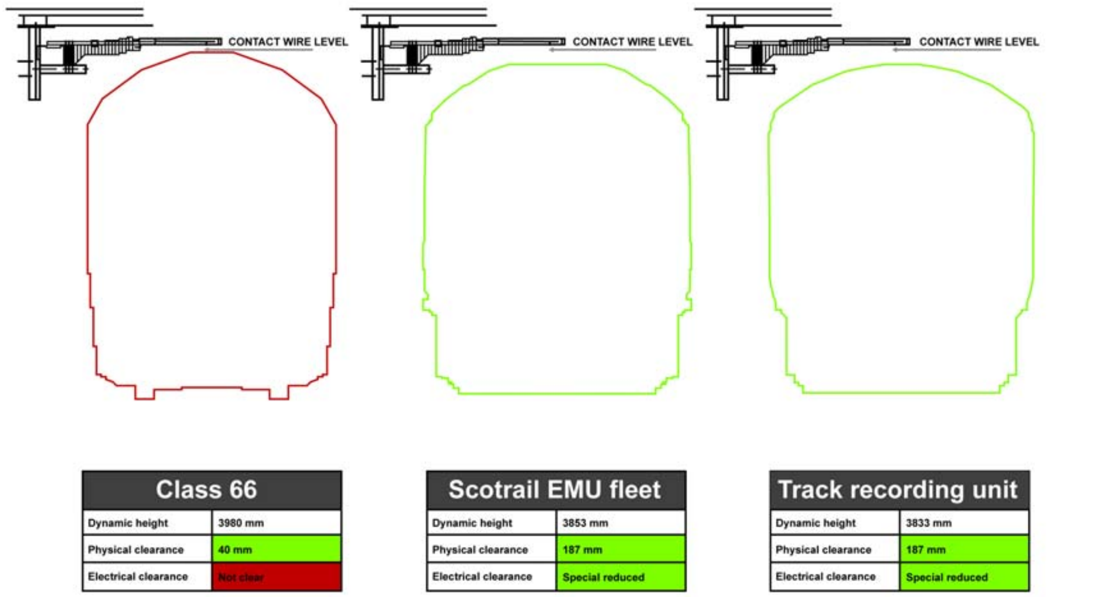
1 – For avoiding reconstruction of challenging structures

These options relate to possible candidates already identified in the Network RUS: Electrification Strategy. Example options are considered as case studies.

Case study – Paisley Canal extended neutral sections electrification (source: Network Rail)	
Concept	 The Paisley Canal line is operated by three Class 156 DMUs in an area of otherwise electric traction. The route is currently 33 per cent electrified from Glasgow Central as far as Corkerhill Depot on the line to Paisley Canal. The concept is to be able to electrify the remainder of the route and operate the service using existing Class 314 and 380 EMUs. There are no freight services on the route but there is a currently disused oil terminal at Hawkhead for which there are aspirations to return freight traffic so a requirement for freight remains on the route. The planned electrification of the route is included in the Scottish Transport Projects Review. Options were considered to electrify the route using conventional 25kV AC Overhead Line Equipment (OLE) but the cost of achieving standard clearances for nine of the 12 overbridges meant the scheme did not achieve a positive business case.
Infrastructure and rolling stock requirements	The scope of the electrification scheme is to enable a half hourly First ScotRail EMU service to operate whilst maintaining the infrastructure capability for freight traffic to and from the currently disused Hawkhead oil terminal. The electrification needs to maintain the capability for future aspirations for oil traffic as well as the Network Rail Track Recording Unit (TRU), Multipurpose Vehicle (MPV) and infrastructure trains. The proposed EMUs are the current vehicles operating in the area. Following the initial assessment which showed the cost of providing standard clearance for structures would not be feasible, an alternative approach was to consider gauging the OLE around electric trains that use the route, rather than the UK loading gauge. The alternative approach being considered is to: • gauge around electric trains that use the route making use of reduced special clearance • make use of neutral sections under challenging bridges • remote earthing to address freight/infrastructure train gauge (UK innovation). **Figure 6.4** illustrate how this affects different types of rolling stock. Electrical clearances can be achieved for EMUs and the Track Recording Unit, at an OLE wire height which would allow mechanical clearance of a Class 66 freight locomotive but would not permit electrical clearance. It is for this reason that it has been proposed to remotely take isolations, which would allow vehicles where mechanical clearance is possible to operate on the route, without the need for the isolation to be physically earthed locally each time such a train needed to use the line. Certification is needed for the earthing equipment. It is proposed to trial the equipment first to demonstrate the viability of remote isolation equipment and to gain full certification.

Case study – Paisley Canal extended neutral sections electrification (source: Network Rail)

Figure 6.4 - Mechanical and electrical gauge clearance of a Class 66, EMU and Track Recording Unit



Impact

Initial work suggested an approximate infrastructure cost saving of between 20 to 45 per cent.

The table below shows the impact on the rolling stock of the various gauges ranging from full W6 freight gauge clearance (4165mm wire height) to progressively restricted gauges down to E1 (3925mm wire height).

	Full W6 Electrification gauge clearance	E3 Electrification gauge clearance	E2 Electrification gauge clearance	E1 Electrification gauge clearance
Rolling stock which can pass while current live	Full range of W6 cleared rolling stock	All EMUs, loco gauge and some wagons	All EMUs, TRU, MPV and Class 15x	Low profile EMU (Class 314 and 380)
Rolling stock which can pass while current neutral	n/a	Any locomotive gauge stock	Any locomotive gauge stock	All EMUs, TRU, MPV and Class 15x

There are also potentially up to two proposed extended neutral sections which would be required for the avoidance of track lowering. The pantograph of EMUs would remain raised but would be at a height that is too low for electrical clearance. This avoids the cost of interventions to change the infrastructure to achieve electrical clearance.

The present Paisley Canal line timetable often suffers from perturbation because of the tight turnaround times associated with the DMU diagrams that cover the Paisley Canal line. The use of EMU rolling stock with faster acceleration has the potential to improve performance without an increase in line speeds on the route.

Electrification of the route would release three Class 156 DMU sets for use elsewhere within the ScotRail franchise on services where there is overcrowding due to increased patronage.

Feasibility

The remote isolations concept and equipment still needs to be trialled as it is innovative on the UK railways. A draft operational procedure has been considered for remote isolations but needs to be developed further at the next stage of the project. The infrequency of Network Rail infrastructure trains and the absence of any current freight on the route at present mean such a solution would potentially be acceptable. For lines where freight traffic is regular, remote earthing makes the network less flexible and therefore may not be appropriate.

Extended neutral sections cannot be sited in locations where a train might come to halt such as at stations or signals, this restricts the applicability of this technique. Standards cover the circumstances under which extended neutral sections can be used.

Case study – Paisley Canal extended neutral sections electrification (source: Network Rail)	
Conclusion	The conclusion is that the process that has been used to reduce the cost of the Paisley Canal electrification scheme is recommended for consideration to minimise the cost of gauge clearing challenging structures. The use of extended neutral sections or remote earthing needs to be in locations where it is technically and operationally feasible, and subject to the outcome of the development of rules of operation.

Case study D1.2 – Discontinuous electrification – Crewe to Chester

The Railway Safety and Standards Board (RSSB) in conjunction with the Technical Strategy Leadership Group (TSLG) commissioned research to explore the potential to reduce whole life, whole system costs of alternative electrification technologies through case studies. One such case study was the possibility of using discontinuous electrification on the Crewe-Chester route.

The conclusions of this case study have been used in this scoping document to assess the potential for discontinuous electrification on the network.

Case study D1.2 – Crewe - Chester discontinuous electrification (source: RSSB, 'Potential to reduce the cost for electrifying GB railways' (2011)	
Concept	The Network RUS: Electrification Strategy identified the electrification of the Crewe-Chester route to enable electric traction on London Euston to Chester passenger services as a further option for which the business case might be improved by the usage of alternative solutions such as discontinuous electrification. This case study considers discontinuities in the OLE infrastructure on the Crewe-Chester route in the form of either: • extended neutral sections where there is insufficient electrical clearance • gaps in the OLE where there is also insufficient mechanical clearance. To traverse these discontinuities the rolling stock might have to be adapted as follows: • more than one pantograph per train for short discontinuities less than 50 metres, which would mitigate the risk of gapping • an additional safety critical automatic control system to lower and raise pantographs where there is insufficient mechanical clearance (irrespective of gap length) • energy storage for longer discontinuities greater than 50 metres.
Infrastructure and rolling stock requirements	Extended neutral sections and gaps greater than 50 metres in the OLE along the route for structures too complex to gauge clear. This scenario assumes: • no OLE in Chester station • pantograph lowering for gaps where there is also insufficient mechanical clearance • two pantographs per train • sufficient energy storage (supercapacitors) for trains to depart Chester station • bespoke rolling stock would be required.
Impact	The scenarios as they have been assessed do not include benefits to passengers only the differential whole life costs of operation, maintenance and capital expenditure. There are no freight benefits.
Feasibility	There is a potential reduction in the electrification infrastructure capital expenditure when compared to the base 25kV AC OLE case because of the assumed extended neutral sections and a large number of gaps. However, this cost reduction is exceeded by the energy storage costs and frequency of replacement. The average approximate distance between discontinuities is short. Given the average distance between discontinuities, trains would have insufficient time under power, to open and close the circuit breaker or lower and raise the pantograph and energy storage will discharge significantly. It is therefore not thought to be operationally feasible.
Conclusion	The key drivers are the energy storage operating costs versus the avoided OLE infrastructure capital expenditure. Costs associated with the avoided OLE infrastructure includes: • additional extended neutral sections • contact wire terminations • providing trains with more than one pantograph • pantograph control systems where there is insufficient mechanical clearance to raised pantographs. The concept could become financially feasible with longer life and a lower cost of energy storage. The point at which this occurs has been assessed in sensitivity analysis. However, the number and proximity of gaps in the OLE infrastructure mean that the scenario is not thought to be technically feasible over this route. While the number of gaps could have been reduced to make the solution technically feasible this would have reduced the infrastructure savings and therefore any benefit of using discontinuous electrification.

