



# Long Term Passenger Rolling Stock Strategy for the Rail Industry

Sixth Edition, March 2018



This Long Term Passenger Rolling Stock Strategy has been produced by a Steering Group comprising senior representatives of:

- Abellio
- Angel Trains
- Arriva
- Eversholt Rail Group
- FirstGroup
- Go-Ahead Group
- Keolis
- Macquarie Rail
- MTR
- Network Rail
- Porterbrook Leasing
- Rail Delivery Group
- SMBC Leasing
- Stagecoach

***Cover Photos:***

***Top: Bombardier built Class 158 DMU from the early 1990s***

***Middle: New Siemens built Class 707 EMU***

***Bottom: Great Western Railway liveried Hitachi Class 802 Bi-mode awaits roll-out***

## Foreword by the Co-Chairs of the Rolling Stock Strategy Steering Group

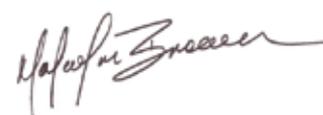
The Rolling Stock Strategy Steering Group is pleased to be publishing the consolidated views of its cross-industry membership in this sixth edition of the Long Term Passenger Rolling Stock Strategy. The group is formed of representatives from rolling stock owners, train operators, Rail Delivery Group and infrastructure owner Network Rail, and endeavours to provide an up-to-date, balanced and well-informed perspective on the long term outlook for passenger rolling stock in the UK.

Investment commitments made in recent years are now being delivered in volume and the benefits of modern, technically advanced trains are being enjoyed by passengers on an increasing number of routes. A further 1,565 vehicles were ordered during the last year, bringing the total commitment since 2014 to nearly 7,200 vehicles. New train manufacturers continue to be drawn to the UK and other new entrants to the vehicle leasing market have brought additional investment and competition to the specialist sector.

Extensive new train orders will cause significant numbers of existing electric multiple unit vehicles to be displaced in the next few years. Many will be scrapped, but others have significant remaining life and opportunities to return these vehicles to service are becoming limited. This brings financial risk to their owners and the overhaul and refurbishment sector of the supply chain, which would historically have modernised these vehicles to meet passenger expectations. Increasingly competitive markets in manufacturing, refurbishment and finance will respond to deliver competitive rolling stock and meet demand in times of change, but to develop effectively and deliver optimum whole life cost solutions to the industry, the market requires a steady evolution of long-term policy.

While our long term overall forecasts remain similar to previous years, the constitution of the fleet is likely to change in coming years with increases in self-powered and bi-mode vehicles offsetting decreases in pure electric vehicles. Developments in the field of traction power sources are expected to bring innovative alternatives to diesel engines, thereby improving the sustainability of rail transport without necessarily expanding the overhead power network.

We have noted and will continue to monitor the recent softening of passenger demand, particularly in the south-east, but as with Brexit the impacts of this trend are within the range of growth scenarios incorporated and modelled within this strategy. Industry and government investment continues in anticipation of a further doubling in passenger demand over the next 30 years and we hope that this strategy will assist others in understanding how they may contribute and share in this growing sector.



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*A refurbished Class 321 "Renatus" EMU*

## Executive Summary

This sixth annual edition of the Long Term Passenger Rolling Stock Strategy (RSS) follows previous editions in setting out a range of forecasts for the likely size and mix of the national rolling stock fleet required to accommodate future passenger numbers over the next 30 years to 2047. It continues to draw on outputs from the rail industry's Long Term Planning Process but has also considered recent developments, including the as yet undetermined impact of Brexit and the changes in electrification and train power strategy announced by the English government.

Each edition of the RSS has included shorter-term fleet size forecasts to 2024. The associated forecasts for the number of new vehicles required have been revised upwards with each annual update of the RSS as the additional commitments made by the industry have surpassed all previous expectations. The number of new vehicles committed for delivery in the five-year period that commenced in April 2014 (CP5) and in the early years of CP6 is now 7,187 – more than 50% of the current in-service fleet of 14,025. These new vehicles have a capital cost of more than £13 billion, and around 50% will be built in Britain. The average age of the national fleet is estimated to fall from 21 years to 15 years by March 2021, while the numbers of vehicles in service will grow by 6% next year and by a further 5% to 13% by 2024.

Major orders for new build vehicles coupled with the reduced electrification programme has so far resulted in over 4,000 vehicles being displaced from service in the next 3 years. Many of these vehicles are near the end of their life, but 150 are brand new. As at March 2018, there are over 1,500 vehicles less than 30 years old that do not currently have a future lessee, so while over 7,000 vehicles will be built, the net impact on the national fleet total will be less than this number. Displaced, serviceable vehicles bring challenges to the supply chain, notably for owners who may have idle assets, but also for overhaulers who would historically have refurbished mid-life vehicles for their next role.

Pure electric vehicles now comprise 72% of the national fleet and over 80% of committed new vehicles, but interest in vehicles of other traction types is rising rapidly following two far reaching policy announcements. In July 2017, the English government expressed reduced ambition in its network electrification programme and instead encouraged increased use of bi-mode trains. Bi-mode trains are capable of operating using more than one source of electrical power. Currently, all 1,030 bi-mode trains on order or operating in the UK have diesel generators as their on-board power source – but batteries or hydrogen cells are amongst future alternatives. In February 2018, the Minister for Transport challenged the industry to take all diesel engines off passenger trains by 2040 and commence a trial of hydrogen powered trains as soon as possible. However, a successful hydrogen powered train has yet to be put into public service and there is currently no viable alternative to the diesel engine for rail traction application. For rail to retain its historical reputation as an environmentally friendly and sustainable form of transport, extensive innovation and development in the field of traction power sources will be required.

The long term rolling stock outlook remains unchanged with a national fleet increase of between 40% (5,500 vehicles) and 85% (12,000 vehicles) forecast over the next 30 years. The mix of traction power amongst these vehicles is uncertain, but with the industry predicting another doubling of demand in the next 30 years and the franchising authorities continuing to invest based on similar expectations, the long term outlook remains positive. The strategy emphasises the resulting benefits to passengers and the wider community, including improvements to capacity, punctuality, reliability, passenger facilities and the environment.

One notable change in this edition of the RSS is the absence of the Depot & Stabling section found in previous editions. With the increasing national fleet size, this subject was found worthy of its own publication, and the Passenger Depot & Stabling Strategy, will be published later in the year.

## A. Introduction – Goals and Scope

1. This is the sixth annual edition of the Long Term Passenger Rolling Stock Strategy (RSS). It represents a collaborative, industry-led strategy for passenger rolling stock. The work is led and funded by a Steering Group (RSSSG) whose membership is open to senior representatives of the Rail Delivery Group (RDG, including Train Operating Company (TOC) Owner Groups and Network Rail) and rolling stock owners (ROSCOs). The current participating member companies are listed on the inside cover page.
2. The RSS has been developed by the industry – TOCs, ROSCOs, and Network Rail – to provide a forecast of the future UK passenger fleet size and composition, providing a baseline for planning and giving visibility to the supply chain. It is updated annually to reflect latest policy and product development, insight into current order volumes and changes brought about through the letting of the latest franchises. While the industry has developed the RSS, the DfT has separately produced its “Rolling Stock Perspective” document, setting out the features and improvements it wishes to see in UK rail passenger vehicles. These two publications complement each other to indicate how vehicles operating on the UK rail network might meet the expectations of the government and of passengers in years to come.
3. Following the comprehensive update of the RSS for the last fifth edition, this sixth edition incorporates adjustments to reflect the key developments that have impacted the market over the last year. Specifically, this entails an updating of the model that underpins the forecasts, consideration of the impacts of changes in electrification strategy and reduced diesel use announced during the last year together with current trend changes such as the recent slowing rate of growth in passenger demand.
4. The fundamental aim of the RSS is unchanged from the first edition published in February 2013, as follows:

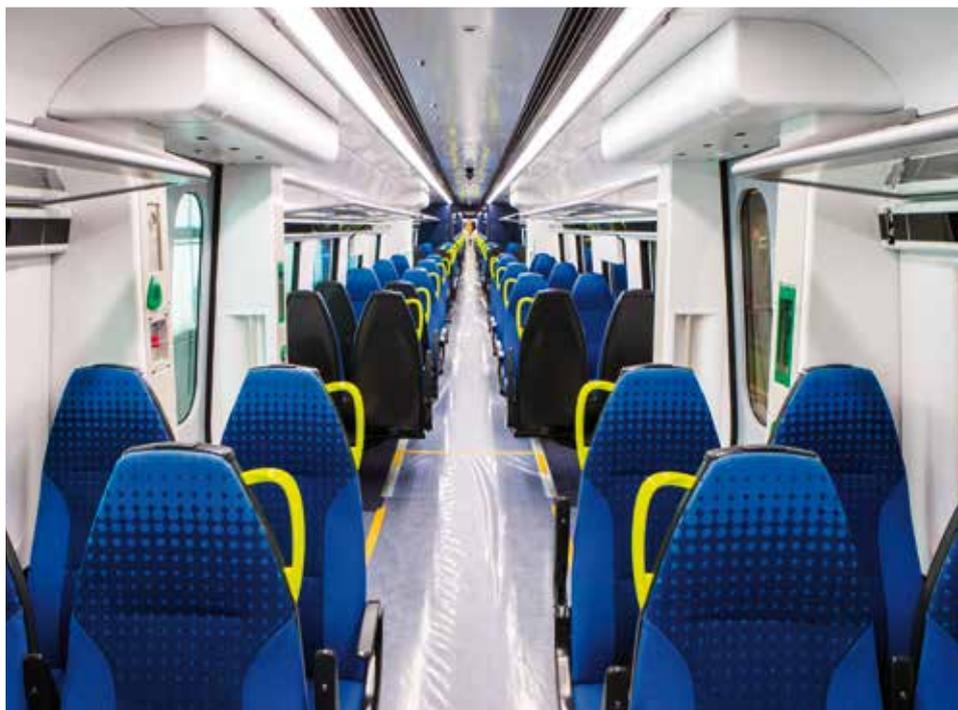
Set out the dimensions of industry-wide rolling stock requirements over a 30-year horizon in the context of growth, committed and likely network developments and the direction of government policy, without imposing constraints on the market to deliver appropriate solutions.

A key objective of the Strategy must be to promote better value for money from the rail industry. The Strategy should therefore as a minimum indicate the manner in which it might reduce not only rolling stock unit costs and wider industry costs, but also increase train capacity, route capacity and industry revenues.

5. The RSS is intended to add value by:
  - facilitating a whole-system approach to strategy, bringing together demand growth, infrastructure, train services and fleet scenarios;
  - providing a backdrop for and an input to longer term planning, by train builders, owners (ROSCOs), TOCs, Network Rail, franchising authorities and their suppliers;
  - identifying opportunities to smooth peaks and troughs of workload;
  - highlighting priorities for improving value for money; and
  - identifying and analysing issues of concern for the short, medium and long term.

6. All fleet size numbers and forecasts contained in the RSS exclude any existing vehicles that are off-lease and also new vehicles that have been built but have not yet been introduced into passenger service. The RSS continues to be widely read in the industry and is viewed by the supply chain as a critical part of providing greater visibility for potential investments. RSS forecasts are used by the National Skills Academy for Rail (NSAR) to analyse future manpower requirements for apprenticeships and for the design, manufacture, modification and maintenance of railway rolling stock and referenced in government briefing papers.
7. The RSS is consistent with the industry's Long Term Planning Process (LTPP). The fifth edition of the RSS was developed in parallel with and provided inputs to the rolling stock, depot and stabling, and environmental components of the LTPP for Control Period CP6 (2019 to 2024), and specifically for the Initial Industry Advice documents (IIAs) prepared by the rail industry. The RSS model for this sixth edition contains revisions that reflect:
  - The High Level Output Specifications (HLOSs) published in the Spring of 2017;
  - The latest Kent, West Midlands and Chiltern route studies published in 2017.
  - The Secretary of State's statement of 20th July 2017 (electrification)
  - The Route Strategic Business Plans (RSBPs), replacing the previous Industry Strategic Business Plans (ISBPs), are expected to be incorporated in future editions of the RSS as they become available.
8. RSSSG has set out the key principles which should apply regarding the provision of rolling stock. Alongside government's important role in setting out the strategic direction and broad outcomes, RSSSG asserts that:
  - rolling stock provision should be the result of market-driven initiatives, procured in a competitive environment to deliver that long term strategy; and
  - the franchising model has proven itself to be an excellent mechanism to deliver value for money rolling stock provision;
  - the new RSBPs represent an opportunity for fleet driven infrastructure requirements to be incorporated into long term strategy at route level in a timely manner;
  - short term budget constraints should not prejudice the delivery of optimum whole-life, whole-system costs and benefits of rolling stock.
9. As it has evolved through its annual revisions, the RSS has taken and will take account of:
  - changes to the franchising programme;
  - new franchise commitments, noting the impact of the credit now being given in the evaluation of franchise bids for quality to be delivered by train operating franchises;
  - changes in peak period and all-day passenger demand;
  - the Market Studies and Route Studies published by Network Rail since 2013;
  - Network Rail demand forecast updates under the Continuous Modular Planning Process;
  - the Rail Industry Sustainable Development (SD) Principles;
  - Network Rail's Enhancements Delivery Plan and its updates; and
  - changes in government policy and strategy on infrastructure investment and network funding.
10. For each annual iteration, the emerging work has been discussed with the train builders that are members of the Railway Industry Association (RIA). RIA, the train builders and their suppliers have welcomed the creation of the RSS and its annual updates. The involvement of all parties and the confidential sharing of data with the RSS project authors contribute to the integrity of this strategy.

