May 2011

Network RUS: Passenger Rolling Stock

Draft for Consultation

Network Rail

Foreword

I am pleased to present the latest output from the Network Route Utilisation Strategy workstream: a draft strategy for passenger rolling stock procurement and associated infrastructure planning. The document has been produced in conjunction with train operators, representatives of customers, manufacturers and rolling stock owning groups as well as the Department for Transport, Transport Scotland, the Welsh Assembly Government, The Passenger Transport Executive Group and Transport for London.

Under whichever structure the British railway network has been organised, the alignment of passenger rolling stock procurement with a) customer needs and expectations and b) the characteristics of the railway infrastructure has always been complex. The historical development of the railway saw different track and loading gauges, different platform heights and lengths, different signalling systems, different braking systems, different types of electrification, different lengths of vehicles, different policies on maximum gradients (affecting train weights and speeds), different interior layouts of rolling stock, different operating practices, and so on and so forth. Indeed, several of these differences were originally intended deliberately to prevent competition from other companies.

Whilst, over the years, many attempts have been made to homogenise both rolling and fixed assets, only seldom since the original construction of lines have the two been considered together; and almost never across the network as a whole. This reflects, in part, the differing life expectancies of the various assets. As a result, there exists a plethora of varying types of rolling stock, to a degree incompatible with each other, and often constrained to discrete parts of the network. This in turn has resulted in considerable inefficiencies in rolling stock procurement, as fleets, recently in particular, have tended to be ordered in small, bespoke batches.

Extreme complexity, however, is no reason for inaction, inertia or quiescence. The need safely to drive inefficient costs out of the industry is paramount. This draft RUS concludes that, over the next two generations of new rolling stock, potentially hundreds of millions of pounds could be saved.

Its conclusions are entirely consistent with the findings of the recently published Rail Value for Money Study by Sir Roy McNulty.

To achieve this will require the procurement of rolling stock to be fully aligned with planning the capability of the infrastructure across the entire network. Piecemeal approaches, or approaches which give low priority to whole-life whole-industry costs, to operational flexibility, or to the interface between wheel and rail, are unlikely to prove efficient.

Going forward, we seek to work with our industry partners and, through engagement with the Rail Delivery Group, to take on the challenge of driving out unnecessary cost from the planning of future rolling stock, together with the infrastructure to accommodate it, to the ultimate benefit of passenger and taxpayer alike.

Paul Plummer

Director, Planning and Development

Executive Summary

Passenger rolling stock costs are currently in the order of £1.8 billion per year. This represents around 15 per cent of the annual costs of operating the railway as a whole. The Network Route Utilisation Strategy (RUS): Passenger Rolling Stock document has taken a long term view of future passenger rolling stock and the infrastructure it operates over to establish whether there is potential to plan the railway more efficiently.

Other than the Freight RUS, which was established in 2007, the Network RUS is the only RUS which covers the entire network. Its network-wide perspective, supported by a stakeholder group with network-wide expertise, enables the development of a consistent approach to issues which underpin the development of the network. It is intended that the outputs of this RUS will be used in subsequent industry planning, thereby ensuring that the key issues will be dealt with consistently.

The Network RUS is overseen by a Stakeholder Management Group consisting of Network Rail, Department for Transport (DfT), Transport Scotland, the Welsh Assembly Government, Transport for London (TfL), the Passenger Transport Executive Group (PTEG), the Association of Train Operating Companies (ATOC), freight operating companies, Passenger Focus, London TravelWatch, the Rolling Stock Companies (ROSCOs), the Rail Freight Group and the Freight Transport Association. The Office of Rail Regulation (ORR) attends the Stakeholder Management Group meetings as an observer. The Passenger Rolling Stock workstream was developed by a Working Group consisting of Network Rail, ATOC, DfT, Transport Scotland, Passenger Focus, PTEG, ROSCOs, TfL and The Railway Industry Association (RIA) (representing a number of train manufacturers), again with the ORR as observer.

Despite the unique role of the Network RUS in the RUS programme, the approach followed is similar to other RUSs by considering the current situation, drivers of change, gaps and options to address the gaps. It has considered stakeholder aspirations, including those who use, fund, procure, operate and build rolling stock.

The passenger network is currently operated by more than 12,000 vehicles, divided into 64 different rolling stock classes. There have been more than 5,000 new vehicles introduced since 1996, and substantial new orders for long distance high speed, Thameslink and Crossrail vehicles are expected in the near future. A large proportion of the fleet, however, is considerably older. Historically the railway has considered commercial asset life as a nominal 30 years for diesel trains, and 35 years for electric trains. In theory, over the next ten years a quarter of the fleet would need to be replaced on this basis. Recent research suggests that rolling stock can be life extended considerably. If the life of much of the stock were to be extended for five years, 12 per cent of the fleet would need to be replaced in that period. In addition, if the rail industry were to accommodate the forecast growth in usage, it would require additional vehicles. Given that the Competition Commission reported that the average cost of a vehicle in recent years has been around £1.1 million[1], this would involve considerable outlay at a time when the industry and its funders are striving to bring down costs.

The draft strategy concentrates on the opportunities for efficiencies which arise when purchasing new rolling stock. It considers how planning the rolling stock and infrastructure together can enable the network to become more inter-operable to enable rolling stock which serves a particular market sector to go anywhere on the network it is required.

The key principles used to develop the strategy are:

a) Exploit the economies of scale in procurement wherever feasible
b) meet the needs of each market sector when ordering rolling stock
c) consider those infrastructure works needed to allow the rolling stock to be inter-operable within the market sector it serves
d) consider the phasing of future rolling stock procurement and infrastructure planning, including the potential for extending the life of existing vehicles.

[1] Recent reports from a number of ROSCOs suggest that this figure may be conservative.

The strategy is purposely kept at a high level to identify the principles of what can be achieved. It avoids the detailed specification of trains, other than to identify the key needs of each market, highlighting key economies of scale which help to reduce production costs and those physical characteristics of the trains and infrastructure which enable rolling stock to be more inter-operable across the network. It is anticipated that train operating companies would be involved in the detailed specification of trains, giving them the ability to be innovative in the product that they bring to the market. Particularly through re-franchising where it offers value for money.

Information provided by a number of train manufacturers through RIA, suggests that there are considerable economies of scale to be had from reducing the variety of different rolling stock designs. Based on this information, it is estimated that in the region of £75 million or eight per cent of the average procurement cost is spent on non-recurring costs including research and development of bespoke rolling stock.

Whilst a reduction in the number of train types is attractive in theory, it only becomes attractive in practice if the train types procured match the needs of the market and can operate freely on the network where they are required. With this in mind, the RUS Working Group considered the passenger and operational needs of the main market sectors and concluded that there was a need for three distinct categories of train:

a) Type 1: long distance high speed
b) Type 2: interurban, regional, outer suburban and a variant for rural services
c) Type 3: inner suburban.

Passenger requirements were considered throughout.

The RUS then continues to identify the infrastructure works that are required to enable inter-operability within a market sector. It looks at where trains of each sector might be expected to operate. A map of the network is presented which shows that it is a complex picture – with many lines being used by more than one market sector and by freight services. Having identified the routes on which the rolling stock will operate, it considers what gauge, platform length, route availability and platform stepping distance issues would need to be considered to ensure inter-operability.

Given that freight operates over much of the network and that the Network RUS: Electrification has established a case for electrification of much of the network, freight gauges and electrification clearances will remain an important determinant of gauge but passenger rolling stock vehicle length will also need to be considered.

The RUS recommends that further work is carried out to specify passenger vehicles which meet the aspirations of each market sector and to a gauge which would enable inter-operability between routes. It takes the current procurement processes for the Intercity Express Programme (IEP), Thameslink and Crossrail as a starting point and concentrates on the remainder of the network. It proposes that the rail industry develops a standard kinematic envelope from an understanding of both the passenger and Train Operator needs as well as the infrastructure. The analysis in the RUS suggests that a 23 metre vehicle could be deployed across a considerable amount of the network with relatively low costs for infrastructure interventions. It is envisaged that a 20 metre variant might be required for those parts of the network where a business case for 23 metre vehicles could not be made.

Finally, the RUS considers the phasing of the strategy. The manufacturers represented by RIA suggest that up to 20 per cent of procurement costs could have been saved between 1988 and 2010 if there had been continuity of orders. Whilst this is a sizeable figure, the maximum savings are unlikely to be achieved in the future, primarily because a number of factors preclude a smooth procurement profile:

- Budgets in any financial year will be determined by affordability
- rolling stock procurement often occurs in conjunction with franchise replacement
- the need to phase rolling stock procurement with infrastructure upgrades such as Thameslink and Crossrail.

This makes it difficult to smooth the procurement profile to achieve maximum savings.

It is recommended that the benefits of maintaining continuity of rolling stock production are considered at an early stage in refranchising, which is the main influence of fleet size and deployment of rolling stock as well as enhancement programme developments. The detailed requirements for the development of the infrastructure should be included in Network Rail's Route Specifications.

It is further recommended that the gauging work required to accommodate trains of each type should be carried out at the same time as other gauging activity on the route. As a guiding principle, a structure should only be re-built once. If it needs to be gauge cleared for freight or electrification (in line with the Strategic Freight Network or the Network RUS: Electrification strategies), this work should be done at the same time, ensuring that the new design is consistent with all three strategies.

The Working Group would welcome responses to this draft for consultation and details of how to respond can be found in **Chapter 8**.

Contents

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 working 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 publication, Scotland's Railways. The recommendations of a RUS and the evidence of relationships and dependencies 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).

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 document starts by describing, in **Chapter 2**, the role of the Network RUS in the RUS programme. It describes the scope of the Network RUS: Passenger Rolling Stock Strategy including the key issues which it will consider and the time horizon which it addresses. It outlines the policy context and the relationship between the RUS and related policy issues which are being considered concurrently by our funders.

Chapter 3 presents the baseline for this study. It describes the current passenger rolling stock fleet, the market sectors which they serve and the needs of passengers.

In **Chapter 4** the drivers for change are set out, and in **Chapter 5** the Draft for Consultation describes the gaps and options relating to passenger rolling stock and the infrastructure.

Chapter 6 outlines the options which were proposed by the RUS Working Group to bridge the gaps identified and in **Chapter 7** outlines the emerging strategy of the Draft for Consultation.

Finally, **Chapter 8** describes the consultation process and invites comments from stakeholders. It also outlines the next steps that will be undertaken before final publication and establishment with the ORR.

2 Scope and planning context

2.1 The role of the Network RUS within the RUS programme

Other than the Freight Route Utilisation Strategy (RUS) which was established in May 2007, the Network RUS is the only RUS which covers the entire network. Its network-wide perspective – supported by a stakeholder group with network-wide expertise – enables the development of a consistent approach on a number of key strategic issues which underpin the future development of the network.

The unique nature of the Network RUS, the broad range of its stakeholders and its inevitable interface with other key strategic workstreams make it somewhat different from the geographical RUSs. As a result, the Network RUS team has developed a meeting structure, industry consultation and programme to ensure that it too produces key, timely and thoroughly consulted deliverables.

There are currently five Working Groups of the Network RUS, some of which have already been published and been established with the ORR:

- Working Group 1 – Scenarios and long distance forecasts (published and established)
- Working Group 2 – Stations (consultation published)
- Working Group 3 – Passenger rolling stock and depots
- Working Group 4 – Electrification (published and established)
- Working Group 5 – Alternative solutions to efficiently delivering passenger demand (work commenced 2010).

2.2. 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, which will be used in subsequent industry planning, thereby ensure that key issues are dealt with consistently throughout the RUS programme.

It enables strategies to be developed which by their very nature cross RUS boundaries (eg the development of future rolling stock families and electrification) or benefit from the development of strategies for best practice for different sectors of the railway.

2.3 Organisation: Stakeholder Management Group and Working Group

In common with all other RUSs, 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
- Freight Transport Association
- London TravelWatch
- Passenger Focus
- Passenger Transport Executive Group (PTEG)
- Rail Freight Group
- Rolling Stock Companies (ROSCOs)
- Transport for London (TfL)
- Transport Scotland (TS)
- Welsh Assembly Government (WAG)
- 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 Working Groups manage each workstream as if it were a 'mini' RUS. 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 'mini RUS' 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.

2.4 Network RUS workstreams

The first meeting of 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 Passenger Rolling Stock Working Group consists of members of the following organisations:

- ATOC
- DfT
- Network Rail
- Passenger Focus
- PTEG
- Railway Industry Association (RIA)
- ROSCOs
- TfL
- Transport Scotland
- Welsh Assembly Government
- ORR (in the capacity of observer).

2.5 Time horizon

The Network RUS takes a thirty year perspective to be 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 Project Review (2008).

2.6 Planning context

The DfT published its 'Delivering a sustainable railway' White Paper in July 2007. It provided a vision for the next thirty years for rail planning in England and Wales. Over this period, it envisaged a doubling of passenger numbers and of freight transported by rail. It envisaged a railway which would expand to meet the increased demand, reduce its environmental impact, and meet increasing customer expectations, whilst at the same time continuing to improve its cost efficiency.

The White Paper stated the case for future rolling stock investments and suggested that a fleet with an average age of 15 years created the right balance between customer and environmental considerations. It said that:

> "Investment in new rolling stock is an important part of improving the customer environment".

The DfT's 'Rail Technical Strategy' was produced to accompany the White Paper. The strategy brings together a long-term vision of the railway which optimises the use of existing technology and predicts the impact of new technology.

It identifies a number of long term themes for change:

- Optimised track-train interface
- high reliability, high capacity
- simple, flexible, precise control system
- optimised traction power and energy
- an integrated view of safety, security and health
- improved passenger focus
- rationalisation and standardisation of assets
- differentiated technical principals and standards.

The most directly relevant theme to this RUS is the optimisation of the network. This highlights that the railway is multifunctional and is required to serve the passenger market sectors as well as freight. The strategy envisages a network that can be considered in the following segments:

- a "multifunctional core" which is capable of carrying any kind of traffic
- a "suburban metro" railway, which is optimised to provide high capacity
- a "regional" railway, which is optimised for lower cost.

A number of other themes, however, are relevant, notably the optimisation of the track-train interface theme which makes reference to a vision of light but strong rolling stock and the 'high reliability, high capacity' theme.

The strategy expresses that customer needs and expectations will change substantially over a 30 year period. It says:

> "what is accepted now in terms of service quality is unlikely to be acceptable in thirty years"

The strategy asserts that the average passenger will change. They will become taller, wider and older than now. The future of the railway sees a transport sector that needs to accommodate high demand.

2.7 Scope of this RUS

The RUS takes a long term view of future passenger rolling stock and the infrastructure it will operate over to establish whether there may be potential to plan the railway more efficiently. It has considered stakeholder aspirations, including those who fund, procure, operate and build the rolling stock.

The RUS seeks to enhance the understanding of the issues regarding rolling stock passenger needs and the infrastructure required to accommodate them. Specific aims agreed by the SMG are:

- To determine the baseline which will include the characteristics and disposition of rolling stock that currently operates on the network. The baseline will include maps showing the routes on which existing rolling stock (suitably grouped) currently runs
- to develop an understanding of the generic passenger requirements relating to rolling stock according to different market sectors (e.g. long distance and suburban)
- to use the evolving Strategic Freight Network Strategy to understand synergies with the requirements for freight
- to identify the drivers of change that impact upon passenger rolling stock design and usage across the network. These drivers may arise from changes in the passenger needs of each market sector and a combination of operational, environmental (e.g. carbon), legislative, infrastructure and technology driven requirements. It will also take cognisance of the established Network RUS electrification strategy
- to identify options for rolling stock and infrastructure, in light of the possible technical and environmental issues faced by the rail industry
- to evaluate future rolling stock / infrastructure options on a whole industry whole life cost basis
- to identify a longer term rolling stock and related infrastructure “specification” for each route. A case study will initially be used to test and refine the methodology.

The business case will be evaluated against a base of do-nothing, and appraised according to current DfT guidelines. A preliminary evaluation of schemes will establish a priority list for appraisal.

As mentioned in **Chapter 1**, the RUS outcome will help inform the Department for Transport (DfT) and Transport Scotland's High Level Output specifications.

This RUS takes into account relevant findings from a number of on-going workstreams, notably the DfT’s Technical Strategy Leadership Group (TSLG), and the on-going technical and strategic thinking underlying the development of a new Intercity Express train have been recognised.

3 Baseline

3.1 Current vehicles over the network

In Great Britain, most passenger rolling stock is owned by Rolling Stock Companies (ROSCOs) and leased to passenger Train Operating Companies (TOCs). Passenger rolling stock falls into three broad types: locomotive hauled vehicles, electric multiple units (EMUs) and diesel multiple units (DMUs). Multiple unit sets are self-contained for power, with a driving position at each end. Within each of these types there are individual classes, typically manufactured over a period of one to four years. Vehicles or units within a class share characteristics of vehicle length, traction arrangements and door position. It is possible to couple together units of the same class, and in some cases units of different classes can couple with each other, in order to create a longer train under the control of one driver.

The size and disposition of the rolling stock fleet varies over time, with the withdrawal of older vehicles, and the introduction of new vehicles. The allocation of vehicles within and between TOCs also changes over time. The baselining information presented here provides a snapshot at December 2010. It includes vehicles leased by TOCs, as well as vehicles which are potentially useable and in store.

3.1.1 Passenger rolling stock fleet size

As of December 2010, the total rolling stock fleet comprised over 12,200 passenger carrying vehicles, made up of approximately 1,200 locomotive hauled vehicles, 8,100 vehicles in electric multiple units and 2,900 vehicles in diesel multiple units. The predominant type of vehicle is the EMU, which makes up about 66 per cent of the fleet, with DMUs comprising about 23 per cent and locomotive hauled vehicles (including DVTs) about 10 per cent. The number of passenger vehicles, and, in the case of multiple units, the number of units, in each class, are shown in **Tables 3.1**, **3.2** & **3.3**.

Table 3.1 – Passenger locomotive hauled vehicles

Class	Grand Total
Mk2 coach (night stock)	22
Mk3 coach High Speed Train (HST) – excluding Class 43 power cars	716
Mk3 coach	178
Mk3 coach (night stock)	61
Mk4 coach (including Driving Van Trailers) – excluding Class 91 power cars	271 (302)
Grand Total (including Driving Van Trailers)	**1248 (1279)**

Table 3.2 - Diesel multiple units

Class	Number of vehicles	Vehicles per unit	Number of units
121	2	1	2
139	2	1	2
142	188	2	94
143	46	2	23
144	30	3	10
144	26	2	13
150	48	3	16
150	226	2	113
153	70	1	70
155	14	2	7
156	228	2	114
158	57	3	19
158	280	2	140
159	90	3	30
165	81	3	27
165	96	2	48
166	63	3	21
168	20	4	5
168	27	3	9
170	267	3	89
170	86	2	43
171	44	2	22
171	20	2	10
171	24	4	6
172	48	2	24
172	45	3	15
175	22	2	11
175	48	3	16
180	45	5	9
185	153	3	51
220	136	4	34
221	200	5	40
221	16	4	4
222	42	7	6
222	85	5	17
222	16	4	4
Grand total	**2891**		**1164**

Table 3.3 - Electric multiple units

Class	Number of vehicles	Vehicles per unit	Number of units
313	192	3	64
314	48	3	16
315	244	4	61
317	288	4	72
318	63	3	21
319	344	4	86
320	66	3	22
321	468	4	117
322	20	4	5
323	129	3	43
332	25	5	5
332	36	9	4
333	64	4	16
334	120	3	40
350	268	4	67
357	296	4	74
360	84	4	21
365	160	4	40
375	30	3	10
375	408	4	102
376	180	5	36
377	708	4	177
377	84	3	28
378	228	4	57
379	240	4	60
380	64	4	16
380	66	3	22
390	44	11	4
390	468	9	52
395	174	6	29
442	120	5	24
444	225	5	45
450	508	4	127
455	548	4	137
456	48	2	24
458	120	4	30
460	64	8	8
465	588	4	147
466	86	2	43
483	12	2	6
507	96	3	32
508	117	3	39
Grand total	**8097**		**2029**

3.1.2 Vehicle characteristics

There are a number of characteristics which distinguish the various classes of rolling stock in operation on the network. These include maximum speed, number of vehicles which operate in formation, seating capacity and weight of unit. Vehicle dimensions also vary between classes. **Appendix A** details the passenger rolling stock fleet characteristics.

3.1.3 Maximum speed

The maximum speed at which the various classes of existing rolling stock operate is often lower than their maximum capability because of restrictions imposed by infrastructure. In the case of locomotive hauled stock, the maximum speed is dependent upon the capability of the locomotive power and the brake force of the coaches. Rolling stock currently falls into three categories of speed.

There are a few classes with a maximum speed of 70mph, such as the Class 314 and Class 378, which are usually, although not exclusively, deployed on services where sustained running at higher speeds is precluded either by the stopping pattern or by line speed constraints. Rolling stock with a maximum speed of 75mph typically operates on inner suburban, rural and shorter distance regional services. Approximately 40 per cent of DMUs and 32 per cent of EMUs are in this category.

A significant number of vehicles run at a maximum speed of 90mph or 100mph. Classes in this range are generally deployed on services with longer distances between stops, and over routes where the maximum line speed is higher. This is typically on outer suburban, regional or interurban services. This is the predominant category for multiple units which comprise approximately 42 per cent of DMUs and 62 per cent of EMUs.

The fastest rolling stock currently on the GB domestic network has a maximum operating speed of 125mph, or a design speed of 140mph in the case of Mark 4 and Class 390 vehicles. However, existing infrastructure constraints preclude running at more than 125mph on routes other than High Speed 1 (HS1). The fastest rolling stock is generally deployed on inter city type services, although extensions to these services run beyond the core long distance high speed routes. Most daytime locomotive hauled rolling stock falls into this category. The proportion of DMUs and EMUs (by vehicle) in the highest speed category is approximately 20 per cent and 7 per cent respectively.

3.1.4 Number of vehicles per train

Diesel multiple unit formations vary from one to seven vehicles in length, with the majority of DMUs formed as two-car units, reflecting the lower levels of traffic of the routes on which they operate. There are single car units which operate on routes with very low traffic, and four, five and seven-car units which operate on longer distance services with higher loadings.

The majority of EMUs are formed as four-car units. Certain classes have longer formations. The current longest are up to nine-car. However, some Class 390s are currently being lengthened to increase formations to 11-car.

The minimum length of an EMU which draws its current from the third rail is two-cars. Even if the demand on such an electrified line were low enough to require no more than a single vehicle, it would not be practical to use a single car unit unless it had an auxiliary power source. A single vehicle would be short enough to be in danger of stopping in a position where none of its shoes were in contact with the conductor rail, and therefore would be unable to move. In the case of EMUs which draw current from the overhead line, the minimum length currently operated is three cars (although there have been two-car units in the past) which reflects the demand typically seen on such routes.

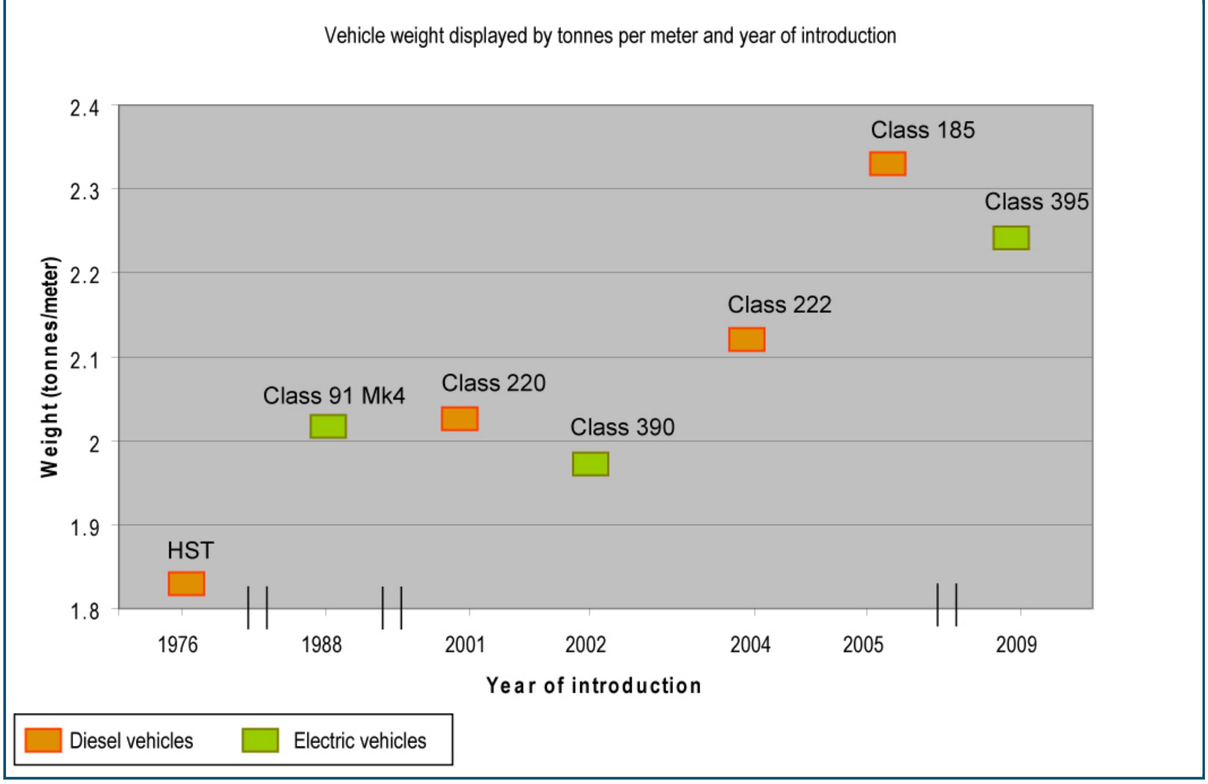
3.1.5 Seating capacity

The seating capacity of an individual unit will depend on the door position, the interior design of the rolling stock, the density of seating and the use of space within the vehicle while providing for other customer requirements, such as luggage space, guard's office, catering provision and toilets. The capacity can vary significantly between individual units or vehicles in a class, because of differences in interior layout, and can often be changed during the lifetime of the vehicle. The interior layout will be influenced by the type of journey for which the train is used. Longer distance services generally have a medium density of seating, with higher densities for shorter distance services. Some rolling stock used on inner suburban services has a higher proportion of space for standing passengers.

3.1.6 Vehicle weight

Vehicle weight is influenced by design, the materials used in its construction and the provision of on-board facilities such as air conditioning and retention tank toilet systems. **Figure 3.1** shows that the tendency has been for the vehicle weight to increase over time, reflecting features such as additional on-board equipment and increased crash worthiness requirements. The greater weight affects the operating cost of the trains, as well as tending to increase wear and tear on tracks. Recent rolling stock specifications have attempted to reverse this trend of increasing vehicle weight. For example, the invitations to tender for the Thameslink rolling stock programme and Intercity Express Programme (IEP) set weight targets.

Figure 3.1 – Weight comparison of some EMU and DMU vehicles procured in the UK since 1976



3.1.7 Vehicle length

With the exception of Pacer DMUs (Classes 142 to 144) whose vehicles are approximately 15 metres in length, rolling stock has a vehicle length of approximately 20 metre or 23 metre. The majority of DMUs are 23 metres long with the exception of the Class 150 vehicles which are 20 metre long. Vehicles of Classes 323, 332, 380, 390, 442 and 444 vehicles are 23 metre long, other EMU vehicles are 20 metre long. Daytime locomotive hauled stock vehicles in regular service are 23 metre long. There has been more recent consideration by the Department for Transport (DfT) toward the introduction of a 26 metre vehicle suitable for long distance high speed services.

3.1.8 Coupling compatibility for multiple working

A feature of multiple unit operation is that the length of trains can be increased by coupling individual units together if there is sufficient demand to justify it. Units can be coupled with other units of the same class and in some cases with units of different classes. In general the ability to couple with other units of different classes is greater with older classes of unit than in those produced since privatisation of the railway began in 1996.