Gap D – coasting, discontinuous or discrete electrification may enable more efficient operation of passenger services

2 – Innovative low cost forms of electrification

These options expand beyond the Network RUS: Electrification Strategy to consider additional potential options which are facilitated by discrete electrification.

Option D.2.1 – Discrete electrification

For this option a high level assessment of the market for operational cost viability of energy storage EMUs across the network has been undertaken. This analysis indentified the number of routes and vehicles which might be converted to include energy storage based on a range of prices of the energy storage and ranges of the energy storage technology away from the OLE. This analysis is intended to inform the rail industry and its suppliers in terms of the price and capability of energy storage which would be able to make a contribution to reducing the cost of operating the railway.

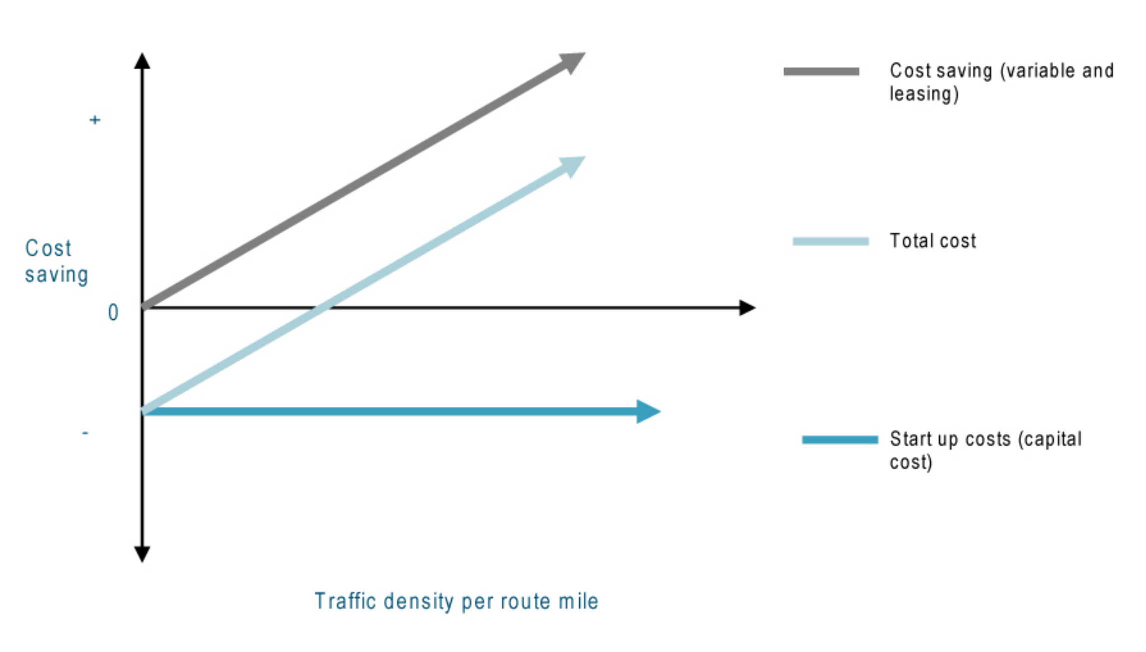
In **Table 3.6** in **Chapter 3** the general characteristics of a number of types of energy storage are presented. For the length of gaps involved in discrete electrification which are potentially in the order of tens of kilometres only batteries have the necessary range to power a train for this distance. This option therefore focuses on batteries as the assumed energy storage media which has the potential to develop to the extent they could be used in this application. Even so batteries have a wide variety of capabilities and differing characteristics so this analysis is intended only to identify the capabilities and price that would be needed by the rail industry for discrete electrification to be viable in the future.

Discrete electrification involves the deployment of new technology which is not in heavy rail commercial service in the UK or anywhere else in the world. This lack therefore presents uncertainty over the capability, cost and operational impact. A reliable appraisal resulting in a specific benefit cost ratio (BCR) or net present value (NPV) cannot be generated. It is for this reason that a market study has been conducted to understand the indicative size of the potential market based on a range of prices and capabilities of battery technology. The energy storage technology is developing in both price and capability. For this reason a range of capabilities and costs have been considered in order to understand the point at which it could become viable. The RUS has a time horizon of 30 years so the capability that has been used is deliberately aggressive in order to take account of the potential for the technology to develop. The capability is not one that can in all instances be achieved by technology available today.

In order to understand the business case for discrete electrification the scoping document firstly presents a theoretical business case for conventional electrification in **Graph 6.1**. This is then contrasted with the drivers of a discrete electrification business case.

Graph 6.1 shows in graph form the capital cost of OLE which is offset by the variable cost savings over the period of the appraisal. The case for electrification of a route rests on the volume of traffic per kilometre which generates the variable savings compared to the cost of running diesel trains. If enough traffic passes over a route, the variable cost savings (see Network RUS: Electrification Chapter 3), potentially offset the capital cost of the electrification infrastructure. Electrification is more likely to have a business case in places where the volume of trains means that the infrastructure is highly utilised.

Graph 6.1 – Electrification business case: costs per traffic density per route mile

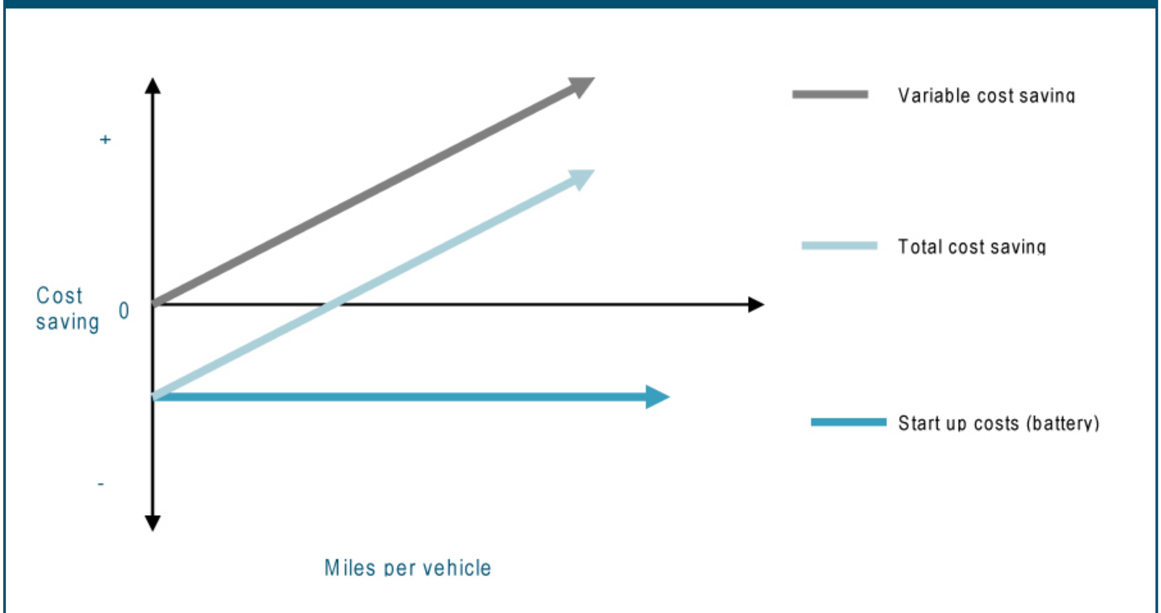


Graph 6.2 presents a similar but subtly different business case for discrete electrification. In contrast to conventional electrification the fixed start up cost is not infrastructure but the battery on the rolling stock. In the same way as electrification this cost is potentially offset by variable cost savings in comparison with diesel traction. The cost assumptions are set out in **Table 3.7** in **Chapter 3**.

A discrete electrification business case would be positive if the rolling stock runs sufficient vehicle miles in order to generate a variable cost saving which exceeds the fixed cost of the battery over the battery's lifetime and also the cost of additional electrical and pantograph control equipment. The business case therefore relates to the utilisation of the rolling stock. In the same way as an electrification business case depends upon the utilisation of the infrastructure, a discrete electrification would depend upon the number of miles per vehicle per annum.

The additional weight of battery in comparison to conventional EMU would increase the track access charges and energy consumption of a battery power unit. This would mean that while discrete electrification would potentially reduce the OLE infrastructure capital and maintenance costs, the variable savings of an EMU with batteries would be lower than for a conventional EMU. It is therefore a trade-off between reduced OLE infrastructure capital and maintenance costs versus the fixed battery cost and lower variable cost savings in comparison with a conventional EMU.

Graph 6.2 - Discrete electrification business: case cost savings by miles per vehicle



This means that where conventional electrification has a business case this would be the more advantageous option. It is only for those lines where low traffic volumes, and therefore likely absence of a viable electrification business case, combined with aging self powered rolling stock means that in the future an alternative solution such as discrete electrification would be desirable.