11. Businesses in the rail supply chain have emphasised that the short, medium and long term forecasts stretching out 30 years which are provided in the RSS, far from being of merely theoretical interest, are of great value to their future business strategies, and have in specific cases been discussed in some detail with their parent companies. The Rail Supply Group Sector Council receive briefing on each issue of the RSS, facilitating active debate on long term planning. Along with the National Infrastructure Plan, the DfT's franchise timetable and the plan for improving the visibility of future investments set out in the RSG strategy, the RSS forms part of a new set of complementary long term industry plans to help the supply chain understand future opportunities and plan to deliver this efficiently including by investing in people, innovation, facilities and equipment in the UK.



*Interior and exterior views of the first CAF Class 195 DMU for Northern, ready to leave the factory.*

## B. Principal Changes Incorporated in this Sixth Edition of the RSS

12. As Brexit will have an unknown impact on the performance of the UK economy it is worth repeating that the fifth edition of the RSS considered how this might impact rolling stock forecasts and the position is unchanged. Examination of the Network Rail Market Studies published in 2013 demonstrates that the ‘Struggling in Isolation’ scenario (on which the low scenario of the RSS is based) incorporates assumptions for economic growth and employment that are far more pessimistic than the worst case post-Brexit downside assumptions of the Office of Budget Responsibility (OBR) and other analysts. It can therefore be argued that potential negative consequences of Brexit for the RSS are already contained within the envelope of forecasts outlined in this updated RSS.
13. Whilst the economic impact of the decision to leave the EU is uncertain, the medium to long term drivers of rail growth remain fundamentally robust. As a result, it is difficult to construct plausible scenarios in which rail passenger demand growth stagnates, particularly in markets where rail is fundamentally aligned to the direction of economic development – commuting into large cities, high speed travel between our urban areas, and providing connections to international gateways. The DfT Strategic Vision for Rail, published in November 2017, envisages growing demand in these markets, and a commitment to invest and expand the network accordingly.
14. The rail industry does, however, anticipate a slower pace of growth in the very short term which RSSSG recognises may impact upcoming franchise competitions. Revenue and traffic data indicates that commuter behaviour and journey patterns in London and the south east started to change in 2016. In particular, commuter season ticket revenue has fallen, while at the same time peak time day ticket revenue has increased – albeit by a smaller factor. TfL electronic ticketing initiatives, including C-PAY and daily/weekly capping, are providing passengers with alternatives to the traditional season ticket, while Network Rail believe that the unusually high volume of infrastructure work on routes including Thameslink, Crossrail and Gospel Oak, together with summer closures at Waterloo, have also adversely impacted passenger demand. Study to establish the cause of wider travel pattern changes is ongoing. Brexit and economic uncertainty are known to be affecting commuter confidence and has reduced demand for longer period season tickets, but the behavioural impact of other factors such as electronic ticketing on the underground is not fully understood. This change in pattern is primarily apparent in the south-east, however commuting into regional cities, along with other regional and long distance travel, continues to grow. RSSSG will continue to monitor this trend, but its current impact is comfortably contained within the L/M/H growth scenarios in the RSS model. The latest DfT overcrowding data collected in autumn 2016 are in Table 1:

**Table 1 - Commuter Passenger Counts**

	Average Annual Growth 2012 - 2016		Annual Growth 2015 - 2016	
	AM Peak Hour	AM All Peak	AM Peak Hour	AM All Peak
London & SE	1.9%	2.9%	-1.4%	0.1%
12 Regional Cities	3.4%	2.7%	3.0%	2.5%

*Source: DfT Table RAI0212 Peak Rail Capacity*

15. The committed components of railway route enhancements have been revised through the Hendy Review process and government strategy change, but while the planned scope of electrification has been reduced, other infrastructure improvements on routes such as the Transpennine, Midland Main Line and Brighton Main Line are expected to progress in response to passenger demand. While the industry recognises electrification as a driver of revenue, passengers are attracted by new trains, with improved performance, journey times and connectivity regardless of traction type. With IEP introduction and other enhancements continuing, significant growth can still be expected. Major schemes such as HS2 and Crossrail 2 add to the above numbers, and further growth can also be expected as the result of improvements to be secured through the franchising process and delivered by train operators. These improvements in capacity and quality are expected to make a substantial contribution to demand and revenue growth during CP6, supporting a long term growth profile that anticipates a doubling of passenger demand again over the next 30 years.
16. It will be seen that the “headline” figures for total national passenger fleet size growth over 30 years contained in this RSS are a little lower than in previous editions of the RSS. In the High scenario, this figure is now 85%, compared with 89% last year and 99% in the fourth edition, but these reducing percentage growth figures reflect the delivery of new vehicles increasing the size of the current fleet base to its current level of 14,025 vehicles rather than a decrease in the long term capacity requirement. The total national fleet size forecast in the High scenario of this updated RSS for 2047 is 25,969. The reduction in the “headline” percentage fleet size is expected to continue in response to the current high level of new build orders, but the rate of change is uncertain, as this is dependent on the extent to which displaced vehicles are utilised elsewhere on the network. If new build vehicles displace older vehicles on a like for like basis, this investment will have limited impact on the ability of the national fleet to meet forecast passenger demand growth. The national fleet size has grown by 4.8% in 2017/18. It is forecast in this RSS to grow by a further 6% by the end of CP5, and by between a further 5% and 13% in CP6. (See Table 4 in Section G below).
17. Overall, the long term fleet size forecasts have remained relatively stable over the five editions of the RSS. The figure for the national fleet size after 30 years in 2042, in the High Scenario of the first edition of the RSS (published in February 2013), was 24,548.
18. A bigger change in the 30-year fleet size forecasts relates to the forecast mix of ‘Electric’ and ‘Self-Powered’ vehicles. As outlined in Section E below, this results from changes in this RSS to RSSSG’s assumptions for the pace and extent of new electrification beyond CP5. These assumptions have been scaled back as described in Section E, as a result of delays and reductions in the delivery of the electrification programme in CP5.
19. As has been the case since the first edition of the RSS, the electric category of rolling stock includes bi-mode trains. These are electric trains which can be powered not only from an external electrical supply, but also from power sources on the train such as diesel engines, or potentially, in the future, by alternative sources such as hydrogen fuel cells.
20. The total number of new vehicles committed for delivery in the five-year period that commenced in April 2014 (Control Period 5, CP5) and in the early years of CP6 (2019 to 2024) is now 7,187. International interest in manufacturing and leasing new trains for the UK market has grown over the last five years. Five train builders, with finance from many existing and new sources of funding, are now involved in this large programme of growth and fleet replacement. As is outlined in Appendix 5 and in Sections G and H of this RSS, these new orders comprise several varieties of pure electric, pure diesel, bi-mode and loco-hauled

vehicles. Bi-mode vehicles for the UK market are now being built for both 125 mph intercity services and 100 mph regional services, for six train operators. If the extent of ongoing electrification assumed in this updated RSS were to prove to be too optimistic, then fewer of the uncommitted new vehicles (required both for ongoing growth and to replace the ageing ex-BR fleets) might be pure electric than had previously been thought. Nevertheless, it is still forecast that the great majority of new vehicles now committed for delivery in CP5 and CP6 and forecast in this RSS to be required over the subsequent 20 years will be pure electric vehicles.

21. The growing influence of quality and capacity in the evaluation of new franchise bids by DfT has again been evident in franchise competitions over the last year. Following a complete fleet replacement with 1,043 new vehicles on the East Anglia franchise, new builds have continued to feature in winning operator bids. The South-West competition brought an order for 750 EMU vehicles, while West Midlands competition saw the placing of an order for 333 EMU and 80 DMU vehicles, financed through Corelink Rail Infrastructure, a new entrant to the UK rolling stock finance market. An updated table of all the confirmed rolling stock orders is included as Appendix 5 of this RSS.
22. The increase in size of the national rolling stock fleet as a result of new vehicles ordered since the last edition of the RSS is currently unclear. Since the advent of the rolling stock market at privatisation of the railway in 1994, demand for rail vehicles has generally exceeded supply, and new build vehicles have added to the national fleet unless they either displaced life-expired rolling stock for scrapping or specialist heritage operations. However, when the 1,431 vehicles ordered in 2017 are delivered, they will displace significant numbers of vehicles with serviceable life, for which, at the current time, there are no future TOC lessees. Some of these displaced vehicles are over 35 years old – but others are brand new. The total number of vehicles forecast to be displaced by 2021 is nearly 4,000. It is too early to comment on the future of these vehicles, save that while some are certain to be scrapped, others are likely to find new lessees. Vehicle owners will remain responsible for the management of their assets.
23. With the exception of the former Section L on Depots, Stabling, Skills and Infrastructure, all other sections of this RSS have been revised and updated. Section L has been removed from the RSS as its content will be addressed by a new stand-alone document the “Passenger Depot & Stabling Strategy” which is programmed for publication by RDG in 2018.



*Siemens Class 700 Desiro City EMU for Thameslink*

Credit: Siemens.com-press

## C. The Approach Adopted for the Strategy

24. As in the previous editions, scenarios for fleet size have been modelled by five-yearly Control Period for the whole of the 'main line' passenger fleet including England, Wales and Scotland, London Overground, Crossrail and HS2 but excluding vehicles off-lease or not yet introduced to service, and also excluding London Underground (LUL), light rail, tram-train, charter and international fleets.
25. Each of the existing fleets and committed new fleets has been categorised by one of seven generic types of train:
  - A. Shorter Distance Self-Powered (e.g. diesel, generally with 75 mph maximum speed);
  - B. Middle Distance Self-Powered (e.g. diesel, with 90/ 100 mph capability);
  - C. Long Distance Self-Powered (e.g. diesel, with 100/ 110/ 125 mph capability);
  - D. Shorter Distance Electric (generally with 75 mph maximum speed);
  - E. Middle Distance Electric (with 90/ 100/ 110 mph capability. Some future trains may require 125 mph capability);
  - F. Long Distance Electric (with 100/ 110/ 125/ 140 mph capability); and
  - G. Very High Speed Electric (140 mph and above, for domestic services on HS1 and HS2).
26. Information about which of the existing and committed new fleets have been categorised in each of these seven categories is contained in Appendix 4. Bi-mode fleets are included in the electric fleet categories. Individual class numbers have not been used in the analysis of future fleet sizes beyond CP5. The RSS is not a 'cascade plan' for the deployment of rolling stock, nor is it in any way prescriptive. Consistent with RSSSG's support for market-based approaches, it is not intended to constrain TOCs and funders from making the best possible decisions about rolling stock procurement, maintenance, enhancement, life extension and replacement based on thorough business case analysis.
27. The RSS originally used demand forecasts published in the Network Rail Route Utilisation Strategies (RUSs) in 2011. Projections have subsequently been updated to be consistent with the forecasts of peak period (and in some relevant cases all-day) passenger demand to 2023 and 2043 as included in the Market Studies and Route Studies published by Network Rail since 2013.
28. At the heart of the RSS, and facilitating its updates, is a spreadsheet model. The Market Study-based peak period passenger demand forecasts for growth and the selected electrification scenarios are route-specific, and these have been used to provide bottom-up inputs to the spreadsheet model using the existing franchise map for convenience (with the addition of Crossrail and HS2. Preliminary estimates have also been included for Crossrail 2 and East-West Rail). For each TOC, the total fleet size was then determined for each of the three composite scenarios at the end of CP5 (2019), at the end of CP6 (2024) and in the year 2047. The implications for the end of CP7 and for the end of CP8 have then been determined by a process of interpolation, taking account of any date-specific commitments or assumptions.

29. These forecasts and scenarios for long term peak period passenger demand growth and electrification cannot, of course, quantify unpredictable external factors (e.g. for the economy after Brexit), or for future government policy (e.g. in relation to fares, investment in rail infrastructure, or road pricing, etc). The RSS has taken account of such uncertainties by developing three composite scenarios and by treating the RSS as a living entity. As is demonstrated by the fact that this is now the sixth annual edition of the RSS, the intention is that RSSSG will continue to update the RSS annually to reflect industry and external developments including the franchising, route enhancement and electrification programmes, and emerging government policy.
30. The three composite scenarios used to underpin the RSS take specific account of future electrification, as this will typically lead to significant fleet change and through this and other benefits, drive demand growth. Previous editions of the RSS have linked the three high / medium/ low overall growth scenarios to corresponding scenarios for electrification. Following the strategic change in approach to electrification by the government announced in July 2017, the electrification assumptions in the RSS model have been significantly revised and are discussed further in Section E.
31. The Route Studies contain, and the future RSBPs will update, many route-specific infrastructure and timetable options for increasing capacity beyond CP5. Some of the presently committed enhancements including the IEP, main line electrification, Thameslink, Crossrail, and HS2 projects will provide additional capacity well beyond these timescales. On some routes it may be possible to lengthen trains or run more trains within the existing infrastructure. On others, schemes considered in the Route Studies and to be developed in the RSBPs will be needed to provide sufficient paths, station capacity, depots and rolling stock stabling capacity. The costs and benefits of many of these schemes have not yet been established. The LTPP will address these issues progressively, route by route, but with each one being such a significant project, they will only be updated when required to inform impending strategic decisions. TOCs, ROSCOs, Network Rail and the franchising authorities work through these processes to identify good value for money outcomes and to develop an overall rail development strategy, mindful of the need to improve industry efficiency and to reduce total levels of subsidy.