Table 3.4 shows which classes of units can run in multiple with each other. Within each group, any pair of classes can couple together. Note that there are four classes of DMU and ten classes of EMU that cannot couple to any other class; these have been omitted from this table and discussed further in **Chapter 5**.

3.1.9 Operational flexibility

The operational flexibility of the fleet is dependant upon a number of factors including vehicle/network compatibility and whether the rolling stock is suitable for the market sector needs. To operate on a route the vehicle and network need to be compatible in key areas such as gauging, power supply and the stepping distance between the train and platform. A number of vehicles currently operating on the network have been designed specifically to work on particular routes, for example the Class 390 which is deployed on the West Coast Main Line where its tilting ability enables it to operate at higher speeds on a the route which has many curves.

3.2 Current market sectors and how they are served

The diversity of rolling stock currently operated is best understood by considering the market sector they serve. A useful classification is the definition of market sectors used in the 2007 Rail White Paper, namely:

- Long distance high speed
- Interurban
- Regional
- Outer-suburban
- Inner suburban
- Rural

These can all be defined by the services which are offered to the passenger. Some routes are used by services from several market sectors. The ultimate destinations and the intermediate station stops will often define the service classification.

Table 3.4 – Vehicle class compatibility

Compatibility of groups:	
DMU	150, 153, 155, 156, 158, 159, 170
	165/0, 165/1, 166, 168
	142, 143, 144, 150, 153, 155, 156, 158, 159
	220, 221, 222
	175, 180
EMU	317, 318, 319, 320, 321, 322, 323
	375, 376, 377, 378
	350, 360, 380
	313, 314, 315
	444, 450
	455, 456
	458, 460
	465, 466
	507, 508

3.2.1 Long distance high speed

The long distance high speed market sector is distinguishable by the service requirements in that they operate over the longest distances, have a greater distance between stops and travel at high speed. A typical long distance high speed route would be London to Edinburgh or London to Manchester. Vehicles that serve the long distance high speed sector typically need to accommodate high numbers of seated passengers and offer a choice between standard and first class accommodation. Long distance high speed vehicles are the longest vehicles within the current fleet and typically operate at 125mph.

3.2.2 Interurban

The interurban market sector accounts for medium distance routes between regional centres. A typical route of the interurban sector would be Birmingham New Street to Liverpool Lime Street via Crewe or Glasgow Queen Street to Edinburgh Waverly via Falkirk High. The vehicles that serve the interurban sector are required to cover the long distances efficiently whilst offering a high level of passenger comfort. The typical operational speed of vehicles operating interurban services is 100mph.

3.2.3 Regional

The routes served by the regional sector are middle distance – a typical route being the London to the Cotswolds or Inverness to Aberdeen service. The regional sector services are often lower frequency at around one train per hour or less. Vehicles that serve the regional routes cover the intermediate distances efficiently and offer a high capacity of passenger seating. The operational speed of vehicles that operate within this sector is typically 100mph.

3.2.4 Outer suburban

A typical outer suburban route is from London Waterloo to Basingstoke. The vehicles that serve this sector need to be able to cover the distances efficiently, meaning that they need to be capable of good acceleration and braking performance with an operational speed of up to 100mph. The high speed profile of the outer suburban vehicles is to ensure that the vehicle keeps up with traffic on main line sections. Doors need to allow large numbers of passengers to board and alight quickly.

3.2.5 Inner suburban

The inner suburban sector operates over routes that serve densely populated areas. The services cater for high passenger numbers travelling over short distances. A typical inner suburban route would be Moorgate to Welwyn Garden City or Glasgow Central to Nielson. Due to the frequent stopping pattern of these services vehicles are required to have high acceleration and braking performance whilst the spacing of stops means that a top speed of 75 mph would normally be adequate. Large numbers of passengers need to board and alight efficiently in order to reduce the dwell time. This influences the door, vestibule and the interior design of the vehicle which typically need to accommodate a large proportion of standing passengers over short journeys.

3.2.6 Rural

The rural sector serves a variety of routes that include short branch lines of a few miles, such as Truro to Falmouth Docks, and longer distances like Morecambe to Leeds. In Scotland the Far North Line operates rural services from Inverness to Wick and Thurso. Although the passenger journeys of some rural services may not be long distance, an appropriate level of comfort is expected. The interior layout may vary and it may not be necessary for the vehicle to have multiple doors. The top speed of the vehicle is typically 75mph as some services are required to use main lines, although on branch lines the speed is likely to be lower. Most rural routes are not electrified so the vehicles which operate on these services are typically self powered.

3.3 Market sector needs of rolling stock

The rolling stock needs of each market sector vary because of the service and passenger requirements. **Table 3.5** outlines the high level passenger market sector needs. The long distance high speed and interurban market sectors require a vehicle that can seat many passengers and travel at high speeds whereas vehicles which serve the inner suburban routes are required to carry high passenger numbers over relatively short distances and need passengers to board and alight efficiently. The outer suburban and regional routes require a vehicle that can operate efficiently over middle distances and offer the passenger a high level of comfort. The rural routes tend to serve fewer passengers than the other market sectors, although the distances are variable, and as such the vehicles need to offer a level of comfort for a range of journey types.

Table 3.5 – Rolling stock requirements by market sector

Market Requirement	long distance high speed/Interurban	Outer suburban/Regional	Inner suburban	Rural
Design and /interior features				
Seating capacity	High	High	Low	Medium
Standing capacity	Low	Medium	High	Medium
Train length/number of carriages	Long	Long/medium	Medium	Medium/short
Premium service required?	Yes	Desirable	Not essential	Not essential
Toilet facilities	Required	Required	Not essential	Desirable
Designated luggage space	Under/between seats, luggage racks, overhead shelving	Under/between seats, luggage racks, overhead shelving	None	Under/between seats, luggage racks, overhead shelving
Air conditioning/heating	Yes	Yes	Yes	Yes
Safety/security	All emergency and security equipment should be provided as standard. CCTV and staff presence may also be required			
Seating type	Comfortable, soft padding, ergonomic shape	Basic, durable, easy to clean	Basic, durable, easy to clean	Basic, durable, easy to clean
Seating layout	Airline seating, table seats/drop-down tables	Airline seating, table seats/drop-down tables	Flexible (seats, perch and tip-up seats)	Flexible
On-board information	Display dot matrix and automatic announcements			
At-seat accessories	Wi-fi, at seat lighting, power outlets, magazine racks, adjustable blinds	Wi-fi, at seat lighting, power outlets, magazine racks, adjustable blinds	None	None
Grab rails/poles/handles	Yes	Yes	Increased number of grab rails/poles/handles	Yes
Accessibility features				
Wheelchair and buggy space(s)	Yes	Yes	Yes	Yes
Nappy-changing facilities	Yes	Desirable	No	Desirable
Priority seating	Yes	Yes	Yes	Yes
Service characteristics				
Service frequency	Medium	High	High	Medium/low
Frequency of stops	Low	Medium	High	Medium
Passenger access/egress speed	Minimise dwell time		Minimise dwell time, increase space surrounding doors	Minimise dwell time
Traction power	AC or self powered	AC, DC or self powered	AC or DC or self powered	AC, DC or self powered
Operational speed range	125 – 140mph	100 – 125mph	70 – 90mph	70 – 90mph

3.3.1 Determining rolling stock allocation

Franchising and market sector requirements play a part in the allocation of rolling stock to services for each market sector. Other factors such as physical characteristics and the interface between the rolling stock and the infrastructure also come into play. These factors will be discussed further later in the document.

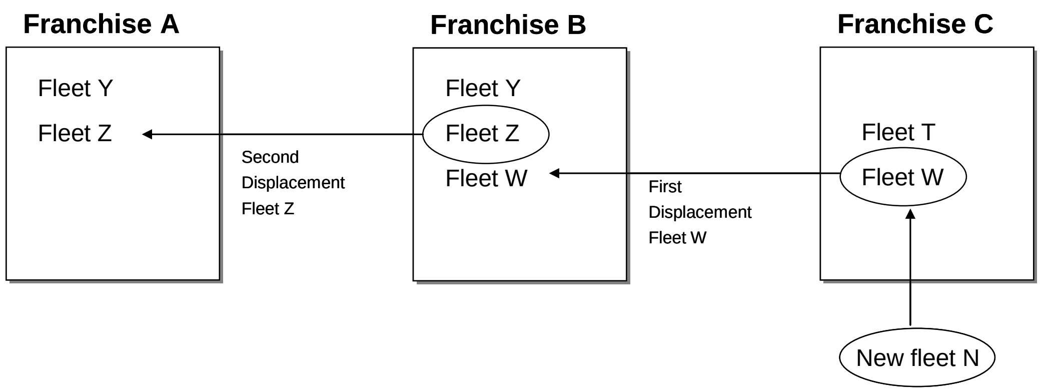
Franchise renewal provides an opportunity for the introduction of new or cascaded rolling stock (rolling stock transfer between routes) as well as the re-introduction into service of existing rolling stock previously held in store. In the past franchise agreements have specified the services and routes of a specific franchise including an overview of the rolling stock available for the specific franchise.

3.3.2 Vehicle cascade

When new vehicles are introduced on to the network by an operator, they may trigger the displacement of incumbent rolling stock for the re-use on other service groups within the operating area or to another franchise elsewhere on the network. Subsequent cascades may also occur if the cascaded rolling stock triggers displacement of other rolling stock on the other franchises. So far, most cascades have provided only one iteration of fleet cascade. The key 'triggers' are depicted generically in **Figure 3.2**.

New fleet Introduction: When new vehicles are introduced they can displace existing fleet and trigger the movement of the existing fleet either wholly or partly. For example, new Class 378 trains on London Overground made Class 313s surplus to requirement. These vehicles were then re-deployed to Southern for its Coastway service and to First Capital Connect to provide extra capacity on urban metro services into London Moorgate.

Figure 3.2 – Fleet cascade



Source: Competition Commission report April 2009

Franchise obligation: There may be a franchise obligation to renew or replace the rolling stock. This could be to provide 'extra capacity' for growth on certain routes, either providing additional vehicles or 'route extension' where the same fleet is required to be extended in service to additional routes on the network.

Changes in demand: Timetabling requirements sometimes lead to a change in demand for rolling stock and as a result rolling stock is transferred from one franchise to another to satisfy the changes in demand. For example, Class 150s were transferred in 2005 from Anglia, where the vehicles were not required, to Arriva Trains Wales, which was experiencing growth in demand.

Short-term loan and return: A short-term need is sometimes addressed by the hire of rolling stock on the understanding that the rolling stock will be returned.

This is often caused by other cascades taking place. For example Class 321s were used in 2007 to supplement the c2c fleet while Electrostars were being modified and tested for regenerative braking capability and London Midland has loaned Class 153 vehicles to Northern Rail to strengthen their fleet.

Swaps: In some instances one TOC has exchanged rolling stock with another. Swaps typically occur because alternate rolling stock may meet the operational requirements or a particular route better. These transactions may involve new lease agreements between the relevant TOCs and ROSCOs.

Figure 3.3 summarises the types of cascades that have taken place between 1998 and 2008 as detailed in the Competition Commission report analysis. It shows the reasons for movements of rolling stock by number of vehicles and percentage of total. This clearly shows that the vast majority of cascades (70 per cent) are "first displacements" (i.e. one stage cascades). The next closest is "subsequent displacement" at 12 per cent.

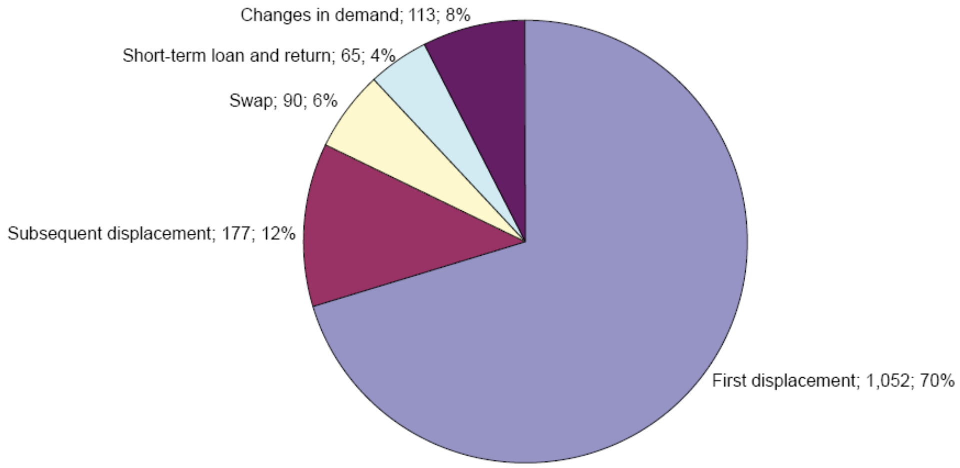
Commercial considerations

The main factors which influence the commercial life of rolling stock are:

- External events
- physical condition
- market considerations
- changes to attributes of infrastructure.

Under each of these elements there are a number of trigger events that would require some consideration. These events, possible responses to them and the extent to which they might influence the commercial life of rolling stock are discussed below:

Figure 3.3 – Fleet cascade types



Source: Competition Commission report April 2009

External events

External events include changes in the market, the introduction of new legislation and changes to whole life cost which may make it increasingly attractive to run electric traction rather than diesel services on electrified lines. **Table 3.6** shows the principal factors and their potential effect on the commercial life of rolling stock.

Physical condition of vehicles

The physical condition of a vehicle is an important determinant of its commercial life, as it will influence the cost with which the vehicle can be kept in a suitable state for continued service. **Table 3.7** shows the principal factors and their potential effect on the commercial life of rolling stock.

Table 3.6 - External Events which effect the commercial life of vehicles

Factor	Trigger	Possible responses	Considerations which affect the degree to which factor influences vehicle life
Market size or composition	downturn in demand in market segment or line closures	withdraw, redeploy or store vehicles	would address in longer term by adjusting new build, could lead to early withdrawal of oldest vehicles
	growth demand in market segment faster than can be accommodated by building new	life extend vehicles/redeploy	would address in longer term by adjusting new build, could lead to life extension of oldest vehicles
Legislation	a property of the vehicle ceases to be compliant with legislation	modify (where possible), seek derogation or withdraw	date of trigger is fixed once legislation is enacted (unless derogation obtained)
Whole life cost	significant increase in cost of diesel or biofuels	refit with fuel efficient engines (where possible) or withdraw	size of differential in fuel cost, and extent of electrification, will influence vehicle life foregone

Table 3.7 – The impact that vehicle condition has on rolling stock commercial life

Factor	Trigger	Possible responses	Considerations which affect the degree to which factor influences vehicle life
Bodyshell condition	bodyshell becomes weak / corroded to extent that integrity is lost	withdraw vehicle	fundamental determinant of commercial life
Bogie /wheel set condition	bogies or wheel sets worn / corroded beyond repair	replace bogies / wheel sets or withdraw vehicle	bogies can be re-used on compatible vehicles, so likely to affect vehicle life only if remaining life is short
Engine / traction motor condition (for motored vehicles)	maintenance cost increases and /or reliability / availability falls to unacceptable level	replace or heavy overhaul or withdraw vehicle	engines can be replaced, in some cases traction motors re-used on compatible vehicles, but at significant cost
Technical obsolescence	computer systems controlling operation of vehicle or signalling / train interface can no longer be supported	replace systems or withdraw vehicle	depends on extent to which modular design allows straightforward replacement / re-use of systems
Traction package obsolescence	traction package becomes difficult /impossible to maintain	replace package or withdraw vehicle	traction package can be replaced, so likely to affect vehicle life only if remaining life is short

Market considerations

Market considerations will also influence the commercial life. The extent to which the condition and performance of vehicle is suitable for the markets it serves may diminish with the age of the vehicle, particularly when set against rising passenger expectations.

Table 3.8 shows the principal factors which may impact upon demand and consequently impact upon the commercial life of rolling stock.

Changes to attributes of the infrastructure

Changes to attributes of the infrastructure will potentially affect the suitability of certain classes of rolling stock for the infrastructure, which in turn may also influence the commercial life of the vehicles.

Table 3.9 shows the principal factors and their potential effect on the commercial life of rolling stock.

3.4 Routes which serve each market sector

The maps in **Figures 3.4**, **3.5**, **3.6**, **3.7**, **3.8** and 3.9 show the routes which constitute each market sector. The maps illustrate that whilst some routes are relatively simple and serve only one market sector, the majority are complex and serve multiple market sectors and as such a variety of rolling stock types operates over them.

Table 3.8 – Impact of market considerations on the commercial life of rolling stock

Factor	Trigger	Possible responses	Considerations which affect the degree to which factor influences vehicle life
Passenger experience	overall passenger experience deemed no longer acceptable	withdraw vehicle	poorest quality vehicles generally on low revenue routes, so difficult to make business case for replacement on this factor alone
Journey time	market growth/market review requiring faster rolling stock	cascade or withdraw vehicle	provided mechanisms exist for sensible cascade, likely to influence vehicle life only if among the oldest in the fleet
Vehicle interior	vehicle interior becomes "tired" – less attractive to market	cascade vehicle or interior refit / refresh / refurbish /re upholster heavy interior clean	range of responses is sufficiently wide that response likely to be driven by remaining life of vehicle (as determined by other factors), rather than affecting vehicle life

Table 3.9 – Changes to attributes of the infrastructure

Factor	Trigger	Possible responses	Considerations which affect the degree to which factor influences vehicle life
Speed	line speed (or differential line speed) increase allowing faster rolling stock	cascade or withdraw vehicle	significant infrastructure upgrades should be planned in conjunction with rolling stock replacement plans
Performance characteristics	capacity constraint requires trains of similar characteristics on congested route	modify, cascade or withdraw vehicle	the primary effect of these factors is likely to be on vehicle *deployment* (provided mechanisms exist for sensible cascade) but could affect vehicle life at the margin
Vehicle or axle weight	change in use / asset condition requires light weight (or low axle weight) vehicles	cascade or withdraw vehicle	
In Cab signalling (ERTMS)	provision of ERTMS on route	modify, cascade or withdraw vehicle	significant infrastructure upgrades should be planned in conjunction with rolling stock

Figure 3.4: Long distance high speed services (indicative)

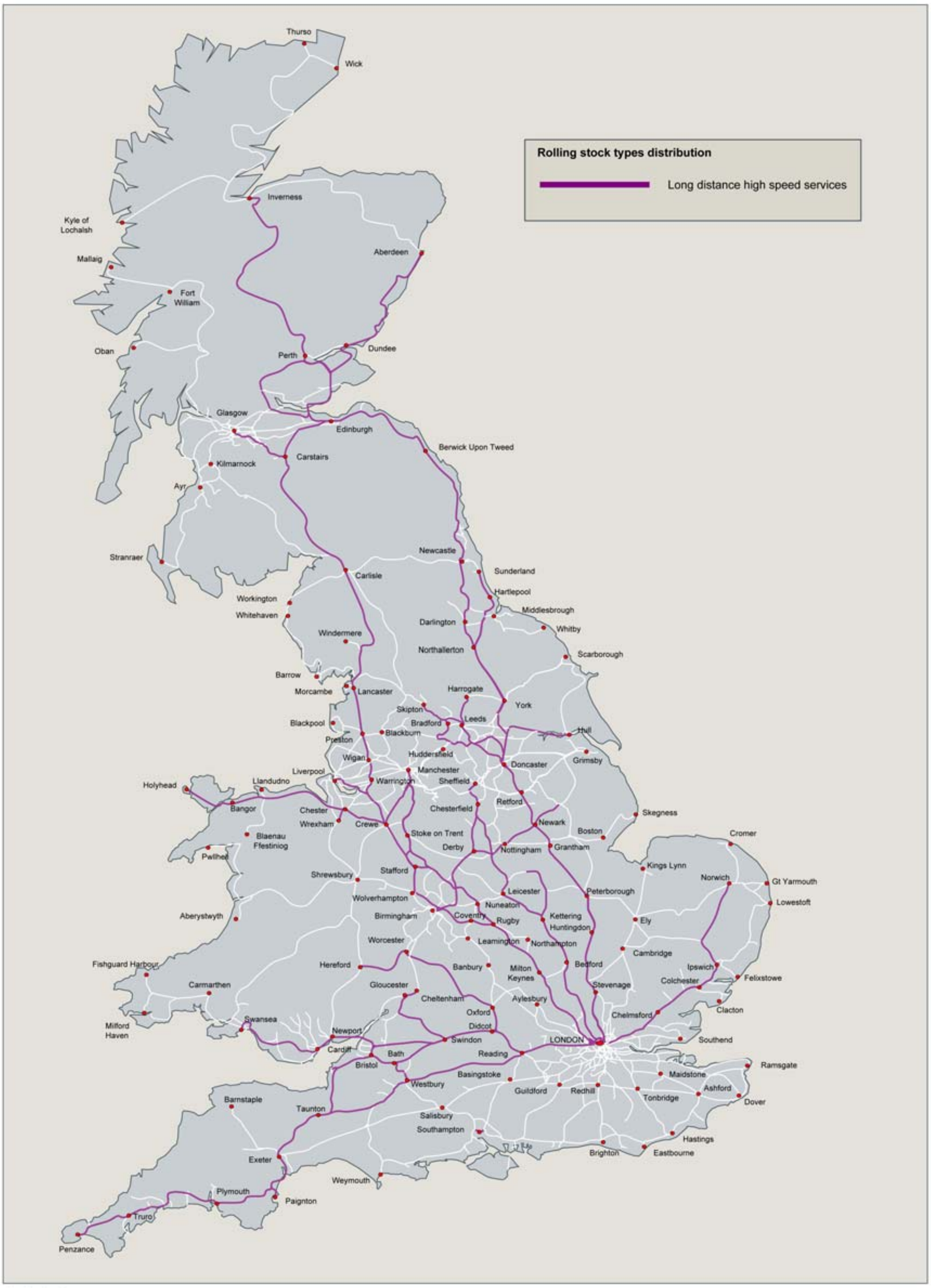


Figure 3.5: Interurban services (indicative)

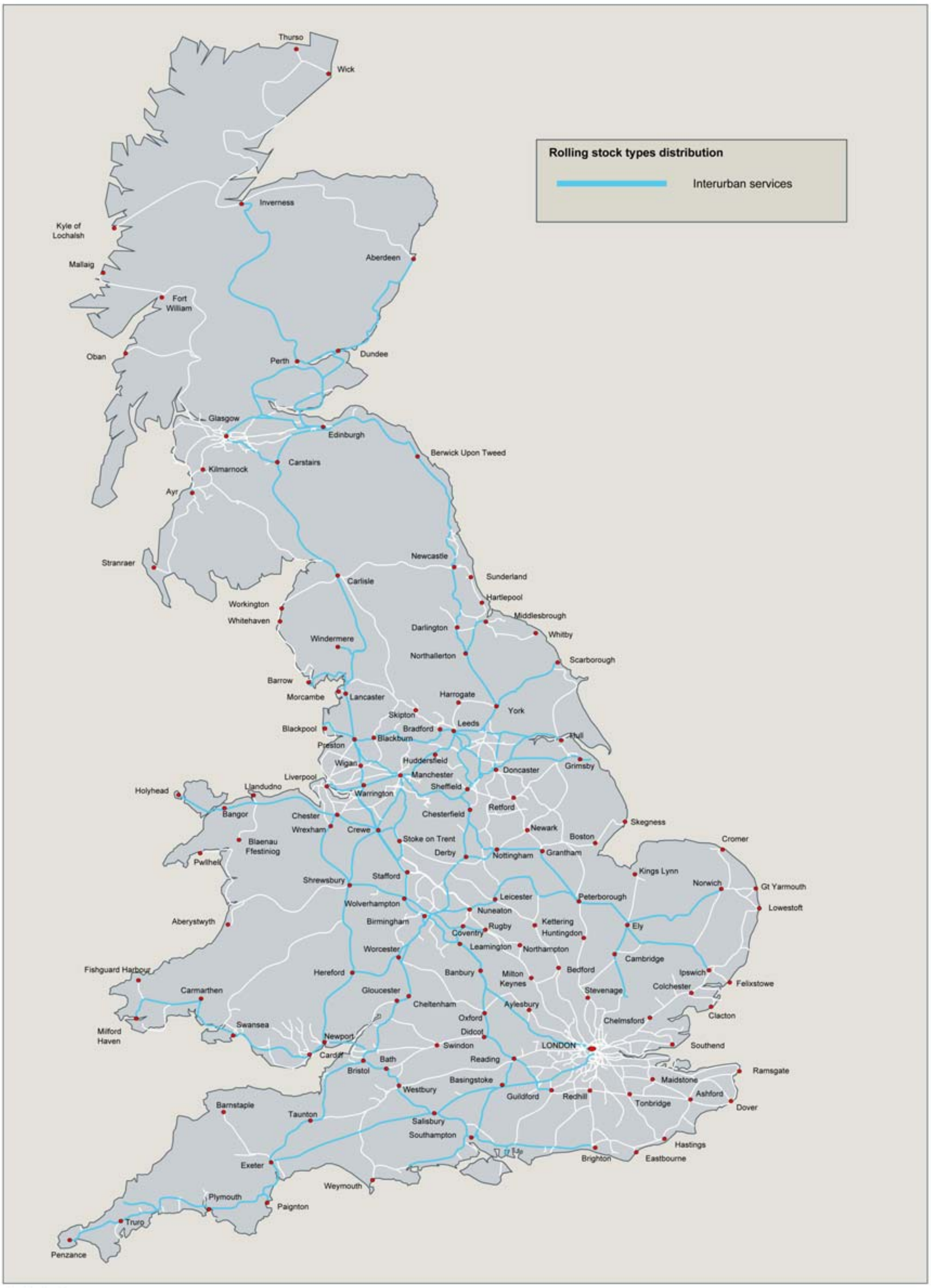


Figure 3.6: Inner suburban services (indicative)

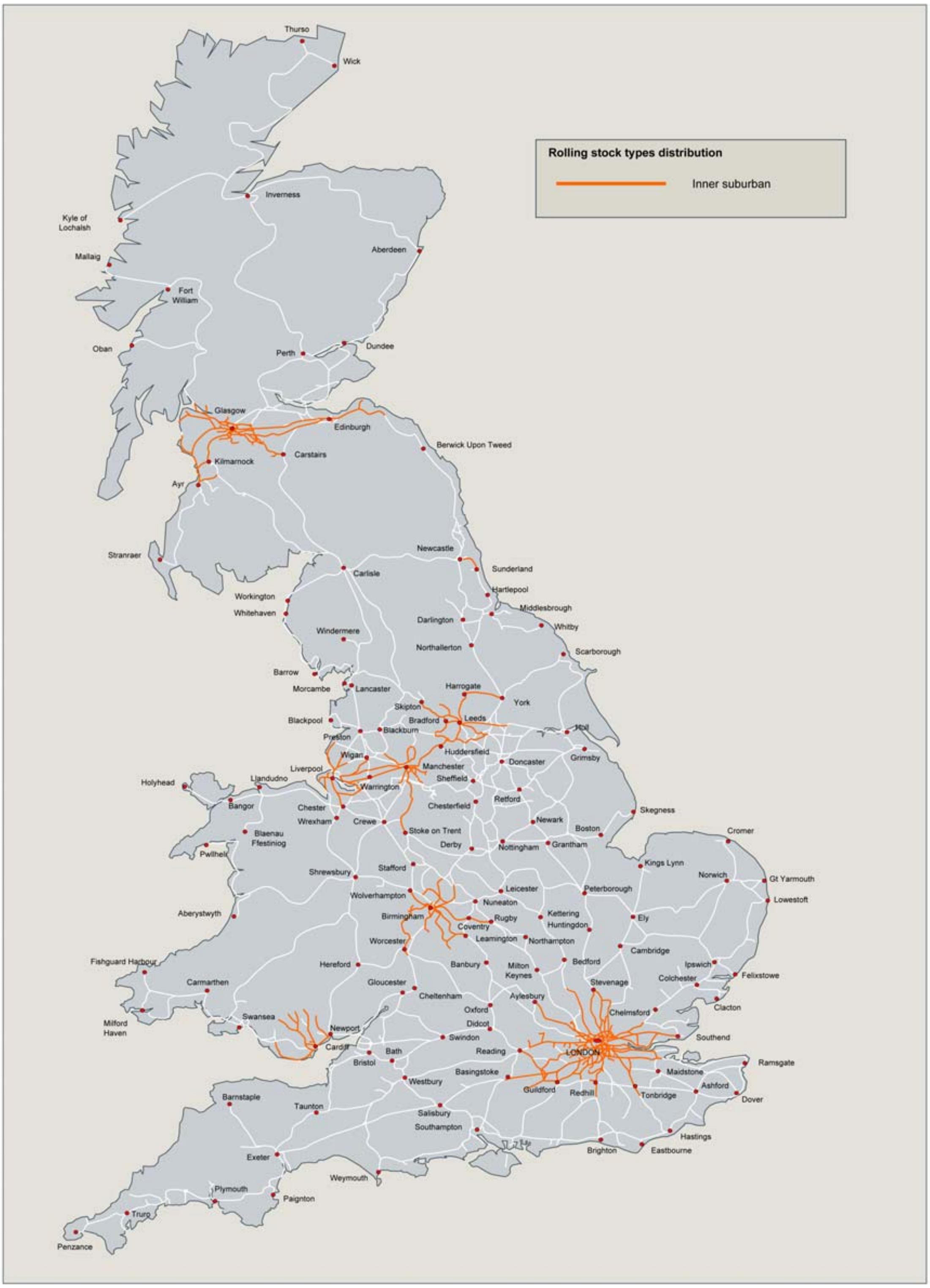


Figure 3.7 Outer suburban services (indicative)