The factors that would reduce the favourability of a discrete electrification business case are anything that:

- reduces the miles per vehicle
  - peak strengthening where additional units are used primarily to provide services during peak times but are not used in service in the off-peak
  - low speed of trains means that while they might be well utilised in terms of time in service, but the average distance they cover each day is low
  - percentage of time as turn around time where a unit spends periods of the day in a terminating platform before forming its next service thereby reducing the miles operated each day
  - availability - island fleets particularly of less than ten units have a less than optimal percentage of spare cover reducing the average miles operated per vehicle (see **Graph 3.4** in **Chapter 3**)
  - additional time taken to recharge the battery which exceeds the available time in the current rolling stock diagrams.

- greater capital costs, which might for example include:

  - additional OLE to wire bay platforms or extend existing OLE
  - in order to avoid the operational disadvantages of a small sub-fleet a larger number of vehicles may require the installation of battery storage in order not to constrain the flexibility of deployment
  - work to strengthen power supplies at charging locations
  - the need to replace batteries more frequently than expected.

Reductions in average vehicle mileages will mean the variable cost saving per vehicle is reduced. This means that the fixed battery cost is more difficult to overcome. Given the likely extent of the battery cost it is unlikely that any increase in vehicle numbers over the current fleet could be supported as the variable cost savings per vehicle would reduce.

Any capital costs to implement the discrete electrification scheme will increase the fixed cost of the proposal. This increases the cost hurdle that variable cost savings must overcome without necessarily increasing the benefits of the scheme.

The modelling that has been carried out does not include any element of optimism bias, or additional capital expenditure that might be required. It also does not include the impact on taxation or the cost of carbon. Carbon has not been included because the modelling is for the assumed life time of the battery and not the rolling stock. In the period of the life of an individual battery the cost of carbon may not be that significant at current prices but in the future carbon prices may have a more substantial impact on the business case.

The modelling has some assumptions on battery capability which go beyond the current capability of the technology, on the assumption of further improvements as wider industry efforts to improve battery capability continue. The timescales when this solution might be required are also at a point in the future when the absence of viable options to either for new diesel rolling stock or to electrify means an alternative solution is needed. It includes elements of conventional operating and maintenance costs as well as battery costs but does not include capital costs or timetable changes. Therefore it may be the case that some fleets may not currently be able to operate. In addition there are a number of unknown costs which may be required, such as power supply strengthening or additional electrification infrastructure at platforms or depots, whilst benefits such as improved acceleration are also, as yet, unknown.

It should also be noted that the modelling has used generic inputs and assumes a like-for-like conversion of service pattern and units. In reality specific factors such as unit length and fleet availability may be affected by conversion. To develop the model the work has assumed that high speed, freight, or current electrically operated services are not involved. Key inclusion criteria have included a requirement for modelled services to operate, to an extent, under the OLE or to or from an electrified terminal station. A maximum distance of 75 miles away from the OLE was assumed, which included the possibility of running 74 miles to an electrified platform. 75 miles was either assumed to be between two points of electrification or the round trip to return to electrification. This left in the region of 100 service groups which fitted this criterion which in turn enabled an estimated number of vehicles per service group and miles from billing data to be calculated. The analysis only considers current service groups and does not consider the impact of uncommitted electrification schemes.

Graph 6.3 shows the demand curve for the potential 550 vehicles modelled. Of these, around 200 are reliant on charging entirely in a bay platform, 100 have less than five miles of running under the OLE and 250 operate for more than five miles under the OLE. It is clear from this that the ability for vehicles to charge quickly is essential if the number of vehicles and therefore utilisation is to remain within the current fleet numbers required to deliver the timetable. As has been discussed above, if the current timetable cannot be operated within the same number of units due to charging requirements it is unlikely that a business case would exist as the balance of variable cost savings depend upon vehicle utilisation.

The conclusion of the price analysis is that once the fixed cost of installation of the battery on an EMU falls below around £95,000 per vehicle there is the potential for a cost saving in comparison with DMU operation. This does not indicate that these routes would necessarily be feasible with today's battery technology as the 75 miles range that underpinned the route selection is a very aggressive target. As battery cost declines to below £30,000 this starts to mean that all considered routes could be converted as it represents the difference in DMU to EMU costs and therefore any distance operated would result in a saving over DMUs.

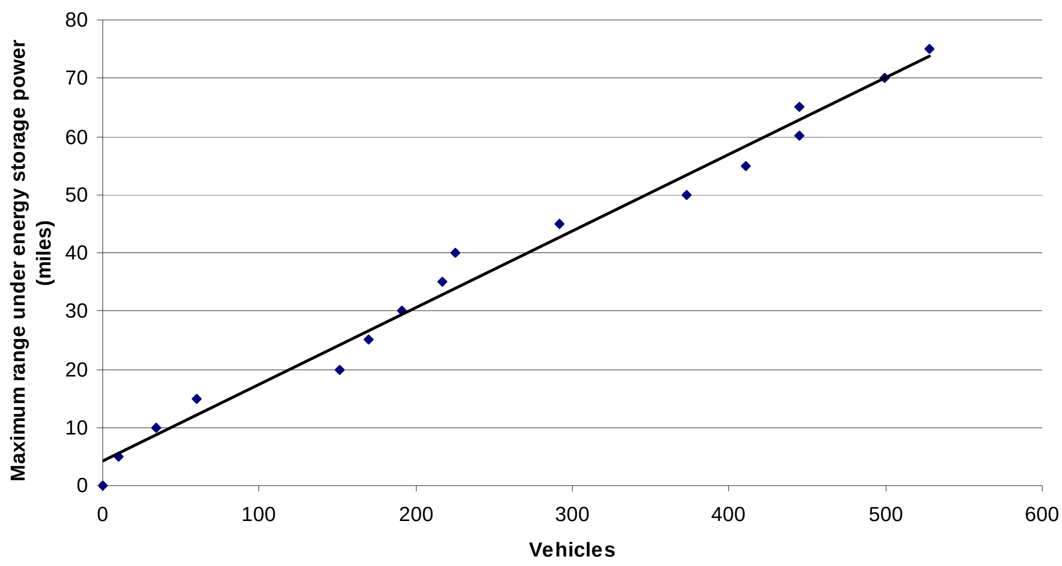
As well as the current range of batteries being to some extent uncertain, the cost of energy storage is unclear. A wide range of estimates of cost have been seen in previous studies and the upper end of these estimates is considerably above the threshold at which any vehicles in the graph would be viable. The other area of uncertainty is future forecasts for battery costs. Some studies suggest that battery costs will fall substantially over time driven largely by developments in the automotive sector. However, the uncertainty of current and future prices means that this strategy presents potential battery costs as a range.

Graph 6.4 shows the potential market for vehicles based on a range of distances that the battery is capable of travelling away from the OLE up to a maximum if 75 miles. This assumes that the range can be delivered by a charging time that means that no additional vehicles are required. As has been noted above, unless the charging time is capable of being accommodated within the existing number of units to operate a timetable it is unlikely that variable cost savings could off set the fixed cost of batteries.

The market shows a linear relationship between distance travelled away from the OLE and the numbers of vehicles on routes which could therefore potentially operate using an energy storage EMU. This means that the range of the battery which can deliver an existing timetable for the same number of vehicles results in greater number of potentially converted DMUs. This suggests that there does not appear to be a cluster of routes around a common distance of gap in the OLE provision. The relationship is therefore a simple one which suggests the further a battery can power a train the bigger the potential market in terms of vehicle numbers.

It has been suggested that by electrifying a nodal location from which a number of services radiate and using discrete electrification, it might be possible to convert a substantial area of DMU operation to electric traction while minimising the infrastructure capital expenditure. Based upon the analysis of battery price to vehicle demand and the cost factors if new infrastructure was required, this would provide not necessarily provide additional benefits.
If this was the case it would raise the fixed cost

Graph 6.4 – Potential number of vehicles: energy storage device range away from OLE (miles)



hurdle which variable cost savings based on the operation of energy storage EMUs would be required to overcome. This scoping document has not considered the impact of additional OLE infrastructure or nodal electrification. It has also not compared the cost of conventional electrification with discrete electrification. In conclusion this option has found that there may be a may be a market for discrete electrification in terms of cost savings in comparison with DMUs. However, this is dependent upon the price of batteries and also their capability to deliver a range off the wires at the same level of rolling stock efficiency as current DMUs.

Community rail

This section outlines the two key gaps which can be identified between today's railway and a future railway which could realise the benefits outlined in the drivers of change from community rail initiatives. The two gaps are:

- **Gap F** – the potential role of community rail in obtaining value for money in the local railway
- **Gap G** – the potential role of community rail in encouraging greater involvement of the local community in the local railway.

Type F gaps relate to the potential ability of community rail initiatives to generate either additional revenue, minimise costs, target spending, improve the deployment of resources based on local priorities and secure 3rd party funding.

Type G gaps relate to the potential ability of community rail initiatives to encourage greater involvement in the local railway through greater local involvement either in volunteering or decision making.

Gap F – the role of community rail in obtaining improved value for money

Some parts of the rail network are focused on providing largely social benefits and much of this network operates away from the major conurbations and is focused on rural counties such as Lincolnshire, Devon, Cornwall and Cumbria. Improved value for money could be realised by reductions in cost and increasing revenue. Community engagement has been most successful in activities to increase patronage, with the aim to reduce subsidy by increasing revenue.

Options to address this gap are detailed in the following tables.