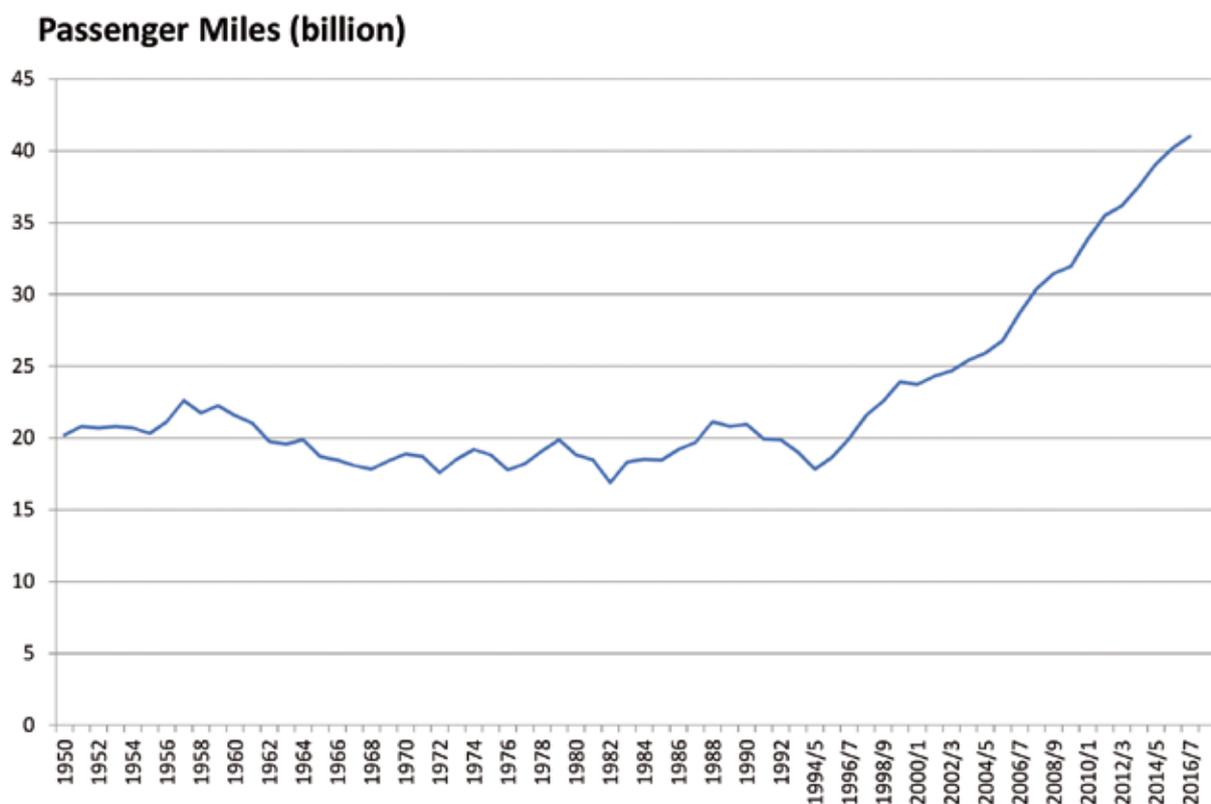


*Four Class 377 "Electrostar" EMUs at Clapham Junction*

## D. Planning for Growth – Sources of the Assumptions Adopted

32. Total passenger miles grew by 120% in the 21 years between 1995/6 and 2016/17, an average compound rate per year of 3.8%. (Source: DfT and ORR data). Even in the six years of lower economic growth after 2007, the average annual growth in passenger miles was 3.5%, significantly out-performing economic growth, other transport modes in Great Britain and other railways in Western Europe. Passenger demand for rail transport in the UK has proved remarkably resilient over time and both government and the industry expect long term growth to be maintained.
33. The sustained rate of passenger mile growth seen over the last 20 years on a substantially unchanged network contrasts sharply with the pattern of relatively constant or slowly declining demand seen over the previous 45 years, as shown in Figure 1. This contains passenger miles data up to March 2017. There is evidence of some softening in the levels of growth in passenger journeys and passenger revenue in London commuter areas since 2016, but growth on regional and long distance routes continues to grow steadily. As emphasised in this section, however, the forecasts of future rolling stock requirements are based on a broad range of forecasts of future peak period passenger demand.

**Figure 1 - National Rail Passenger Miles per Year, 1950 to 2016**



*Source: ORR Data Portal (Includes non-Franchised TOCs)*

34. The industry Rail Delivery Group forecasts a doubling of passenger demand over the next 30 years, while the Department for Transport expresses confidence in long term growth in its “Connecting People: a strategic vision for rail” publication and the Scottish government remains committed to providing capacity for future growth. Noting these positive long term outlooks, RSSSG will continue to monitor the current softening of demand in the south-east but believes the current perturbations in demand are catered for within the range of RSS growth scenarios.

35. Various studies have attempted to determine why the unprecedented period of sustained growth over the last 20 years had not been predicted. Data analysis has not been able to categorically identify the root causes, but it appears that this is the result of a combination of:
- changes in the external environment (e.g. population, housing and labour market factors);
  - changes affecting competing modes (e.g. declining ownership and use of cars by younger males); and
  - initiatives and improvements introduced by the rail sector, including:
    - financial incentives on TOCs to grow their businesses;
    - access to private sector capital;
    - frequency, journey time and rolling stock quality improvements;
    - cost and time-savings of advance purchase fares and smart cards;
    - technology enabling rail passengers to make better use of on-train time;
    - improved revenue protection and associated data collection; and
    - expansion of station car parks.
36. National rail passenger revenue has more than doubled in real terms from £4.2 billion to £9.4 billion between 1995/6 and 2016/17 (at 2016/17 price levels; source ORR revenue data and ONS CPI data). The gross revenue received has helped to pay for the very substantial investment programme that the industry is undertaking in CP5. The same opportunity exists in future to help pay for further growth in capacity, in a sustainable manner.
37. Absence of granularity in demand forecasting creates challenges in terms of long term forecast construction as well as understanding of short term perturbations. With annual industry revenue now approaching £10 billion, minor percentage perturbations in demand mean significant revenue variation for TOCs. Recognising this weakness, RDG will reissue the industry Passenger Demand Forecasting Handbook (PDFH) in 2018. Development and testing of the new version has entailed extensive back-casting with new algorithms, which are believed to capture better the detailed factors affecting rail demand and thereby offer significantly improved forecast accuracy.
38. To assess the implications for the number of vehicles needed in the future, RSSSG originally examined the relationship between demand and passenger fleet size. The 116% increase in passenger-miles in the 20 years between 1995/6 and 2015/16 was achieved with an increase of just 18% in the size of the total national passenger fleet. This major increase in fleet utilisation efficiency since 1995 was principally achieved by much improved marketing and utilisation of spare off-peak capacity. In addition, changes have been made to the type, configuration and functionality of much of the national fleet. These have increased the average capacity per vehicle. Examples have included:
- Replacement of older slam-door rolling stock with sliding-door vehicles, providing more capacity for peak period passengers;
  - Introduction of trains with metro-style interiors for some inner suburban services south of the River Thames, and on the London Overground;
  - Elimination of many locomotives and non-passenger carrying vehicles (meaning that more of the train is available for carrying passengers);
  - Changes to seating configuration including conversion of some first class accommodation to standard class;
  - Achievement of higher levels of fleet availability, and of higher average train speeds on some routes; and
  - Introduction of automatic passenger load weighing and counting technology on many fleets (which has led to more efficient utilisation of rolling stock).

39. Despite these changes, peak period crowding has become an increasing problem on many routes in London and the regions. In 2016, 2 of the top 10 most crowded trains on the network were in northern cities. While strategic policy changes such as the removal of first class seating from commuter services in the next South Eastern franchise will help mitigate crowding, the scale of capacity increase required to meet demand has led to the major programmes of investment in infrastructure and rolling stock which will come to fruition in CP5 and in the early years of CP6.
40. The four Network Rail Market Studies, for the London & South East (L&SE), Long Distance, Regional Urban and Freight markets respectively, underpin the LTPP. The peak period passenger demand forecasts and freight demand forecasts contained in the Market Studies continue to form a key input to the twelve Route Studies being produced by Network Rail, nine of which have been published in final form with one other being available in draft form.
41. The Market Studies and Route Studies are more useful than the RUSs in that:
  - they provide forecasts of peak passenger demand by main route and for the principal regional cities in 2023 and 2043, whereas the previous 2011 RUS documents covered a period of around 20 years only; and
  - in most cases they incorporate four alternative composite long term demand scenarios comprising a wide range of macro-economic and micro-economic factors, demographics, 'consumer tastes', and 'the supply of travel opportunities'.
42. The forecasting methodology adopted for the RUSs, Market Studies and Route Studies focuses primarily on route-specific morning peak period passenger volumes and peak capacity, since that is what determines strategic level planning of railway infrastructure, rolling stock and timetables. Peak period passenger demand has risen more slowly than off-peak passenger demand, but with the exception of London commuting in the last 18 months discussed in paragraph 14 of this RSS, growth has been steady. Over the last 5 years, morning peak TOC passenger numbers into London have increased at a compound rate of 2.8% per year, while the average increase for ten regional cities in England and Wales has been 2.7% per year (Source: DfT data July 2017 for Autumn 2016).
43. This sixth edition of the RSS employs the principles used in the fifth edition, and fleet size growth forecasts continue to use more of the route-specific or city-specific passenger growth forecasts from the Market Studies and Route Studies. Wherever it is relevant and possible to do so, the fleet size growth forecasts for the RSS use the Market Study scenarios, adopting their associated overall range of growth. Enhancements to the methodology by which the analysis takes account of DfT data for current non-compliant levels of crowding on some peak flows into London and other cities have been retained.
44. Growth in peak period demand of higher than the High growth scenarios may occur, as many of the additional (presently uncommitted) future route enhancements or service enhancements will themselves produce additional peak period growth requiring fleet growth. Conversely, the franchise bidding process can unlock opportunities to improve capacity utilisation further (for example through improvements in timetable design, fleet configuration, fleet availability or fleet utilisation). This can be facilitated by flexibility in franchise specifications and change mechanisms in franchise contracts, and by TOCs continuing to adopt and improve the range of ideas listed in paragraph 38 above. The easiest of such opportunities have already been implemented, but more can be achieved through the effective specification and management of franchises, and by the introduction of rolling stock with a higher average capacity per vehicle, as will for example be achieved by the new rolling stock fleets being procured for the East Anglia, South Western and West Midlands franchises.

45. The Market Studies and Route Studies include forecasts for morning peak passenger demand growth for all the principal routes to London, for nine regional cities in England and Wales, for the principal cities in Scotland, and for all-day flows between pairs of 12 British cities. The Market Studies and Route Studies have also provided a useful shorter-term focus on morning peak period passenger demand (and hence for fleet sizes) to 2023, and by extrapolation to the end of CP6 in 2024, as described in Sections G and H of the RSS.
46. The shorter-term focus strengthened in the fifth edition of the RSS has been continued in this sixth edition. Fleet size estimates have been developed as follows:
  - A. Fleet size forecasts to the end of CP6 for some TOCs are largely determined by existing or recently negotiated commitments from franchisees or the franchising authorities. TOCs in this category comprise Abellio East Anglia (AEA), Arriva Rail North (ARN), Caledonian Sleepers, c2c, Crossrail, TransPennine Express (TPE), Great Western Railway (GWR), GoVia Thameslink Railway (GTR), London Overground, Merseyrail, ScotRail, Virgin Trains East Coast (VTEC), London Northwestern Railway (NWR), South Western Railway (SWR), and Virgin Trains West Coast (VTWC).
  - B. Fleet size forecasts to the end of CP6 for a second group of TOCs have been based on forecasts for growth taken from the Market Studies. TOCs in this category comprise Chiltern, CrossCountry and Southeastern.
  - C. Fleet size forecasts to the end of CP6 for the remaining TOCs are to some extent speculative at present, as these TOCs are currently (or shortly will be) affected by re-franchising. As with the TOCs in category B, the forecasts are based on forecasts of growth taken from the Market Studies, but these will be updated when actual franchise commitments are known. TOCs in this category are Arriva Trains Wales (ATW) and East Midlands Trains (EMT).
47. The estimates of fleet requirements for Crossrail and Phases 1 and 2 of HS2 are based on the latest available information from Crossrail and from HS2 Ltd, as well as discussions with them about options for growth after initial service introduction.
48. Forecasting requirements for Open Access operators is difficult as with the exception of those with known long term track access contracts, their long term strategic plans are not in the public domain, and they depend on the future allocation of train paths. Their combined fleets currently represent 0.5% of the total national passenger fleet, but prospects for future growth have been included within the High, Medium and Low scenarios of the RSS.