Figure 3.8 Regional services (indicative)

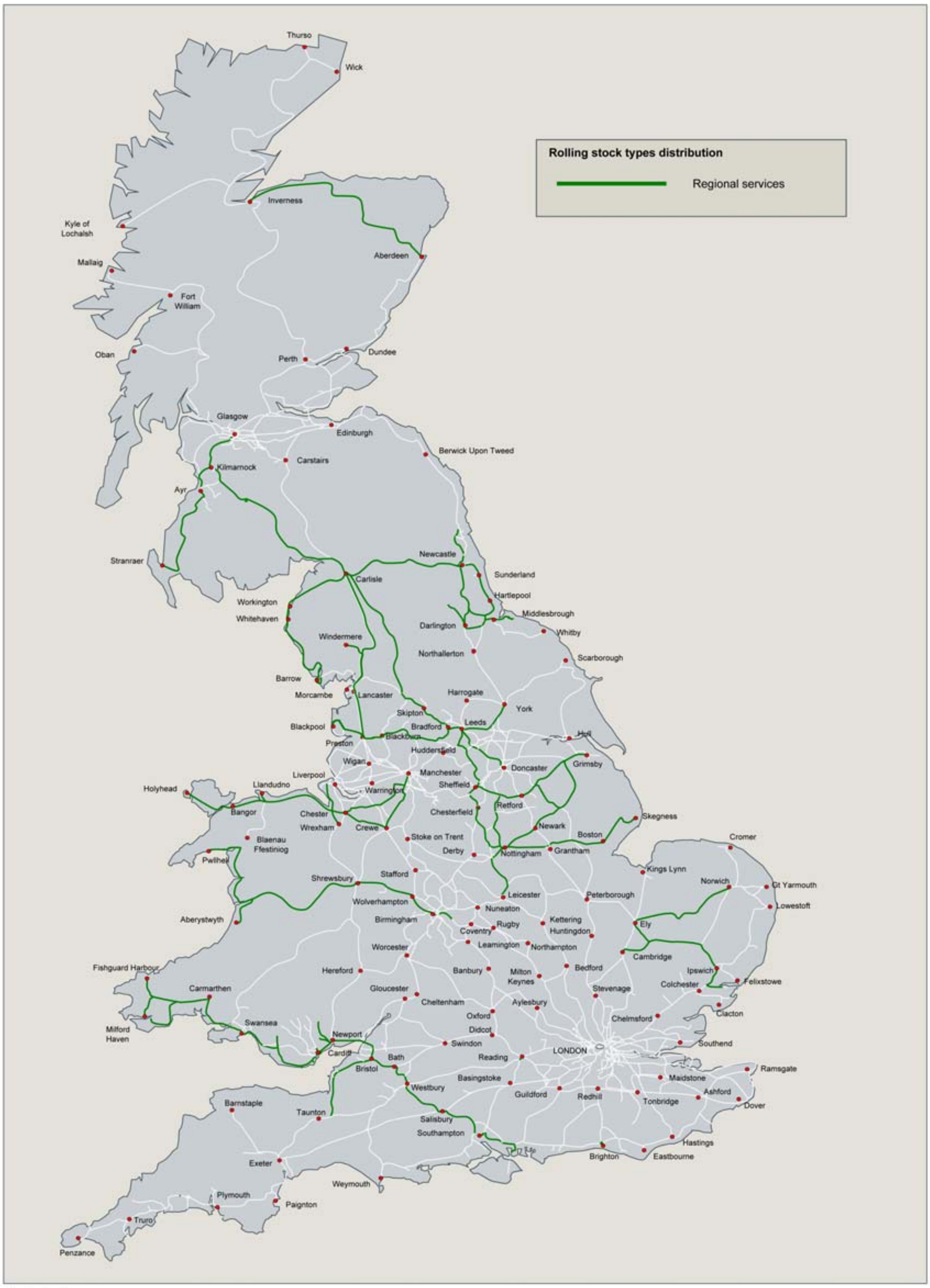


Figure 3.9 Rural services (indicative)

3.5 Current infrastructure committed plans

During Network Rail's Control Period 4 (2009 – 2014) there are committed infrastructure enhancement schemes which will deliver capacity improvements. These include rolling stock integration and route enhancement work.

3.5.1 Thameslink Programme

The Thameslink Programme incorporates enhancements on the Thameslink routes in the London and South East area. This includes substantial remodelling of the London Bridge Corridor as well as other enhancements to the outer areas, such as the provision of platform extensions, power supply upgrades, route clearance works and additional stabling facilities. The Thameslink programme has phased delivery over three key outputs, one was completed in March 2009, the other two are due for completion in December 2011 and December 2018 respectively. New rolling stock is expected to be introduced on Thameslink services from 2015.

3.5.2 Intercity Express Programme

On 1st March 2011, the Government announced that it has decided to resume the Intercity Express Programme procurement. The first of the new trains are expected in service on Great Western Main Line in 2016 and the East Coast Main Line by 2018.

The Intercity Express Programme has been led by the Department for Transport, with assistance from across the rail industry, since November 2005.

The Programme seeks to replace the "Intercity 125" High Speed Train diesel fleet procured by British Rail during the 1970s and 1980s with a new, higher capacity, more environmentally friendly train.

The programme will see the building of a substantial number of electric and bi-mode (diesel and electric) long distance trains which will run to Great Western Main Line stations including Oxford, Swindon, Reading, Cardiff Central, Swansea, Bath and Bristol Temple Meads and to East Coast Main Line stations such as Peterborough, York, Doncaster, Newcastle, Edinburgh Waverly, Aberdeen and Inverness.

3.5.3 Electrification

There is an electrification programme in the North West and on the Great Western Main Line. On 1st March 2011 the Government announced that the Great Western element of the programme would be extended westwards to Bristol Temple Meads and Cardiff Central. **Figure 3.10** maps the current electrified routes, committed schemes and the core schemes in the Network RUS: Electrification strategy.

3.5.4 Crossrail

The Crossrail project aims to deliver infrastructure enhancements to enable operation of 24 trains per hour from central London to destinations such as Heathrow Airport, West Drayton and Maidenhead in the west and Abbey Wood and Shenfield in the East initially. The scope of works includes:

- Construction of subsurface railway infrastructure under central London with a tunnelled extension to Docklands via Canary Wharf
- platform extensions for stations from Maidenhead to Abbey Wood and Shenfield to cater for 200 metre long electric trains
- enhancements to the existing infrastructure
- the development of appropriate depot maintenance facilities.

As well as infrastructure enhancements there are plans to order a fleet of new trains of 200 metres in length.

3.5.5 Train lengthening programme

The train lengthening programme will allow the operation of longer trains on key routes within the south east of England. The programme of enhancements will provide the following capability:

- Ten-car capability on certain suburban services on the Wessex route into London Waterloo
- ten-car capability on certain suburban services on the Sussex route into London Victoria
- ten-car capability on certain suburban services on the Sussex route into London Bridge
- twelve-car operation on the Sussex route from East Grinstead into London Victoria and London Bridge
- twelve-car capability on certain Kent route suburban services into London Charing Cross and Cannon Street
- twelve-car capability on the Anglia route (Tilbury Loop and Ockendon Branch) into London Fenchurch Street
- twelve-car capability on the certain West Anglia services on the Anglia route into London Liverpool Street.

The capability changes will be delivered to different timescales across Control Period 4. Longer services will be possible on or before the December 2013 timetable change date.

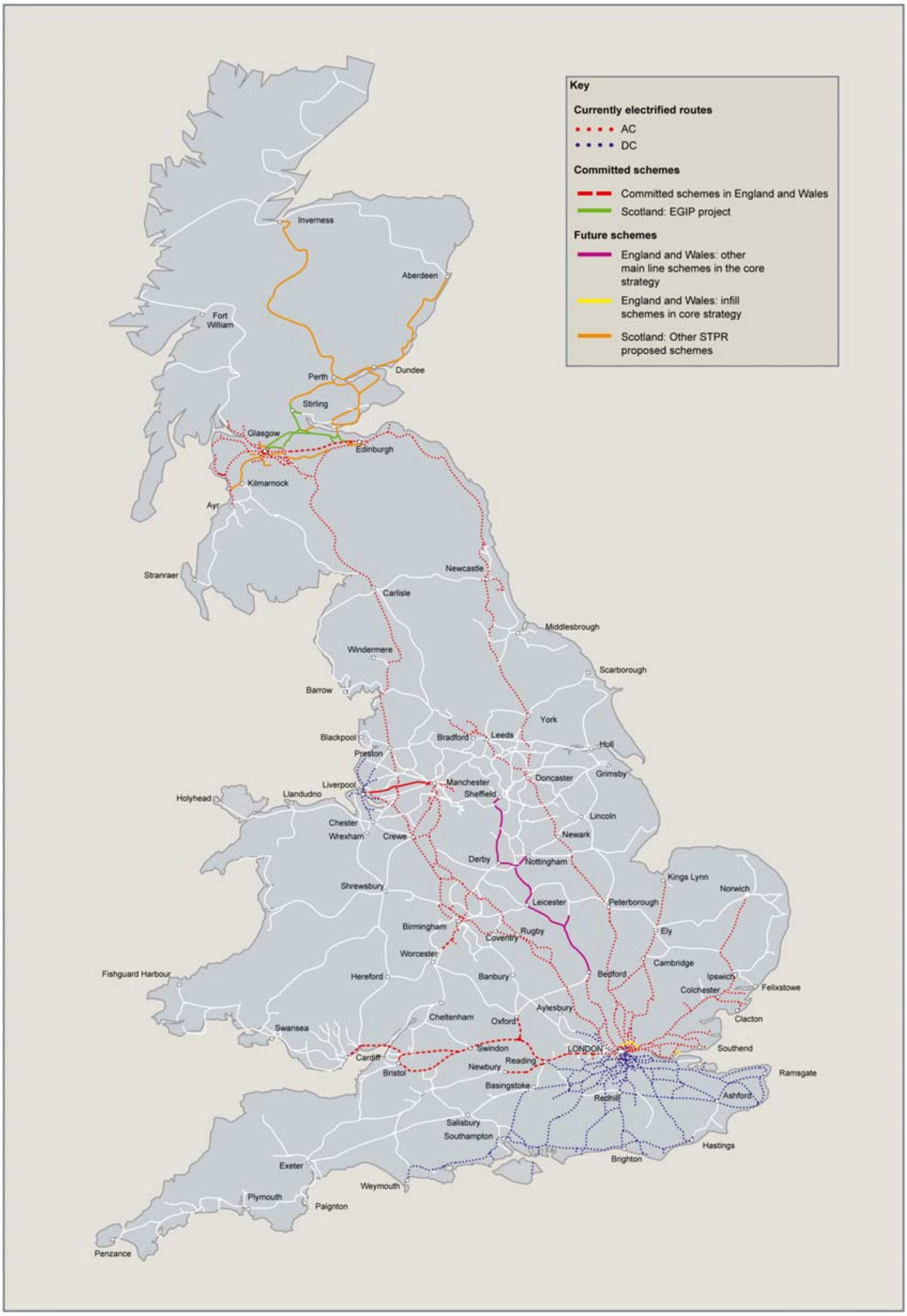
3.5.6 Edinburgh to Glasgow Improvements Programme

The Edinburgh – Glasgow Improvement consists of a series of improvements, including electrification, between Scotland's two largest cities and the wider central Scotland corridor. Work is scheduled to be completed by 2016.

The improvements are designed to support the communities, environment and economy of the region. The project will provide an immediate boost to the local economy during construction, but more importantly will stimulate long-term growth and unlock investment opportunities in the area.

The project is planned to deliver a faster and more frequent service between Edinburgh Waverly and Glasgow Queen Street along with new or increased service opportunities. Investment is planned at Haymarket station to improve the current facilities and concourse, as well as providing an interchange with the Edinburgh tram.

Figure 3.10 England and Wales core electrification strategy and Scotland schemes (Source: Network Rail 2011)



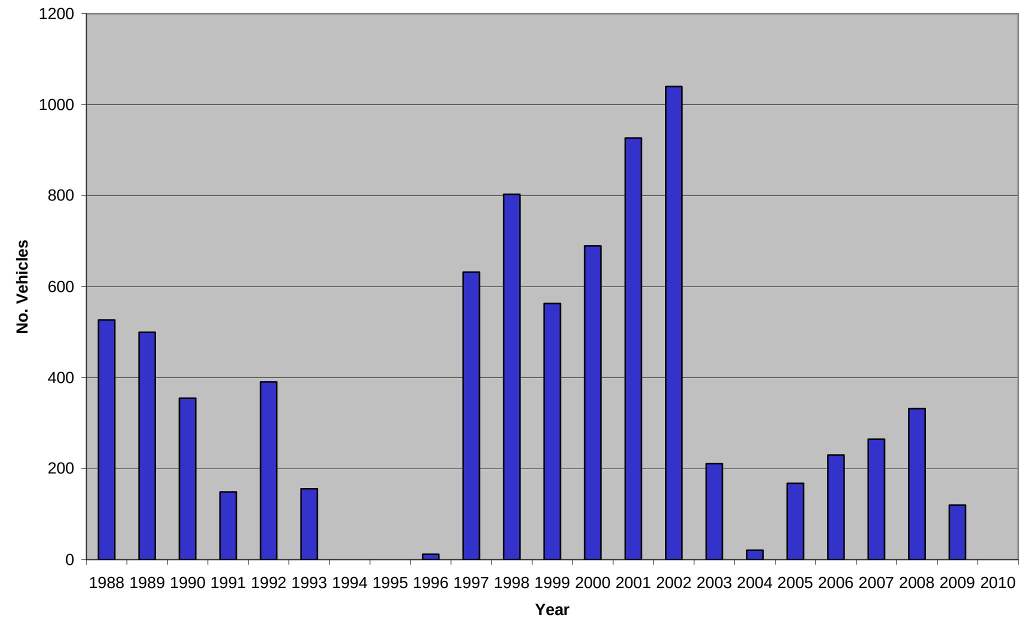
3.6 Current rolling stock costs

Rolling stock costs can be broken down into initial costs and operational costs. The costs of rolling stock vary according to the class of vehicle; however the costs associated with an electric vehicle are distinctly lower than that of an equivalent diesel vehicle.

3.6.1 Procurement & leasing costs

Although the procurement of new rolling stock is an infrequent event, the costs involved are considerable. **Figure 3.11** shows the past procurement of DMU and EMU passenger vehicles in Great Britain. The graph highlights that there has not been a consistent pattern of procurement. There were no orders placed between 1994 and 1997 around the time which the industry was privatised.

Figure 3.11 – Passenger rolling stock orders between 1988 and 2010



Source: Rail Industry Association (2010)

The procurement costs of rolling stock is dependant on a number of factors, particularly, the vehicle class and traction type. External factors such as exchange and funding rates also have an influence. The cost of rolling stock has varied considerably in recent years. **Figure 3.12** shows that between 1998 and 2007 there were approximately 4,648 vehicles ordered with a total value of just over £4.6 billion (Source: Competition Commission), the average cost per vehicle being approximately £1.1m. A number of ROSCOs have reported that the average cost of rolling stock has risen above this.

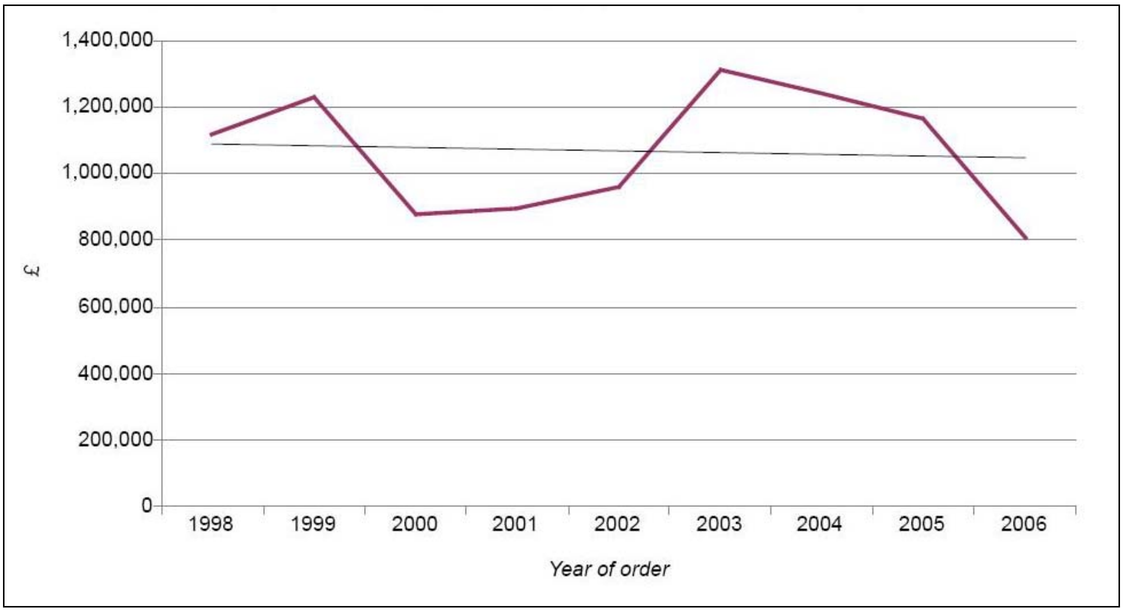
Since privatisation, the ROSCOs have financed new rolling stock. The DfT and operators have been involved in the procurement and specification of vehicles to meet the aspirations of the high level output specification (HLOS).

The total leasing and maintenance costs of rolling stock can generally be considered as approximately 15 per cent of the total industry costs at around £1.8bn. **Table 3.10** estimates the typical operational costs of a diesel and electric vehicle. Costs will vary by the class of unit, but, on average the costs of operating an electric is considerably less than that of a diesel vehicle.

3.6.2 Maintenance costs

Rolling stock maintenance costs are dependent upon a number of factors such as the class, traction type and age of vehicle. Electric vehicles have a lower maintenance cost than diesel vehicles. The frequency of maintenance is lower for electric vehicles, and this in turn gives higher vehicle availability i.e. the ratio of the number of vehicles available to operate the service to the total number of vehicles in the fleet. This is discussed further in the established Network RUS: Electrification strategy.

Figure 3.12 – Average price per vehicle (nominal) by year of order since privatisation (1998 – 2006)



Source: Competition Commission report April 2009

Table 3.10 - Typical operational costs of diesel and electric passenger vehicles (Source: ATOC)

	Typical value for diesel vehicle	Typical value for electric vehicle
Maintenance cost per vehicle mile	60 pence	40 pence
Capital lease cost per vehicle per annum	£110,000	£90,000

4 Drivers of Change

This chapter outlines those factors which could potentially drive a change in the industry's approach to a strategy for new rolling stock on the network, given the objectives of the industry's stakeholders. The predominant drivers are related to the objectives of: delivering the railway more efficiently; maintaining and improving the industry's environmental credentials; and taking advantage of technological developments.

4.1 The need to minimise whole industry whole life costs

The cost of running the British rail network is currently estimated to be £10.9 billion per annum, of which approximately £4.8 billion is funded through subsidy. The rail industry, Department for Transport (DfT), Transport Scotland and the Welsh Assembly Government are united in an objective of minimising these costs. Rolling stock procurement and operation costs are substantial. Between 1998 and 2007 approximately £4.6 billion was spent on the procurement of new vehicles [2]. As such a large cost item, reductions in the costs of rolling stock have the potential to make a substantial impact on the overall costs of the railway. A number of manufacturers of rolling stock vehicles have indicated that the cost of rolling stock could be substantially reduced if larger orders of a consistent vehicle type were procured over a period of time. Similarly, a number of manufacturers have stated that the rolling stock supplied to Britain in the past has often been of a bespoke design which contributes towards a higher unit price than would be the case if there were repeat orders of the same design. There would inevitably be certain design considerations which would be specific to the Britain, such as the vehicle size which differs from that produced for gauges in Europe. Nonetheless, manufacturers believe that efficiencies could be obtained from using design platforms which comprise standardised equipment.

The operational railway is a complex system where many interfaces exist between rolling stock and the infrastructure which it is required to operate over. Historically the national rail network was developed in various stages and as a result there are variations across the network in electrification, gauge and platform lengths. The variation of the network has, in part, contributed to the introduction of the many different rolling stock types in operation today, with each type having a different amount of network coverage. Given the variations across the network, it is important that rolling stock and the infrastructure are planned together to ensure vehicle and network compatibility in meeting passengers' needs. Rolling stock which is planned to serve a whole market sector rather than a route could enable both whole life cost savings and enhanced operational flexibility of a fleet.

4.2 Increased electrification of the railway

The established Network RUS: Electrification Strategy was published in October 2009. The DfT has announced that it is prepared to fund substantial elements of the core strategy which included electrification of the Great Western Main Line from London Paddington to Cardiff Central, Bristol Temple Meads, Newbury and Oxford, electrification of the route between Liverpool Lime Street and Manchester via Newton-le-Willows, between Liverpool Lime Street and Wigan North Western and between Manchester and Blackpool North, electrification to Bolton, Preston and Blackpool in northwest England. Transport Scotland is progressing with additional electrification between Edinburgh Waverly and Glasgow Queen Street and has included more extensive electrification plans in their Strategic Transport Project Review.

The extent of further network electrification will clearly have a bearing on the number of electric vehicles and self powered vehicles within a fleet. If the electrified network is increased further, then the proportion of the fleet which needs to be self powered will be reduced. Electric vehicles offer many cost advantages over diesel-powered vehicles. In the next few years many of the diesel-powered vehicles on the network will approach life expiry, triggering decisions about their replacement. As the cost of diesel fuel rises, the advantages of electrification become more apparent. Electrification of the network brings benefit to freight customers in that they also can operate electric locomotives over a wider range of trunk routes.

[2] Competition Commission, Rolling Stock Leasing Investigation, July 2009

Whilst electrification is an efficient solution for many lines, the Network RUS Electrification strategy recognised that many routes are unlikely to have a business case which would be sufficiently strong to justify investment in conventional electrification infrastructure. On these routes self-powered modes, or cheaper alternatives to conventional electrification may warrant further investigation.

4.3 An increased need for operational flexibility

As funders and operators strive to bring down the costs of the railway, it is becoming increasingly important to identify efficiencies that might arise from optimising operational flexibility. Rolling stock fleets which are cleared for operating widely on the network allow much more flexibility than those with a narrow coverage. Increasing operational flexibility can be efficient for Train Operating Companies (TOCs), the Rolling Stock Companies (ROSCOs) and other investors that supply the vehicles and ultimately passengers benefit from more operationally flexible vehicles where the increased vehicle coverage of routes allows operators to offer new services. The TOCs would benefit by having a vehicle fleet that is less diverse and more interoperable, logistically easier to manage allowing them to respond to demand more easily.

Lessors benefit by having vehicles which are more easily cascadable, thereby potentially maintaining their residual value. Cascading vehicles which are operationally flexible becomes inherently easier as their compatibility with the network and with other vehicles becomes less of a constraining factor.

4.4 Opportunities to exploit technical improvements

Modern rolling stock can offer improved operational performance which can help address customer aspirations. Recent advances in rolling stock design have seen improvements in vehicle acceleration and braking capability, improved operating performance, and, potentially, opportunities to improve the utilisation of network capacity.

Technological advances have also improved reliability as better quality of components and sub-systems enable vehicles to operate with fewer failures. The use of standard components and design platforms by manufacturers has meant that some design features and sub-systems are utilised in greater numbers, eradicating anomalies. The design of the interior fitting of rolling stock can also exploit technological advances to meet passenger requirements. For example, carriages are increasingly fitted with passenger power supply sockets, wifi, modern functional toilets, air-conditioning, customer information screens and disabled passenger access.

New technologies will bring significant changes to the way in which future rolling stock operates. Technologies to reduce noise, emissions and carbon are all in development. Designers are considering battery-powered units, fuel cell engines and innovative ways to electrify routes where infrastructure problems have previously precluded this on the grounds of cost.

Future rolling stock and infrastructure could be based upon more open architecture with standard interfaces and a modular approach to design with ‘plug and play’ equipment to reduce train and infrastructure costs.

4.5 The need to replace ageing rolling stock

Over the next ten to fifteen years, a significant proportion of the passenger rolling stock currently operating on the network will be at least 30 to 35 years old and will require replacement or life extension.

A number of factors determine when a vehicle needs to be replaced and, conversely, whether its commercial life can be extended. These include:

- Economic factors: the operational and maintenance costs associated with a vehicle may make it less competitive than that of new, more modern rolling stock. The current condition of the vehicle may be such that it requires a high amount of investment in order to life extend it for a longer period of time. Any decision to extend the commercial life of a vehicle involves a consideration of the relative value of deferring the replacement expenditure against the additional costs associated with extending its life
- operational factors: the ability of the rolling stock to serve a particular market sector in terms of the operational coverage needs to be considered
- maintenance: the maintenance costs associated with older vehicles vary but can be higher or lower than some new vehicles. The availability of spares and the

obsolescence of parts needs to be considered

- performance: all vehicles need to contribute to service performance targets; if a vehicle is to be life extended, technology upgrades may be necessary. However this may require the use of bespoke sub-systems which can be high in cost
- passenger aspirations: the needs and aspirations of passengers in any market sector change over time. The aspirations may be met by replacement vehicles or by refitting existing vehicles
- service disruption during refits and maintenance: the work necessitated by life extension of vehicles may cause disruption to service provision in times of passenger growth (although this can be anticipated and managed). Vehicle life extension programmes require part of the fleet to be unavailable at any given time. Replacement vehicles may need to be used or services compromised for a period.

4.6 Growth in passenger demand

The industry is currently preparing long term plans for publication in September 2011. It is forecasting that the growth in demand resulting from expected economic growth and population changes will be in the order of 80 per cent by 2034. This excludes additional growth which would be stimulated by further improvements to the railway, which could be significant.

The replacement of existing stock on a like for like basis would not accommodate this growth. The expected growth, in passenger kilometre by sector, is summarised in **Table 4.1**. Although some spare capacity exists on the network at present (and assuming that average passenger journey lengths remain constant), the industry will require additional vehicles to accommodate this growth.

The procurement of new rolling stock needs to be considered against the future passenger growth estimates.