Option F.1 – Additional community engagement	
Concept	The option is to introduce additional community engagement in areas where there is no involvement at present in order to increase revenue.
Impact	Further community involvement would offer the opportunities for improved rail travel experience and increase awareness of the railways within communities. By: • being able to consult with community partners has enabled changes to improve the rail service • to focus investment based on local priorities • supporting volunteering to improve the railways environment.
Feasibility	It is possible for non-community rail routes or services to have a greater degree of community engagement. There is an established process by which involvement is facilitated through the relevant transport agency and the rail industry. It is recognised that the driver of the success of community rail is the degree of involvement from local stakeholders. Therefore, the expansion of community rail or other forms of community engagement is contingent on a community seeking involvement in the rail lines. The line or service can also influence the success of the partnership. Some lines and services may not be appropriate for community involvement such as long distance services which serve multiple communities and markets and routes with mixed traffic types. In such circumstances, station user groups or adoption groups may be appropriate. Volunteer support cannot be seen as a substitute for paid staff or indeed taken for granted. This is because volunteer activities are limited by the level of engagement of volunteers and also because of their own personal time they have to give to a task.
Conclusion	It is unlikely that the rail industry can deliver the benefits associated with community rail without community engagement. Where groups and parties are interested in greater involvement this should be facilitated where the solutions are suitable as community engagement can deliver improved rail experience and increased awareness of the railways.

Option F.2: Wider adoption of community rail techniques

Community Rail has brought innovation to the ways that some lines are managed. The option is to deploy these where there is not community engagement. For instance the Rail Value for Money (RVfM) study published in May 2011 notes that operators of rural routes should be afforded greater flexibility than is currently allowed by franchise obligations to determine appropriate retail outlets. For analytical purposed the option is split into a three sub-options:

1. Ticketing
2. Retailing
3. Marketing.

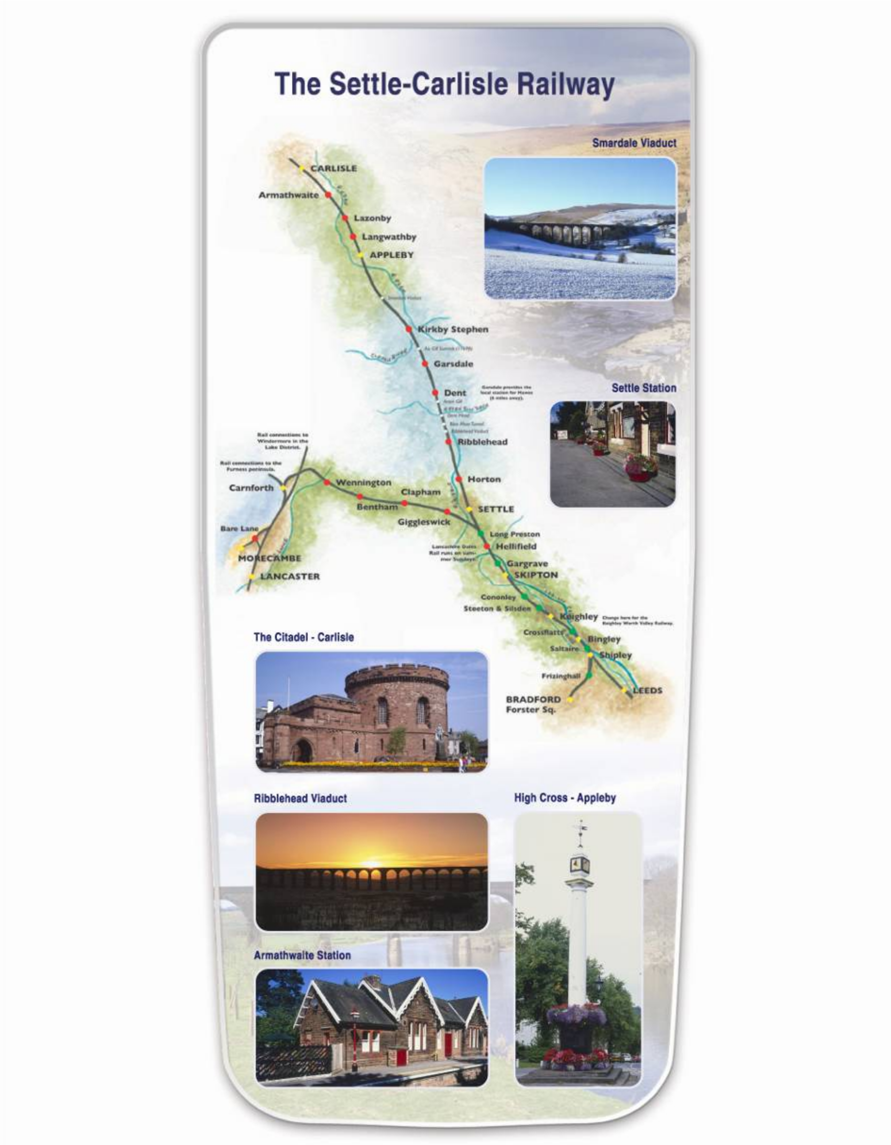
Option F2.1 – Wider adoption of ticketing strategy	
Concept	Community rail approaches to ticketing are seen as effective ways to attract additional passengers to rail and improve services. The option is to adopt some of these techniques elsewhere, even if a partner is not present.
Impact	Through community engagement new ticketing types such as ranger and rover tickets have been introduced. These are designed to offer flexibility in the use of rail services. These ticket classes are widely used on other parts of the network. Increasing ticket prices has been used by communities as a way to raise funds to improve rail services, particularly in order to fund Sunday services. These increases are typically not designed to reduce the subsidy, instead they are a way to try and fund improved services at minimal cost. The effectiveness of alternate pricing strategies will vary by market. On largely commuting lines or stations research indicates that a decrease in price would not generate sufficient additional demand to offset the reduction in revenue from existing customers. Outside of the commuting market where travel is more discretionary there is greater ability to lower fares to attract passengers.
Feasibility	The ability of train operating companies (TOCs) to set prices on many routes is restricted by the regulatory cap on prices and increasing prices involves a lengthy consultation process. The presence of the community partners makes it possible to raise fares, without necessarily having to go through the full consultation process. A good example of this approach is on the St Ives Bay line where in 2004 “Ranger” rickets were introduced at St Ives, St Erth and Lelant Saltings with a standard £4 fare for all local journeys. TOCs are currently incentivised to lower prices where it represents an improved outcome through the franchising process. Therefore, it is likely that the opportunities for changes may be made around the margins where specific local circumstances exist.
Conclusion	Community engagement in rail has in some instances been an important facilitator in the ability to adjust fare levels to meet community needs. While this could be done without their involvement consultation costs could outweigh benefits and would not necessarily involve the community in the decision making process. Other than that TOCs are currently able to price fares lower to manage demand and will do so where a business case exists. Likewise they can introduce ranger tickets if there is a business case.

Option F2.2 – Wider adoption of retailing strategy	
Concept	Community rail approaches to ticket retailing are viewed as effective ways to attract additional passengers to rail. Ticket sales at local shops such as those on the Tamar Valley are seen as a good way to address the lack of ticket offices. Likewise there are examples of community shops or commercial companies selling tickets at stations.
Impact	Research indicates that staffed ticket offices, retail facilities and the presence of staff at stations are all valued by the travelling public. If ticket retailing facilities can be provided using alternative methods of sale it may be possible to increase patronage. There is a potential synergy that other retail facilities (café, shops etc) would also improve the station environment and improve security. The impact of these activities will be greater for business and leisure traveller in comparison to commuters. The extent of the additional patronage delivered by these services are capped at two per cent of starting (base) demand in appraisal guidance, but survey evidence and the changes in demand on the Tamar Valley line suggests higher demand may be experienced. At Northwich station train operator Northern introduced a new ticket to encourage local

Option F2.2 – Wider adoption of retailing strategy	
	off-peak travel, and this ticket was made available from a café on the station which had been opened as part of a redevelopment.
Feasibility	There have been some successes in providing alternate retailing for instance the Carnet ticketing on the Tamar Valley branch. This requires support from the local authority to manage as the train operator has not seen it as being commercially viable to operate. Merseyrail are adopting M2Go (a concept that combines ticket sale and a shop environment) as a way to improve retailing at stations and many commercial shops operate across the network. It is important to note that along with the benefits of alternative retailing strategies on an individual or small scale there are potential challenges and costs. This point is illustrated by the introduction of Carnets where the CRP is responsible for their distribution to retailers which would otherwise be a cost that could not be covered by the increased revenue.
Conclusion	Alternative methods of ticket retailing have been employed by community rail indicating that it is feasible. Wider application will be best assessed on a case by case basis as commercial and specific factors will dictate the success of individual options.

Option F2.3 – Wider adoption of marketing strategy	
Concept	Community railways have undertaken a wide range of marketing and promotional activities designed to increase patronage. Operators of visitor attractions, other tourism bodies and transport operators are likely to have shared interests in encouraging more visitors and sustainable access. Successful examples include the provision of cycle hire at Windermere and Brockenhurst stations.
Impact	Increasing patronage will help to reduce subsidy as long as it is done in a value for money approach. TOCs are able to undertake value for money advertising. Therefore, additional advertising would be aimed at producing benefits for the wider community. For instance an increase in revenue experienced by local business that could result from increased rail patronage or the reduction in road congestion. On this basis much advertising is undertaken in partnership between TOCs and local communities in order to promote both rail and the communities' attractiveness to visitors.
Feasibility	TOCs currently invest in advertising with community rail partnerships as a commercial measure. For instance joint advertising is undertaken between First Great Western and the Devon and Cornwall Partnership. **Figure 6.5** shows some illustrative marketing material for the Settle and Carlisle line that highlights the attractions along the route. Initiatives can also extend to information provision in circumstances such as engineering blockades. For example, the renewal of the Arnside railway viaduct caused major changes to travel plans for passengers' on the Barrow in Furness to Carnforth railway line in spring 2011. A team from Trans Pennine Express, First Rail Support, Northern Rail, Network Rail, the Furness and Lakes Line CRPs joined with rail user groups, Furness Line Action Group and the Leeds Lancaster Rail User Group to ensure that posters and timetables reached all relevant stations and also offsite information outlets including libraries, Tourist Information Centres, Post Offices and village shops.
Conclusion	Advertising in conjunction with community rail partnerships, local tourism authorities and other parties appears to be successful way to attract additional patronage. The incentive structures are such that where the opportunity to increase revenue through advertising exists it can be expected that TOCs would take this up. Therefore the impact of community advertising is likely to increase the economic benefits of the railway through its affect on the local economy.