## E. Electrification – Prioritisation and Analysis

49. Electrification has been historically considered to offer major new opportunities to reduce unit costs of rolling stock operation and maintenance, and to provide additional capacity, reliability and environmental benefits. After a long period when little new electrification was undertaken in Britain, a major programme to electrify 1,850 track miles commenced in control period 5. Whilst some sections such as Paddington/Didcot and Edinburgh/Glasgow via Falkirk are now available for use, engineering challenges and cost increases resulted in a number of schemes being delivered later than planned and a weakening of business cases for others. These issues led to the Department for Transport requesting that Network Rail undertake a thorough review of its CP5 enhancement programme to 2019 in England & Wales (The Hendy Review). Consequently, some English schemes were cancelled or reprogrammed for delivery in Control Period 6.
50. The present total national Network Rail track mileage is 19,399 track miles (as distinct from route miles, and excluding depots and sidings), referred to in this RSS as 'single track miles' (STMs) – (source Network Rail Annual Return 2017). Of this, 8,106 STMs (42%) are electrified and 11,293 STMs (58%) are non-electrified. Nationally, 28 STMs of new electrification were completed in 2016/17 compared with 18 STMs in 2015/16, and 91 STMs in 2014/15. During CP4, 204 STMs were newly electrified.
51. In a written statement to Parliament on 20th July 2017, the government announced a strategic change in its approach to electrification. The government declared that it was committed to utilising the best available technology in rail transport projects, and new bi-mode trains meant that electrification was not now considered essential for the delivery of journey improvement. Electrification would be undertaken only where it delivered a genuine benefit to passengers that could not be achieved with other technologies. Within this announcement, electrification projects west of Cardiff in South Wales, Oxenholme – Windermere branch and Midland Main Line were deemed not required, the government considering that their outputs could be more appropriately delivered by bi-mode or other technologies.
52. On the Great Western route, there are several route sections that were initially designated for electrification but have since been re-classified as deferred. These route sections include Didcot – Oxford; Bristol TM to Bristol Parkway (Filton Bank); Bath-Bristol (west of Thingley) and Thames Valley (Henley & Windsor). Unlike route sections that have been cancelled, electrification of these sections is still understood to have merit and remains under consideration, but timing and interface with other infrastructure works has caused them to be paused.
53. There are other routes on the Network, such as Transpennine, where a wide range of infrastructure enhancements are under consideration and electrification may feature, but Department for Transport confidence in electrification is now significantly diminished, and future proposals will need strong justification against revised criteria. The commitment to a rolling programme of electrification beyond existing schemes would enable the rail industry to continue to develop its skills and capacity to deliver, potentially offering efficiency savings over a more 'stop-go' approach, but such a scenario now appears unlikely. With Sheffield now included on the HS2 network, commercial justification for continuous electrification of the Midland Main Line appears unlikely. The Scottish government strategy includes having 35% of its network electrified by 2032 as part of its Climate Change Plan, and so long as electrification costs can be contained, the pattern of gradual expansion of the Scottish network looks set to continue.

54. Against this background of strategic change in government policy in England and Wales, RSSSG has again amended its assumptions for electrification during and beyond CP5. The RSS reflects significantly lower rate of expansion of the electrified network and a reduced total programme. RSSSG has modelled this programme through the removal of the “high level of future electrification” scenario as this now appears unlikely to arise in the period covered by this RSS.
55. There are now two electrification scenarios in the RSS model. The first (low) scenario encompasses those ongoing schemes to which franchising authorities are still committed, while the second (medium) scenario encompasses those schemes that have been declared “deferred”, plus Scottish projects yet to have funding confirmed. The three composite demand / electrification growth scenarios in the RSS are now defined as:
- ‘Low’: Low growth combined with a low level of committed future electrification.
  - ‘Medium’: Medium growth combined with a medium level of committed future electrification.
  - ‘High’: High growth combined with a medium level of future electrification.
56. The two scenarios for electrification have been constructed as shown in Table 2 below. This is a strategic view only, designed to give a potential sense of scale for the electrification programme beyond CP5. The respective figures used in the fourth and fifth edition of the RSS are also shown for comparison.

**Table 2 – Illustrative Electrification Scenarios (Track Miles that might be Electrified)**

% Electrified	Low	Medium	High
RSS 6th Edition	48% by 2039	50% by 2039	N/A
RSS 5th Edition	58% by 2039	63% by 2039	68% by 2046
RSS 4th Edition	62% by 2034	67% by 2039	72% by 2045

*Source: RSSSG Analysis using Network Rail data*

57. Over time, electric trains have generally proved to be more reliable, efficient, environmentally friendly and cheaper than those powered by diesel engines, and further electrification of the national network increases the opportunity to operate these types as part of a modern passenger transport system. On these grounds, RSSSG supports the expansion of the electrified network wherever there is a viable commercial case.
58. Bi-mode trains offer significant passenger benefits through being able to operate off the electrified network, however, with diesel engines as the secondary power source, they have drawbacks in terms of less power when in diesel mode, increased weight, increased complexity and maintenance and they are less environmentally sustainable. The introduction of new trains with extensive use of diesel power does not align with other long term government strategies targeted at ending the sale of internal combustion engine road vehicles in 2040, nor recent ministerial ambition stating that diesel engines should be removed from passenger rail vehicles completely by 2040. Investment in innovation to develop new technologies that might feature as an alternative to diesel in bi-mode trains, such as that described in paragraph 68 of this RSS, is therefore seen as essential to ensure that rail continues to deliver on its reputation as an environmentally friendly and sustainable form of transport.
59. Conversion of DC-electrified routes to AC or to dual-voltage capability has been ignored for the purposes of this analysis. Proposals for the route between Basingstoke and Southampton to be converted on this basis have been removed from the RSS model.

## F. The Present Fleets and Future Capability Requirements

60. Details of the composition of the existing fleets, and of committed changes to the end of March 2017 are summarised in Table 3 below, using the definitions in paragraphs 25 and 26 above (see also Appendix 4).

**Table 3 – Present Fleet Composition (including Committed Changes to March 2018)**

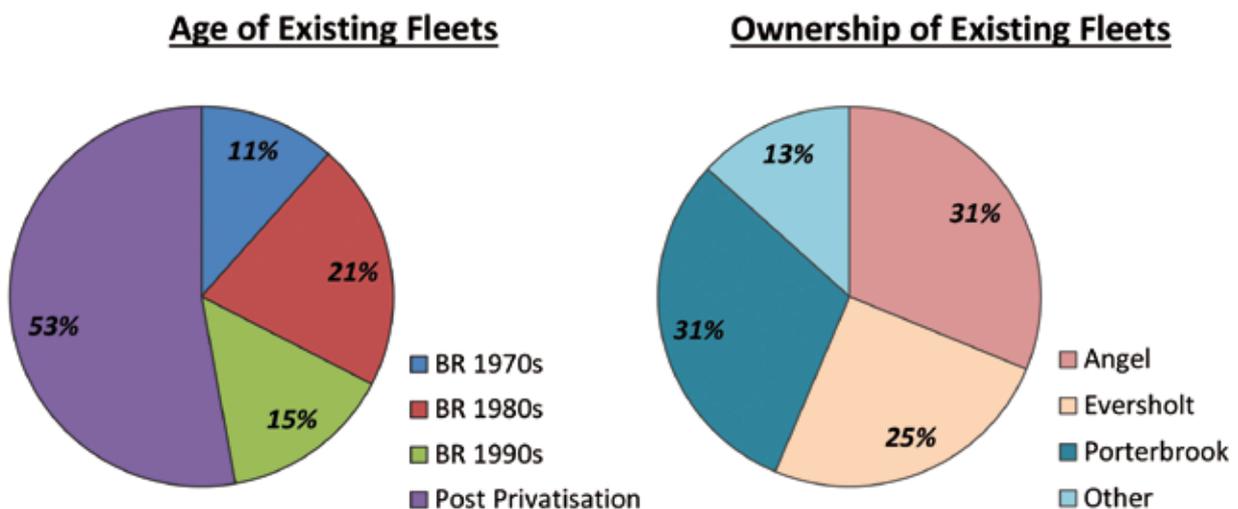
Generic Type	Total Vehicles, March 2018
A. Shorter Distance Self-Powered (e.g. diesel, generally with 75 mph maximum speed);	1,055
B. Middle Distance Self-Powered (e.g. diesel, with 90 or 100 mph capability);	1,384
C. Long Distance Self-Powered (e.g. diesel, with 100 or 125 mph capability);	1,432
D. Shorter Distance Electric (generally with 75 mph maximum speed);	2,521
E. Middle Distance Electric (with 90/ 100/ 110 mph capability);	6,211
F. Long Distance Electric (with 100/ 125/ 140 mph capability);	1,248
G. Very High-Speed Electric (140 mph and above)	174
<b>TOTALS</b>	<b>14,025</b>

*Source: Analysis from TOC, RDG and ROSCO data for the end of March 2018.*

61. Figure 2 shows that, of these 14,025 vehicles:

- 7,377 (53%) have been built in the last 22 years (since privatisation); and
- 1,845 (13%) are owned by parties other than the three largest ROSCOs.

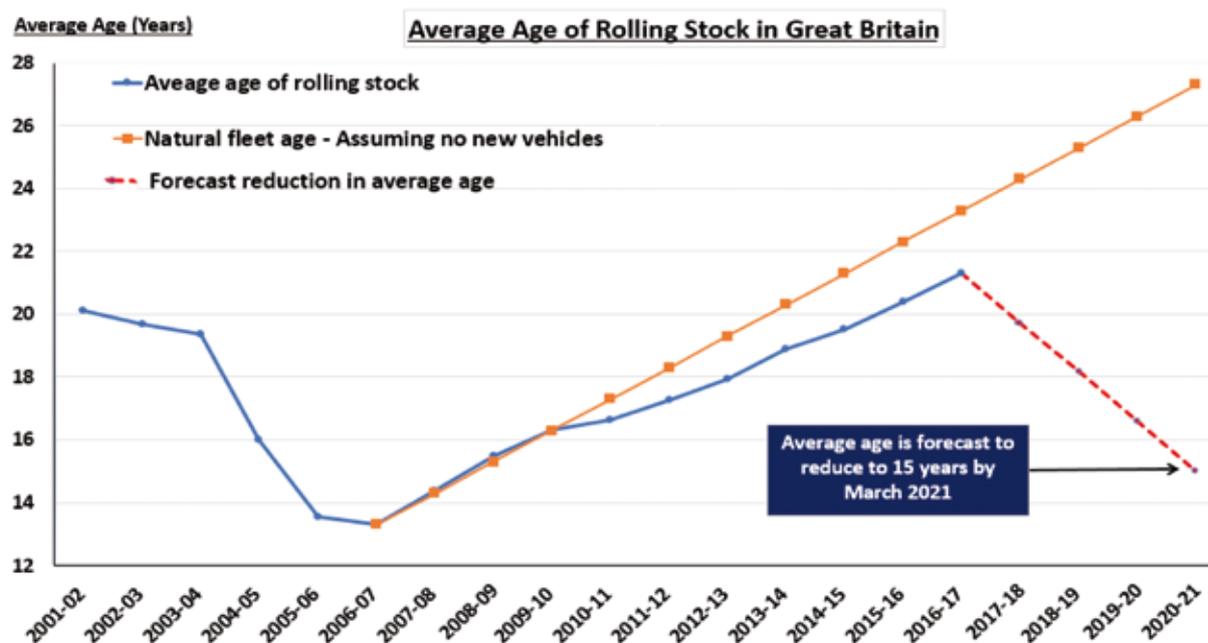
**Figure 2 - Present Age and Ownership of the National Passenger Rolling Stock Fleet**



*Source: Analysis from TOC, RDG and ROSCO data for the end of December 2017*

62. As detailed in Appendix 5, 7,187 new vehicles are committed for delivery in CP5 and early CP6 and in consequence over 4,000 will be displaced. 2,400 of these displaced vehicles are over 30 years old and many are unlikely to see further service in the UK. The combined effect of these vehicle movements is forecast to reduce the average age of the national fleet to 15 years as shown in Figure 3.

**Figure 3 - National Fleet Average Age Forecast**



Source: Analysis from TOC, RDG and ROSCO data for the end of March 2017

63. For the future, 'Self-Powered' units will include any type of train which cannot collect electrical power when in motion, from an overhead or third rail source. This may include classic diesel-powered units and also 'hybrid' units incorporating an internal combustion engine or hydrogen fuel cell with some form of electrical or mechanical energy storage. Throughout this RSS, 'electric' units include not only pure electric but also 'bi-mode' trains (such as Hitachi's Class 800 and 802 trains, and the Stadler 'Flirt' bi-mode trains for East Anglia) which can both collect power when in motion from an overhead or third rail source, and also generate power from an on-board source.
64. None of the older diesel fleets have engines that are compliant with EU legislation regarding emissions from diesel engines for new rail vehicles, known as Stage IIIB. The situation for these vehicles is as follows.
- Existing EU and UK legislation does not prevent the continued operation of any of the present British DMU fleets, thanks to an amendment agreed in 2011.
  - None of the present British DMU fleets are at any risk of being unable to operate as a result of non-availability of diesel engines or spare parts for diesel engines.
  - Legislation prevents any more engines of the present types being manufactured for these fleets, but engine components can be manufactured, and a float of additional spare engines will become available for the older DMUs when electrification starts to reduce the size of these fleets in future years.