Table 4.1 – Summary of long term passenger growth

Market	Passenger km Growth to 2034	Average Rate Per Year
London commuter	+40%	1.3%
Long distance	+68%	2.0%
Regional urban commuter	+104%	2.8%
London other	+90%	2.5%
Regional urban other	+116%	3.0%
Rural	+90%	2.5%

Source: Planning Ahead 2010 (RFOA, ATOC & Network Rail)

4.7 Environmental concerns

The environmental challenges that the UK faces are considerable and the railway must continually consider ways to improve its performance. The Government has set a general target of reducing carbon dioxide emissions by 80 per cent by 2050. Whilst rail produces less carbon per passenger kilometre than its main competitor, the private motor vehicle, nonetheless it will need to ensure that it innovates to maintain that position. Other transport modes will undoubtedly face similar challenges in meeting improvement targets. However, as the asset life of, say, a motor vehicle is shorter than that of rolling stock, so the implementation of new technology may be faster in these other modes.

The procurement of new and more modern rolling stock can offer benefits of reduced emissions by addressing technical and operational changes:

- Technical changes: new rolling stock can weigh less, have improved aerodynamics, reduce traction system losses, use regenerative braking, improve space utilisation and improve passenger comfort
- operational changes: modern rolling stock designs can offer increased load factors and efficient driving strategies.

The extension of the electrified network will bring an opportunity to replace diesel vehicles with more environmentally friendly electric vehicles. Life extension of existing vehicles could well include more modern traction packages.

In overall terms, rail's carbon emissions are relatively low, with rail responsible for less than 1 per cent of total Great Britain's carbon emissions. Increasing numbers of passenger and freight services, combined with the introduction of heavier and higher performance trains, has resulted in modest increases in rail carbon emissions over the past decade. However, rail's carbon efficiency – measured in terms of the amount of carbon emitted per passenger or tonne transported – remains good. In addition, the net impact of increasing rail activity on carbon emissions must take account of modal shift, where passengers and goods travel by rail instead of road or air. If a strong modal shift can be demonstrated, then additional rail activity could lead to a net reduction in carbon emissions.

However, it is clear to the Government that rail must improve its carbon efficiency in order to maintain its environmental advantage over other modes and to reduce its operating costs. The rail industry has also recognised the importance of improving its environmental performance to its longer term success. The sections below discuss a range of issues relevant to this.

4.8 Legislation

A number of pieces of upcoming legislation will influence the rolling stock choices that are made by the industry. New vehicles which are brought onto the network must be compliant with current legislation.

4.8.1 Accessibility

Rail Vehicle Accessibility Regulations (RVAR) have applied to all new rail vehicles entering service in Great Britain since 31 December 1998. They standardised accessibility requirements to meet the needs of disabled passengers including, for example, provision for wheelchair users, the size and location of handrails, handholds and control devices as well as the provision of passenger information systems and other equipment. However, on 1 July 2008, a new European standard for the accessibility of passenger rail vehicles, the Technical Specification for Interoperability for Persons with Reduced Mobility (PRM TSI) came into force. The PRM TSI applies to all trains used on the interoperable rail system, which comprises the major lines of the mainline rail system in Britain. It also covers the accessibility of railway stations and related infrastructure. To avoid dual application by domestic and European access regimes, the scope of RVAR was reduced to non-heavy rail only. 46 per cent of the national heavy rail fleet has been built to modern access standards, as at March 2011.

As well as new rail vehicles, the PRM TSI also applies to older rail vehicles (those introduced prior to 1999) when they undergo refurbishment. The law requires that all rail vehicles, both heavy and light rail, must be accessible by no later than 1 January 2020.

4.8.2 Interoperability

Interoperability is a European initiative aimed at improving the competitive position of the rail sector with other transport modes, and in particular with road transport.

The Government expects interoperability to benefit the United Kingdom (UK) by:

- Delivering economies of scale in the cost of components and equipment through the single market
- providing a consistent and simple pan-European approvals system for putting railway assets into service
- reducing, to the extent that it will be possible for the UK, the barriers to the through operation of trains throughout Europe.

Interoperability will grow by the progressive adoption of technical standards as the rail system is renewed or upgraded, and new assets are built. Interoperability can be effectively achieved or built into enhancements only when a railway asset is at the design and build stages of its lifecycle. This is why the regulations are directed at new build and at major work during the life of the asset which presents opportunities to increase standardisation.

The rail industry needs to engage with the Railways (Interoperability) Regulations 2006 whenever it is embarking on a project for new build, or upgrade or renewal of existing assets. The regulations establish a framework and set standards within which that project must be carried out. They do not require the industry to undertake work purely for the purpose of delivering interoperability.

The DfT is working with the railway industry to ensure that the UK Interoperability Implementation Plan will add commercial and technical value to the UK.

4.8.3 Non-Road Mobile Machinery Directive

The Non-Road Mobile Machinery (NRMM) European Directive regulates exhaust emissions from non-road machinery engines, including those powering diesel rolling stock. NRMM sets engine exhaust emissions limits for new engines for non-road applications, including rail. This will require increasingly stringent standards for new engines, including new replacement engines which may be a driver of change for replacement of self-powered rolling stock.

4.8.4 Management of noise

EU Directive 2002/49/EC on the management of environmental noise requires member states to produce noise maps and action plans for major transport infrastructures including railways. The directive requires railway operators to consider noise impacts when drawing up action plans regarding infrastructure. By 2013 Member States must ensure that all authorities have drawn up action plans for all major railways in their territories.

In order to adhere to the Directive, in 2010 the Government published the Noise Policy Statement for England (March 2010). It seeks to fulfil the directive's requirements.

It is considered that railway lines carrying more than 80 trains each way per day will have to adhere to the directive. As yet it is unclear as to how this will directly impact upon existing rolling stock and when planning for new rolling stock.

5 Gaps

5.1 Introduction

This chapter outlines the key gaps which can be identified between today's railway and a future railway and which, if bridged, could exploit benefits derived from the drivers of change identified in **Chapter 4**.

The gap types are:

Type A: Rolling stock replacement
Type B: Planning infrastructure and rolling stock together
Type C: Operational flexibility
Type D: Legislation.

5.2 Type A: Rolling stock replacement

In developing the gaps, Network Rail asked a range of questions about rolling stock capital costs to the Railway Industry Association (RIA), which represents UK-based railway suppliers. RIA's rolling stock manufacturer members are Bombardier Transportation, Alstom and Siemens. The questions were:

- How does the length of passenger rolling stock vehicles affect cost?
- what is the variation in vehicle cost with order volume?
- what is the cost of discontinuous rolling stock procurement?

In part based on RIA's evidence, Type A gaps have been identified as a basis for analysis. These will help in identifying the major opportunities which could be considered for inclusion in a passenger rolling stock strategy.

Type A gaps are those where there is a requirement to replace ageing rolling stock or procure new rolling stock to accommodate growth. This may present an opportunity to procure future rolling stock in a more cost efficient manner.

The Working Group have undertaken extensive consultation with industry stakeholders to gain an improved understanding of the cost of providing new rolling stock and of the interdependencies between the business models of train builders (and their suppliers) and the activities of key industry organisations such as Government, lessors, Train Operating Companies (TOCs) and Network Rail.

Four gaps have been identified which relate to rolling stock replacement, they are:

Gap A1: Insufficient rolling stock to meet future growth
Gap A2: Better alignment of rolling stock replacement to match market sector needs
Gap A3: Economies of scale
Gap A4: Continuity of procurement.

Each gap has been explained in turn.

5.2.1 Gap A1: Insufficient rolling stock to meet future growth

By 2034 total national passenger demand is forecast to grow by approximately 80 per cent. The growth is expected to be stimulated by growth in employment, population and the economy. Beyond this background growth significant additional growth may be stimulated by further improvements in rail services and other drivers of change.

Accommodating this growth presents a challenge to the industry.

Capacity already exists to accommodate some of this growth during off-peak periods, and to a lesser extent during the peak by increasing rolling stock seating density or more efficient resource allocation. However, in the medium to long term, if rail is to exploit the opportunities which arise from the forecast demand, additional capacity will be needed, which will require the procurement of additional passenger rolling stock to run longer and more frequent services. **Figure 5.1** shows the current fleet of approximately 12,000 vehicles being withdrawn from service over time as they reach the end of their theoretical commercial life. The commercial life of rolling stock tends to be 30 years for diesel vehicles and 35 years for electric vehicles and coaching stock, however there are some vehicles within the current fleet which will be operational beyond this. On the basis of this assumption, by 2030 over half of the current fleet will require replacement, although it should be noted that rolling stock is often operated beyond this asset life with investment in life extensions and refreshes.

As discussed in **Chapter 3**, the cost of procuring rolling stock is high. Affordability plays a major part in any rolling stock procurement decisions that are made. If rolling stock costs remain high there may be a trend to consider alternative solutions or forgo the procurement of new vehicles.

Gaps exist where there is a need for new rolling stock in the future. **Figure 5.1** shows a scenario of the rate of life expiry of the current and committed fleet of rolling stock based on the theoretical commercial asset life quoted above.

Table 5.1 details the fleet size split by market sector and the average annual requirement for new vehicles based on a) no growth and b) a 1.25 per cent per annum long term traffic growth trajectory, which is consistent with the longer term view of demand growth.

New vehicles may in some instances have less capacity than the vehicles which they replace. This is because of changing legislative requirements, such as the provision of accessible toilets and crumple zones, and changing passenger expectations about facilities, which reduce the available space. The impact on capacity will need to be considered on an order-by-order basis. Excluding these considerations, the forecast growth and the predicted removal from service of some of the current fleet, shows that there could be a need to procure over 8,000 vehicles in the next twenty years alone.

Figure 5.1 – Scenario of life expiry of the existing and committed UK passenger rolling stock fleet

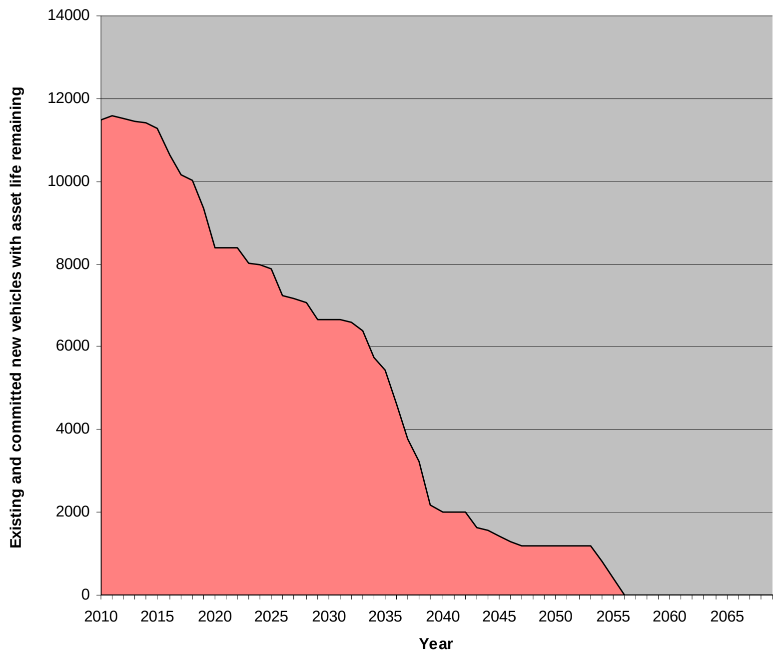


Table 5.1 – Annual vehicle replacement at selected growth rates and life expiry scenario

Market sector	Average annual vehicle replacement at selected annual traffic growth rates	
	Replacement due to life expiry only, no traffic growth (new vehicles per year)	Replacement due to life expiry plus additional vehicles to accommodate long-term traffic growth at 1.25% (new vehicles per year)
Long distance high speed	62	90
Interurban	37	46
Regional	37	50
Outer-suburban	164	246
Inner-suburban	54	95
Rural	11	12

5.2.2 Gap A2: Better alignment of rolling stock replacement to match market sector needs

As discussed in **Chapter 3**, each of the market sectors has different requirements of the rolling stock which serves them. Currently there are 16-20 broad types of rolling stock serving the six market sectors.

It is important that the needs of the market sectors are considered when new rolling stock is procured in order for the vehicles to remain fit for purpose over the duration of their life.

Market sectors can change over time. They may grow or decline and passenger expectations may change. Passengers' preferences change and their perception of rolling stock varies accordingly. The Government's 2007 Rail White Paper described a future where passengers would be more affluent and there would be a high demand for rail to accommodate passengers travelling over greater distances. In the development of a market sector, new rolling stock can be introduced or existing vehicles may be overhauled in order to become up-to-date with passenger requirements. Rolling stock overhaul may involve new interior layouts being fitted as well as other technological advancements.

Gaps may exist where passenger market sector needs have not been identified when rolling stock is introduced.

5.2.3 Gap A3: Economies of scale

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'.

As introduced in **Chapter 3**, there are 16-20 broad types of rolling stock in use over the network, each with a set of bespoke major components and associated research and development costs. Whilst some elements of the design would be common to rolling stock produced for the global market, much of the design would necessarily be bespoke. As a result, Great Britain has not been able to exploit fully the economies of scale in rolling stock production.

A reduction in the number of variants, and an increase in the size of each group, 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.

Gaps exist where there has not been the ability to exploit economies of scale when procuring new rolling stock. High start up cost of production and small fleets of bespoke rolling stock designs increase the overall cost of rolling stock.

5.2.4 Gap A4: Continuity of procurement of rolling stock

As discussed in **Chapter 3**, in recent years the number of new vehicles ordered has not been consistent. **Figure 3.11** within **Chapter 3** shows the number of new vehicles ordered each year in Great Britain since 1988 until 2010. Over this period procurement of new rolling stock has been planned around replacement of fleets upon life expiry, such as the deployment of Class 220/1 vehicles on the Cross Country franchise in 2001/02 and the Class 390 rolling stock on the West Coast Main Line in 2002. This has led to a stop/start pattern of orders. A large bespoke order to replace a fleet has tended to be preceded or followed by several years with lower numbers of orders.

Lengthy gaps between orders have meant that once an order has been completed train builders and their suppliers have taken a view that it is not always commercially viable to maintain the level of productive capacity that is required to meet similarly sized future orders of the same design. The result of this is that a new rolling stock order usually involves mobilisation of productive capacity from scratch. This requires procurement of industrial hardware, production line set up, and recruitment in both train builders and their suppliers prior to the start of work, and redundancy and asset wastage once the order has been completed.

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.

Gaps have been identified where the discontinuous production of vehicle designs increases the cost of procuring new vehicles.

5.3 Type B: Planning infrastructure and rolling stock together to reduce whole industry, whole life costs

Type B gaps are those which relate to planning of the infrastructure and rolling stock together, which if optimised could potentially offer future cost efficiencies in rolling stock procurement for the railway.

There are many interfaces that exist between the rolling stock and the infrastructure which it operates over. The interfaces can be considered to affect both the operational performance of a vehicle as well as the experience which the passenger has. The network gauge, for example, affects where a vehicle operates. The platform/vehicle interface can affect passenger access as areas of the network are subject to variation of the platform position.

Four gaps have been identified which relate to planning the infrastructure and rolling stock together, they are:

Gap B1: Infrastructure not always planned for future vehicle designs
Gap B2: Vehicle length
Gap B3: Vehicle and network gauge
Gap B4: Platform/train interface.

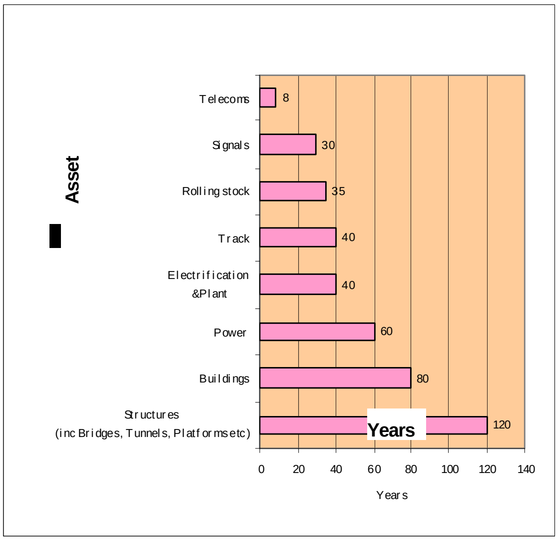
Each gap has been explained in turn.

5.3.1 Gap B1: Infrastructure not always planned for future vehicle designs

Structures over the network tend to have a longer asset life than other components of the railway system. Bridges, tunnels and viaducts, for example, exist which are over 150 years old and have seen little change since they were first constructed. This means that some of the oldest structures on the network have potentially seen at least five generations of rolling stock.

Figure 5.2 shows the typical asset life of some of the railway system components. However, there is considerable variation of asset life of the same types of structures depending on a variety of factors including construction material.

Figure 5.2 – Typical railway asset life



Because rolling stock tends to have a much shorter asset life than the major structural components of the railway it has, in the past, been accepted that new vehicles would be introduced to match the existing capability of the routes for which the rolling stock is to be deployed. The routes which serve the market sectors are often diverse in nature and the infrastructure is often variable in its physical capabilities. This situation has led to the development of rolling stock which is designed to operate over a particular route and not widely deployable across similar routes within the same market sector.

More recently, new railways such as High Speed 1 (HS1), and re-opened railways like the route between Airdrie and Bathgate, have been designed with both future rolling stock and infrastructure in mind.

Gaps exist where some structures over the network have not been designed to consider the future rolling stock types which may be required to operate.

5.3.2 Gap B2: Vehicle length

A gap has been identified where cost efficiencies could potentially be made if vehicle lengths are optimised to achieve the lowest capital cost train configurations. RIA have identified that the costs to rolling stock can be broadly divided into two categories:

- Costs which rise roughly in proportion to the length of the vehicle – bodyshell, seats etc
- costs which do not have a direct dependency upon length of the vehicle – bogies, cabs, air conditioning etc.

RIA has stated that although the second category of costs are not directly related to length, they are not fixed costs. The optimum choice of bogie design or air conditioning arrangement etc is not generally the same for vehicles of a differing length, even if the vehicle is intended for the same kind of service. RIA has estimated that the cost of manufacturing the following vehicles varies proportionally according to length:

- A 23 metre vehicle is between ~8 per cent and ~12 per cent more expensive than a 20 metre vehicle
- a 26 metre vehicle is between ~15 per cent and ~25 per cent more expensive than a 20 metre vehicle.

It must be noted that all other factors affecting costs (ie those not relating directly to the vehicle configuration) are excluded from the figures above. Specifically this includes commercial considerations and the one-off costs that apply to fleets, not to individual vehicles (such as design, development and approvals costs). The one-off cost factors were explored within Gap A3: Economies of scale. Consideration of these costs lead to the conclusion that longer vehicles are more expensive than their shorter equivalents. However, when choosing the lowest capital cost train configuration, there are some instances where the overall train costs using longer vehicles for the equivalent seating capacity is less expensive. For example:

- A 10 x 23 metre train is ~7 per cent to ~12 per cent less expensive to produce than a 12 x 20 metre train
- a 9 x 26 metre train is ~6 per cent to ~14 per cent less expensive to produce than a 12 x 20 metre train.

Again, these figures do not consider one-off costs. Considering these costs, trains with equivalent capacity made up of longer vehicles may offer the opportunity to reduce the capital cost of a train. Choosing a comparative train length which comprises fewer vehicles may reduce maintenance costs as in some cases there may be a reduction in the number of bogies or air conditioning equipment.

Gaps have been identified where efficiencies could be made in the future procurement of rolling stock by using fewer but longer vehicles delivering the equivalent seating capacity. This gap would need to be considered along with the infrastructure costs associated with the introduction of longer vehicles.

5.3.3 Gap B3: Vehicle and network gauge

Gaps exist where vehicles within the fleet cannot be used across all routes serving a similar market sector due to mismatches with the vehicle and network gauge.

Network gauge can vary across the routes of each market sector dependent upon the type of structures which are present across them. There are variations throughout the network, generally arising from the building practices of the Victorian train companies. In London and the South East, for example, there are areas which have a smaller network gauge due to the structures and the nature of the curved track which brings particular challenges at platforms and tunnels.

The structures which may impact on a route's gauging capability range in complexity and cost to alter. Generally the most complex structures are viaducts, over-bridges and tunnels. Platforms, crossings and line-side equipment are in most cases less expensive to alter.

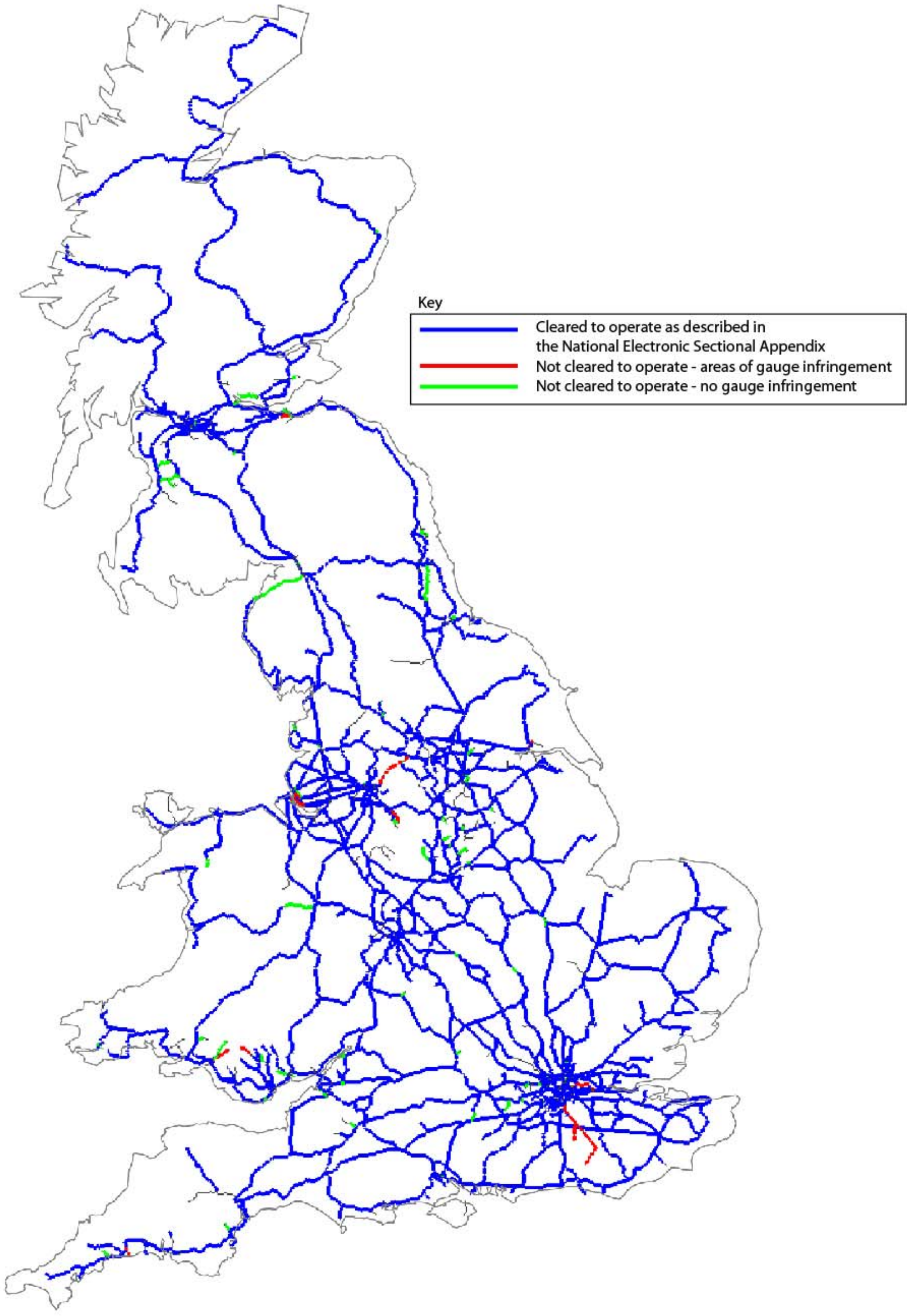
The network gauge plays a key part in determining the coverage of vehicles which operate over the network.

The network gauge needs to be considered along with the dimensions of particular rolling stock in order to understand if a vehicle is compatible with a particular route. Once the rolling stock dimensions have been considered, factors such as the vehicle's dynamic performance need to be understood as this can further increase the space required between the vehicles and the structures. This is called a vehicle's kinematic envelope. Subtle differences in vehicle design can impact upon their interface with the network.

Figure 5.3 maps the coverage of the MK II coach, which is a 20 metre long vehicle designed to be able to 'go-anywhere' on the network. The blue lines show where it is currently cleared to operate as identified within the National Electronic Sectional Appendix (NESA), the red lines show areas of the network where there may be some gauge infringement and the green lines denote where the vehicle is not cleared to operate but may be able to as there are no gauge infringements. **Figure 5.4** maps the equivalent coverage of the Class 166, the high proportion of red lines shows that there are potentially a higher number of gauge infringements.

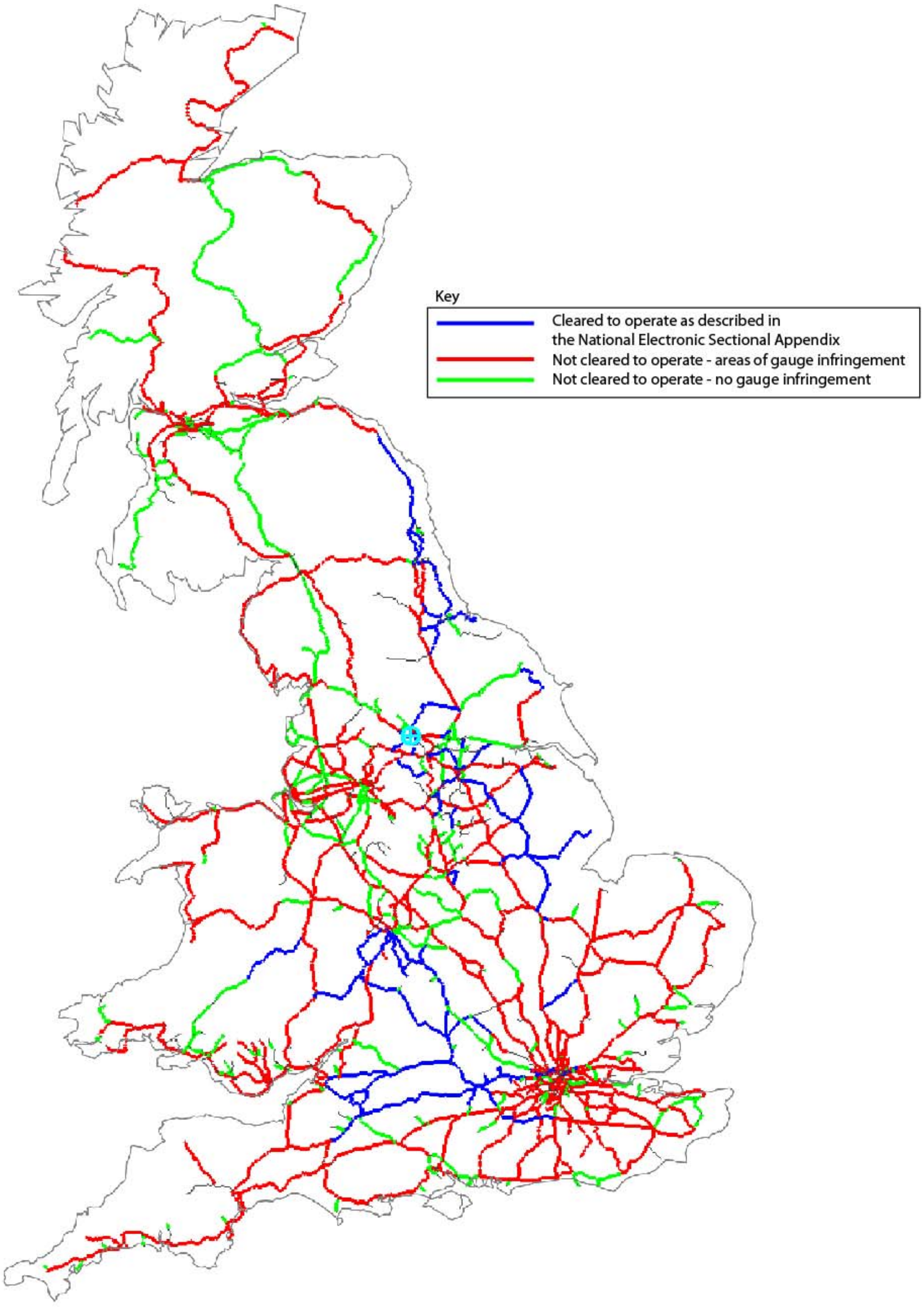
Gaps have been identified where variations in vehicle and network gauge may inhibit vehicle coverage of the routes.