Figure 6.5 - Marketing Material for the Settle and Carlisle line (Source: Northern Rail)



Gap G – the role of community rail in encouraging greater involvement in the local community in the local railway

The second community rail gap identified in **Chapter 5** concerns the role of community rail in encouraging greater involvement in the local community in the local railway. This gap explicitly explores the role that the local community can have in developing rail routes and services. Options to address the gap of the role of community rail in encouraging greater involvement in the local community in the local railway include:

1. local service decisions and fare levels to optimise capacity usage to local priorities
2. micro-franchising to potentially increase local control in line with local needs and priorities.

Option G1: Local input into decision making	
Concept	Community rail has enabled decisions to be made about social rail services with community engagement. Stakeholder engagement in the specification process on regional lines could permit improved timetables that meet the community needs.
Impact	Engagement through the community rail process has allowed communities to specify their needs clearly to the railway and in some cases this has led to improvements in the rail service pattern and at stations. Timetabling driven by local needs could offer much more flexibility with services reflecting the peaks and troughs of the markets that are served. The Rail Value for Money report suggests that such an approach would give much greater scope for integration with other modes of transport and that this should include common timetables that link at key interchanges.
Feasibility	Community rail services are often resource constrained and cannot be increased without a step change in costs. There are, however examples where community rail involvement has suggested timetable changes which have brought benefits to the line as a whole such as those agreed with the Devon and Cornwall CRP and implemented on the Barnstaple line. The Heart of Wessex CRP was asked specifically how the station enhancements fund should be spent.
Conclusion	Community engagement has delivered improvements in the way services are developed. Local input into decision making can be seen in a number of devolved structures, such as through Passenger Transport Executives, and is not unique to community rail. However, community rail is one example of how to achieve greater local input particularly where groups in a local area are interested in becoming more involved in decisions about their local rail services. The public accountability that this involvement in decision making has will depend upon the nature of the groups represented. For example, for designated community rail lines and services Local Authorities are central to such partnerships so there is likely to be clear local democratic accountability.

Option G.2: Micro franchising	
Concept	Micro franchising has been proposed as an alternative way of procuring regional railway services. It is a step further than community rail, with the running of the railway taken over by the community, or by a concession smaller than the conventional franchise.
Impact	A micro franchise is intended to provide a more cost effective and better integrated service within a local area. The scoping document has not appraised the benefits of micro franchising; a potential significant disadvantage would be the loss of economies of scale and increased transaction costs as compared with a larger franchise, and the concept would have to demonstrate significant benefits, such as efficiency savings or improved revenues, to compensate.
Feasibility	Introduction of micro franchises would require action from existing franchising authorities. The Department for Transport (DfT) is planning to consult shortly on devolution of rail powers in England, and the impact of this will be considered after the publication of this scoping document for consultation for the draft and final RUS.
Conclusion	The scoping document has not developed to option in significant detail and the outcome of the DfT consultation will be considered in the final RUS.

Summary

This chapter has analysed the options for the three groups of alternative solutions. The next chapter, Emerging conclusions, will draw up the conclusions for the individual options to present an emerging strategy.

7 Emerging conclusions

7.1 Introduction

The objective of this Route Utilisation Strategy (RUS) is to develop a strategy which presents alternative solutions to carrying the future demand for rail passengers which contribute to the objective of ensuring increased value for money. The following gaps have been proposed to develop this strategy in the scoping document:

- **Gap A** – city centre major station capacity and or capacity on inner suburban routes
- **Gap B** – connectivity with city centres and their suburbs to create new journey opportunities, access new markets, and opportunities for new stations
- **Gap C** – cost effective ways of delivering services or new journey opportunities, access new markets, and opportunities for new stations
- **Gap D** – coasting, discontinuous or discrete electrification may enable more efficient operation of passenger services:

  1 by avoiding reconstruction of challenging structures
  2 innovative low cost forms of electrification
- **Gap E** – coasting, discontinuous or discrete electrification could enable new services to operate
- **Gap F** – the potential role of community rail in obtaining value for money in the local railway
- **Gap G** – the potential role of community rail in encouraging greater involvement of the local community in the local railway.

The results of the analysis of the options in **Chapter 6** have been used to develop emerging conclusions. The emerging conclusions for each of the alternative solutions that have been considered are set out in turn. The scoping document has considered two technological sets of options, tram and tram train conversion, and innovative forms of electrification involving varying lengths of gaps in the overhead line infrastructure. To balance the otherwise technological focus of the scoping document community rail as a concept of management philosophy involving the community in the development of the railway has also been assessed. It is recognised that the options that have been considered are only a sub-set of all the possible solutions that are available. These options have been selected on the basis that they have not or are not planned to be considered as part of the existing railway industry planning process, along with their ability to contribute to the gaps being faced.

It is recognised that there are a wide range of possible alternative solutions that could be considered and that that many of the alternative solutions analysed in this RUS are in part outwith Network Rail's direct sphere of core expertise. Uniquely therefore there will be two phases of consultation with the responses to this scoping document informing the work to develop the full draft strategy.

7.2 Network Rail's role

The role of Network Rail in connection with the emerging conclusions of this scoping document ranges from full involvement in the potential development of future schemes to facilitating the realisation of locally developed plans and priorities. With tram and tram train conversion except where proposals are entirely on the heavy rail network, any schemes are likely to involve solving transport problems in the wider transport network. It is therefore likely that Network Rail may not be the party who is most involved in developing and planning the conversion scheme as a whole. In these cases Network Rail sees its potential role as facilitating the needs of other parties such as Passenger Transport Executives (PTEs) in developing schemes. This scoping document recognises that Network Rail and the rail industry as a whole does not necessarily have direct experience in tramways and wider public transport and the RUS is intended to provide a heavy rail perspective to help facilitate future proposals. Community rail is also not something that can be imposed by the rail industry as it needs partners who wish to engage and it is not intended that this RUS impose solutions where they are not wanted.

7.3 Tram and tram train conversion

Tram and tram train are likely to be driven by local transport planning and priorities rather than by national plans. This RUS seeks to complement that local process by setting out the contribution which conversion of heavy rail infrastructure or services to be operated by tram or tram train can make in solving transport gaps. It has not been possible to make a high level cost comparison between heavy and tram because the latter generally involves a whole system transformation. Instead the options that have been analysed consider the general factors of cost and demand impact that make up the case for tram or tram train conversion.

Conversions to tram style vehicles and tram train are not 'cheap' solutions in rolling stock capital cost terms. However, they do offer the prospect of lower operating and maintenance costs than their heavy rail equivalents and the ability to uniquely improve city centre penetration and connectivity. The complexity of rolling stock which is able to travel in a street environment shared with other road vehicles and pedestrians means that a tram is similar in cost to the equivalent capacity Electrical Multiple Unit (EMU). As the rolling stock increases in complexity to be able to operate on both tramway and the heavy railway so the cost increases. There is also a cost of conversion of heavy rail services to be operated by a tram vehicle and this is likely to involve electrification on non-electrified heavy rail routes.

There are likely to be a range of conversion costs for the infrastructure depending on the need for electrification and additional enhancements required. Connection costs to an existing tramway could also vary considerably depending on the complexity and length of the new link. Tram conversion could be cheaper than tram train, but, is only possible where segregation can be achieved. This segregation could be total, or where heavy rail traffic levels are lower and the risk mitigation appropriate such as through the train control system. Tram train has greater flexibility of deployment but the additional interfaces between tram and heavy rail create complexity and cost. Conversion of heavy rail infrastructure and services have been and are likely to be a key feature of any future tram networks or extensions to existing tramways because conversion of heavy rail infrastructure if an available option is potentially lower cost than the construction of new on street tramway sections. On street tramways may have longer journey times as a result of more frequent stops and interactions with traffic.

For this reason the direct comparison between on street tramway and heavy rail conversion may not be relevant as the markets that they serve are potentially very different. On street tramways allow far greater connectivity by taking passengers directly to or from their destination or origin. For example, the conversion of the Rochdale via Oldham line to the Manchester Metrolink system is also diverting from the heavy rail alignment into the centre of Oldham and extending into the centre of Rochdale using new portions of on street tramway. This provides greater penetration of urban areas than the original heavy rail service. It is important therefore to focus on the transport problem and the market served rather than only on lines which are straightforward to convert to tram or tram train.

Trams have the potential to reduce the cost of enhancements where routes can be fully segregated. Trams are not likely to be an option where on street running is not utilised as they are expensive rolling stock which require electrification or if diesel are more complex and likely to be more costly than a light weight Diesel Multiple Unit (DMU). The business case drivers for such electrification would be the same as for any other route and the level of traffic density is central to whether a business case would be feasible. However, most routes which might be considered in more rural areas for a tram conversion have low traffic density. There are relatively few instances where such lines exist that are electrified and are also able to be fully self contained. The Watford Junction-St Albans Abbey line is virtually unique in this respect.

This leads to a possible conclusion that a railway operated with a light weight self powered vehicle which might adopt some of the feature of a tram in terms of train control systems and axle weight to minimise whole life costs might be a more appropriate way to address the gap to achieve a lower whole life cost railway on low traffic density routes.