- Notwithstanding continuing work to reduce the environmental impact of existing diesel engines, the business case for retro-fitting a Stage IIIB compliant diesel engine (or engines) to any of the recent British DMU types is likely to be challenging. However, there are two examples of the installation of Stage IIIB compliant engines on older vehicles. The D-Train project being developed by Vivarail demonstrates the feasibility and business case of fitting pairs of smaller Stage IIIB compliant automotive diesel engines beneath former LUL vehicles, while the Class 769 (Class 319 Flex) units are EMUs that have undergone bi-mode conversion utilising Stage IIIB compliant engines.
65. The diesel engines being fitted to the Class 800, 801, 802 and 803 trains being built by Hitachi for GWR, VTEC, TPE and Hull Trains TOCs are compliant with Stage IIIB, as will be the diesel and bi-mode vehicles being procured for the ARN and AEA franchises. The Class 68 locos now being used by Chiltern Railways and ScotRail and to be used by TPE are compliant with the previous Stage IIIA requirements.
  66. While the current legal and regulatory environment supports the continued operation of diesel engines on rail as outlined above, the industry recognises the worldwide environmental pressures mounting on the use of diesel engines. The English government has declared a sales ban on all petrol and diesel powered cars and vans from 2040, while this deadline is 2032 for Scotland. Normal rail vehicle life expectancy would see diesel operation for some years beyond these dates, but the Minister for Transport's recent call for all diesel engines to be removed from rail passenger vehicles by 2040 is typical of the pressure building on the industry to adopt new clean traction technology to the same timescales as other modes of transport.
  67. The perceived flexibility of bi-mode trains, together with escalating electrifications costs has brought significant pressure on electrification business cases and is considered to have influenced the government's strategic policy change on electrification last year. Bi-mode trains currently being introduced to service are demonstrating the flexibility of this type and are attractive to passengers. The bi-mode descriptor is normally taken to mean a vehicle capable of drawing traction power from an external electrical power source, in addition to a self-contained source on board. Typically, this is currently a diesel engine, but other sources such as batteries and fuel cells can be expected to emerge in commercial solutions in the near future. The strategic direction from the English government provides incentive to the industry, both in the UK and abroad, to innovate in this field.
  68. Beyond the innovation already undertaken by Hitachi, Stadler and others in bringing new electro/diesel bi-mode vehicles to the market, the rail industry is already developing alternative traction solutions. In 2013, Network Rail and Bombardier announced the Independently Powered EMU (IPEMU) project and the prototype converted unit entered service in January 2015 with a battery powered range of 37 miles. Just three years ago, this project offered the first real insight into the potential for new traction technology and since that time, innovation has progressed rapidly. Products now operating or in advanced development include:
    - Bombardier have secured €3.7m funding from the German government to develop a battery equipped version of their TALENT 3 EMU for operation on non-electrified rural German lines. Using Bombardier traction batteries, the pre-series demonstrator Battery-EMU will start tests in mid-2018. It will operate in passenger service for 12 months in 2019 in Southern Germany and will have the capability to run independently for up to 40 km off catenary with Li-ion batteries. Re-charging is through catenary supply and takes only 10 minutes. This is similar to the light rail network in Nanjing, China where Bombardier trams have been operating since 2014 on a city network where only 10% of the network has catenary power.

- Alstom have contracted to deliver 14 x 4-car 'Coradia iLint' trains into traffic in Germany in 2021. This train has a top speed of 87mph and a range of over 600 miles. The unit is powered by a hydrogen fuel cell which exhausts only water vapour. The train also uses battery power for auxiliary systems and to capture regenerative energy when braking – which is then used to supplement hydrogen under acceleration. The hydrogen power solution requires depot support facilities that can store hydrogen – akin to the way diesel is currently stored. Rail may be better suited to this power source than road as local rail fleets tend to operate on depot-centric diagrams, meaning only a limited number of storage facilities are required to support extensive operations. Hydrogen can be readily derived from water using electrical power, which can be ecologically generated by wind, solar, or hydro-electric sources, meaning that hydrogen generation can be entirely sustainable, or alternatively make use of excess grid power as a form of energy storage.
- Porterbrook recognised the potential for innovation with its Class 319 Flex project. These units were being displaced from Thameslink and to create new opportunities, Porterbrook has developed a new bi-mode Class 769 unit by retrofitting Stage IIIB compliant diesel engines and alternators. The technology uses a proven diesel engine coupled to an alternator to directly power the existing DC bus line. By retaining the existing traction equipment, pantograph and/or shoe gear the Flex project will allow operation under AC overhead, DC third rail or non-electrified lines. Eight AC/diesel powered units will be operated by Northern, and another five by ATW. The aim is to deliver performance as good as existing DMUs with significantly reduced fuel costs when operating as a bi-mode. The modular design concept allows for future development with the use of traction batteries for providing a boost to peak acceleration.
- Siemens are working with Ballard, Actia and Toshiba to develop the hybrid X-EMU, which incorporates both hydrogen fuel cell and battery technology into a regional EMU. Siemens judge catenary power to be overall most efficient form of delivering power to an electric traction motor (c.80%), compared with batteries at c.65% and hydrogen and diesel at c.25%. With current battery technology only capable of delivering c.80km range, the X-EMU platform optimises the efficiency of batteries over shorter distance with that of fuel cells over longer distances. While the train will initially be more expensive than current DMUs, lower operating costs mean whole life cost of the modular system is estimated to be c.25% less than current DMUs. The modular traction system employed in the X-EMU will have the potential to be retro-fitted to some of Siemens' more recent rail vehicles.
- UK start up Vivarail have developed a multiple unit train that can draw power from AC or DC power networks and supplement this with a diesel engine in a classic bi-mode format. Three 2-car units have been ordered by West Midlands Trains for its Bletchley – Bedford service. With a grant from Innovation UK, a battery only solution has been developed (range c.80 miles; speed 60mph; acceleration  $1\text{m/s}^2$ ) – but this can be supplemented with charging from traditional trackside external AC or DC supplies, or through a bespoke static interface at specific locations where the train comes to a stand. This system provides opportunity for electric traction without trackside electrification infrastructure, and the bespoke system is expected to include innovative charge bank solutions to utilise off-peak or sustainable power solutions. Demonstrating the pace at which this technology is moving, a hydrogen fuel cell variant is already under development.

69. These examples show how swiftly innovative solutions are being developed and brought to market. In the UK the RSSB Future Railway Programme has organised competitions to encourage the development of novel technical solutions for the next generation of rail vehicles, the knowledge gained through such projects being made available to the wider supplier base through RSSB and academic forums. The IPEMU was the first project developed under this structure, and further innovative traction solutions under development include a digitally controlled hydraulic displacement transmission, multi-fuel engines capable of running on natural gas and diesel, and energy storage using high density flywheels. A Very Light Rail Vehicle is being developed by a consortium led by Transport Design International and Warwick Manufacturing Group.
70. The development of the new technologies mentioned above also brings issues for financiers and asset owners. With rail vehicle assets typically having long lives, asset owners need to be confident that their new assets will be in demand over such a period. This will require careful consideration of the respective merits of different vehicle drive train configurations and their ease of adaptation as new technologies come to maturity. With London being one of four European capitals already planning to ban diesel engines from their roads by 2025, pressure to reduce emissions means rail vehicles designed around a diesel power source alone may carry an inherent risk of obsolescence prior to the end of vehicle design life.
71. While significant new builds of rolling stock are generally welcomed across the industry, a consequential adverse impact is being felt in the vehicle overhaul and refurbishment sector. Here the outlook now appears even weaker than last year following the relatively large amount of modification work required for completion by December 2019 in order to comply with the legislation for Passengers of Reduced Mobility (the PRM-TSI requirements). As discussed in Section H, the volume of new vehicles is such that displaced vehicles, the refurbishment of which is the traditional core market for this sector, are facing an uncertain future. This specialist sector is reliant on major modification and refurbishment work, and the current low demand for this work threatens those employed in it and its future ongoing capability.



*Porterbrook Class 319 EMUs undergoing conversion to Class 769 Bi-mode units*

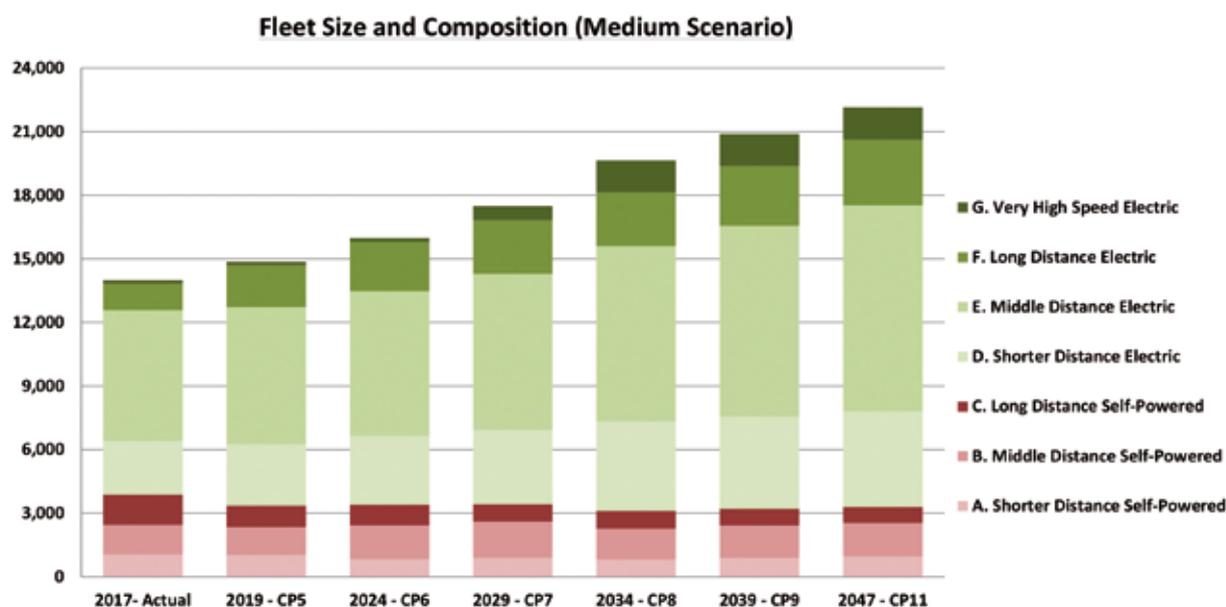
## G. Fleet Sizes and Compositions to 2047

72. As described in paragraph 55 above, the three growth scenarios have been combined with two electrification scenarios to obtain three composite scenarios within the spreadsheet model to 2047, for each TOC. The aggregated results are summarised in Figure 4 and Table 4 below.
73. The key developments over 30 years highlighted in Table 4 are:
- an overall increase of 40-85% in the size of the total national passenger fleet;
  - the electric fleets (including bi-mode) rising from 72% of the national fleet to up to 86% by 2047; and
  - the self-powered fleets (excluding bi-mode) falling from 28% of the national fleet to 19% or less.
74. It can be deduced that in the Low scenario, a minimum of 10,600 new electric and bi-mode vehicles would be required by 2047, from today's base position. This figure comprises the sum of:
- 6,600 which is the net increase in electric vehicles over 30 years, in the Low scenario;
  - 4,000 to replace the BR-procured electric fleets (all of which would be a minimum of 51 years old in 2047).

In the Medium and High scenarios, this minimum total of 10,600 new electric vehicles to be constructed by 2047 would rise to 12,700 and 15,000 respectively.

75. It can similarly be deduced from Table 4 that 1,350, 2,000, or 3,500 new self-powered vehicles would be required to be built over 30 years, in the three scenarios, assuming the replacement of all the 2,600 BR-procured diesel vehicles. These volumes represent an increase of over 50% over the forecast in the fifth edition of the RSS, but do not take account of the probable shift toward self-powered vehicles if viable alternatives to diesel powered traction are developed.

**Figure 4 – Fleet Size and Composition (Medium Scenario)**



**Source:** Analysis as in Table 4.

Note: The RSS includes bi-mode vehicles in the totals for the corresponding electric category.

**Table 4 – Aggregated Results of Fleet Size Changes for the National Passenger Fleets to 2047 (Low, Medium and High Scenarios)**

Sub-Group	Committed Total Vehicles Period 13, 2017/18	Forecast CP5, March 2019			Forecast CP6, March 2024			Forecast CP7, March 2029			Forecast CP8, March 2034			Forecast CP11, March 2047		
		Low	Med.	High	Low	Med.	High									
<b>A. Shorter Distance Self-Powered</b>	1,055	1,011	1,024	1,037	784	821	938	807	886	1,054	700	810	1,028	750	949	1,290
<b>B. Middle Distance Self-Powered</b>	1,384	1,306	1,318	1,350	1,480	1,600	1,764	1,530	1,712	1,984	1,296	1,469	1,848	1,394	1,591	2,228
<b>C. Long Distance Self-Powered</b>	1,432	1,013	1,013	1,034	915	975	1,019	720	816	964	727	827	1,086	599	762	1,291
<b>D. Shorter Distance Electric</b>	2,521	2,865	2,894	2,903	3,178	3,241	3,316	3,301	3,503	3,738	3,950	4,217	4,523	4,100	4,496	4,942
<b>E. Middle Distance Electric</b>	6,211	6,461	6,461	6,461	6,693	6,832	7,167	7,075	7,374	7,900	7,741	8,273	8,989	8,681	9,722	10,897
<b>F. Long Distance Electric &amp; Bi-Mode</b>	1,248	1,974	1,974	1,974	2,284	2,328	2,347	2,313	2,523	2,676	2,194	2,529	2,783	2,566	3,088	3,530
<b>G. Very High Speed Electric</b>	174	174	174	174	174	174	174	614	664	747	1,429	1,513	1,760	1,448	1,536	1,792
<b>TOTALS</b>	<b>14,025</b>	<b>14,804</b>	<b>14,858</b>	<b>14,933</b>	<b>15,508</b>	<b>15,971</b>	<b>16,725</b>	<b>16,360</b>	<b>17,479</b>	<b>19,064</b>	<b>18,038</b>	<b>19,637</b>	<b>22,018</b>	<b>19,538</b>	<b>22,145</b>	<b>25,969</b>
Effective Capacity Growth from December 2017		6%	6%	7%	11%	14%	19%	17%	25%	36%	29%	40%	57%	40%	58%	85%