Figure 5.3 – Routes with structures with foul or special reduced clearances to a Mk II vehicle



Source: Rail Safety Standards Board (RSSB), Report T787, September 2009

Figure 5.4 – Routes with structures with foul or special reduced clearances to a Class 166 vehicle



Source: Rail Safety Standards Board (RSSB), Report T787, September 2009

5.3.4 Gap B4: Platform/train interface

The vehicle platform interface can be considered as the horizontal and vertical distance between the train and platform. The interface is impacted by the design of the rolling stock and the platform as well as the track alignment. The following design features can impact upon the interface:

- Train floor height
- position of the passenger doorways relative to the bogie
- position of a secondary step on vehicles with high floors
- platform height
- rail to platform position (lateral)
- radius of the track
- track cant.

Platforms have been developed over time to different specifications for a variety of reasons; again this is often due to the building practices of our Victorian predecessors. Some platforms on the East Anglia route are now high because the track was lowered to accommodate a past electrification programme. Platforms on the network vary in position relative to the adjacent track. **Figure 5.5** details the position of each platform across the whole network by plotting the height and distance from the running rail. The diagram shows the relationship between the platform edge and the rail. It plots every point along a platform (generally at 5 metre intervals); where lots of these points coincide, a change of colour is used. It shows that most platforms are within maintenance tolerance of the 915 millimetres high from rail, 730 millimetres away from rail mandated for new platforms, with a few exceptions, usually single locations along a platform.

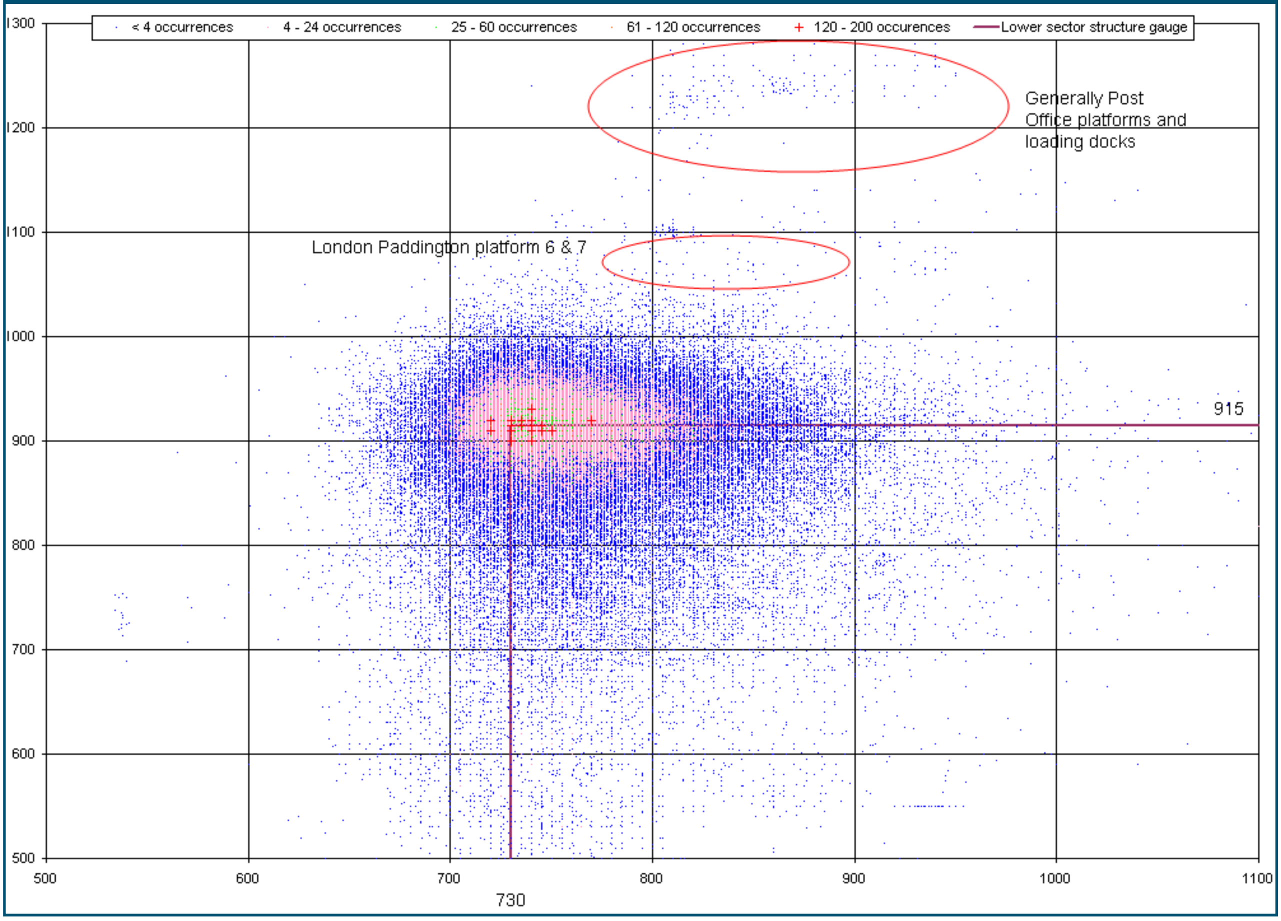
There are a number of platforms that are high, mostly by design, such as Post Office and Heathrow Express platforms. Many more are low mainly due to track works over the years; these may be candidates for Harrington Hump type rectifications. The cluster of points has a tail to the right as lateral clearances have to be increased as track radii approach 360 metres and below.

As track radii decreases, the amount a vehicle throws increases. To allow for this, structures and platforms on tight (<360 metre radius) are moved away from the track. Were the radius is less than 160 metre (which is the Victorian alignment of at least 100 platforms) stepping distances become non compliant and a large gap is present between vehicle and platform, especially those vehicles where the door is positioned at the centre or end of the vehicle. In practice these platforms are very difficult (and expensive) to correct, usually due to the constraint that caused the tight curvature in the first place.

Other factors which can affect the platform and vehicle interface can be influenced by the market sectors which the route serves. For example, a route that serves high speed or freight vehicles may require additional clearance tolerances built into the structures to accommodate high speed or loaded vehicles.

Gaps exist on areas of the network where the match between the vehicle step and platform position are not optimal.

Figure 5.5 – Plot of platform edge positions across the UK network



5.4 Type C: Operational flexibility

Type C gaps are those which affect a vehicle's operational flexibility. The operational flexibility of the fleet can be limited by a vehicle compatibility with other vehicles and its network coverage.

Three gaps have been identified which relate to the operational flexibility of rolling stock, they are:

Gap C1: Vehicle compatibility
Gap C2: Vehicle network coverage
Gap C3: Network electrification

Each of these gaps is explored in turn.

5.4.1 Gap C1: Multiple Unit Vehicle compatibility

As introduced in **Chapter 3**, the number of multiple unit vehicle classes which are compatible with each other is a small proportion of the entire fleet. Many classes serving the same market sector cannot couple or operate together because of differing coupling systems. This creates a barrier to interworking vehicles.

Table 5.2 details the 9 different classes of multiple unit which can only couple and inter-work within their own class. Diesel Multiple Units (DMUs) and Electrical Multiple Units (EMUs) within the fleet cannot operate together although there are a few which can couple for emergency purposes. A fleet that is limited in vehicle-to-vehicle compatibility can be restrictive in terms of operational flexibility. Vehicles that do not interface cannot work together in rescue situations or allow for portion working of trains, where units can be separated in service to efficiently cover routes.

The main reasons for a lack of compatibility between classes of multiple units are:

- There are several types of auto-couplers in use of which only the Scharfenberg and Dellner types are mechanically compatible
- electronic and software systems differ between classes both in terms of train control systems, as well as train management and passenger information systems
- compatible vehicles must have the same maximum operating speed.

Gaps exist where similar vehicles serving a market sector cannot be coupled and operated together due to dissimilar interfaces.

5.4.2 Gap C2: Vehicle network coverage

Vehicle network coverage refers to a vehicles ability to be deployed over the routes of the network. Vehicle network coverage can be determined by the characteristics of the network, such as gauge and power supply or the design characteristics of a vehicle. In its simplest terms, an electric vehicle cannot operate where the network is not electrified. Some areas of the network demand unique vehicle characteristics in order to obtain a desired performance. The West Coast Main Line has significant curves for a long distance high speed route which limit speed without a tilting vehicle design, such as the Class 390, to operate at the maximum achievable line speed.

A number of vehicle types on the existing network have limited coverage due to their gauge; wider vehicles, such as the Class 165/166s are not as deployable across the network. Historically there have been some vehicles developed with wide network coverage in mind.

Table 5.2 – Multiple unit vehicle classes which can only operate within the same classes

DMU	171
	185
EMU	332
	333
	334
	357
	365
	395
	442

The British Rail MK2 coach has excellent network coverage as identified in **Figure 5.3**.

Signalling and radio communication systems can be specific to certain routes restricting the vehicles that can be operated. For example the Cambrian Line has been used as a trial for European Rail Traffic Management System (ERTMS) Level 2 which requires that the rolling stock operated on this route are fitted with Global System for Mobile Communications-Railway (GSM-R) and European Train Control System (ETCS). As ERTMS is implemented across the network the conversion of rolling stock to allow them to operate on these routes will become a wider issue for flexibility of deployment.

The various Strathclyde EMUs were tied to their local area without conversion work, because they were fitted only with Strathclyde Manning Agreement (SMA) voice radio which was not used anywhere else. However, with the advent of GSM-R the radio is becoming standardised.

Gaps are present where rolling stock has limited network coverage and cannot be deployed over all the routes serving a market sector.

5.4.3 Gap C3 – Network electrification

Approximately 40 per cent of the British rail network (measured in track miles) is currently electrified. Two-thirds is equipped with overhead line alternating current electrification, whilst the remainder of the system is predominantly third rail direct current electrification with some small local systems.

A substantial number of self powered trains run on the electrified network (a practice referred to as “running under the wires”). This is commonly the case when a service is scheduled with an origin or destination outside of the electrified portion of the network.

It is unlikely that the electrification of some parts of the network with low value use will have an acceptable business case so a self-powered solution will continue to be required. Environmental targets for the reduction of harmful emissions and the uncertainty of the costs of domestic oil in the future demand that alternative to diesel self propelled vehicles are sought.

Gaps exist where electric vehicles cannot be so widely deployed due to the coverage of the electrified network.

5.5 Type D: Legislation

Type D gaps are those that arise from the introduction of new or changed legislation. In some cases legislation impacts the rolling stock fleet over the longer term with the requirement for the fleet to become compliant within many years. This is often the case where vehicles need extensive modification.

Two gaps have been identified which relate to legislation, they are:

Gap D1: Accessibility
Gap D2: Carbon and emissions

Each gap has been explained in turn.

5.5.1 Gap D1: Accessibility

The legal deadline for all rolling stock to be accessible is significant for rolling stock operators. Whole vehicle classes would require major overhaul works or face removal from the network by 2020. Others will require minor modifications to bring them into line with the Regulations.

Gaps exist where some vehicles within the current fleet require modification in order to become compliant by 2020.

5.5.2 Gap D2: Carbon and emissions

The fuel quality directive sets the maximum permitted sulphur limits in fuel. The directive will see a move to sulphur free diesel by January 2012. It will also bring with it a minimum blend specification for biofuel.

The Non-Road Mobile Machinery Directive (NRMM) sets engine exhaust emissions limits for new engines for non-road applications, including rail. This will require increasingly stringent standards for new engines, including new replacement engines.

Gaps may be present in the future where the affordability of using diesel powered rolling stock requires alternative power solutions to be considered.

5.6 Summary of the gaps

Table 5.3 summarises the gaps which have been discussed within this chapter. **Chapter 6** goes on to discuss options which address these gaps.

Table 5.3 – Summary of gaps		
Gap ID	**Gap name**	**Driver of gap**
	Type A gaps – Rolling stock replacement	
A1	Insufficient rolling stock to meet future growth	• The fleet is ageing • market sector growth scenarios may require additional new rolling stock in order to accommodate increased numbers of passengers • new rolling stock costs are high and it may not be affordable
A2	Better alignment of rolling stock replacement to match market sector needs	• There is not a high level specification that matches the passenger needs of each market sector with the infrastructure, such a specification only relates to the vehicle network interface
A3	Economies of scale	• High start-up costs for vehicle production runs • comparatively small orders of bespoke rolling stock has a higher cost
A4	Continuity of procurement of rolling stock	• Lengthy gaps between rolling stock orders
	Type B gaps – Planning infrastructure and rolling stock together	
B1	Infrastructure not always planned for future vehicle designs	• Lack of coordinated planning of rolling stock and infrastructure can be costly
B2	Vehicle length	• Variety of vehicle lengths serving the market sectors • longer vehicles may offer opportunity to reduce the capital cost of a train
B3	Vehicle and network gauge	• Network gauge variations across routes serving a similar market sector • variety of vehicle sizes which have been developed for particular routes – this manifests into vehicle cascade difficulties • vehicles deployed across the network can vary in size and shape in order to be compatible with the gauge
B4	Platform/train interface	• Vehicle and platform interfaces vary due to the historical development of platforms and a variation of rolling stock step positions • over the network there are some areas which have a mismatch between the vehicles and the platforms causing large gaps, high or low stepping distances
	Type C gaps – Operational flexibility of rolling stock	
C1	Multiple Unit Vehicle compatibility	• Some multiple unit vehicles serving a market sector cannot be coupled and operated together due to dissimilar interfaces
C2.	Vehicle network coverage	• Vehicles serving a single market sector are often not able to operate over the all the sectors routes • electric vehicles cannot be used over non-electrified network • gauge restrictions • in-cab signalling or radio system compatibility may restrict routes on which vehicles can operate
C3	Network electrification	• Increase the operational flexibility of electric rolling stock • diesel vehicles are less desirable on environmental and cost grounds

Table 5.3 – Summary of gaps (Cont)

Gap ID	Gap name	Driver of gap
		Type D gaps – Legislation
D1	Accessibility	• Introduction of legislation may require that some of the existing vehicles are modified in order to remain in service
D2	Carbon and emissions	• Non-Road Mobile Machinery legislation will set targets for exhaust emissions for new engines fitted to rolling stock including replacement engines on old rolling stock. • fuel quality directive which sets the maximum sulphur limits. In the short term this will see a move to sulphur free diesel • noise directives which requires Member States to produce noise maps and action plans for major transport infrastructures including railways

6 Options

6.1 Introduction

This chapter discusses options identified to address the four categories of gaps discussed in **Chapter 5**. In each case, the option selection process was undertaken with the aim of reducing the whole industry whole life cost of passenger rolling stock, and the infrastructure, as well as meeting the passenger requirements of each market sector.

The analysis presented within this chapter is the Working Group's best estimate of the likely financial outcomes of the changes to rolling stock and infrastructure planning postulated in the Route Utilisation Strategy (RUS). However, It is understood that:

- The market conditions required to allow these changes may not currently exist; and
- it may be possible to improve the accuracy of these estimates if more detailed data were available.

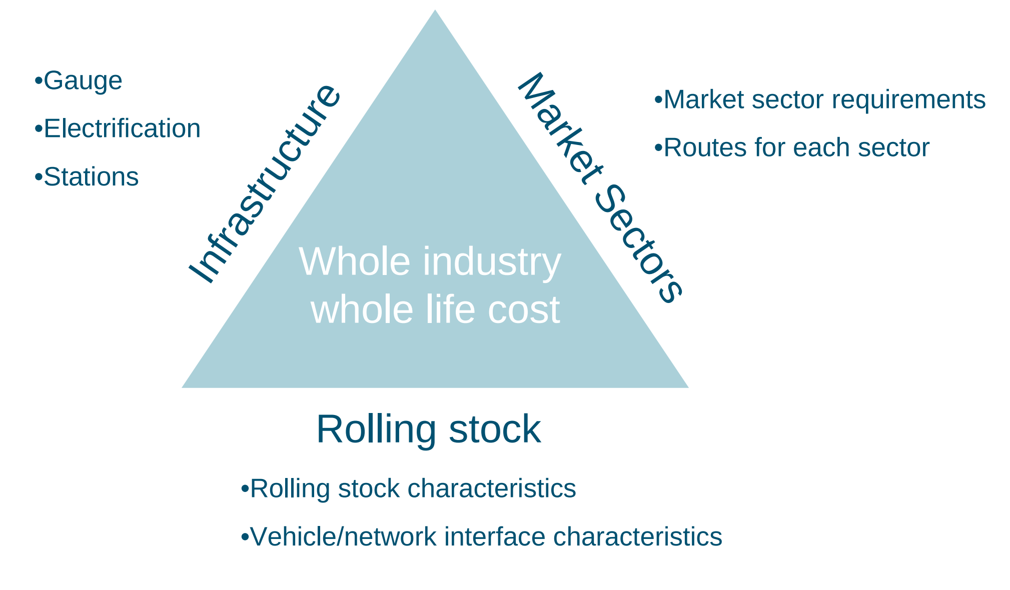
Options have been grouped into categories and a series of matrices are used to show which gaps each option addresses.

The categories that the options have been grouped into are as follows:

1. **Economies of scale and efficient procurement of rolling stock** – these options present the savings which could be achieved by purchasing rolling stock in sufficient volumes and smoothing the procurement over time
2. **meeting the needs of the market sector using fewer types of rolling stock** – this option considers the passengers and operational needs of rolling stock in each market sector. In particular it considers those aspects which interact with the infrastructure
3. **planning the infrastructure together with rolling stock** – these options set out the infrastructure considerations that would be required to ensure that rolling stock identified for a particular market sector can operate where it is needed
4. **options addressing legislative change** – these options relate to the gaps which may arise through the change in legislation affecting accessibility and environmental considerations.

The key finding is that if rolling stock and infrastructure are considered separately, and without reference to service types or market requirements, inefficiencies are likely to result. This interrelationship is illustrated in the diagram **Figure 6.1**.

Figure 6.1 – Relationships comprising whole industry whole life cost



Varying one factor has an impact on the other two elements. For example, if market sector needs change, this may require rolling stock with different characteristics, which in turn may result in differing requirements from the infrastructure. All of the gaps identified have an impact on more than one of the three factors in the diagram. Similarly Options have been considered in this context.

The options considered in this chapter have been set out in turn to build upon each other and are then combined into an appraisal at the end of the chapter. The appraisal discussed in **Section 6.6** combines those options that are dependent upon each other to allow the whole industry whole life cost benefit to be assessed. The options have been combined into the appraisal because beyond considering the viability of the individual options, it is not logical to assess the options in isolation from each other because of the close relationship between the factors which influence whole industry whole life cost.

6.2 Options to achieve economies of scale and efficient procurement of rolling stock

The British passenger rolling stock fleet comprises approximately 12,000 vehicles, where a vehicle is defined as a train carriage with passenger accommodation that forms part of a passenger train set.

The cost of passenger rolling stock to industry is estimated at £1.8 billion per annum based on 2010 fleet data. This includes leasing costs (which will always include an element to recover the fixed cost of purchase) and associated maintenance costs.

As discussed in the baseline, recent experience suggests that replacement of rolling stock is expensive, as the unit price of new trains is typically significantly higher than that of the rolling stock they have replaced. This places an increasing cost pressure on the industry as the fleet continues to age and requires replacement. Within 10 years over a quarter of the fleet will require life extension or be in need of replacement, and within 15 years this will have increased to nearly 40 per cent. Furthermore, the size of the fleet is likely to increase as passenger numbers continue to grow.

Options have been developed which seek to achieve economies of scale in procurement. **Table 6.1** summarises the options and identifies the gaps which they address.

Table 6.1 – Options to achieve economies of scale and efficient procurement of rolling stock

		Type A gaps – Rolling stock replacement				Type B gaps – Planning infrastructure and rolling stock together				Type C gaps – Operational flexibility of rolling stock			Type D gaps – Legislation	
		A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	D1	D2
1	**Meet market needs with more flexible and whole industry whole life cost effective rolling stock**													
1.1	Achieving economies of scale	X	X	X	X	X				X	X	X		
1.2	Smooth the procurement profile by life extension or withdrawing current rolling stock from service early	X		X	X									

Option 1.1 – Achieving economies of scale

As discussed in **Chapter 5**, the evidence collected by the Rail Industry Association (RIA) suggests that non-recurring costs for each order ranges from £10 million to £100 million. This is a wide range, so for the purposes of analysis, an iterative approach has been used to estimate the likely average non-recurring cost per vehicle type if each variant in the fleet is replaced upon life expiry with a new vehicle. Assumptions have been made to produce this estimate.

It has not yet been possible to produce an accurate apportionment of the constituent elements of the one-off non-recurring costs (for example; vehicle design, major component design, testing and approvals). It has therefore been necessary to estimate the number of rolling stock "variants" within the current fleet which have a sufficient number of unique constituent elements to generate the average non-recurring cost implied by the range suggested by RIA. On this basis, it is estimated that there are currently 16 rolling stock variants in Britain, which means the total price paid to provide rolling stock is assumed to include 16 sets of non-recurring costs.

The current fleet of circa 12,000 vehicles including those currently on order, distributed over 16 stock variants would have an average size of 750 vehicles per group. Based on the current estimated average build cost per new vehicle, it is estimated that the total build cost of a new type of train is just under £1 billion.

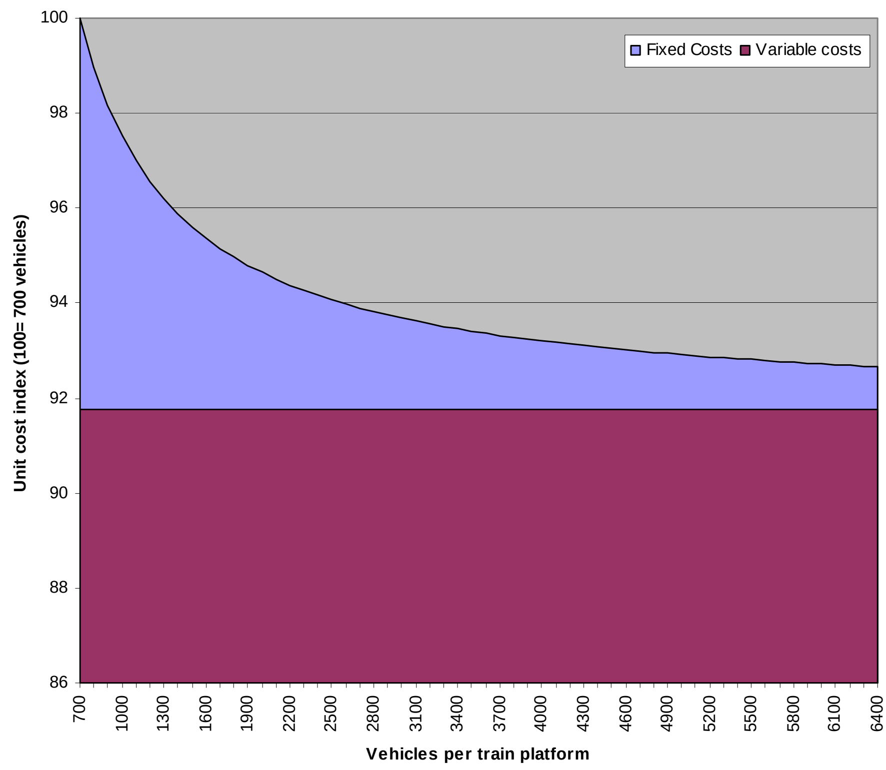
On this basis the £10 million - £100 million range of non-recurring costs is equivalent to between one and 10 per cent of the total costs. Through the process of iteration described below, an estimate of £75 million was reached, which is equivalent to just under eight per cent of the total cost:

- Eight per cent of the £1.1 billion total annual leasing cost to the rail industry is equivalent to just over £85 million per annum
- taking account the likely split of capital and interest repayments, it is estimated that it takes two years to repay £75 million worth of non-recurring capital. This implies one of the 16 types of rolling stock becomes life expired and is replaced every two years
- a 32.5 year average rolling stock asset life divided by 16 types of rolling stock also implies life expiry and replacement of one type of train every two years.

In order to understand the magnitude of efficiency which may be obtainable by addressing economies of scale, it is estimated that the number of types of rolling stock could be reduced from the current 16 broad types to around five. This is discussed further in **Section 6.3** of this chapter.

This reduction in the number of rolling stock variants of around five would increase the average quantity of each variant to around 2,400 vehicles. This would reduce the non-recurring share of the total cost per vehicle from eight per cent to around three per cent and reduce the average cost per vehicle by around 5 per cent. This is illustrated in **Figure 6.2**.

Figure 6.2 - Economies of scale in non-recurring costs



Discussions with manufacturers and rolling stock leasing companies suggest that this reduction would apply to the cost of maintenance as well as the cost of leasing, as the cost of replacement parts largely reflects the cost of building the trains they fit. On this basis it is anticipated that up to £90 million per annum in 2010 prices and values could be saved through an option to reduce the number of train variants.[3]

The potential to exploit savings is dependent on how growth in rolling stock to accommodate increasing passenger demand is deployed over time. For the purpose of analysis, the RUS assumes:

- If the number of generic types of rolling stock increases, but there is no change to the current number of vehicles per variant, an option to reduce the number of train types would be required to make the identified saving
- whereas, if the number of generic types of rolling stock remains the same, but there is an increase in the number of vehicles per variant, a significant proportion of these economies of scale could be achieved without a reduction in the number of train types.

[3] As discussed, the split of this saving by component part will be investigated further during the consultation period. Furthermore, it is likely that use of fewer train variants would produce a saving in staff training costs, however it has not been possible to quantify this.

Option 1.2 – Smooth the procurement profile by life extension or withdrawing current rolling stock from service early

As discussed in the Gaps Chapter, the discontinuity of train orders, that is the large variability in the order profile from one year to the next, years with few orders, and deferral of investment decisions, requires significant mobilisation and demobilisation of the supply chain at the start and end of each order. This imports a significant level of cost into the procurement of new vehicles, which is passed through to the end customer.

Analysis suggests that it would be possible to remove this additional cost by spreading orders for new rolling stock such that the producer of each generic type of train has a guaranteed fixed order of rolling stock over a period of several consecutive years. **Figure 6.3** illustrates the likely cost saving at different volumes of continuous order, and it is estimated that an order of around 200-250 vehicles per year for a period of five years would be required to generate the maximum saving in the cost of producing a single family of rolling stock. This would be achieved by:

- Reducing the number of existing train variants from the current 16-20, with an implied average replacement order per variant over the next 70 years[4] of around 30 vehicles per annum, with two or three variants with an average replacement of close to or in excess of 200 vehicles per annum and
- earlier replacement and/or life extension of rolling stock that these generic types of train would replace in order to spread the order evenly over time.

It is likely that both early replacement and life extension of rolling stock would increase the average cost of rolling stock leasing and maintenance, albeit by a potentially lower cost than the procurement of new trains.

Early replacement of rolling stock would shorten the period of time the asset owner can recover the cost of purchasing rolling stock, and this would be reflected in the price per vehicle. It is estimated that earlier replacement of rolling stock to spread an otherwise one-off order over a period of five years would increase the annual cost over the life of the rolling stock by just over 5 per cent.

Life extension of rolling stock may involve the complete replacement or overhaul of major components which have worn out, and recent evidence suggests that this increases the cost of the rolling stock over remaining extended asset life. For indicative purposes it is estimated that a five year life extension would increase the annual cost by about four per cent, if it were spread over the total life of the rolling stock. The true cost of life extending a vehicle would, in part, be dependent upon where it is within its maintenance cycle. However, life extension of rolling stock may yield short term savings.