Where lines are made self contained there are additional costs such as providing rolling stock maintenance depots. Small rolling stock fleets are potentially less efficient as they require a greater percentage of rolling stock to act as maintenance spare cover. The same can also be the case for overheads which a small operating unit would require which might no longer be shared with a wider network.

Trams may be a cheaper way to open a new route which was suitable for a tram style vehicle. Some of the new tramways that have been constructed have reopened sections of former railway in this way. However, this is still in absolute terms an expensive option and sufficient benefits and appropriate transport gaps must be present for this option to be viable. These gaps are a factor of the existing transport, future demand and characteristics of the route in question.

Tram and tram train conversion of heavy rail infrastructure is most likely to be able to contribute in circumstances where in an urban area with a tramway, possible diesel operated heavy rail routes can be simply and cheaply converted and connected to the tramway. There is then a spectrum of circumstances where tram and tram train are progressively less able to contribute. The emerging conclusions on these factors are presented in **Table 7.1**.

The table sets out the following factors to draw a high level conclusion of the reasons for converting to tram and tram train and where they might be appropriate options in terms of:

- the types of gaps to which tram or tram train conversion can contribute
- the market factors in which tram or tram train conversion can contribute
- the factors affecting the tramway
- the conversion and connection cost of the heavy rail section.

The unique factor that tram and tram train offer is a means of penetration of the city centre and reduction of the walking time or modal interchange time from heavy rail to the point of origin or destination at a cost that may be lower than for heavy rail or a metro.

Tram or tram train conversion is likely to be part of a package of measures affecting a wide range of factors for example:

- city centre penetration
- elimination of interchange
- new stations
- increased service frequency
- fares and ticketing changes
- new rolling stock.

Some of these changes can be achieved – although this may be at a high capital cost – using heavy rail options and this scoping document has sought to isolate the specific impact of tram train using the example of the Marple line in Manchester. Modelling by Transport for Greater Manchester has been presented to illustrate the specific impact of the tram train. For parties considering tram or tram train conversion these will need to be considered along with the full range of appropriate options to solve the gaps in question. In selecting a tram or tram train conversion option it will be necessary to consider if some or all of the benefits could be achieved more cost effectively with a heavy rail or other public transport solution. Where conversion is chosen it will need to be demonstrated that it is the most cost effective and value for money way to address the transport problem and that the conventional solution either is too costly in those circumstances or is not able to deliver sufficient benefits. Tram or tram train may be a lower cost option to heavy rail where the market is the appropriate size and nature.

A direct cost comparison between tram or tram train and heavy rail is not possible because it depends upon the specific circumstances and the gaps which the objectives of any scheme might seek to address. The conclusions of the analysis of the options is therefore that there are some circumstances in which tram or tram train conversion is more likely to be able to contribute. While tram or tram train may generate operating cost savings, enhancements to the network incur capital and operating costs which will need to be demonstrated to be value for money and affordable. The development of any tram or tram train scheme will need to be done on a case-by-case basis as there is no generic formula particularly because it relates to addressing transport issues which cover the wider transport realm and are not just limited to the existing railway network.

Table 7.1 – Emerging conclusions on tram and tram train conversion

		Circumstance in which tram or tram train heavy rail conversion option can address the identified gap	Circumstance in which tram or tram train heavy rail conversion option is less likely to address the identified gaps
Transport gap which merits intervention and resolution	**Gap A – City centre major station capacity and or capacity on inner suburban routes**	Tram or tram train conversion potentially can and has released heavy rail capacity where services can be diverted onto a city centre tramway. This released capacity must be able to resolve the gap. However, due to the cost of the option, particularly where no tramway currently exists it is unlikely to form the sole reason for conversion based on the foreseeable planning horizons of the established geographical RUSs.	Where no tramway exists, or is planned for creation, it is unlikely that conversion will be viable in comparison with heavy rail options to address this gap alone. This option is unable to contribute where converted services are not appropriate for a tram style vehicle either because of speed, distance travelled, or volumes of passengers conveyed. Tram or tram train conversion will not be able to contribute to these types of gap if the capacity released is either not usable or not required for a more economically useful purpose. Conversion will not be a viable option to resolve a capacity gap if more cost effective heavy rail options are available.
	Gap B – Connectivity with city centres and their suburbs to create new journey opportunities, enable new markets, opportunities for new stations	Where gaps in transport provision exist in an urban context where greater city centre penetration, new stations and access to new markets are facilitated by a tram or tram train in a way which are not feasible or cost effective using a heavy rail solution. This option requires the presence of a tramway. Where one does not exist conversion of heavy rail routes to tram or tram train may form part of the proposals to implement a new tramway network.	Where no tramway exists, or is planned for creation, it is unlikely that conversion will be viable in comparison with heavy rail options. It is noted that the city centre infrastructure for the Manchester Metrolink was justified largely on the basis of converting the Bury and Altrincham lines. In this case however the new on street infrastructure was a relatively short section in the city centre. Secondly, it has subsequently formed a part of the core network which obviously has far wider benefits than the original converted lines. This option is unable to contribute where converted services are not appropriate for a tram style vehicle either because of speed, distance travelled, or volumes of passengers conveyed.
	Gap C – Cost effective way of delivering services or new journey opportunities, enable new markets, opportunities for new stations	For new routes where a tram style vehicle is appropriate using tram or tram train may be more cost effective than heavy rail.	There are circumstances where the capital and operating cost of enhancement and new routes may be lower using a tram train and tram solution. However the cost of conversion and connection cost is thought to be such that savings may not outweigh the cost of conversion.
Market	**Is there a tramway with sufficient capacity to connect to?**	If a tramway exists – the feasibility of the connection to the heavy rail network to facilitate conversion to tram or tram train needs to be established.	If capacity does not exist on the tramway the conversion would have to include the capital cost of any enhancement to the tramway.
		If no tramway exists - conversion of heavy rail infrastructure services is likely to form only a part of any proposal to create a new tramway. Conversion of heavy rail infrastructure or services to tram or tram train may form part of a proposal for a new tramway, since where appropriate routes exist, heavy rail conversion may be cheaper and more beneficial than on street tramway construction. Such conversions have formed part of all new tramways with the exception of the Edinburgh tram system.	Where a tramway is not present, a business case would be required for the creation of a system. This case would be wider than the conversion of elements of the heavy rail network alone.

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Table 7.1 – Emerging conclusions on tram and tram train conversion

		Circumstance in which tram or tram train heavy rail conversion option can address the identified gap	Circumstance in which tram or tram train heavy rail conversion option is less likely to address the identified gaps
Market	Existing heavy rail services	Some conversions may not replace heavy rail services and may only make use of former infrastructure or alignments. Where services are replaced the capacity of the existing services and whether they are diesel or electric will determine firstly the suitability for replacement with a tram style vehicle and any benefits in terms of acceleration over the existing rolling stock.	Any replaced capacity needs to be economically useful and useable if it forms part of the justification of the conversion.
		Residual services - all heavy rail services may be retained or some may be withdrawn that can be replaced by tram style vehicles.	If no services are replaced the conversion will result in an additional operating cost and abstraction of revenue from heavy rail which needs to be factored into the business case.
		Choice between tram and tram train will be determined by whether any residual passenger or freight trains need to operate on the route. Where either remaining services will be very minimal or non-existent a tram may be appropriate. Where residual services are significant and continued interaction with the rest of the heavy rail network is required tram train rolling stock needs to be considered.	Where tram or tram train conversion means that passengers are taken away from a heavy rail interchange for onward connections the conversion will form a disadvantage for those passengers.
	Existing tram services	Capacity must exist or will need to be provided on the existing tramway for example by extending an existing tram service. Any additional costs to provide that tramway capacity will need to be considered in the business case for the conversion of the heavy rail infrastructure.	Any benefits of increased tram frequency need to be isolated as these can be achieved potentially by alternative means other than conversion. Where capacity does not exist on the tramway the cost of additional capacity may be prohibitive if the benefits are too limited.
		Residual services - existing tram services may be extended or they may form additional services if the capacity exists. When considering extending existing tram services to form a tram train route a trade off may be required as tram trains may be more expensive in capital and operating cost terms than trams.	If extensions result in too high a frequency of services in the centre this may form a barrier to extensions without further investment in the tramway infrastructure.
	Route characteristics appropriate for tram or tram train	Demand appropriate for a tram style vehicle.	If the demand is too low for a tram style vehicle it is unlikely that sufficient user benefits will exist to off set the cost of conversion. Where demand rises above that which a tram style vehicle at a reasonable frequency can carry then a heavy rail or metro option is more appropriate. This is likely to apply to many Electric Multiple Unit (EMU) operated routes because of the traffic density that justified the original electrification.
		City centre currently poorly served by existing heavy rail or public transport modes where penetration and benefits of tram or tram train access would be desirable.	A city centre well served by heavy rail routes with a high frequency inner suburban service is less likely to benefit from implementing tram or tram train.
		Route length - passenger journeys need to be no longer than is appropriate for tram style vehicles with a relatively high proportion of standing passengers and no additional facilities such as toilets.	Where the route has passenger journeys which are not appropriate for a high number of standing passengers with no toilets, tram style vehicles are not as efficient a means of carrying passengers because of their short unit length and constrained space.