Self-Powered Totals	3,871	3,330	3,355	3,421	3,179	3,396	3,721	3,057	3,414	4,002	2,723	3,105	3,963	2,743	3,302	4,808
Electric & Bi-Mode Totals	10,154	11,474	11,503	11,512	12,329	12,575	13,004	13,303	14,065	15,062	15,315	16,532	18,056	16,794	18,842	21,161
Electric & Bi-Mode %	72%	78%	77%	77%	80%	79%	78%	81%	80%	79%	85%	84%	82%	86%	85%	81%

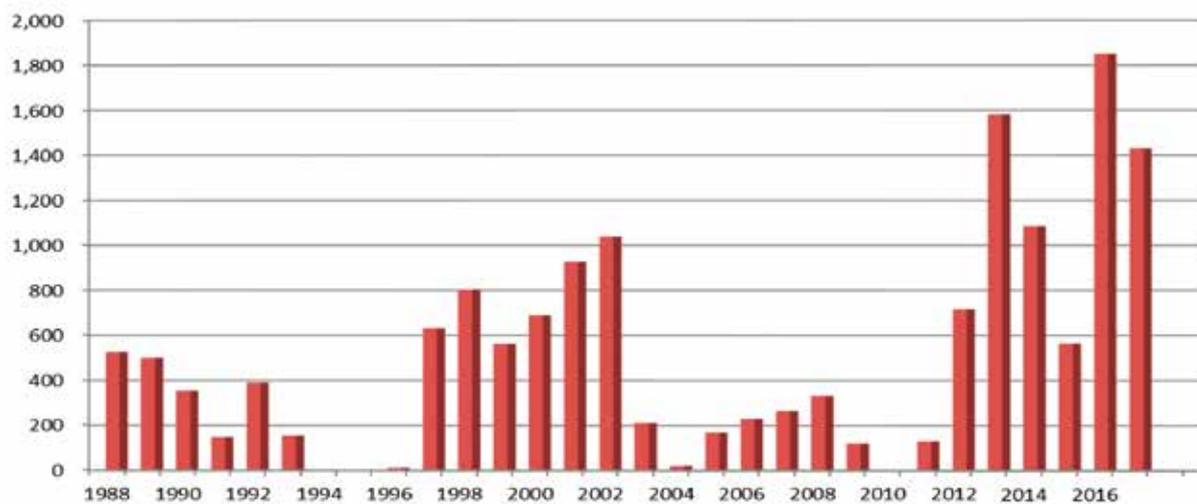
Bi Mode Total	1,032
Bi Mode %	10%

**Source: Analysis using TOC-specific and route-specific peak period growth forecasts and illustrative electrification scenarios as described in this RSS**

Note: The RSS includes bi-mode vehicles in the totals for the corresponding electric category. Committed bi-modes by end of CP5: 772; by end of CP6: 1,030.

76. The historically high volume of orders for new trains in the last six years reflects the lack of such investment in some previous years, plus the implementation of the Thameslink, Crossrail and IEP projects. There is however a risk that this peak of orders will reinforce the historic cyclical pattern of new vehicle construction for the British market that has been a regular feature over the last 30 years. (See Figure 5 below). This is discussed further in Section H below.

**Figure 5 - Orders Placed for Mainline Passenger Rolling Stock (exc. LUL and Light Rail)**



*Source: Railway Industry Association*



*Launch event for Hitachi Class 385 EMUs bound for Scotrail*

## H. Rolling Stock Requirements in CP5 and CP6

77. In previous editions and again for this sixth edition of the RSS, RSSSG felt it important to review the impact of its assumptions for the fleet over the remainder of CP5 and through to the end of CP6, now covering the next six years. This formed a key input to the IIAs for CP6, and to the RSBPs for CP6 published in 2018.
78. The change in English government electrification strategy, coupled with a continuation of widespread fleet renewal and displacement through franchise competition has brought significant change to the UK rolling stock market.

### **Franchise Competition Impact**

79. Prior to 2016, franchise competitions typically generated new build orders through opportunities presented by advancing age of the current rolling stock, or its inability to adapt to wider infrastructure or market change. A market in which there was greater demand than supply led to displaced stock with reasonable remaining life and quality normally being absorbed back into operational service fairly swiftly. The risk of rolling stock with significant asset life being out of service for any material time was perceived as low across the industry.
80. In 2016, the East Anglia competition saw the first complete renewal of rolling stock on a UK rail franchise for over 10 years. All previous vehicles, regardless of age, performance or capability, were contracted to be replaced by new rolling stock. This was seen as a direct impact of the introduction of passenger focus into the DfT competition criteria which, coupled with attractive low financing and manufacturing costs prevailing at the time, created an opportunity for bidders to incorporate radical fleet change at an affordable cost. The factors that facilitated the construction of that winning bid have remained largely unchanged since that time, leading to new build remaining highly attractive for franchise bidders, who may not be influenced or impacted by the risks materialising in the displaced vehicles.
81. From a passenger and operator perspective, new trains are almost always attractive and widely welcomed. A number of their modern features e.g. Wi-Fi, plug doors or information systems, can be found on or retro-fitted to older vehicles, but the attractiveness of a complete new train with modern reliability, serviceability, ease of operation and passenger support is strong. So long as the price is competitive, new trains have the potential to form an attractive financial and operational proposition when competing with refurbished existing stock in current franchise competitions.
82. The South Western and West Midland franchises were both let in 2017, and both saw more displacement of vehicles with significant remaining operating life. In the case of South Western, there was displacement of fleets around 30 years old, but also a new fleet of 150 Class 707 vehicles, which had not even commenced operational service at the time of the competition.
83. The total number of displaced vehicles for which there is currently no contracted lessee at the end of their current lease is 3,934. Just over 2,400 (60%) of these are 30 years old or over, and while some, such as Class 143 & 144 "Pacers", may be considered to be at the end of their operating life, others are fit for traffic and have significant potential for investment in the right circumstances. 270 displaced vehicles are under 10 years old. A list of vehicles forecast to be displaced and for which, currently, there is no contracted future lessee is shown at Appendix 6.

84. The volume and value of vehicles being displaced brings numerous issues and risks to many parties across the industry and it is clear that some of the historical assumptions applied to rolling stock asset management, both financially and operationally, will undergo significant change. Since the inception of the UK rolling stock leasing market at railway privatisation in 1996, rail passenger vehicles have typically been priced over a 30-35 year period, meaning that the capital cost of the vehicle, plus project management, finance and other eligible costs are spread over this period. A nominal amount of off-lease time may be factored into this equation, but in a competitive market this would be kept to a minimum. Among the vehicles identified to be displaced by the end of 2020, only 60% have reached this age. It is therefore clear that many of these vehicles will not have generated the planned investment return on which their purchase was predicated.
85. The impact of vehicles not reaching their planned life is for their owners to manage – and each situation will be different. Owners manage their assets according to their different business models – but as historical asset life assumptions now appear optimistic, a broad reduction in assumed asset life could occur, causing the cost of vehicles to spread over a shorter period.
86. The rolling stock leasing market relies on investment from financial institutions for its capital, who in turn, require a return on their investment commensurate with the perceived associated risk. Rail assets are generally considered long life, steady, base level return investments, their perceived security and low risk resulting in their being particularly attractive to pension funds and others seeking long term investment. Rolling stock owners have been very successful in this market - through Angel, Legal & General pension funds are providing £350m to finance new builds in Anglia and the West Midlands; L&G, Aviva, Scottish Widows and Greater Manchester Pension Fund are among those funding £1bn for the new fleet on South Western through Rock Rail. For these investors to continue to be attracted to rail vehicles, and for the industry to enjoy the associated low funding rates to provide new vehicles when manufacturing costs are attractive, investor confidence needs to be maintained.
87. Even though investment funds are still in good supply, a perceived increase in investment risk can be expected to result in an increased overall cost of funding to the rail industry – but it is likely that the competitive market will seek to contain those pressures in order to win the new orders offered to the market by franchisees. It may be possible to contain these pressures in the short term, but the industry needs to be mindful of whole life cost. Alternative funding models that have the potential to provide attractive short-term costs may be balanced by higher future rates as the new build and funding cost increase over time from their current exceptionally low levels.
88. Following the recent influx of new build electric vehicles, the market opportunity for displaced electric vehicles appears difficult. The South Eastern competition represents opportunity for vehicles able to operate on the DC network, but with the current franchise programme and little new electrification, opportunities for existing, slower accelerating AC only units appear limited. Compatibility of performance characteristics, particularly acceleration and station dwell time, make it more challenging to mix new and existing rolling stock on the same route.
89. There can be no doubt that owners will work diligently to mitigate their risks. Heavy marketing can be expected where there is opportunity and the apparent adversity has already led to innovation. Porterbrook recognised the opportunity to create a bi-mode unit (Class 769) from its Class 319 vehicles, invested accordingly, and has thus far secured leases for 52 of

these vehicles with ATW and Northern. However, opportunities in the UK remain limited, and storing units is expensive if the long term objective is not clear. Dry (unserviced) storage can precipitate rapid asset deterioration, while wet (serviced) storage is expensive but still does not exercise the vehicle to the extent it can be easily put straight back into traffic. The sale or leasing of surplus UK rail vehicles abroad has occurred in the past, but for passenger vehicles, the numbers have been very limited. The narrow UK gauge and high boarding heights are not typically found abroad, but depending on the commercial proposition, the vehicle quality may prove attractive in some markets.

90. Beyond the commercial risks and issues arising from the displacement, there are also a number of operational issues the industry must address and manage, including:

- **Storage:** To place c.4000 displaced vehicles in storage would require over 52 miles of storage sidings – a resource no longer available on the UK network. Owners will manage the handling of their vehicles once they come off lease, but this figure gives scope to just one facet of that task. It is clear that owners will need to balance options including disposal, sale or storage in accordance with their business plans, but there are significant logistical as well as commercial challenges.
- **Performance:** A number of older fleets, particularly older DMUs, due to be displaced have weak performance records – significantly below the current national average of c.15,000 MTIN. Equally, some fleets such as Class 455 and 321 are delivering MTIN at up to 3 times the national average. Multiple factors including operator unfamiliarity, infrastructure interface and new technology introduction can adversely impact the reliability of new vehicles as they are introduced to service – and this becomes visible in MTIN and other delivery measures. Reliability of new vehicles typically rises steadily as these issues are addressed, normally going on to levels at the top of comparable vehicle tables. With this mix of performance influencing pressures, new fleet introductions, and their knock-on displacements may adversely affect route performance and passenger perception in the short term.
- **Cascade Logistics:** Where new fleets displace older vehicles, it is an operational imperative that vehicles are not cascaded out of a franchise until new vehicles are delivered. If new vehicle introduction is delayed, there is a knock-on impact on the release of the vehicles being displaced. The owner of these displaced vehicles may have no involvement in the new stock procurement and is therefore not in a position to influence this process. In the current climate, this unpredictability of supply of displaced vehicles represents a risk to a new franchisee, implicitly decreasing the attractiveness of those vehicles compared with new vehicle procurement.
- **Overhaul Supply Chain:** Older vehicles are typically maintained by franchise operators with support from a wide network of industry component suppliers. This supply chain covers all the vehicle – from trim parts to heavy component repair and full vehicle refurbishment. When large fleets of new build vehicles are introduced, the requirement for component overhaul reduces in the short term, and market for refurbishment of older vehicles decreases. It is now exceptional for new vehicles to be ordered and introduced to service without an associated maintenance agreement with the manufacturer covering at least the duration of the introducing franchise. Manufacturers will still have a requirement for component support, but in the first half of vehicle life, opportunities for suppliers outside the OEM supply chain are limited.

- **Manufacturer Sustainability:** Following some years of very weak demand that saw UK train manufacturing capability reduced to a single facility, train manufacturers have enjoyed a buoyant market in the UK since 2010. Orders were placed for over 6,500 vehicles in the last 4 years alone and the market has welcomed new entrants and investment in new manufacturing facilities, with benefit for all the stakeholders involved. While significant numbers of vehicles continue to be built abroad, there has been major investment in UK manufacturing capacity, but with today's total national fleet of just over 14,000 vehicles, the current level of domestic demand appears unsustainable in the medium term. Even noting the 1,200+ vehicles that are likely to be required for HS2, a feast / famine situation is developing, particularly in the new train component supply chain, where small and medium sized suppliers are faced with tight delivery deadlines for high volumes of material, after which demand may slump. Unless manufacturing capacity is utilised to fulfil significant export orders in a post-Brexit world and ease the cycle of feast and famine, there is a risk capacity will exceed demand across the supply chain in the 2020s, with adverse local economic impact.