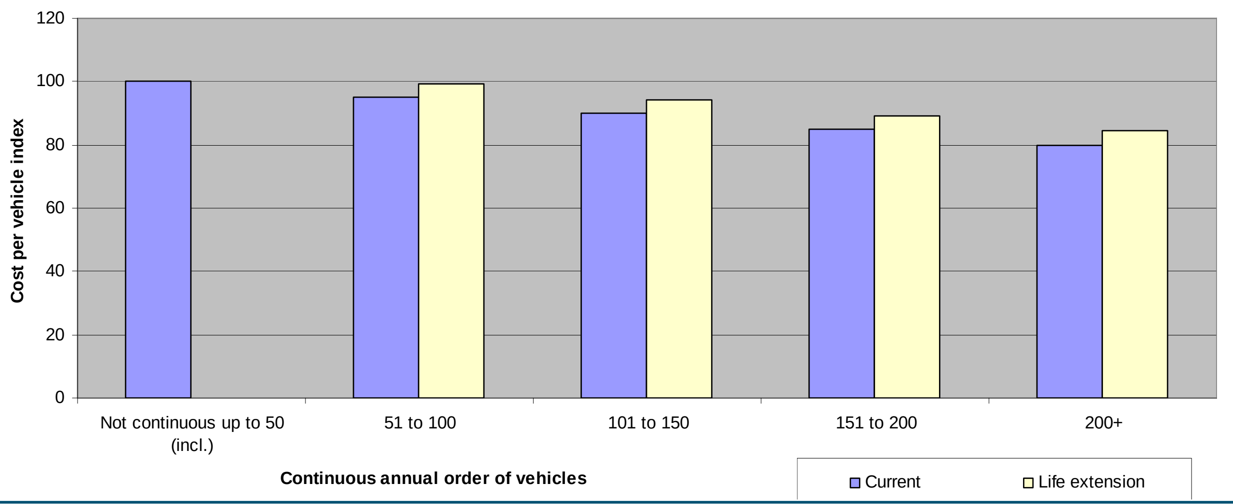
On balance it seems likely that life-extension is less expensive than early replacement and it is estimated that life extension would reduce the maximum potential cost saving through continuous production from the 20 per cent identified by RIA to around 16 per cent. This is illustrated in **Figure 6.3**. However, it is important to emphasise that the implied unit cost saving is a high-level estimate which in reality would depend on the potential to utilise the productive capacity of a plant on other orders.

It is understood that this saving would only apply to leasing costs, as the cost of maintenance is not directly related to the continuity of order. Sixteen per cent of the estimated £1.1 billion total annual leasing cost in 2010 is equivalent to around £180 million.

This saving is dependent on the baseline assumption of how the fleet is expanded to meet underlying demand growth. If the number of generic types of rolling stock increases with no change to the current number of vehicles per variant, then the potential saving identified above would be achieved. If the number of generic types of rolling stock remains the same with an increase over the current number of vehicles per variant, then the saving through this option would be smaller. This is the converse of the potential for economies of scale.

[4] A 70 year period was considered as this covers the complete asset life of the newest existing rolling stock and the trains that replace it

Figure 6.3 – Economies of scale through continuous annual orders of a standard vehicle type



6.3 Options to meet the needs of each market sector with fewer types of rolling stock

Options 1.1 & 1.2 consider the efficiencies that can be obtained through economies of scale and managing a smooth procurement profile. In order to achieve this it was suggested in Option 1.1 that the reduction of rolling stock types may reduce the non-recurring costs associated with each order. This option takes this concept a step further and considers the market sector needs of the rolling stock which serves them in order to reduce the variation of rolling stock procured. **Table 6.2** highlights the gaps which are addressed by this option.

Table 6.2 – Meeting the needs of each market sector with fewer types of rolling stock

		Type A gaps – Rolling stock replacement				Type B gaps – Planning infrastructure and rolling stock together				Type C gaps – Operational flexibility of rolling stock			Type D gaps– Legislation	
		A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	D1	D2
2	**Smooth the procurement the profile of rolling stock**													
2.1	Reducing market sector types	X	X	X	X	X				X	X	X		

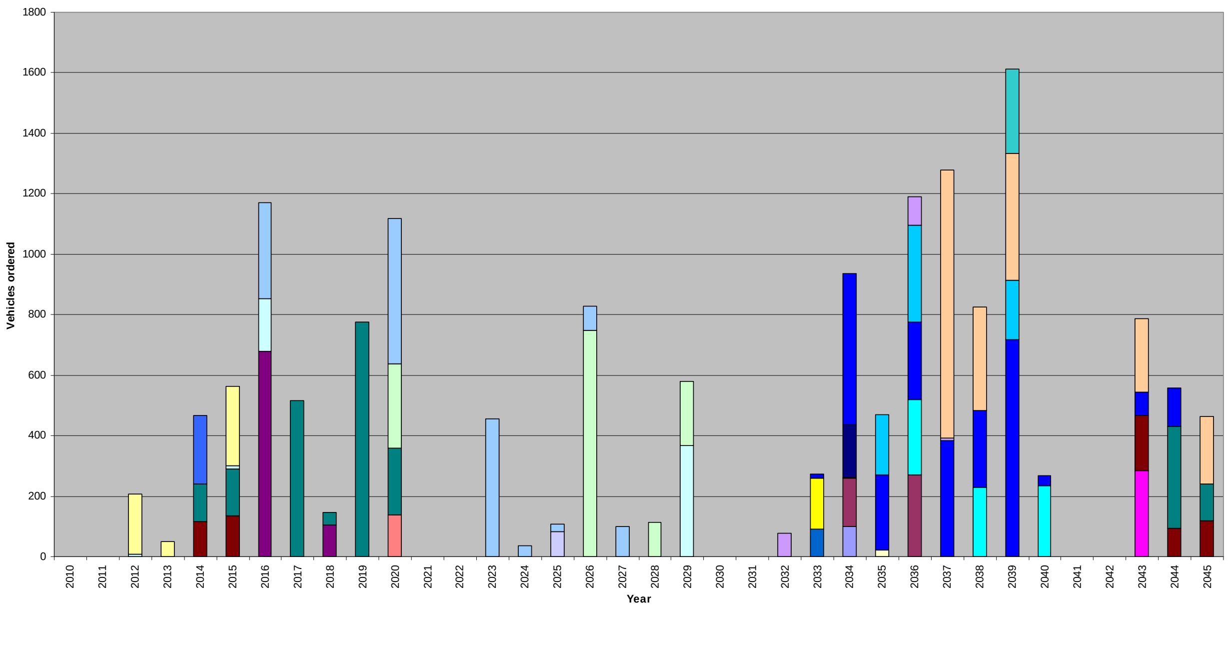
Option 2.1 – Reducing market sector types

A high-level market sector led specification of rolling stock could assist with any future procurement strategy by enabling economies of scale. Economies of scale may result from greater degrees of standardisation in the basic physical characteristics of the rolling stock. A high-level specification for rolling stock that considers the needs of each market sector would help ensure that new rolling stock meets the passenger and operational requirements. This could draw on the approach illustrated by recent schemes such as Thameslink and Intercity Express Programme (IEP) where Passenger Focus managed a survey of passenger requirements to assist with the development of the future rolling stock specification. The Department for Transport (DfT) developed this approach further by announcing that relevant Train Operating Companies (TOCs) will be involved in the detailed design of IEP.

Chapter 3 describes the basic attributes of each market sector and the rolling stock that is currently deployed to serve it. The RUS has undertaken high level development of a specification for rolling stock which addresses the gaps which were identified where there was a mismatch between rolling stock and infrastructure. The option considers whether standardisation of the size of new rolling stock which is introduced to the network would make future cascades and vehicle deployment simpler.

Figure 6.4 illustrates the future pattern of rolling stock replacement over the next 40 years based on the current projection of commercial life expiry. Each colour denotes a broad variation of rolling stock. This shows a sporadic pattern of replacement, likely to impose the cost through discontinuous production identified in **Chapter 5**.

Figure 6.4 – Projected rolling stock replacement based on life expiry of current fleet



Considerations of the market sectors in turn suggest that a more standardised fleet serving each market sector could be achieved as follows:

Outer suburban – replacement of the existing rolling stock with a single variant of trains could increase the average number of vehicles per variant serving the sector from around 700 to nearly 6,000 and provide the opportunity through early replacement and/or life extension to order/replace almost 250 vehicles per year over the appraisal period based upon the central growth assumption. A rolling stock variant of this quantity and a continuous order profile of this magnitude would generate almost the maximum achievable unit cost saving through economies of scale and continuous production.

Interurban and regional – these market sectors are currently served by around 1,200 and 1,100 vehicles respectively. Replacement of the existing rolling stock with a generic type of train for each sector would produce around half of the potential maximum unit cost savings through economies of scale. Individually these market sectors only account for a small proportion of the fleet and as such very little unit cost savings through continuous orders could be achieved.

As the interurban and regional market sectors have similar key requirements it may be possible to specify a single variant of trains to serve both. This would increase the unit cost saving through economies of scale and increase the order size to a level that would generate a unit cost saving through continuous production if early asset replacement and/or life extension were employed.

Rural – taken alone this market sector is too small to exploit the potential savings identified above. However, it would be possible to use a single variant of rolling stock specified for one of the other sectors previously discussed to meet the key requirements of this market. A variant may share similar characteristics such as body shell and traction package.

Furthermore, the key rolling stock speed and passenger accommodation characteristics of the outer-suburban sector are similar to those for the interurban and regional sectors. Analysis suggests that these sectors could be adequately combined and provided with a single type of rolling stock. The rural market sector is accommodated with a variety of rolling stock today, as the sector is too small to account for a single vehicle type it is more cost-effective to include this sector with the outer-suburban group. On this basis, it may be possible to specify a single generic type of rolling stock for all four market sectors.

Inner suburban – this market sector comprises of around 1,700 vehicles, it is sufficiently large enough that specification of a single generic type of train to serve it could generate unit cost savings

Long distance high speed – the rolling stock that is required to serve this market sector is unique in terms of both operational speed and passenger accommodation. Two key factors will influence how this market is served and whether there can be a reduction in rolling stock types:

- The planning process to replace the existing High Speed Train (HST) fleet is underway and the future design is likely to be influenced by this
- high speed tilt enabled vehicles are used on the West Coast Main Line in order to achieve faster journey times. This type of rolling stock is significantly different from rolling stock that does not have this capability and it may not be cost-effective for all long distance high speed rolling stock to share this specification.

Table 6.3 details the high-level rolling stock requirements for the market sectors and introduces the three rolling stock types.

Table 6.3 – Market sector rolling stock requirements

Market sector vehicle type	Maximum speed (mph)	Acceleration	Power requirements	Vehicle length (m)	Tilt variant	Train length (vehicles)	Door layout
Type 1 – Long distance high speed	125 - 140	n/a	25kv electric Diesel Bi-mode	23 or 26	Yes	Up to 12-cars	End
Type 2 – Interurban, Outer suburban, Regional & Rural	100 (occasional 125)	n/a	Dual voltage Self powered	20 or 23	No	Up to 12-cars	Market decision on door position
Type 3 - Inner suburban	Up to 90	High	25kv electric Dual voltage Diesel Bi-mode	20 or 23	No	Up to 12-cars	Market decision on door position

6.4 Options to plan the infrastructure and rolling stock together

Rolling stock and infrastructure cannot be considered as distinct separate systems. In reality they are interdependant. In order to optimise them both in operations, service and whole life terms it is necessary to plan them together.

Figure 6.5 illustrates the interdependency between elements of the rolling stock on the infrastructure. This illustrates that where a factor such as axle load of rolling stock is altered there are implications for the track alignment, route availability and on structures over which rolling stock operates. It is desirable to plan both the design of the rolling stock and any modifications to the infrastructure together to ensure that the interfaces are optimised in terms of whole industry whole life costs.

There are existing examples where such changes to the infrastructure and rolling stock have been planned strategically together. For example IEP and the electrification strategy for the Great Western Main Line have been developed in tandem.

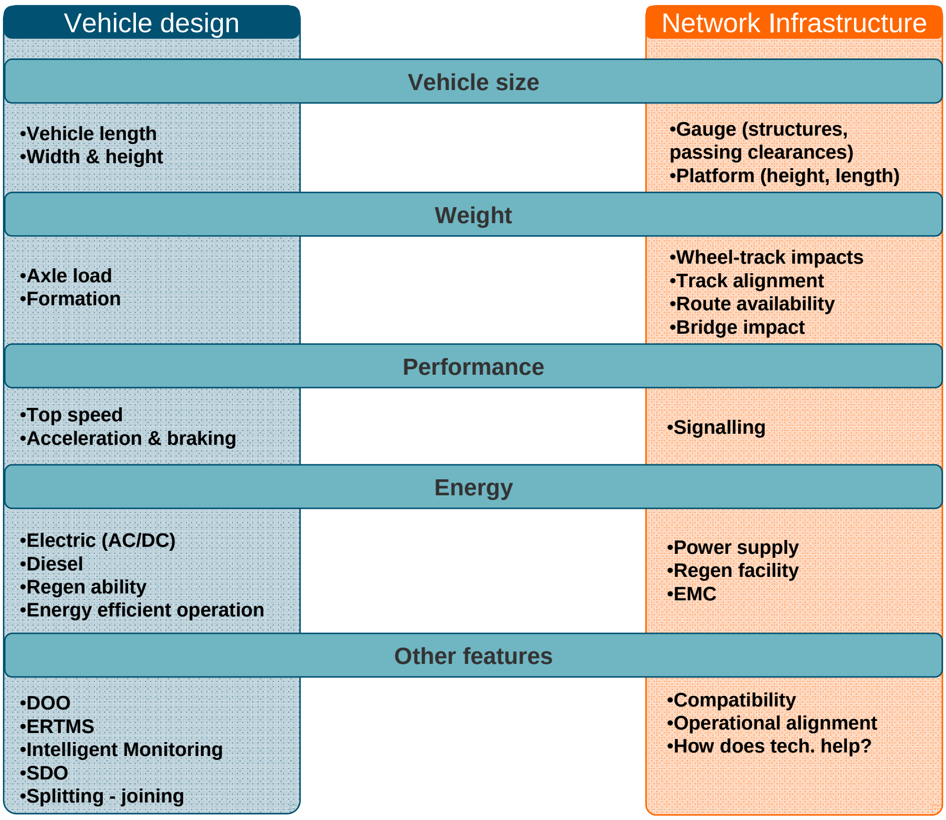
In this case, the considerations of the two elements together had a number of benefits, potentially reducing whole life costs for Great Western Main Line, resulting from electrification and the introduction of high capacity trains.

The accuracy and availability of infrastructure data is also of key importance to rolling stock manufacturers to enable the design of optimised interfaces.

When considering the design and deployment of rolling stock it is important to consider the following interfaces:

Wheel/rail interface – longer vehicles have a higher axle load, this can have an effect on the track geometry and the rate at which it wears. Encouraging the use of vehicles which are more 'friendly' to the track (by reducing the forces generated at the wheel/rail interface) will help to reduce maintenance requirements and the need for premature track renewal. Careful attention to vehicle design, ensuring that the vehicles are suited to the routes over which they will operate and have minimum impact on degradation and damage, can therefore help to maximise rail life. This not only reduces the costs of maintaining the railway, but also increases the reliability, availability and capacity

Figure 6.5 - Impact of vehicle design on infrastructure requirements



of the network for train operators through reducing the amount of time that the network is unavailable due to maintenance activities

Route availability - typically the maximum axle load of the train that can be accommodated on a route. Route availability for passenger rolling stock is normally only limited on the most lightly used branch lines. The design of the future rolling stock should consider the infrastructure it is required to operate over. Infrastructure should always be planned to consider the future rolling stock types and the where the infrastructure is constrained considerations to adapt the infrastructure for the new types of rolling stock may be made

Gauge - the physical clearance between vehicles and structures close to the track. Network Rail has assessed the likely minimum, average and maximum infrastructure cost of the work required to accommodate standard vehicle variants across multiple route sections and market sectors, based on gauge clearance data for a range of existing vehicle types

Platform length - the minimum distance required for a train to stop at a platform. The length of vehicles and their subsequent formation needs to be considered against the routes where they are to be deployed

Platform stepping distances - the distance between a train doorstep and the platform is affected by vehicle length, the position of the door and the radius of the platform. Longer vehicles serving platforms with tight radii may have increased stepping distances. The position of vehicle doors presents a challenge on both concaved and convex platforms where it is difficult to optimise for both scenarios.

The options set out in **Table 6.4** seek to address some of the critical interfaces which need to be considered in order to enable fewer types of rolling stock to operate.

Table 6.4 – Options to plan rolling stock and infrastructure to meet future requirements

		Type A gaps – Rolling stock replacement				Type B gaps – Planning infrastructure and rolling stock together				Type C gaps – Operational flexibility of rolling stock			Type D gaps – Legislation	
		A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	D1	D2
3	**Planning rolling stock and infrastructure together to meet future requirements**													
3.1	European gauge and/or double deck rolling stock	X	X	X	X	X	X	X	X					
3.2	Optimise the vehicle and network gauge appropriately to obtain maximum coverage of market sector	X	X	X	X	X	X	X	X		X			
3.3	Optimise vehicle length	X		X			X							

Option 3.1 – European gauge and double deck

This option considers whether the introduction of double deck rolling stock and European gauge vehicles would provide a cost effective solution to meeting demand.

a) Double deck rolling stock

Double deck vehicles are used across Continental Europe for many services, including high speed inter city and outer-suburban. They can offer increased passenger carrying capacity. However, infrastructure considerations are important as the vehicles have a greater height than standard passenger rolling stock which is operational in Great Britain. Double deck trains can also be subject to higher dwell times as the increased number of passengers board and alight.

A Network Rail and DfT led study in 2007 which considered whether double-deck rolling stock would be appropriate on existing outer-suburban routes on the network was used to inform the option appraisal.

Generally double deck vehicles across Europe are 26 metre long and follow the UIC reference profile shown in **Figure 6.6** compared to the Great Britain Lower Sector Vehicle and Structure Gauges. If Britain was to adopt such a vehicle it would require the wholesale reconstruction of all stations to make them compatible with the required UIC reference profile. Likewise, the distance between the tracks would need to be much wider in order to accommodate the wider vehicles gauge and therefore would require reconstruction of a substantial number of bridges and tunnels. The double deck trains would also be incompatible with under bridge girders and some types of signalling equipment that would also be foul of UIC gauge. Even if the infrastructure work was affordable, it would be impractical because the adjusted platforms would then be incompatible with conventional rolling stock, used across Britain, as the stepping distance would be significantly in excess of the current maximum requirements set for the network.

The constraints across the railway infrastructure meant that the study proposed a double deck vehicle which was able to use standard platforms used across the network and was of 23 metres in length. This precluded continental European double deck vehicles which are typically 26 metres long and have lower floor heights than vehicles used in Britain.

These constraints on the proposed double deck vehicle size (width, height and length) result in relatively little increase in seating capacity of around eight per cent in a 20 metre vehicle or 24 per cent in a 23 metre vehicle.

These compare with values of around 50 per cent for a 'typical' European gauge vehicle of 26m.

The comparison costs for route conversions ranged from £500 million to around £1,300 million with civil engineering works accounting for the majority of this cost.

The option to use this type of rolling stock on the network was therefore discounted both on grounds of affordability and the resulting lack of operational flexibility of such vehicles.

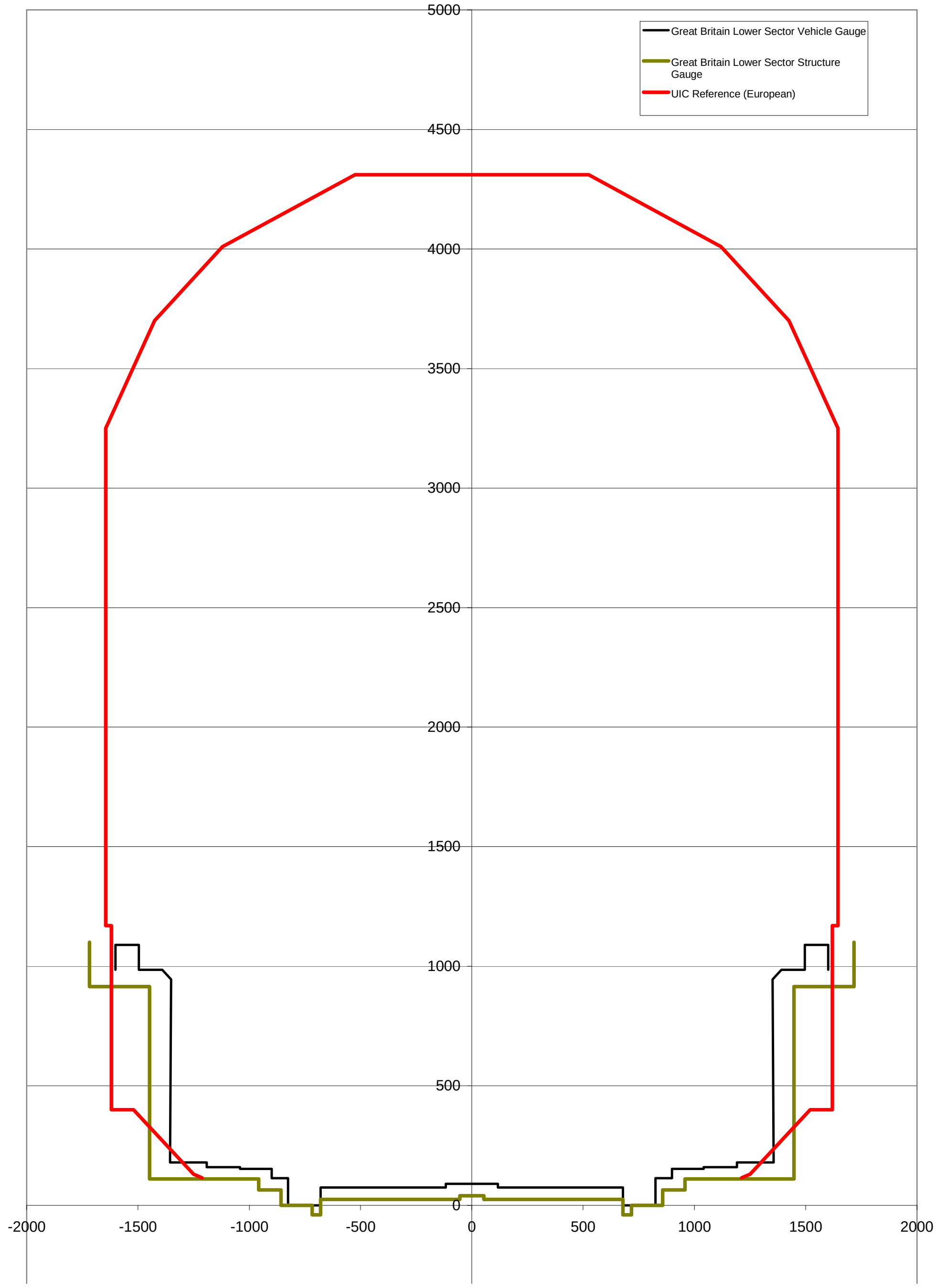
A double deck solution on the existing network would generate relatively low volumes of additional capacity. The benefits would not offset the costs, the significant disruption required to adapt the routes and the resulting long term inflexibility of operation. Double deck could be a viable solution for a new build route where a more efficient vehicle size could be specified.

b) European gauge rolling stock

The RUS considered whether it would be plausible to purchase off-the-shelf European gauge rolling stock for the British market to benefit from procurement savings. As discussed, continental European railways are a larger market than the British railway and consequently have lower unit costs. The vehicles are larger so fewer are required to carry the same number of passengers when compared with current rolling stock operating within Britain. In theory, purchasing rolling stock on the back of other larger orders is a plausible way of reducing rolling stock costs. European vehicle orders are generally for larger fleets and in theory relatively small orders from Britain as an add-on appears economically attractive.

However, as discussed, European gauge vehicles tend to be much wider in the lower body than vehicles used in Britain. **Figure 6.6** demonstrates a UIC reference European gauge plotted to scale against the commonly used British lower sector structure gauge and vehicle gauge. It is clear to see that the lower sector structure gauge becomes foul with the European UIC gauge. Introducing European rolling stock would therefore require a mass rebuild of existing lower sector structures such as platforms and bridge girders along with the widespread need for slewing of track. As described in the section on double deck vehicles, the cost of such a mass rebuild is very high and if changes were made to the infrastructure those areas of the network would become incompatible with existing vehicles operating on the network. The option of purchasing off-the-shelf European rolling stock was therefore discounted.

Figure 6.6 – UIC Reference (European) gauge comparison with Great Britain lower sector stucture and vehicle gauges



Option 3.2 – Optimise vehicle and network gauge

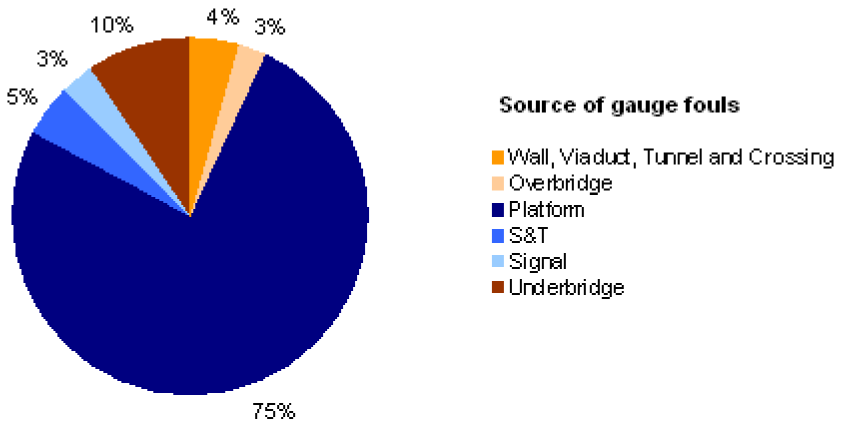
The conclusion of Option 3.1 is that European gauge and double deck vehicles are unlikely to be cost effective given the infrastructure configuration of the network. For this reason it is not proposed to further appraise the possible option to adapt the network to accommodate European gauge rolling stock. Instead Option 3.2 considers whether it may be possible to optimise the vehicle and network gauge in order to achieve greater vehicle coverage within the existing vehicle lengths that exist on the British network.

The RUS has considered the impact of expanding the coverage of vehicles that are 23 metre in length across the entire network through the development of a standard kinematic gauge. Whilst much of the network is already cleared for 23 metre trains to run, certain sections of the network, such as parts of the former Southern region, are only gauged for the operation of 20 metre vehicles.

A series of vehicle profiles which currently operate on the network was considered to understand the implications for infrastructure gauge if a single kinematic envelope were to be used. The analysis showed that a high proportion of sub-standard clearances was related to platform vehicle clearances. The analysis suggests that a gauge compatible with a 23 metre vehicle may be developed. If this were possible there would potentially be fewer sub-standard gauging clearances. **Figure 6.7** shows the proportions of sub-standard clearances revealed by this analysis.

The analysis suggests that replacement of the 23 metre fleet with one or more generic 26 metre equivalents would barely cover the cost of the additional gauge clearance work, and it is unlikely that a net saving would be achieved once the cost of platform extension work is included.

Figure 6.7 – Sub-standard gauge clearances across the whole network with a variety of existing vehicle gauge profile



Option 3.3 – Optimise vehicle length to reduce capital cost of a train

As discussed in the **Chapter 5**, the provision of equivalent on-train capacity through use of trains comprising longer, but fewer, vehicles may generate a cost saving, as the components that do not vary with the length of a vehicle are more expensive than those that do. Using fewer vehicles may equate to fewer bogies, wheel sets and vehicle inter-connections.

The basic reasons for lengthening vehicles are as follows:

Efficiency – to reduce the number of vehicles that need to be procured for the equivalent amount of capacity

Capacity – to maximise the use of available timetable capacity by having fewer longer vehicles per train.

The simplest way to achieve this would be upon life expiry to replace the 20 metre (including 17 metre pacer) with a 23 metre vehicle train fleet.