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Table 7.1 – Emerging conclusions on tram and tram train conversion

		Circumstance in which tram or tram train heavy rail conversion option can address the identified gap	Circumstance in which tram or tram train heavy rail conversion option is less likely to address the identified gaps
Market	**Route characteristics appropriate for tram or tram train**	Stopping density - tram style vehicles have a lower top speed but higher acceleration in particular in comparison with DMUs. This means that routes where they are most advantageous in terms of conversion to heavy rail are ones with dense stopping patterns currently operated by DMUs. This would tend to suggest inner suburban currently DMU operated routes.	Where the distance between stops is higher the lower top speed of a tram will mean that it is not an appropriate vehicle as it will result in a slower passenger journey and an inefficient usage of capacity. There is less benefit in acceleration when a tram is compared to an EMU, this means that there are likely to be fewer benefits in converting routes which are already operated by EMUs.
	New stations	New stations where sufficient demand may be accommodated by the lower cost of construction of tram stop style stations. This cost reduction applies primarily where separated from any heavy rail.	Where insufficient demand exists, or the extra stop would too adversely affect other passenger's journey times new stations will not be justified even if they are lower cost than heavy rail stations. New stations where heavy rail trains still operate will not be able to realise the same extent of saving as where the route is fully segregated. Conversion of existing stations for low floor trams will be an additional cost of conversion.
	Frequency changes	Tram and tram train conversion does not provide an increase in frequency or other expressions of capacity output without a corresponding increase in operating costs. Tram or tram train can facilitate a frequency increase through bypassing congested sections of heavy rail line on the fringe of city centres.	A tram style vehicle is unlikely to be introduced in order to increase capacity because the heavy rail options to lengthen trains provide a higher maximum capacity.
Tramway system	**Connection cost**	The technical, geographic and operating complexity of the connection to a tramway is likely to be one of the major cost drivers of any conversion which will determine its feasibility.	Where the cost of connection is high this is likely to mean that a route is not viable for conversion.
	Capacity	Capacity must exist on the tramway and any capital or operating costs in providing additional capacity to accommodate an extension will need to be factored into the business case.	Where capacity does not exist on the tramway the cost of additional capacity may be prohibitive if the benefits are too limited.

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Table 7.1 – Emerging conclusions on tram and tram train conversion			
		Circumstance in which tram or tram train heavy rail conversion option can address the identified gap	**Circumstance in which tram or tram train heavy rail conversion option is less likely to address the identified gaps**
Heavy rail system conversion	**Traction choice**	The benefit of trams in comparison with DMUs is greater than that of EMUs in terms of acceleration. EMUs are also generally of longer formation and therefore higher capacity. This means conversion of DMU services may bring more benefits. Electrification is likely to form part of the conversion cost because of the types of services appropriate for conversion and the probable absence of a viable self powered tram or tram train. The route for conversion must therefore have sufficient traffic density to justify electrification. The voltage to which a route is electrified would depend on the balance of cost of a tram DC system versus the cost and strategic need for compatibility with 25kV AC heavy rail Overhead Line Electrification (OLE). 25kV AC OLE may be more cost effective over longer distances or for higher speeds because of the reduced requirements for substations and lower transmission loss. These lower costs are balanced against the higher costs of structure gauge clearance.	Where the route for conversion does not have sufficiently dense traffic it is likely that the cost of electrification will be prohibitive. Where a route replaces existing EMUs the benefits may to be more limited in comparison with conversion of DMUs. Bi-mode rolling stock may be prohibitively expensive.
	Rolling stock	Rolling stock will be required to operate the converted services either tram or tram train depending on the conversion type. Orders of sufficient size minimising bespoke designs where practical are more likely to result in affordable rolling stock for a tram or tram train scheme.	The greater the complexity and the bespoke elements of the design the more challenging the affordability of the vehicle becomes. Small order sizes will also compound issues of affordability.
	Platforms	Depending upon the platform height of an existing tramway a choice between high and low floor tram style vehicles will need to be made. The additional heavy rail platform conversion costs of low floor trams would need to be balanced against the potential benefits of a low floor system in an on street environment. For existing tramways the choice is likely to be driven by the floor height of existing trams which with the exception of Metrolink are all low floor. High floor trams are less common than low floor trams and tram trains. This may be an issue for rolling stock procurement but some suppliers do have high floor product ranges.	

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7.4 Alternative methods of delivery of electric traction on lower traffic density routes

A number of possible means for providing electric traction on lower traffic density routes have been considered. They focus on reducing the cost of provision of fixed infrastructure and progressively shifting the balance of spending to the rolling stock in order to reduce the whole life cost of the whole railway system. This approach is not to suggest that conventional 25kV AC OLE is not cost effective, instead it is to address the issue that it may only be appropriate for routes where a sufficient density of traffic is present which give a variable operating cost saving to offset the capital expenditure on OLE infrastructure.

For routes with lower line speeds, other lower cost options such as using 25kV AC trolley wire electrification may be appropriate. This kind of electrification has not been implemented outside of locations such as terminal stations, freight yards, or depots but may be possible for routes with line speeds of less than 60mph. This approach should be considered where appropriate for future electrification schemes but will need to be balanced against the savings in conventional electrification costs that could be delivered through efficiencies and economies of scale.

The emerging conclusions are as follows for the three types of electrification involving progressively larger breaks in the OLE and the usage of energy storage.

7.4.1 Coasting

Coasting can reduce the cost of OLE. Extended neutral sections for electrically powered rolling stock to coast through with physical but not electrical clearance using neutral contact wire to avoid gauge clearance for some structures has been considered. However, it is only appropriate for reducing the cost of gauge clearing structures in locations where no electric train would ever be likely to come to a standstill and become stranded due to the absence of a power source. It imports significant operating risks to the network and will only be able to contribute where these can effectively be managed. Where technically and operationally feasible the process outlined in **Chapter 6** that has been used to reduce the cost of the Paisley Canal line proposed electrification scheme is recommended. This makes use of gauging around the passenger trains on the route and has proposed remote earthing to take isolations for freight trains which would have mechanical but not electrical clearance at some points on the route.

7.4.2 Discontinuous electrification

Discontinuous electrification could in theory also reduce the cost of structures but may require bespoke rolling stock with energy storage installed to allow trains to cross the gaps in the OLE. Based on Technical Strategy Leadership Group (TSLG) research this solution would appear not to have a high level business case with current energy storage prices. This is because the cost of energy storage and increased complexity of rolling stock does not outweigh the avoided cost of infrastructure. Secondly, the complexity of operating a route with large numbers of small gaps in the OLE is challenging and may not, above a certain number and frequency, be operationally feasible.

7.4.3 Discrete electrification

The analysis of this option in **Chapter 6** has undertaken a market study based on lower speed diesel operated routes and the extent of current and committed electrification. Discrete electrification involves the use of energy storage, assumed to be batteries, to power a train across a gap in electrification. Batteries have been assumed because of their balance of acceleration and range. The technology of batteries is still developing and is not certain in its price or capability. The analysis has considered the high level market size for conversion based on two factors:

1. the price of battery energy storage
2. the range of the battery away from the OLE with the ability to recharge within the current timetable and rolling stock diagrams.

In order to take account of development of the technology over the 30 year time horizon of the RUS an aggressive assumption about the maximum range has been assumed. This was in order to establish a possible market size if the technology was to develop to this point. The analysis of the affect of price took an upper maximum range of 75 miles for operating away from OLE either between electrified areas or as a round trip. The 75 miles distance would assume a straight conversion of the estimated number of units allocated to each service. The analysis found that at the upper estimates of cost of energy storage no cases were viable. However, there is the potential for a saving over DMU operation to exist as the price approaches the lower end of the range of estimated costs. Over time it is uncertain how energy storage costs will reduce and how performance will improve. Whilst there are expectations of substantial cost reductions, this strategy has not sought to address this question. Instead the scoping document has considered the point at which the price would have to fall to be economically useful for the rail industry. The numbers of units is intended as a guide to orders of magnitude rather than absolute routes. This is because the impact of the numbers of batteries and vehicles purchased on the unit cost of energy storage in the rail sector may be considerable.

The analysis of the factors affecting the energy storage business case found that the less utilised the rolling stock in terms of annual average miles per vehicle the fewer variable savings result and therefore the less likely to favour conversion to battery power from DMU. The analysis includes factors such as:

- peak strengthening
- low speed
- turn around time in diagrams
- the percentage of maintenance spare cover in a fleet.

The analysis did not take into account any capital costs associated with conversion from DMU which might include additional OLE in locations such as bay platforms and power supply strengthening in charging locations. Any additional capital cost will increase the fixed cost hurdle which the variable cost savings must overcome to be financially positive.

Battery range away from the OLE but with a recharge time that could at worst match the current timetable and rolling stock diagrams was used to understand the impact of capability on the potential high level market size for energy storage vehicles. Any factor that increased the unit requirement for a given service based on the price analysis was assumed to mean that a positive financial case would be made challenging.

A linear relationship was found between the distance travelled away from the OLE under battery power and the number of vehicles which might in theory be potentially converted from DMU to battery power. While this is in some senses a statement of the obvious what it suggests is that there are not a cluster of services with say a requirement for 30 miles range away from the OLE. This means that there does not appear to be a threshold distance which if achieved would see the potential to convert proportionally larger number of DMU vehicles. It also means that batteries would appear to be the appropriate technology with their balance of range as well as acceleration. This is because if a short range of say less than 5 miles was the maximum a particular energy storage technology was capable of without additional infrastructure there would be limited potential to convert units from DMU operation.

The main conclusion in addition to battery range criticality is that based on the proportion of electrification for most of the routes, charging time – or the ability to replace depleted batteries quickly - would also be critical as it is not likely to be economic to convert DMU services if there is a requirement to increase the number of units to operate a given service.