### **Electrification Strategy Change Impact**

91. A market historically dominated by electric and diesel driven trains has been opened up through the English government's expressed preference for bi-mode and technologically innovative traction. While electric trains should always provide the optimum solution on totally electrified areas of the network, bi-mode trains now feature heavily at the crossover point, and the shift to greener transport solutions is providing the thrust for traditional diesel vehicles to be redefined as "self-powered" – and competing with battery, hydrogen and other innovative forms of power solutions on environmental credentials.
92. The high costs and high project delivery risks associated with the expansion of the electrified network can in many cases be avoided through innovation in rolling stock, while the avoidance of electrification infrastructure investment in the short-term can also ease spending pressures for the government of the day. Rolling stock is typically financed through non-government sources, so while the cost of bi-mode and other solutions may be higher than for a pure EMU, if the bi-mode vehicle can meet reliability and quality targets, passengers can enjoy connectivity benefits while the government avoids investment cost and risk.
93. Whilst the recent change in strategy may have distinct benefits for government, the delayed and curtailed electrification plans have reduced cascade opportunities for current passenger vehicles on two fronts. Firstly, the demand for new electric trains is reduced as less routes are available to electric traction. Bi-mode traction may be introduced where former diesel fleets were life expired, but where recently built diesels are in operation the pressure for replacement is removed. The second pressure is that when new electric fleets are introduced, the opportunity to cascade displaced vehicles to newly electrified regional routes has been lost. These two factors are bringing particular pressures on recently built, and/or high performing electric fleets displaced in recent franchise competitions – including Thameslink, South Western and East Anglia.

94. It had also previously been thought that the continuing programme of electrification would produce a flow of mid-life DMUs for use on non-electrified routes. On this basis it had originally been calculated in the early editions of the RSS that there would be only a small requirement for new diesel vehicles or other self-powered rolling stock. Each successive edition of the RSS has however indicated an increasing likelihood that orders for additional new self-powered vehicles would be required. Delays in electrification programmes, together with continuing high rate of growth of passenger demand have increased that pressure and resulted in the higher numbers now declared in paragraph 75 above. In the ARN franchise, the DfT's decision to eliminate the 214 Pacer vehicles contributed to the placing of an order with CAF for 140 new DMU vehicles, plus the first order for 32 newly converted Class 769 Flex bi-mode vehicles from Porterbrook, initially required to mitigate particular electrification delays. Stadler Rail entered the UK rolling stock market in 2016 through an electro-diesel bi-mode order for 138 vehicles for the AEA franchise, while CAF secured orders for 80 DMU vehicles in the West Midlands in October 2017. ATW ordered 20 Class 769 Flex vehicles to facilitate the release of DMUs for PRMTSI work, while London Northwestern will be launch customers for the Vivarail Class 230 bi-mode. Together with Chiltern (refurbishment and loco haulage) and ScotRail (HST refurbishment), these are clear examples the market responding to the continuing demand for self-powered vehicles and utilising new technology to produce incremental benefits.
95. The total number of new vehicles committed for delivery in CP5 and in the early years of CP6 is now 7,187, with 1,557 new vehicles being ordered in the last 12 months. The corresponding totals in the third, fourth and fifth editions of the RSS were 3,800, 4,500 and 6,010 respectively. These growing volumes contrast sharply with the total of 1,055 vehicles delivered in CP4. The new vehicles will have a total capital cost of around £13.8 billion and over 50% of the new vehicles will be built in Britain. Over 5,100 of these new vehicles will be financed by parties other than the three principal ROSCOs. The total size of the national fleet is rising faster than at any time in recent decades.
96. The constitution of new order commitments since the commencement of CP5 in 2014 is shown at Appendix 5, and the timelines for delivery are included in Appendices 1-3. Orders placed since publication of the last RSS have been dominated by 1,485 EMU type vehicles, accompanied by 80 DMU vehicles. Excepting the refurbished bi-mode conversions from Vivarail and Porterbrook, no new build bi-mode vehicles were ordered, but all these procurements were commenced prior to English government policy changes.
97. The updated fleet size forecasts contained in Table 4 of this RSS show the electric and bi-mode fleet totals are expected to increase by a net of approximately 2,700 vehicles during the course of CP5 in response to new build delivery of 3,961 vehicles of similar type. For CP6, orders of 2,873 vehicles to date are likely to precipitate a net increase in the electric and bi-mode fleet of between 855 and 1,530 vehicles. The difference between these figures and the new build delivery figures results from the number of vehicles displaced by new builds, but it is not possible to predict how many older electric vehicles will be permanently retired during these control periods, nor how many may temporarily be off-lease at the end of 2019 and then return to service during CP6. The next new build programme that does not directly displace current vehicles in service is expected to be HS2, for which delivery is anticipated in CP7, when around 500 vehicles are forecast to be required, with a further 700 to 800 in CP8.

98. Within the electric and bi-mode grouping, the number of bi-modes is expected to increase, detracting from both EMU and DMU numbers. Vehicles originally specified as electric in the IEP project have had their specification changed to bi-mode, and the supply market was already adjusting to this trend in advance of the change in English government strategy. As a share of total new vehicle commitments made since 2014, 1,030 (14%) will be capable of bi-mode operation, dominated by over 770 deliveries associated with the IEP/AT300 builds. While no orders were placed for bi-mode trains in the last 12 months, the DfT has yet to complete a franchise competition under the recent electrification strategy change, so the impact of this on franchise bidder rolling stock proposals is unknown.
99. In the latest DfT franchise replacement programme, there are six franchises planned to be let in the next three years (see Appendices 1-3). These franchises currently contain over 1,100 BR-procured vehicles (excluding those vehicles for which replacement plans already exist). These will range between 25 and 40 years old at the start of CP6 in 2019. While the fleet composition of each new franchise will be contractualised from the proposals of the winning franchise bidder, the government has already demonstrated its commitment to improving the quality and capability of rolling stock. Hence either extensive refurbishment - or replacement - of these ageing vehicles may be expected in CP6.
100. From a supply chain point of view, LUL's rolling stock requirements are a further factor impacting the rolling stock supply chain. Although not considered in the RSS, it should be noted that the complete renewal of the Victoria Line and sub-surface fleets between 2009 and 2016 has required nearly 1,800 new vehicles, all built by Bombardier in Britain, and utilising the same supply chain capability as main line rolling stock. TfL plan to replace trains on the Piccadilly, Central, Bakerloo and Waterloo & City lines – in an order that is expected to be c.1,600 vehicles, commencing in 2023, but the rate of delivery on these programmes will be slower than previously thought, such that the last Central Lines trains will not be delivered until 2032.
101. A completely steady new build programme for rolling stock is unlikely ever to occur in Britain. Smaller peaks in demand for new build vehicles will occur in consequence of refranchising timescales, where decisions to procure new rolling stock will, in many cases, be triggered by franchise award. Nevertheless, the forward projections of rolling stock fleet sizes offered by the RSS should provide a greater degree of predictability for suppliers and assist them in matching their manufacturing capability to forecast demand patterns.
102. The change in government strategy that is impacting the EMU market is also expected to impact the DMU market for different reasons and to a different degree. All the Type A short-distance DMUs and many of the Type B DMUs were procured by British Rail between 1985 and 1992. It can be expected that most if not all of these will have been withdrawn by the late 2020's, as they will all be 35 years old or more at this time. A total of 1,350 Type B and Type C diesel vehicles have been built in the last 20 years. In theory, many of these could still operate beyond that date, if environmental legislation and the supply of engines permit, but the continuing the trend of cross-party political ambition to improve sustainability and the quality of environment and facilities offered to passengers works against this. The continued procurement and operation of DMUs will be affected by two key pressures, the utilisation of bi-mode vehicles to optimise use of network power supplies in creating continuous journey opportunities for passengers, and the rate of development of self-powered vehicles that are not reliant on diesel engines. The revised scope of the future electrified network means that self-powered vehicles are likely to be in greater demand in the short to medium term, but the use of diesel engines is sub-optimal in sustainability terms. With political desire to cease the use of diesel engines in passenger rail vehicles from 2040, innovation to reduce the impact of diesel emissions from new or refurbished self-powered vehicles prior to that date is likely to be the key to maintaining their attractiveness after that deadline.

103. Based on the figures in Table 4, a total of between 2,700 and 4,800 self-powered vehicles will be required in service in 2047. Once again, these are higher figures than were calculated for the earlier editions of the RSS, because of the changes now assumed for future electrification (see section E above). It is not clear how many of these might in fact be built as bi-mode trains, and this may only become apparent as franchising authorities provide clarity on the progression of current electrification schemes, especially in England & Wales. The volume of new self-powered or bi-mode vehicles that may be required to be built in the 30 years to 2047 is likely to be dependent on the rate and extent of innovation in the field of sustainable traction sources. If sustainable traction solutions capable of matching current train performance are successfully brought to market, this would significantly change the future market mix of traditional electric vs self-powered rolling stock. Applying recent political policy changes to the RSS model has already resulted in forecasts for self-powered vehicles alone rising by more than 50% over those in the previous edition of the RSS.
104. All rolling stock must comply with the PRM-TSI requirements by December 2019. Fleet owners have taken the initiative to have most of this work undertaken during the downtime required for heavy maintenance. Good progress is being made on delivery, and all the planned work is expected to be complete before the December 2019 deadline. Progress is tracked by the DfT in its “List of rail vehicles built or refurbished to modern accessibility standards” (last updated in January 2018). However, the vehicles identified for modification in the plans were, with minor exceptions, vehicles that the owners envisaged would still be in service in December 2019, given the leases already in place and the cascades resulting from the CP5 and CP6 electrification programmes. In response to delays in the delivery of the electrification programme, some vehicles have already been identified and added to the programmes for modification (e.g. CrossCountry HSTs).
105. During CP5 and CP6, the European Train Control System (ETCS) will be fitted (or preliminary work carried out) to many existing and new fleets in preparation for the roll out of the European Rail Traffic Management System (ERTMS). The roll out of ERTMS is being developed via Strategic Outline Business Cases (SOBC) to consider using ETCS to resolve problems such as capacity on eight specific routes. The SOBC will then determine how ERTMS will be rolled out in CP6 and CP7. It is unclear on how fast the deployment will be but is expected that a considerable part of the national fleet will be fitted by the end of CP7. The TOCs and fleet owners can potentially achieve whatever rate of fleet fitment is required to meet the new programme, subject to careful management of fleet availability and system reliability issues. It will be damaging and expensive however, if a firm and stable plan for ETCS fitment cannot be achieved in the near future. The present uncertainty runs the risk of waste of effort and cost. In some cases, the timescale and costs of ETCS fitment may influence the decision as to whether a particular fleet should be life-extended or replaced. The recent Early Contractor Involvement collaboration between the Digital Railway Programme and suppliers has identified the potential for cost reduction through removing this uncertainty, as well as developing a specification for making trains ‘ETCS ready’ which would accommodate all suppliers’ equipment and therefore maximise market competition.

## I. Passenger Requirements and Benefits

106. With the government emphasising that the passenger must be firmly set at the heart of the UK railway, franchisees are more focussed than ever on endeavouring to make sure the rolling stock they operate meets, or exceeds, passenger expectations. Rolling stock has a high initial capital cost, and is generally long lived, with a typical service life of 30 years or more
107. The large numbers of new vehicles now committed for delivery as summarised in Appendix 5 will result in the average age of the national fleet falling from 21 years to 15 years by March 2021 (See Fig 3). This indicates that for an asset with a typical service life of around 30-35 years, there will then be balance between full life utilisation of assets and the introduction of new vehicles. This document sets out to inform the industry of the likely developments in market demand, and thereby the likely profiles of the fleet platforms available and required for rail operations.
108. When bidding, franchisees form their views on passenger expectations for their market and the affordability of the various fleet solutions available to them. It is true that new vehicles are more efficient and more technically advanced, but trains may be refurbished during their lifetime adding facilities such as Wi-Fi and power sockets in response to passenger demand. While some older trains do not find favour with passengers, older rolling stock does not necessarily mean dissatisfied passengers. While Merseytravel are renewing their fleet in 2020, it is notable that in the autumn of 2016, the Merseyrail fleet achieved a score of 95% for overall customer satisfaction, despite the youngest vehicle in the fleet being over 35 years old.
109. This RSS takes the best available knowledge in the industry and translates the forecast growth and economic changes into a range of likely numbers and types of vehicles that might be required to meet the anticipated volume of demand; and, given the approximate age profile of the fleet, the likely numbers of new vehicles that might be required.
110. RSSG's calculations of the range of growth in the size of the national passenger fleet not only take account of the forecast growth in peak period passenger numbers, but also of the ambition to achieve compliance with peak period crowding standards where this is not the case at present. For commuter fleets, total capacity is driven by morning peak period demand. This demand could be mitigated by varying factors such as reduced pricing in the shoulder peak, but to date, all trials of such structures have proved unsuccessful in moving demand away from the busiest peak hour.
111. The RSS does not seek to offer analysis based on the features of the product that might be offered to passengers but considers the basic operational aspects of train services – e.g. features required to optimise network capacity, or for high speed intercity trains compared with local commuter trains.
112. The setting of aspirations for passenger rolling stock, primarily from a passenger perspective, is undertaken by the DfT in its publication 'Rolling Stock Perspectives – Moving Britain Ahead'. This sets out government aspirations for passenger rolling stock towards which the industry should work, with particular reference to passenger facilities and sustainability. These are described in high-level terms, for five generic types of fleet – Very High Speed, InterCity, InterUrban, Metropolitan and Rural/Regional. More detailed requirements are included as appropriate in the individual ITTs for franchise competitions, and it is understood that these will always take precedence over the more general aspirations contained in 'Rolling Stock Perspectives'. Examples in the ITTs for the Northern, TPE and East Anglia franchises included

mandatory provision of Wi-Fi, power sockets, and controlled emission toilets. Industry analysis has indicated that by 2020, 98% of rolling stock will be fitted with controlled emission toilets. This figure is based upon known rolling stock changes, existing franchise commitments and implementation of DfT policy to future franchise competitions. The figure also assumes that investment is made in provision of waste emptying facilities at depots and at other stabling points.