Table 6.5 shows a matrix of train lengths which result from combinations of 20 and 23 metre vehicles. The colour coding highlights the closest match between a train length comprised of 20 metre vehicles when compared to a train comprised of 23 metre vehicles. It shows that an 8-car train comprised of 20 metre vehicles can be replaced by a 7-car train comprised of 23 metre vehicles for only a change in overall length of one metre. However, for formations of 20 metre vehicles greater than eight replaced by 23 metre vehicles, the train length increases. By contrast, formations of less than 8-cars long the overall train length reduces.

As a consequence, in order not to reduce capacity, it is either necessary to reduce the number of multiple units and therefore driving cabs or lengthen trains. While train lengthening may be a plausible solution to accommodate in some locations, infrastructure work would be required to accommodate longer trains across the network. Where fixed (or longer) formations are required there is likely be reduced operational flexibility.

Table 6.5 – Matrix of Train Lengths from comparable numbers of 20 or 23 metre vehicles

20 metre vehicles																								
1	20	23	20	46	20	69	20	92	20	115	20	138	20	161	20	184	20	207	20	230	20	253	20	276
2	40	23	40	46	40	69	40	92	40	115	40	138	40	161	40	184	40	207	40	230	40	253	40	276
3	60	23	60	46	60	69	60	92	60	115	60	138	60	161	60	184	60	207	60	230	60	253	60	276
4	80	23	80	46	80	69	80	92	80	115	80	138	80	161	80	184	80	207	80	230	80	253	80	276
5	100	23	100	46	100	69	100	92	100	115	100	138	100	161	100	184	100	207	100	230	100	253	100	276
6	120	23	120	46	120	69	120	92	120	115	120	138	120	161	120	184	120	207	120	230	120	253	120	276
7	140	23	140	46	140	69	140	92	140	115	140	138	140	161	140	184	140	207	140	230	140	253	140	276
8	160	23	160	46	160	69	160	92	160	115	160	138	160	161	160	184	160	207	160	230	160	253	160	276
9	180	23	180	46	180	69	180	92	180	115	180	138	180	161	180	184	180	207	180	230	180	253	180	276
10	200	23	200	46	200	69	200	92	200	115	200	138	200	161	200	184	200	207	200	230	200	253	200	276
11	220	23	220	46	220	69	220	92	220	115	220	138	220	161	220	184	220	207	220	230	220	253	220	276
12	240	23	240	46	240	69	240	92	240	115	240	138	240	161	240	184	240	207	240	230	240	253	240	276
		1		2		3		4		5		6		7		8		9		10		11		12
	23 metre vehicles																							

Less than 3 metres difference between combinations	Train length (m)
Between 3 & 4 metres difference between combinations	Train length (m)
Greater than 4 metre difference	Train length (m)
Longer vehicle (23 metres)	
Existing vehicle (20 metres)	

If odd numbers of vehicles make up a train comprised of more than one multiple unit, then they must be formed of two lengths of units e.g. a 3-car and a 4-car forming a 7-car. In this scenario two sub-fleets would be required to operate a service. The alternative is a fixed 6-car formation thereby eliminating two driving cabs. However, the consequence of fixed 6-car formations will be to increase the minimum off-peak formation by three vehicles and thereby increase costs.

Currently 59 per cent of Diesel Multiple Units (DMUs) are 2-car units and 69 per cent of Electrical Multiple Units (EMUs) are 4-car units. These units when used in multiple, generally operate with other units to form an even number of vehicles per train. While there are some combinations in which two different length units are coupled together, in most instances all units are the same length when working in multiple, for example 4-car units may operate in the following combinations:

- 4-car
- 8-car (4+4)
- 12-car (4+4+4).

Vehicle lengthening is likely to result in either longer trains or longer fixed formation multiple units. The specific implication of these changes may be easy to accommodate if there is sufficient platform length on a route, or operational and market considerations mean that fixed or longer formations are appropriate.

However, more detailed analysis would be required on a route-by-route basis to establish the impact of longer vehicles.

Increasing the length of multiple unit formations, or moving to fixed formations increases the available seating and standing capacity for a given length of train because it eliminates space taken up with driving cabs at the end of multiple units. The Thameslink Rolling Stock Programme is specified to be in two fixed formation lengths, 8-car and 12-car. Currently on the Thameslink routes EMUs are 4-car units and may operate either singly as a 4-car, or an 8 or 12-car train. By contrast an 8-car fixed formation train eliminates two driving cabs, and a 12-car eliminates four driving cabs. This space then becomes available for passenger accommodation, thereby maximising the capacity for passengers of a 240 metre long train. Fixed formation trains by definition can only be operated in one length, so may provide significantly more capacity than is actually required in off-peak periods, and operating costs per mile are more expensive than in a situation where train length can be reduced in the off peak period by uncoupling and berthing parts of the train consist.

Strengths of fixed formations:

- Maximises seating and standing capacity for a given length of train by removing driving cabs, making them available for passenger usage. This is relevant where all other means of maximising capacity have already been employed on a line of route. Where train frequency and train length have been taken to a practical maximum a fixed formation train allows the last elements of capacity to be obtained before more radical and costly solutions to obtain more capacity are required, such as double deck trains or indeed entirely new railway lines
- fixed formation vehicles can share auxiliary equipment across the whole train length and remove the need for duplication.

Weaknesses of fixed formations:

- Loss of flexibility, fixed formations can only work as one length and therefore rolling stock cannot be altered in length to match demand
- in the off-peak with a fixed formation capacity may be excess of demand. This incurs increased operations, maintenance and variable track access costs without a commensurate level of passenger revenue
- depots and stabling facilities have to be full train length
- fixed formation fleets require fewer driving cabs to be produced, this means that:
  - multiple destinations cannot be served by splitting and joining
  - if a driving vehicle is defective the whole fixed formation must be withdrawn from service
- in the future if trains are reduced in length then the spare vehicles cannot easily be formed into additional trains as driving cabs may be in shorter supply than would be the case if the trains were designed to be worked in multiples
- only able to be split in a depot in limited combinations, for a 12-car it may only be possible to split into two 6-car sections to undergo maintenance because of the shared auxiliary equipment
- in extreme cases a driving cab damaged beyond repair might mean the whole train has to be withdrawn.

Fixed formation trains allow maximisation of capacity once all other conventional means of increasing capacity have been exhausted. However, this capacity comes at the cost of flexibility and the ability to match supply, in terms of train length, to passenger demand. Fixed or longer formations are therefore a toolkit option for consideration when increasing capacity.

At this stage it is difficult to recommend a network-wide strategy of vehicle length serving the market sectors because the scope of infrastructure work required to accommodate the train lengthening is yet to be determined. The infrastructure work required for train lengthening can be extremely complex. The analysis shows that opting for longer vehicles where train lengthening programmes are being considered to increase capacity, can contribute toward the overall cost efficiency of a fleet serving a particular route.

6.5 Options addressing legislative change

Options have been considered to address the legislative changes which bring change to the accessibility and environmental impact of rolling stock. **Table 6.6** which gaps each option addresses.

Table 6.6 – Options to reduce rolling stock diesel engine emissions

		Type A gaps – Rolling stock replacement				Type B gaps – Planning infrastructure and rolling stock together				Type C gaps – Operational flexibility of rolling stock			Type D gaps– Legislation	
		A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	D1	D2
4	**Options addressing legislative change**													
4.1	Compliance with legislation – all new engines must not exceed target emissions													X
4.2	Use bio fuels to comply with the fuel quality directive													X
4.3	Rolling stock accessibility												X	

Option 4.1 – Compliance with legislation – all new engines must not exceed target emissions

All new engines fitted to non-road mobile machinery, which includes rolling stock, should be compliant with the Non-Road Mobile Machinery (Emission of Gaseous and Particulate Pollutants) Regulations 1999. This includes older rolling stock which is being fitted with a new engine. The implications of compliance may be challenging to accommodate the size of engines which comply with the legislation, increased fuel consumption and increased capital cost of the resulting diesel powered rolling stock.

Option 4.2 – Use bio fuels to comply with the fuel quality directive

The increased use of bio fuel is required in order to comply with the Fuel Quality Directive and minimise the harmful emissions from diesel powered vehicles.

Option 4.3 – Rolling stock accessibility

While the DfT is clear that an accessible rail fleet will be achieved by 1 January 2020, it recognises that there is little value in correcting minor non-compliances which do not materially reduce their accessibility to disabled passengers but can cost a significant amount to rectify. Instead, focus is being concentrated on those non-compliances which truly prevent disabled people from accessing rail vehicles. This "targeted compliance" approach is being applied on a case-by-case basis in consultation with the rail industry and follows an assessment which identifies those areas, such as passenger information systems, where compliance by 2020 will be required.

6.6 Appraisal

This section presents a financial appraisal of **Table 6.3**, which summarises the recommended combination of options 1.1, 1.2, 2.1, and 3.2, namely:

- Specifying the key major characteristics that trains servicing each market sector require (see **Table 6.3** for an example specification)
- procuring only one generic type of train for the combined interurban, outer-suburban, regional and rural sector, and one generic type for the inner suburban sector. AC electric, DC electric, dual voltage and self-propelled sub-variants would be required but no other major components would differ
- life extension of existing rolling stock to spread the order of these new replacement trains as evenly as possible, mimicking fixed term and quantity framework agreements
- infrastructure gauge clearance to enable operation of these new generic vehicles over all or most of the network as appropriate.

The appraisal compares the whole life cost saving through economies of scale and continuous production, with the cost of the enabling gauge clearance work. This calculation is based on a conservative central assumption that the price of rolling stock remains the same as currently in real terms, although a sensitivity test has also been included based on an estimate of the real price inflation that occurs when life expired trains are replaced with new equivalent rolling stock. A conservative central scenario is considered because the estimate of real price inflation is approximate at this stage in the RUS process, and further validation from industry partners is required.

Figure 6.8 details the estimated whole life cost saving over a seventy year appraisal period. Seventy years was chosen because it represents approximately the whole commercial life of new vehicles and their subsequent replacement. This is a slightly longer appraisal period than typically used in the RUS process in order to consider the cost saving over both the maximum remaining asset life of the existing fleet and the complete asset life of the generation of rolling stock that replaces it. The potential cost saving is presented in a range based on a minimum, maximum and average view of the infrastructure cost.

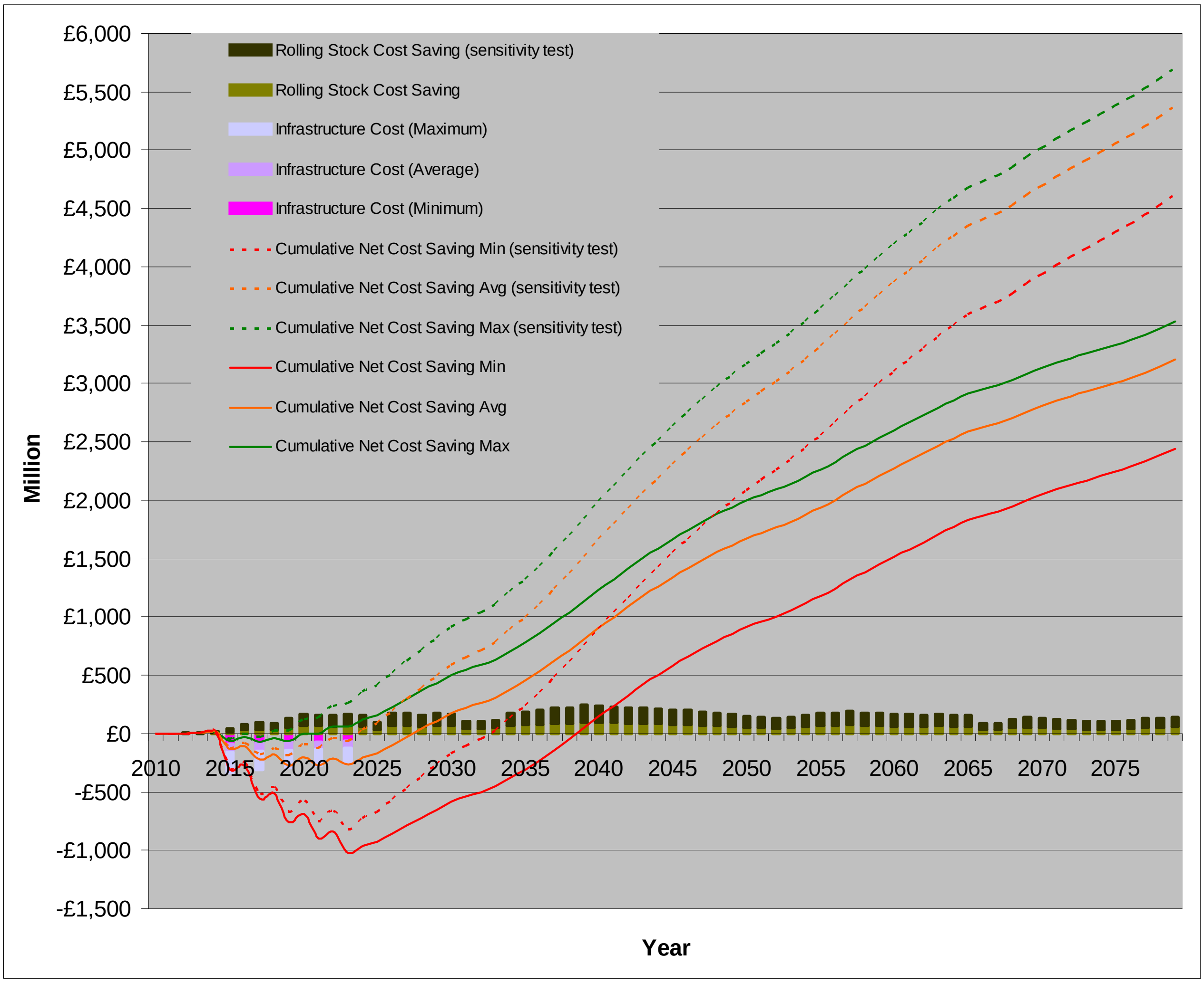
The total whole life rolling stock cost saving is estimated at around £3.9 billion over the appraisal period, which is approximately seven per cent of the estimated total cost of GB rolling stock. This is equivalent to a reduction of £120 million of the current annual cost based on zero real inflation in the price of new rolling stock, increasing to £180 million in the sensitivity test where an estimate of this inflation is included.

The cost of the required gauge clearance work to enable the vehicles to operate is estimated to range between £0.4 billion and £1.5 billion over the appraisal period, with a central estimate of £0.7 billion. This is based on data for 13 common existing sub variants of EMU and DMU stock, and implies that the total cost saving will be at least double the cost of the infrastructure investment.

If it were to be assumed that the infrastructure work commenced in, say 2015, and took 10 years to complete, the central estimate suggests that payback could be achieved by 2028. This would move forward to 2022. The sensitivity test based on real inflation in the price of new rolling stock, suggests that payback would be achieved by 2024. This would move forward to 2018 under the minimum infrastructure cost scenario.

This variation in the payback period with the scope of gauge clearance work illustrates the potential value in joint specification of rolling stock and infrastructure capability.

Figure 6.8 Whole life cost profile



This section presents an assessment of the risks in the analysis presented above, the opportunities for some further cost savings, and some recommendations for further detailed analysis during the RUS consultation period. It is proposed that the following items be considered further in the consultation period:

Composition of a train variant

As discussed previously it has not yet been possible to produce an accurate apportionment of the constituent elements of the one-off non-recurring costs, and hence establish the precise definition of a train variant. This limits the applications of the current analysis for planning, and further work will be conducted during the RUS consultation period to address this, including an analysis of how the introduction of more standardised rolling stock could improve interoperability across the network.

Incremental savings

The incremental rate of savings relating to the increase in the size of a continuous order of rolling stock has been inferred from the evidence provided by industry colleagues. Given that the numbers form a large range, the accuracy of the analysis would benefit from some further consideration. It is unlikely that this would pose a significant risk to the conclusion that a significant net whole life cost saving could be achieved as the specification of a single generic type of train for the outer-suburban sector would generate the maximum unit cost reduction, and the resultant total cost saving would be greater than the maximum likely cost of gauge clearance of the whole network for a single train variant. This means that the incremental savings identified in relation to the other market sectors are less critical to the conclusions.

Use of fewer longer vehicles

The estimated cost reduction presented in the previous section excludes the potential savings through replacement of 20 metre vehicles (including the 17 metre pacer fleet) with equivalent capacity trains comprising 23 metre vehicles. This is because the combined cost of enabling gauge clearance and platform lengthening work could outweigh the potential saving. Whilst this is true at the national level there may be routes or self-contained lines where platform lengthening may not be required through re-deployment of rolling stock and/or local operating derogations. These issues will be investigated further in partnership with local stakeholders.

Minimising the scope and cost of gauge clearance

The lowest infrastructure cost in the range presented in the previous section is based on gauge clearance of the network for the existing train type which would produce the fewest number of current infrastructure fouls. If all generic train variants for every sector except for the long distance high speed market could be specified to operate within the same kinematic envelope as this train type, the payback period on the investment would reduce markedly.

7 Emerging strategy

7.1 Introduction

The Network Route Utilisation Strategy (RUS): Passenger Rolling Stock document has taken a long term view of future passenger rolling stock and the infrastructure it will operate over to establish whether there may be potential to plan the railway more efficiently. It follows a similar approach to other RUSs by considering the current situation, drivers of change, gaps and options to address the gaps. It has considered stakeholder aspirations, including those who fund, procure, operate and build the rolling stock.

Chapters 3 and **4** described the rolling stock currently operating on the GB rail network and key drivers of change which, when considered together, suggest that there could be significant potential for efficiency if a whole industry whole-life cost approach were to be adopted to planning the introduction of new rolling stock and infrastructure. The need to take advantage of potential efficiencies is made more urgent by an increasing requirement to replace ageing rolling stock and procuring new stock to accommodate growth.

Four groups of gaps were identified in **Chapter 5** based on a consideration of the effects of the drivers of change on the baseline. The gaps related to the requirement to replace existing rolling stock (Type A), the potential for planning infrastructure and rolling stock together (Type B), the potential for increasing operational efficiency (Type C) and those triggered by legislation (Type D).

Chapter 6 examines the requirements of each market sector and identifies options for future passenger rolling stock to meet its needs. The options include a consideration of whether there could be opportunities to exploit economies of scale through the production of fewer rolling stock variants.

The RUS then proceeds to examine the suggested rolling stock types alongside the network over which they may need to run in order to assess the scale of any infrastructure works that may be required. It considers the advantages of planning the infrastructure consistently for the needs of each market sector including the advantages of enabling rolling stock cascades and 'go-anywhere-it's needed' rolling stock for each market sector.

This chapter outlines the resulting emerging strategy. It brings together the key strategic passenger rolling stock issues of concern to funders, Train Operating Companies and Network Rail, along with the railway industry's customers and stakeholders.

Section 7.2 outlines the principles adopted in developing the strategy. This is followed in **Section 7.3** by a consideration of the rolling stock requirements of each market sector, identifying a number of common characteristics between each sector. **Section 7.4** discusses the infrastructure required to accommodate the rolling stock requirements and explores how a common kinematic envelope design might be useful for enabling stock to be more inter-operable over the network. Finally **Section 7.5** discusses the phasing of the emerging strategy, including the interaction with major projects and franchising.

7.2 Developing the emerging strategy

Passenger rolling stock costs are currently in the order of £1.8 billion per year, around 15 per cent of the annual costs of operating the railway as a whole. The strategy concentrates on the opportunities for efficiencies which arise from replacing existing rolling stock when it comes to the end of its commercial life. It considers how planning the infrastructure and rolling stock together can enable the network to become more inter-operable to enable rolling stock which serves a particular market sector to go anywhere on the network it is required.

The key principles used to develop the emerging strategy are:

a) Exploit the economies of scale in procurement wherever feasible
b) meet the needs of each market sector when ordering rolling stock
c) consider those infrastructure works needed to allow rolling stock to be inter-operable within the market sector it serves
d) consider the phasing of future rolling stock procurement and infrastructure planning – in the light of re-franchising, major schemes etc.

The emerging strategy is purposely kept at a high-level to identify the principles of what can be achieved. It avoids detailed specification of trains, other than to identify the key needs of each market, highlighting key economies of scale which may help reduce production costs and those physical characteristics of the trains and infrastructure which would enable rolling stock to be more inter-operable over the network. It is anticipated that train operating companies will be involved in the more detailed specification of trains.

Similarly, whilst it identifies the infrastructure works that would be needed to deliver a more flexible inter-operable railway for each market sector and present the high level case (using unit costs) that suggests that they will be high value for money, it does not cost every infrastructure intervention in detail. Local characteristics of each route will result in a wide range of costs in both gauge clearance and, where appropriate, platform length or height changes.

The network is currently operated by 12,229 passenger vehicles, which are members of 64 different rolling stock classes. There have been more than 5,000 new vehicles introduced since 1996, and substantial orders are being placed for new long distance high speed, Thameslink and Crossrail vehicles. A large proportion of the fleet is considerably older. Historically the commercial asset life of rail vehicles has been considered to be 30 years for diesel units, and 35 years for electric units, although a number of vehicles have exceeded this. Recent research has suggested that the life can be extended by many years. In theory, over the next ten years, over a quarter of the fleet would need to be replaced if its life were not extended beyond 30 or 35 years (for diesel and electric rolling stock respectively). If the life of much of the stock were to be extended by 5 to 10 years, less than 12 per cent of the fleet would need to be replaced. In addition, if the rail industry is to accommodate the forecast growth in usage, it is likely to require a substantial number of additional vehicles in order to increase rather than simply maintain rolling stock capacity.

Given that the average cost of a vehicle in recent years has been between £1.1 million and £2 million[5], this potentially would involve considerable outlay at a time when the industry and its funders are striving to bring down its costs.

[5] Source: Competition Commission and Rolling Stock Companies (ROSCOs) reports

7.3 Rolling stock types by market sector

The RUS recommends that the industry and its funders consider the efficiencies which could result from procurement by reducing the variety of train types that are procured. The analysis in **Chapter 6** suggests that, whilst this is a range, approximately £75 million or eight per cent of the total procurement costs is spent on research and development per bespoke order. It is recommended that consideration is given to the procurement of rolling stock which has many common features with other rolling stock which serves the same market sector. This may involve moving to common types of rolling stock type which share a number of common components, known as a 'common platform'. Any reduction in the number of different types of vehicles procured will in turn lead to an increase in the size of order for each type of vehicle. This will reduce the unit costs of vehicles further.

Whilst the reduction in the number of different train types sounds an attractive proposition in theory, it only becomes attractive in practice if the train types match the needs of the market and can operate freely on all parts of the network where they are required. Passenger requirements were considered throughout the process. The RUS examines the requirements of the rolling stock in each market sector (as defined by the Department of Transport's 2007 Rail White Paper) at a high level. It suggests that, whilst there are understandable local variations in market needs, at the same time there will be common requirements that define the needs of each sector. The market sector requirements are then used to produce a very high level specification of a type of vehicle to meet the needs of each market.

This section takes the consideration of the requirements of each of the market sectors identified in the 2007 Rail White Paper as discussed in **Chapter 6** and combines them into three key types, that is

- **Type 1**: long distance high speed
- **Type 2**: interurban, outer suburban, rural and regional
- **Type 3**:inner suburban

Type 1: Long distance high speed (LDHS)

The long distance high speed sector includes high speed services between large urban areas such as London and Leeds. It accounts for approximately 18 per cent of the total fleet.

This sector is unique in its requirements and should be accommodated by types of vehicle which meet its particular requirements.

Its key requirement is a maximum operating speed of typically 125mph, ability to operate in long formations of up to 10 or 12-cars on the busiest routes, doors at the end of each carriage, with on-board facilities such as catering, toilets, luggage storage and staff accommodation.

Most long distance high speed services run on lines that are electrified or are recommended to be considered for electrification by the Network RUS Electrification Strategy so it is recommended that the bulk of this fleet is comprised of vehicles capable of running under 25kv AC electrification. Given that future electrification is subject to affordability constraints, it is likely that there will be an on-going requirement for bi-mode vehicles (or a limited self-powered fleet) to run over sections of line which the Government does not plan to electrify in the foreseeable future.

The Department for Transport (DfT) is committed to the Intercity Express Programme (IEP), which will be the predominant train for the long distance high speed sector. On 1st March 2011, it confirmed a programme which will see the building of a combination of around 100 electric trains and bi-mode - diesel and electric - trains which will run on the Great Western Main Line and the East Coast Main Line.

The final specification of the train is to be determined by the DfT in negotiation with the supplier. The train operating companies will contribute to the design and specification of the new fleet in greater detail than they had before.

Network Rail has been funded in the current control period to carry out initial works with a view to accommodating IEP vehicles which are expected to be 26 metres in length. Given the efficiencies which might be achieved by moving to fewer types of trains, it is recommended that the IEP is taken as the starting point for the long distance high speed family of trains.

In some instances the physical characteristics of the route may lend themselves to a different design. For example, on West Coast Main line, the use of tilt-enabled 125mph operation is advantageous to achieve faster journey times.

Type 2 – Interurban, Regional, Outer Suburban and Rural

Type 2 consists of a very wide-ranging group of market sectors. There could be considerable cost advantages if each of these market sectors were served with similar types of vehicle. Whilst the basic construction might be similar, it is anticipated that Train Operating Companies (TOCs) would be involved in determining the details of the design, interior fittings and set-configuration which would be expected to vary to meet the needs of specific markets.

a) Interurban and regional markets

The interurban and regional sectors account currently for approximately 20 per cent of the total fleet. The sectors have a number of common characteristics which may make it possible to serve them with as little as one or two generic types of train with the appropriate gauge and traction power.

The key requirements for rolling stock include a maximum operating speed of around 100mph (with some instances where 110mph or 125mph would be advantageous), and the ability to operate in both medium size formations (3 – 5-cars), and long formations (6 – 10-cars) on busier routes. The flexibility of being able to operate in multiple units is helpful to meet lower levels of demand in the off-peak. The vehicles in this fleet would be 20 metre and 23 metre to give the flexibility to match supply and demand.

The services that operate on this sector are predominantly on routes which are either currently electrified or are recommended for consideration for further electrification by the Network RUS: Electrification Strategy. In the latter case, it is recommended that a decision about the future electrification of the route is made in conjunction with the rolling stock procurement decision.

It is envisaged that as the extent of the electrified network increases the proportion of self powered vehicles within this fleet will decrease.

b) Outer suburban markets

The outer suburban sector describes the market for medium distance commuting to and from major employment centres. It is the largest market sector which accounts for 45 per cent of the total fleet. The key requirements for rolling stock include a maximum operating speed of around 100mph, door layouts that allow quick boarding and alighting, and the ability to operate in a number of different formations between three and twelve vehicles in length. The interior design for this vehicle should be configurable to meet the level of market demand.

The Thameslink Programme currently underway will include the procurement of new units to operate the revised service structure. Whilst the final design of the vehicles has not yet been determined, a high-level specification has been published. The train will be of a metro-style, designed to accommodate large numbers of people over the approaches to London but also to provide a comfortable environment for passengers on longer journeys. They will allow rapid boarding and alighting and have a traction and braking profile that is in accordance with the operation of up to 24 trains per hour within the central core section of the route and have main line railway operating speeds up to 100mph.

The London Crossrail programme is also beginning the process of procuring new vehicles. It is anticipated that these vehicles will be approximately 200 metres and based on existing technology adapted to meet the service needs.

The basic characteristics identified in the Thameslink specification are in line with those identified in this RUS for the outer suburban railway. Economies of scale of production could be achieved if the Thameslink and other outer suburban stock have a common kinematic envelope, allowing for market-focused interiors. Rolling stock in this sector is likely to require 4, 5 and 6-car variants, doubling up if necessary to 8, 10- and 12-cars. This RUS suggests that the demand characteristics would suggest that there might be a requirement for a 20 metre and 23 metre variant.