There are also other potential uses and benefits of energy storage which could be used to avoid the need for power supply strengthening by smoothing out the peak power requirements of EMUs. These additional benefits have not been considered because they are hard to quantify and this is a high level market assessment focusing on discrete electrification. The technology could also be employed in different ways to the ones considered to hybridise self powered rolling stock to increase fuel efficiency as has been done in the automotive industry. However, it is important to understand that the case for conversion to hybrid vehicles in the bus industry has been undertaken on the basis of an environmental case rather than a purely financial case.

The time horizon of this strategy is 30 years and within that timeframe it is far from certain how both capability and the price of energy storage technology will progress. However, if suppliers are able to provide technology at a price which has been indicated and of a sufficient capability then there is the potential for a market to convert DMU operated services to independently powered EMUs using batteries which power them away from the OLE and which and are charged when under the OLE.

This scoping document recognises the ongoing role of conventional electrification in improving the capability, cost-effectiveness and performance of the railway. However, this is not to suggest that conventional electrification is not cost effective, instead it is to recognise that it may only be appropriate for routes where a sufficient density of traffic is present. Consequently the rail industry needs to keep track of developments in energy storage technology and to understand better the potential operational implications so that it can take advantage of it should the cost and capability improve to make it a viable proposition. Similarly the industry needs to continue to investigate opportunities to reduce the cost of conventional electrification.

7.4.4 Community rail

Since its inception community rail has introduced new ways of increasing ridership and economic benefit to local communities. Options have been considered for the potential role of community rail in obtaining value for money for the railway and encouraging greater involvement of the local community in the local railway. These options recognise that the history of community rail's achievement focuses on means to increase ridership and revenue. There have also been successful examples of involvement in developing rail routes and services.

These outcomes are to be welcomed and have been expanding with four new Department for Transport (DfT) designated routes in 2011 alone. The objectives of community rail are endorsed by the rail industry and its funders who would therefore wish to see the concept extended. However, as has been noted a number of times in this scoping document, the railway industry cannot impose partnership so its main role is to facilitate partnerships and work with those groups and partnerships that do emerge.

7.5 Summary

Alternative solutions are not appropriate in all instances and are not a panacea but they do have roles which they can fulfil. This is no different from conventional heavy rail solutions which are also good at certain functions but are not appropriate for all transport problems. Thus far the RUS scoping document has analysed three specific areas in tram and tram train, innovative electrification and community rail. It has sought to identify the circumstances in which these solutions can contribute to addressing gaps. The aim of identifying the areas in which these solutions might contribute is to focus the resources of the rail industry and its stakeholders. This might enable more effective targeting of particular gaps or enable suppliers to develop solutions further based on the needs of the rail industry.

In concluding the scoping document for consultation it is important to note that some of the solutions that have been considered are in part outside of the area of core experience of Network Rail. The experience of tram operators or from different sectors such as automotive has been sought in producing this document. In recognition of the contribution that others might be able to make to a two stage consultation approach has been proposed which is outlined in more detail in the next chapter, **Chapter 8** which explains the consultation arrangements for this scoping document and invites feedback and input in developing this strategy.

8 Consultation and Next Steps

8.1 Stakeholder consultation

Consultation with stakeholders is essential to the successful development of a Route Utilisation Strategy (RUS). Close involvement of stakeholders helps to ensure that:

- The correct gaps are identified
- the widest range of options is considered
- the delivery of the outcomes is faster.

It is recognised that in considering alternative solutions there may be a wide range of views and experience from other industries and contexts which may be relevant to the issues that are addressed by this RUS workstream. We welcome input from all perspectives to ensure that the strategy is able to draw upon the most appropriate solutions for catering for future rail passenger demand in a more cost effective manner.

Unlike other RUSs it is therefore proposed to have a two stage consultation process. The first consultation on this scoping document poses an emerging conclusion to which consultation responses are welcomed both in the generality and to some specific questions. The specific questions consultees are invited to respond to are:

1. Have the appropriate options been considered to address the gaps raised in this document and if not what other or different options to address those gaps would you consider to be appropriate and why?

2. Has the analysis of the options considered the appropriate factors? If there are further factors that should be considered please provide evidence where possible.

3. Do you agree with the emerging conclusions that have been reached on the basis of the analysis of the options?

Following a 60-day consultation period, the responses will be considered and further analysis will be undertaken as appropriate. A draft for consultation will be developed and will be consulted upon in the same manner as other workstreams that have formed the Network RUS.

The recommendations of a RUS – and the evidence of relationships and dependencies revealed in the work to arrive at them – form an input into the strategic decisions made by the industry's funders.

8.2 How you can contribute

We welcome contributions which will help us develop this RUS. This scoping document has a consultation period of 60 days. The deadline for responses is therefore 30 April 2012 although earlier responses would be very much appreciated. After this period, Network Rail will consider each of the responses it receives and, where appropriate, undertake further work to the RUS in discussion with the Working Group. Having considered the consultation responses and potentially undertaken further work, a second consultation draft will be issued for a 60 day consultation. In response to this second consultation a final strategy will be published.

Consultation responses can either be submitted electronically or by post to the addresses below:

NetworkRUSAlternativeSolutions@networkrail.co.uk

Network RUS Consultation Response
Network Rail
4th Floor, Section O
Kings Place
90 York Way
London
N1 9AG

Please be aware that all responses will be posted on our website.

The final RUS will become established 60 days after publication unless the Office of Rail Regulation (ORR) issues a notice of objection in this period.

References

- ACORP, Making a difference – the value of community rail volunteering report, July 2009
- ACORP, The Value of Community Rail Partnerships, June 2008
- Business Enterprise and Regulatory Reform, Energy White Paper, 'Meeting the Energy Challenge', May 2007
- Business Enterprise and Regulatory Reform, Energy consumption in the United Kingdom, 2008
- DfT, Rail White Paper, 'Delivering a Sustainable Railway', 2007
- DfT, Rail Technical Strategy, 2007
- DfT, Low Carbon Transport Innovation Strategy, 2007
- DfT, Review of Community Rail Development Strategy, 2007
- Realising the Potential of GB Rail, Final Independent Report of the Rail Value for Money Study, Detailed Report, 2011
- DfT, Green Light for Light Rail, 2011
- Network Rail, Tram Train Trial Project Route Selection Report, 2008
- Network Rail, Network RUS: Electrification, 2009
- Network Rail, Tram Train Trial Interim Learning Report, 2010
- Network Rail, Network RUS: Passenger Rolling Stock, 2011
- ORR, Railway Safety Publication 2, Guidance on Tramways, 2006
- ORR, Guidelines on Route Utilisation Strategies, 2009
- RSSB, T633, Study on Further Electrification of Britain's Railway Network, 2007
- RSSB, T777, Understanding the effect of 'gaps' in electrical continuity of the traction contact system Gaps in electrical conductivity of the overhead line AC traction system, 2010
- RSSB, T779 – Energy storage systems for railway applications – Phase 1, 2010
- RSSB, T779 – Energy storage systems for railway applications – Phase 2, 2010
- RSSB, Potential to reduce the cost for electrifying GB railways, 2011
- SRA, Community Rail Development Strategy, 2004
- Transport Scotland, Strategic Transport Projects Review, 2008
- Welsh Government, National Transport Plan, 2010

Glossary

ACORP – Association of Community Rail Partnerships

ATOC – Association of Train Operating Companies

CCTV – Closed Circuit Television

CLDG – Clitheroe Line Development Group

Control Period – Network Rail five year funding period e.g. Control Period 4 is from 2009-14

CRP – Community Rail Partnership

D&C – Devon and Cornwall

DCRDF – Designated Community Rail Development Fund

DfT – Department for Transport

DMU – Diesel Multiple Unit

EMC – Electro Magnetic Compatibility

EMU – Electric Multiple Unit

EVRDC – Esk Valley Railway Development Company

Forecast – an estimate of patronage in a given future year

Franchise – Public Service Contracts for passenger rail services operated by Train Operating Companies for defined periods

Gauge – the physical clearance between vehicles and structure close to the track

GPS – Global Positioning System

GSM-R – Global System for Mobile Communications-Railway

Hbf – Hauptbahnhof (main station)

HLOS – High Level Output Statement, the Secretary of State for Transport (for England and Wales) and

Scottish Ministers (for Scotland) are obliged to send to the ORR a high level output specification (HLOS) and a statement of funds available, to ensure the railway industry has clear and timely information about the strategic outputs that Governments want the railway to deliver for the public funds they are prepared to make available. ORR must then determine the outputs that Network Rail must deliver to achieve the HLOS, the cost of delivering them in the most efficient way, and the implications for the charges payable by train operators to Network Rail for using the railway network
kWh – kilowatt hour
MTI – Market Town Initiative
Multiple Unit – a train formed of two or more vehicles with traction power distributed throughout the train. Some multiple units can be coupled together with other multiple units to form a longer train at times of peak demand
NPV – Net Present Value
OLE – Overhead Line Electrification
ORR – Office of Rail Regulation
PTE/PTA – Passenger Transport Executive/Authority
PTEG – Passenger Transport Executive Group
RFG – Rail Freight Group
RIA – Railway Industry Association
ROSCOs – Rolling Stock Companies
RSSB – Rail Safety and Standards Board
RUS – Route Utilisation Strategy
RVAR – Rail Vehicle Accessibility Regulations
RVfM – Rail Value for Money
SMG – Stakeholder Management Group
SRA – Strategic Rail Authority (no longer in existence and replaced by DfT)
STPR – Scottish Transport Projects Review

TENS – Trans European Networks
TfL – Transport for London
TOC – Train Operating Company
TSLG – Transport Strategy Leadership Group
VTAC – Variable Track Access Charges
WG – Welsh Government

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