The fleet serving the outer suburban sector must be able to operate on both the electrified (overhead and third-rail) and parts of the network which are recommended for future electrification by the Network RUS: Electrification Strategy. It is envisaged variants of the vehicle will include 25 KV electric, DC electric and dual voltage. Self powered vehicles may be required if a future business case for electrification on any of these routes does not warrant further investment.

c) Rural

The rural sector describes the market for travel between small communities in rural areas. The key requirements for rolling stock in this sector include an operating speed of up to 90mph and the ability to operate in short or medium formations of up to four vehicles in length.

This is a small sector which accounts for two per cent of the total fleet. Given the earlier discussion on the economics of small orders, it is unlikely that this sector could economically be served by a bespoke vehicle. It may be more economical to serve this market group with a vehicle designed for the regional market. Given that the routes in this sector are not recommended for future electrification in the Network RUS: Electrification strategy, it is anticipated that the vehicle will be a self-powered variant.

Type 3 Inner suburban

The inner suburban sector describes the market for short distance commuting to, from and within major employment centres, for example the "Great Northern Inners" service group to/from Moorgate. This sector accounts for 15 per cent of the total fleet. The inner suburban market has distinct requirements and it is envisaged that this would have its own vehicle type distinct from that operating in the other markets.

The key requirements of the rolling stock which serve this sector include fast acceleration and braking, a maximum operating speed of up to 90mph, door layouts that allow quick boarding and alighting, and the ability to operate in a number of different multiples between two and 12-car formations.

As with all vehicles, the interiors of these vehicles would need to be specified by the TOCs according to the market need. It is anticipated that many of these vehicles would be configured with a high proportion of standing room to meet the heaviest demand approaching the city centre(s).

It is anticipated that the vehicle length for the inner suburban vehicles would predominantly be 20 metre but that that consideration be given to considering whether procurement of a 23 metre variant is required to meet demand. All inner suburban routes are either currently electrified or are on those routes which were recommended for consideration for electrification in the Network RUS Electrification strategy so there will be a requirement for DC and AC, or dual voltage variants of the vehicle. As with other sectors, there may be a requirement for a self powered vehicle if a subsequent business case or affordability constraint meant that unelectrified lines remained so.

Summary

Table 7.1 shows the high level characteristics which have been identified for Types I to 3. Each of the vehicle types would account for a large portion of the total fleet and would be expected to have variants of power or vehicle length. To achieve economies of scale in procurement, however, it is may be appropriate for these to be produced to a common platform to avoid one-off start-up costs.

7.4 Infrastructure works required to allow inter-operability within a market sector

The RUS analysis has identified which lines on the network are used by trains serving each market sector. It is clearly a complex picture – with many lines being used by trains of more than one market sector (for example long distance high speed and outer suburban or inner suburban and outer suburban) and, indeed with freight.

If the economies of scale of moving towards a reduced number of rolling stock types are to be realised then it will be necessary for the chosen types to go virtually anywhere that its market sector needs it to go. For example, if there was only one type of outer-suburban rolling stock, it would be necessary for it to be capable of operating on all outer-suburban routes.

To achieve this it is important that rolling stock and infrastructure are planned together, in particular the gauge of structures, platform length, platform stepping distances, the ability of the network to accommodate different axel weights the total weight of potentially heavier longer vehicles.

In particular, stepping distances need to be considered on platforms located on tight curves, this in turn may effect the rolling stock design. Asset plans would need to consider the requirements of each vehicle type and where multiple types operate, the prevalent requirements.

Figure 7.1 shows the network classified according to where the proposed three main vehicle types would be expected to operate. There are seven combinations; each shown in a different colour on the map. The combinations include a few routes where a single vehicle type operates but much of the network would be operated by two or more types.

Table 7.1 – Vehicle Types 1, 2 and 3

Market sector vehicle type	Required characteristics						
	Maximum speed (mph)	Acceleration	Power requirements	Vehicle length (m)	Train length (vehicles)	Door layout	Major facilities
Type 1 – Long distance high speed	125 – 140	n/a	25kv electric Diesel Bi-mode	23 or 26	Up to 12	End	Catering, large luggage, staff, toilet.
Type 2 – Interurban, Outer-suburban, Regional & Rural	100 / 110 (occasional 125)	n/a	Dual voltage Self powered	20 or 23	Up to 12	Market decision on door position as well as consideration of stepping distance	
Type 3 - Inner suburban	Up to 90	High	25kv electric 3rd rail Dual voltage Diesel Bi-mode	20 or 23	Up to 12	Market decision on door position as well as consideration of stepping distance	

Figure 7.1 – Future rolling stock types deployed over the network (indicative)

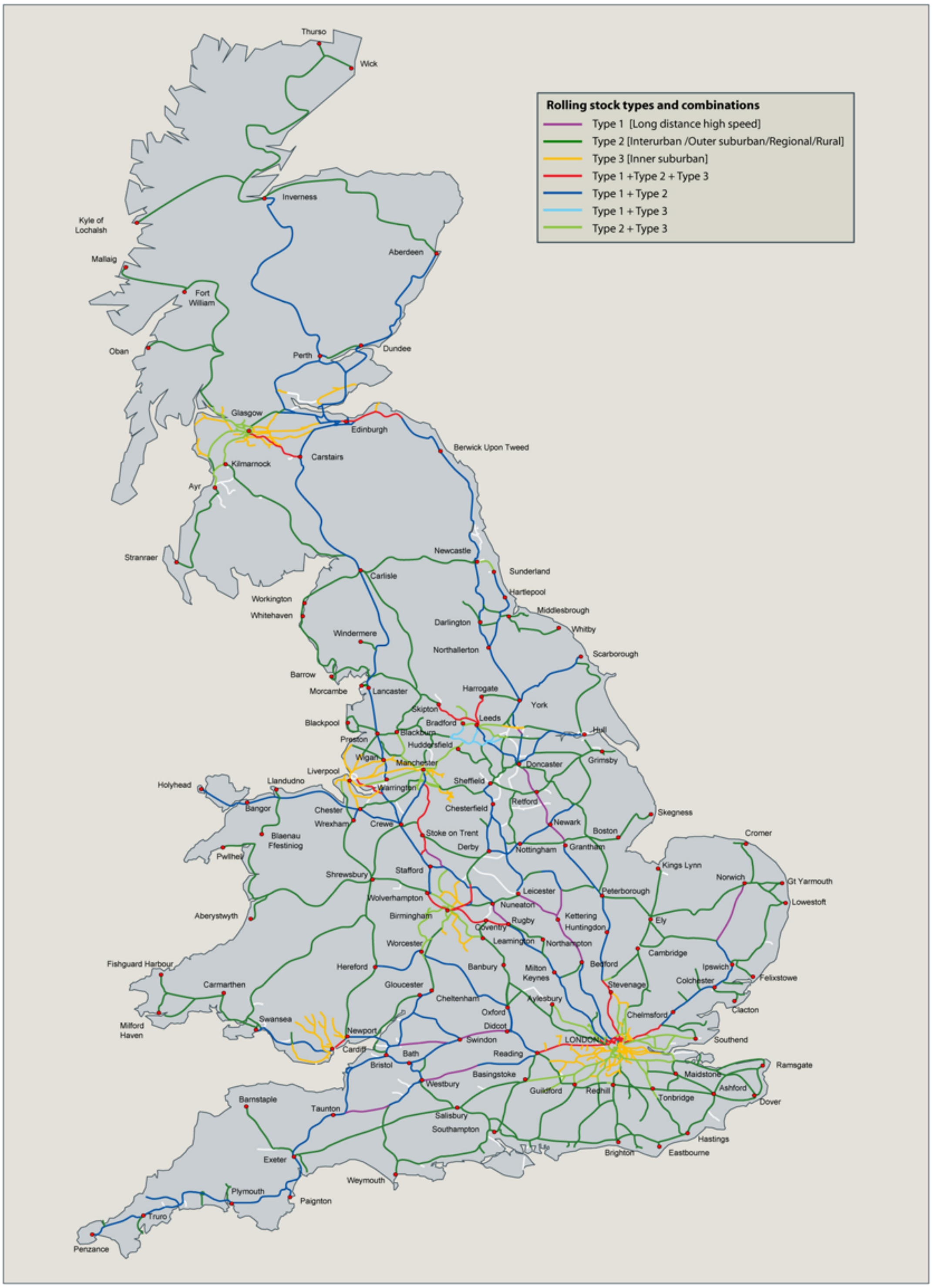


Table 7.2 shows each combination in turn and expresses some of the high level considerations when planning the infrastructure.

Table 7.2 – Infrastructure requirements for rolling stock types over routes

Infrastructure segment	Optimised for	Infrastructure requirements	Energy	Rolling stock characteristics segment
Type 1	Long distance high speed	Gauge to accommodate the longest vehicles. 23m or 26m for future IEP trains platforms lengths to accommodate the longest trains where trains pass at high speed through stations, platforms must be of a sufficient width to ensure the safety of station users route availability for the longest and heaviest formations in the fleet signal spacing suitable for high speed vehicles Gauge to allow for tilt trains on West Coast Mainline	Electrified: -25Kv AC -regeneration capability small proportion of non-electrified lines used for services	High speed trains carrying a high volumes of seated passengers electric, self-powered and bimode vehicles
Type 2	Rolling stock serving regional, Interurban, outer-suburban and rural market sectors	Gauge to accommodate vehicles of 20m and 23m platforms lengths according to the service requirement, but generally range from 3 to 12-car in length	Electrified: -25Kv AC -750v DC -regeneration capability some non-electrified lines used for services	Mix of electric and self-powered rolling stock door arrangements are dependent on specific market sector
Type 3	Rolling stock serving inner suburban market sector	Maximum availability track layouts for maximum capacity station layouts for high throughput and minimum enhancement gauge to accommodate 20m & 23m vehicle lengths. Vehicles operating in London South East areas may require to be 20m due to gauge restrictions platform lengths to accommodate vehicles between 2 and 12-cars	Electrified: -25Kv AC -750v DC -regeneration capability small proportion of non-electrified lines used for services	High density rolling stock catering for passengers travelling short distances in urban centres

Table 7.2 – Infrastructure requirements for rolling stock types over routes

Infrastructure segment	Optimised for	Infrastructure requirements	Energy	Rolling stock characteristics segment
Type 1 + Type 2	Long distance high speed	Gauge to accommodate the longer, faster vehicles, 23m and 26m in length high speed vehicles require increased clearances at platforms are required to accommodate variations in rolling stock length and door configuration	Electrified: -25Kv AC -750v DC -regeneration capability some non-electrified lines used for services	High speed vehicles need good low speed performance to keep up with other traffic in congested areas
Type 1 + Type 3	Long distance high speed	Gauge to accommodate the longer, faster vehicles, 23m and 26m in length high speed vehicles require increased clearances at platforms are required to accommodate variations in rolling stock length and door configuration	Electrified: -25Kv AC -750v DC -regeneration capability some non-electrified lines used for services	High speed vehicles need good low speed performance to keep up with other traffic in congested areas
Type 2 + Type 3	High passenger capacity	Platforms are required to accommodated longer vehicle formations and different door configurations	Electrified: -25KV AC -750v DC -regeneration capability some non-electrified lines used for services	
Type 1 + Type 2 + Type 3	Long distance high speed	Where all three types need to be accommodated by the same infrastructure it will be necessary to build compromises in: gauge to accommodate the widest and fastest vehicles platform lengths will need to accommodate the longer trains within the fleet. This will be driven by the service patterns and passenger loadings. vehicle door positions may vary where differing train types use	Electrified: -25Kv AC -750v DC -regeneration capability some non-electrified lines used for services	

Table 7.2 – Infrastructure requirements for rolling stock types over routes

Infrastructure segment	Optimised for	Infrastructure requirements	Energy	Rolling stock characteristics segment
Freight	Shared usage between freight and passenger rolling stock	Heavy freight axle loading freight gauge capability requires consideration towards platform edge position signal spacing to account for long freight train formations	Electrified: -25Kv AC -750v DC -regeneration capability non-electrified lines	

Freight operates over much of the network. It will often be the determinant of Route Availability (RA) and of the height and width elements of gauge. The Freight RUS and the Strategic Freight Network documents explain freight gauges in more detail and include maps of the routes which have been identified as candidates for gauge clearance for freight. Given that the optioneering in this RUS has dismissed double-deck trains and European gauge trains, fully laden intermodal freight trains will generally be the tallest vehicles operating on the network.

Gauge clearance, however, is determined by length of a vehicle as well as height and width. Length is rarely a factor for freight vehicles or their wagons but can affect the ability of passenger vehicles to operate on parts of the network.

The RUS recommends that further work is carried out to specify passenger vehicles to meet each of the three market sector types discussed to a gauge which would enable interoperability between routes. This approach would potentially facilitate cost savings and flexibility whilst allowing operators to influence the detailed design of trains for the markets they serve.

Consequently, the RUS does not recommend specific rolling stock platforms or rigid train types. Instead it is proposed to recommend that the rail industry develops a standard kinematic envelope from an understanding of the requirements of both rolling stock and infrastructure.

The development of a standard kinematic envelope will give a rational basis for the future vehicle designs. The analysis undertaken in the RUS suggests that a single type of 23 metre rolling stock can be deployed across most of the network with relatively low costs for infrastructure interventions. This could be viewed as the starting point for route which might require type 2 trains (or any combination of trains where type 2 was the largest train on the route). The desire is for a ‘go anywhere’ gauge. A deviation from this requirement may occur if there were structures which prove, upon investigation, not to be cost effective to clear. In such cases it might be more appropriate to procure a 20 metre variant of the vehicle. The development of the kinematic envelope should take cognisance of the dimensions of the Thameslink and Crossrail vehicles when they become available.

Similarly, the new IEP trains are being designed in parallel with the development of an understanding of the works needed to clear the gauge for vehicles of 26 metre long on key long distance high speed routes.

A move towards the reduction in rolling stock variants and an associated joining up with infrastructure planning is consistent with the objectives of the European Commission in pursuing its interoperability initiative and a drive towards a common European market for railway assets, materials, components and processes. Increasingly, new rolling stock and infrastructure is specified together in Train Infrastructure Interface Specifications (TIIS).

7.5 Phasing of emerging strategy

In the course of the RUS, manufacturers have pointed out that there would be potential savings if the procurement profile were to be smoother, that is, if similar size orders were placed regularly rather than the pattern of peaks and troughs which has occurred in recent years. As with any manufacturing process, costs can be avoided if the production line does not go through repeated patterns of stop/start. Our analysis suggests that up to 20 per cent of rolling stock procurement costs could have been saved between 1988 and 2010 if there had been greater continuity of orders. It is reasonable to suggest that considerable savings could be possible in the future if the future order profile offers greater continuity.

Whilst the savings from continuous production are potentially sizeable, the maximum savings are unlikely to occur in reality, primarily because the following factors make it difficult to smooth the procurement profile in order to achieve maximum savings:

- Budgets in any financial year will be determined by affordability which is likely to vary year on year
- the dates at which existing rolling stock is expected to reach the end of its commercial life do not follow a smooth pattern. Recent research, however, suggests that some vehicles' lives can be extended by a number of years
- rolling stock may be procured as part of the train operator re-franchising process
- competition requirements suggest that more than one manufacturer would be involved
- the need to phase rolling stock procurement with major infrastructure upgrades such as Thameslink, Crossrail and High Speed 2.

Indeed early replacement will shorten the period of life of the asset which may be reflected in its lease cost. Similarly life extension may lead to a requirement for complete overhaul of the vehicles or increased maintenance, also increasing costs. Nonetheless it is recommended that life extension is considered if it enables tangible procurement benefits from achieving a smooth order profile.

It is recommended that the benefits of maintaining continuity of rolling stock production are considered in procurement decisions and at an early stage in re-franchising and enhancement programme development.

It is proposed, that consideration should be given to the development of a to bring together rolling stock replacement dates and franchise replacement dates to maximise the potential procurement savings. An infrastructure plan based on the requirement of each rolling stock type could then be developed to be delivered in advance of the rolling stock's arrival on the network. The detailed requirements would accordingly be built into Network Rail's route asset plans and specifications.

The gauging works required to accommodate the trains of each type should carried out at the same time as other gauging activities on the same route. As a guiding principle, a structure (bridge or tunnel) should be built only once. If the structure is on a route which needs to be gauge cleared for freight or electrification (as defined by the Strategic Freight Network or the Network RUS: Electrification strategy, it should be rebuilt only once, ensuring that it is consistent with all three strategies.

8 Consultation process and next Steps

8.1 Stakeholder consultation

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

- The widest range of options is considered
- The resulting decision approaches an optimum
- The delivery of the outcomes is faster.

The recommendations of a RUS – and the evidence of relationships and dependencies revealed in the work to meet 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 draft RUS. It is available for consultation for 60 days. The deadline is therefore 1st August 2011. After this period, Network Rail will consider each of the responses it receives and, where appropriate, amend the document in consultation with the Stakeholder Management Group. Consultation responses can either be submitted electronically or by post to the addresses below:

PassengerRollingStockRUS@networkrail.co.uk

Network RUS (Rolling Stock) Consultation Response

National RUS Manager

Network Rail

Kings Place

4th Floor, Section O,

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.

Appendices

Appendix A – Rolling stock fleet characteristic

Rolling stock characteristics: diesel mechanical and diesel hydraulic units

Class Number	Class Name	Maximum speed (mph)	Number of carriages	Typical seating capacity of standard unit First Class	Standard Class	Total weight of unit (tonne)
121		70	1	0	65	38
142	Pacer	75	2	0	121	49.5
143	Pacer	75	2	0	92	48.5
144 (2 car)	Pacer	75	2	0	87	48.5
144 (3 car)	Pacer	75	3	0	145	72
150 / 0	Sprinter	75	3	0	240	99
150/1 (2	Sprinter	75	2	0	148	76.4
150/1 (3	Sprinter	75	3	0	224	114.7
150/2	Sprinter	75	2	0	149	74
153	Super Sprinter	75	1	0	72	41.2
155	Super Sprinter	75	2	0	160	77.6
156	Super Sprinter	75	2	0	150	76.5
158/0		90	2	0	138	77
158/0 (3		90	3	0	208	115.5
158/8		90	2	13	114	77
158/9		90	2	0	142	77
159		90	3	24	170	115.5
165/0 (2	Network Turbo	75	2	0	183	79.5
165/0 (3	Network Turbo	75	3	0	289	116.5
165/1 (2	Network Turbo	90	2	16	170	75
165/1 (3	Network Turbo	90	3	16	270	112
166	Network Express	90	3	32	243	117.2
168/0	Clubman	100	4	0	278	171.5
168/1 (3	Clubman	100	3	0	204	132.2
168/1 (4	Clubman	100	4	0	278	175.7
168/2 (3	Clubman	100	3	0	204	134.2
168/2 (4	Clubman	100	4	0	280	178.9
170/1	Turbostar	100	2	24	97	89.8
170/1	Turbostar	100	3	45	119	132.8
170/2	Turbostar	100	2	9	110	91.4
170/2	Turbostar	100	3	7	173	133.7
170/3	Turbostar	100	2	18	96	91.6 - 93.1
170/3	Turbostar	100	3	7	162	137.5

Rolling stock characteristics: diesel mechanical and diesel hydraulic units (Cont.)						
				Typical seating capacity of standard unit		
Class Number	Class Name	Maximum speed (mph)	Number of carriages	First Class	Standard Class	Total weight of unit (tonne)
170/3	Turbostar	100	3	7	162	137.5
170/4	Express (1)	100	3	18	172	132.9
170/4	Express (2)	100	3	18	172	137
170/4	Express (3)	100	3	0	198	136.1
170/4	Express (4)	100	3	0	188	133.8
170/5	Express (5)	100	2	0	122	91.7
170/6	Express (6)	100	3	0	196	134.1
171/7	Turbostar	100	2	9	107	92.5 - 95.4
171/8	Turbostar	100	4	18	167	180.4
172/0	Turbostar	75	2	0	124	83.1
172/1	Turbostar	75	2	0	124	83.1
172/2	Turbostar	100	2	0	124	83.1
172/3	Turbostar	100	3	0	193	121.3
175/0	Coradia 1000	100	2	0	118	101.4
175/1	Coradia 1000	100	3	0	186	148.9
180	Adelante	125	5	42	268	252.5
185	Desiro UK	100	3	15	154	163

Rolling stock characteristics: high speed diesel electric units						
				Typical seating capacity of standard unit		
Class Number	Class Name	Maximum speed (mph)	Number of carriages	First Class	Standard Class	Total weight of unit (tonne)
220	Voyager	125	4	26	160	185.6
221 (4 car)	Super Voyager	125	4	26	160	219.4
221 (5 car)	Super Voyager	125	5	26	220	276
222 (5 car)	Meridian	125	5	50	192	249
222 (7 car)	Meridian	125	8	106	304	337.8
222 (4 car)	Pioneer	125	4	33	148	202

Rolling stock characteristics: Electric Multiple Units

				Typical seating capacity of standard unit		
Class Number	Class Name	Maximum speed (mph)	Number of carriages	First Class	Standard Class	Total weight of unit (tonnes)
313/0		75	3	0	231	104.5
313/1		75	3	0	231	104.5
313/2		75	3	0	196	TBC
314		70	3	0	218	102
315		75	4	0	244	127.5
317/1, 317/5		100	4	22	270	137
317/6		100	4	48	244	137
317/7		100	4	22	172	144.5
317/8		100	4	20	245	137
318		90	3	0	212	110.5
319		100	4	0	319	136.5
319/2		100	4	18	221	136.5
319/3		100	4	0	300	140.3
319/4		100	4	12	274	136.5
320		75	3	0	227	114.5
321/3		100	4	16	292	140
321/4		100	4	28	271	140.4
321/9		100	4	0	293	138
322		100	4	0	291	138.7
323		90	3	0	284	114.7
332 (4-car)		100	4	26	148	179
332 (5-car)		100	5	26	204	214.8
333		100	4	0	343	186.4
334	Juniper	90	3	0	183	124.6
350, 350/2	Desiro UK	100	4	24	200	179.3
357/0	Electrostar	100	4	0	278	157.6
357/2	Electrostar	100	4	0	282	157.6
360/0	Desiro UK	100	4	16	256	168
360/2	Desiro UK	100	4	0	257	168.2
365	Networker	100	4	24	239	150.9
375/3	Electrostar	100	3	24	152	123.1
375/6	Electrostar	100	4	24	218	173.6
375/7	Electrostar	100	4	24	218	158.1
375/8	Electrostar	100	4	24	218	162.3
375/9	Electrostar	100	4	24	250	161.7
376	Electrostar	75	5	0	228	192.9

Rolling stock characteristics: Electric Multiple Units (Cont.)						
Class Number	Class Name	Maximum speed (mph)	Number of carriages	Typical seating capacity of standard unit		
				First Class	Standard Class	Total weight of unit (tonnes)
377/1		100	4	24	222	161.2
377/2	Electrostar	100	4	24	222	168.3
377/3	Electrostar	100	3	24	152	122.4
377/4	Electrostar	100	4	20	221	160.8
377/5	Electrostar	100	4	20	217	160.8
378/1	Capitalstar	75	4	-	146	160.3
378/2	Capitalstar	75	4	-	146	164.8
379	Electrostar	100	4	not yet available	not yet available	not yet available
380/0	Desiro UK	100	3	-	191	132.7
380/1	Desiro UK	100	4	-	265	167.5
390	Pendolino	125	9	145	294	460.7
395	Javelin	140	6	-	340	273.4

Rolling stock characteristics: 750V DC EMUs

Class Number	Class Name	Maximum speed (mph)	Number of carriages	Typical seating capacity of standard unit First Class	Standard Class	Total weight of unit (tonnes)
442	Wessex Electric	100	5	50	264	200.1
444	Desiro UK	100	5	35	299	221.8
450	Desiro UK	100	4	24	233	172.2
455/7		75	4	0	236	132.4
455/8		75	4	0	308	139.1
455/8		75	4	0	316	131.7
455/9		75	4	0	316	130.8 - 132.6
456		75	2	0	152	72.5
458	Juniper	100	4	24	239	169.5
460	Juniper	100	8	47	316	315.2
465/0	Networker	75	4	0	352	133.6
465/1	Networker	75	4	0	352	133.6
465/2	Networker	75	4	0	352	133.6
465/9	Networker	75	4	24	302	138.2
466	Networker	75	2	0	168	72
483		45	2	0	82	54.8
507		75	3	0	192	98
508/1		75	3	0	192-222	99
508/2		75	3	0	219	99
508/3		75	3	0	222	99

Rolling stock characteristics: Loco hauled coaching stock

Class Number	Class Name	Maximum speed (mph)	Number of carriages	Typical Seating Capacity of standard unit First Class	Standard Class	Total Weight of unit (tonne)
HST trailer		125		0 or 46	76 or 0	33-38
Mk 3		125		0 or 48	76 or 0	34-40
Mk 4		140		0 or 46	76 or 0	39-43

Rolling stock characteristics: night stock

Class Number	Class Name	Maximum speed (mph)	Number of carriages	Typical Seating Capacity of standard unit First Class	Standard Class	Total Weight of unit (tonne)
Mk 2 overnight		100		31		33.5
Mk 2 lounge		100		26		33.5
Mk 3a sleeping		100		12 or 13 berths		41-43.5

Appendix B – Glossary

The following is a list of definitions for some of the terminology used in this document:

ATOC – Association of Train Operating Companies
Axle load – the gross vehicle weight divided by the number of axles
Bogie – a supporting frame for wheel axles fitted beneath the end of a rail vehicle
CC – Competition Commission
CCTV – Closed Circuit Television
Coupling – the system allowing one or more vehicles to be attached to each other. There are a variety of types of couplers for passenger rolling stock
CP – Control Period (Network Rail five year funding period e.g. CP4 is from 2009-14)
DfT – Department for Transport
DMU – Diesel Multiple Unit
DOO – Driver Only Operation
DVT – Driver Van Trailer
EGIP – Edinburgh-Glasgow Improvement Programme
EMC – Electro Magnetic Compatibility
EMU – Electric Multiple Unit
ERTMS – European Rail Traffic Management System
ETCS – European Train Control System
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

GRIP – Guide to Railway Investment Projects
GSM-R – Global System for Mobile Communications-Railway
HLOS – High Level Output Statement
HS1 – High Speed 1
HS2 – High Speed 2
HST – High Speed Train
IEP – Intercity Express Programme
Kinematic Envelope – the characteristics of lateral and vertical movement of individual rolling stock vehicles in motion
LDHS – Long Distance High Speed
Locomotive Hauled Coaching Stock – unpowered passenger rolling stock vehicles which are hauled by locomotives. These vehicles are distinct from multiple units (see below) where traction power is distributed throughout the train
LSSG – Lower Sector Structure Gauge
LSVG – Lower Sector Vehicle Gauge
MML – Midland Main Line
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
NESA – National Electronic Sectional Appendix
NGD – National Gauging Database
Night Stock – Coaches used for sleeper trains
NRMM – Non-Road Mobile Machinery
ORR – Office of Rail Regulation
PRM TSI – Persons of Reduced Mobility Technical Specification for Interoperability

PTE/PTA – Passenger Transport Executive/Authority
PTEG – Passenger Transport Executive Group
RA – Route Availability
Regen – Regenerative braking
RFG – Rail Freight Group
RIA – Railway Industry Association
ROSCOs – Rolling Stock Companies
RSSB – Rail Safety and Standards Board
RTS – Railway Technical Strategy
RUS – Route Utilisation Strategy
RVAR – Rail Vehicle Accessibility Regulations
SMA – Strathclyde Manning Agreement
SMG – Stakeholder Management Group
S&T – Signalling and Telecommunications
STPR – Scottish Transport Projects Review
Swept E nvelope – the rail vehicle kinematic envelope (see above) also allowing for the effects of vertical and horizontal curvature of the track
TIIS – Train Infrastructure Interface Specifications
TfL – Transport for London
TOC – Train Operating Company
Track cant – the slope of the track cross-section on a curve where the outside rail is higher than that of the inside
TSLG – Transport Strategy Leadership Group

UIC – Union Internationale des Chemin de fer (International Union of Railways)
WAG – Welsh Assembly Government
WCML – West Coast Main Line

Network RUS – Passenger Rolling Stock – Draft for Consultation May 2011

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