113. In the Rolling Stock Perspectives document the government also sets out its core objectives for the rolling stock market, in which it seeks to balance passenger priorities and the interests of stakeholders. Key features include:
- Provision of sufficient rolling stock to meet capacity demands;
  - Address passenger priorities in respect of quality and accessibility;
  - Maintain a healthy, dynamic and competitive market for new and existing fleets;
  - Foster a vibrant supply chain to support the domestic market and export worldwide;
  - Support the sustainability agenda, innovating and developing skills;
  - Focus on cost, in both the short and long term to ensure value for money.
114. Fleet-related passenger satisfaction is measured and monitored for all TOCs through the National Rail Passenger Surveys (NRPS). These have been conducted on a consistent twice-yearly basis by Transport Focus and its predecessors since the autumn of 1999. The surveys include 18 factors that relate to the design, maintenance, cleaning and operation of rolling stock, as well as many more on every facet of the rail journey experience. In the most recent NRPS survey conducted in the autumn of 2017, the average 'satisfied or good' score for 'Overall Satisfaction with the Train' was 83%. The scope of the NRPS scoring does not generally provide the transparency required to identify feedback to specific fleets but results over time show an increase in satisfaction as measured by this factor, when fleets are renewed or refurbished. This may arise from improvement in ambience as well as reliability improvement that typically accompanies these investments. TOCs on which all or most vehicles have been replaced or had significant interior upgrade, such as c2c, Virgin East Coast, and Virgin West Coast, tend to score highly in comparison with their peers, but other aspects of passenger experience are also included within the factor 'Overall Satisfaction with the Train'. The aspects having the greatest impact on overall satisfaction and dissatisfaction are punctuality/ reliability and 'how a TOC deals with delays', respectively.
115. TOCs and the other stakeholders all use the NRPS surveys as key performance indicators, backed up by data from complaints, social media, mystery shopping etc. For the design of new or refurbished trains, focus groups have value, often supported by mock-ups of proposed train interiors. There are examples of good practice by many TOCs, ROSCOs and train builders that have introduced new and refurbished rolling stock in recent years. The independent passenger representative bodies (Transport Focus and London TravelWatch) can provide qualitative and quantitative research and consultancy into rolling stock design, such as Transport Focus' work for HS2 and for Merseytravel.
116. With commuter route infrastructure typically operating at or near maximum capacity, train features that reduce station dwell time become particularly valuable, especially when the only alternative is expensive infrastructure modification. Measures to reduce the time taken for a station stop might typically include increased standing areas around doorways, but on particularly constrained routes such as those into Waterloo, the route capacity benefits of shorter station stops contributed to the procurement of new fleets with faster acceleration and improved wide door configuration. Vehicle interior configuration, door width, stepping distances, and inter-car gangways are all components of this optimisation process.

117. Statutory requirements for on-train facilities for passengers with reduced mobility are being delivered through the PRM-TSI modifications (see paragraph 104 above). Greater emphasis will also be required to take account of the continuing upward trend of life expectancy of the national population, and of the mean and standard deviation of passengers' heights and weights. Transport Focus has clear data showing how the availability of reasonable space (not necessarily a seat) drives passenger satisfaction.

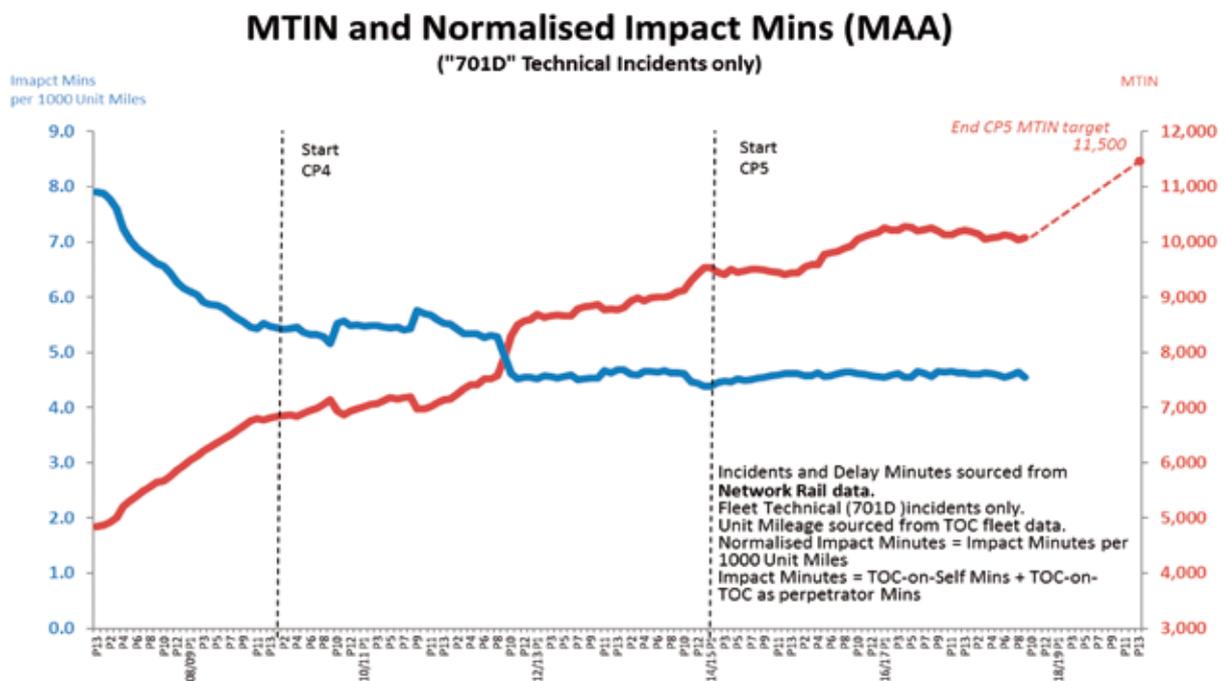


*Class 150 DMU built by BR Engineering Ltd in the 1980s*

## J. Fleet Reliability

118. As outlined in the previous section, punctuality and reliability are the principal factors determining the overall level of passenger satisfaction for any TOC. Rolling stock reliability is also core to the efficient and reliable operation of a congested rail network.
119. Strategic direction in setting the national planned performance levels for punctuality and reliability is provided by the industry's senior performance group, the National Task Force (NTF). The overall national fleet reliability improvement strategy is managed by a Fleet Challenge Steering Group. At a tactical level, reliability statistics for each TOC's fleets and sub-fleets are compiled, monitored and compared using a well-established form of benchmarking originally introduced in 2001. This benchmarking and the associated sharing of good practice continues as 'ReFocus', a 20-Point Plan that is regularly updated and encourages best practice for fleet reliability and other associated rolling stock issues across the industry.
120. The principal key performance indicator (KPI) adopted for rolling stock is the moving annual average of fleet related Miles per Technical TRUST Incident (MTIN MAA), an "incident" being a delay of three minutes or more to one or more services, cancellations and part cancellations.
121. The other principal KPI measures are the MAA of fleet-related 'impact minutes' (i.e. delays caused to all services by fleet technical issues), and the average Delay per Incident (DPI), a measure of the effectiveness of response to an incident. In both cases cancellations and part cancellations are given a deemed delay-minute value.
122. The moving annual averages of total fleet-related impact minutes and of average MTIN are shown in Figure 6 for the period since March 2007.

**Figure 6 - Rolling Stock Reliability Growth since March 2007**



Source: RDG and Network Rail, as monitored by NTF

123. In Figure 6 it can be seen that:

- over most of this period, and apart from during short periods of perturbation caused for example by extreme weather, the MAA of miles per technical incident (MTIN) has been rising steadily, and has improved over this period by more than 100%.
- the MAA of total fleet-related delay minutes had fallen by around one third, but is now on an upward trend. Unlike the MTIN measure, total delay minutes are not normalised in relation to total mileage. Annual timetabled passenger train miles over a basically unchanged network have increased by 14% between 2007/8 and 2016/17 and on many routes there are higher levels of peak passenger crowding. With a more crowded network, incidents now have greater knock-on impact than in previous years unless mitigated through expensive resource and process.

124. The MTIN of each TOC's fleets and sub-fleets is monitored every four weeks by RDG on behalf of ReFocus, using data which excludes certain non-technical fleet related incidents. The results are aggregated into seven fleet types, for which the results are tabulated below:

**Table 5 - MTIN MAA Miles per Technical TRUST Incident, by Fleet Class Group**

Fleet Class Group	MTIN MAA as at Period 9 2017/18
Legacy DMU	7,739
Era 1 DMU	9,550
Era 2 DMU	15,971
Era 3 DMU	12,571
Legacy EMU	17,271
Era 1 EMU	18,608
Era 2 EMU	36,805
Era 3 EMU	9,817
Legacy Intercity Traction	10,065
Era 2 Intercity Traction	22,724
Era 3 Intercity Traction	2,156

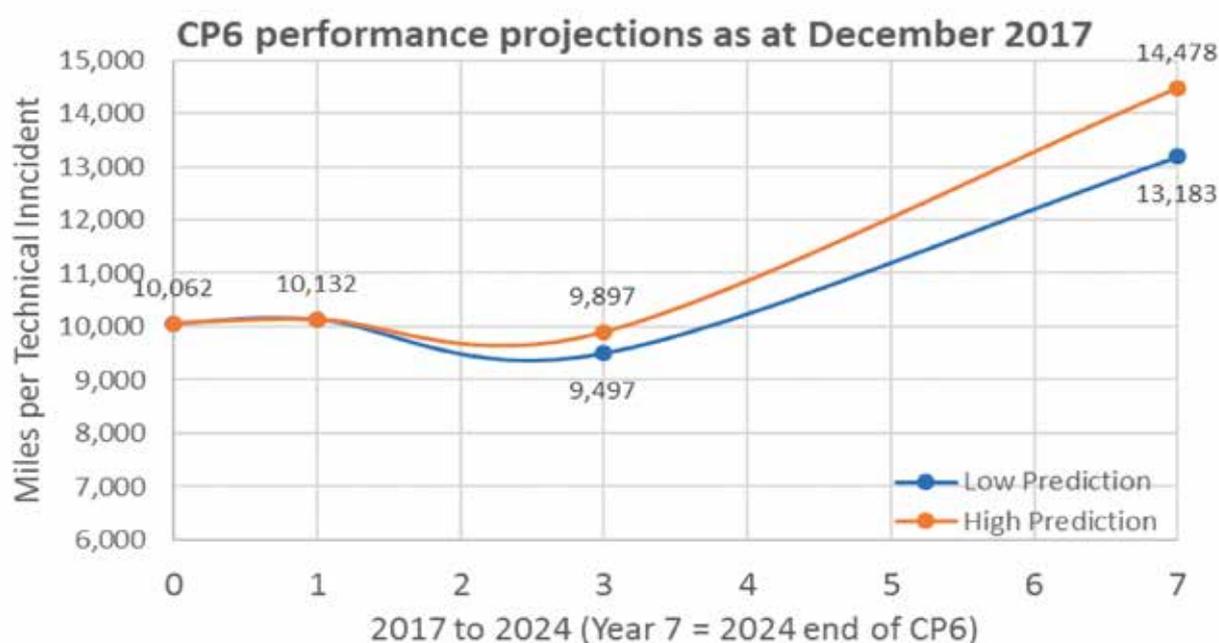
**Source: TOC Inputs to RDG, used for ReFocus Benchmarking**

**RDG Fleet Class Definition: Legacy = Old; Era 1 = Midlife; Era 2 = Modern; Era 3 = New.**

125. While there are individual fleet exceptions, this Table 5 indicates that Era 1 and Legacy rolling stock is generally weaker in MTIN performance terms than modern rolling stock. New vehicles will be new to those working on them and use technology that brings new interfaces with route infrastructure, which in turn may require investment in order that the train can be operated. New signalling systems such as ERTMS bring opportunity for increased service density, but also further technical challenge as route signalling technology and train control systems become more interdependent. The class leading reliability of 'Modern' fleets in all categories indicates that once introductory issues have been resolved, strong reliability can be expected to follow. The challenge to the parties introducing new vehicles is to reduce the time taken to resolve these issues to the absolute minimum, particularly on bi-mode fleets where two traction power systems must combine to meet demanding modern reliability targets.

126. Manufacturers recognise the importance of reliability from point of introduction for new fleets and the reputational impact of a weak new fleet introduction. They also recognise a supply chain that is under extreme pressure and a procurement process in which delays at any point from franchise ITT to award conspire to reduce the time available to build and test new vehicles. The current high demand for new build vehicles places pressures on SME component suppliers and facility bottlenecks where new business is welcomed, but the risk of investment to meet short term peaks in demand threatens future business viability. Programme delays can result and time for reliability enhancing pre-service and endurance testing may be squeezed to ensure on-time delivery. Once in operation, proven vehicle types can significantly reduce reliability risk in subsequent builds but introducing the new products demanded by the UK market can be particularly challenging if the whole franchise procurement process does not run to time.
127. Two of the individual 'Modern EMU' sub-fleets are now achieving MTIN MAA figures significantly over 100,000, with a further 6 sub-fleets achieving over 60,000. The relatively good reliability of the 'Modern EMU' fleets results from a combination of:
- effective contractual arrangements and incentives;
  - the improved extent of system redundancy and other design features;
  - widespread real-time condition monitoring, and the associated condition-based maintenance; and
  - the inherent reliability of the traction systems of a modern EMU.
128. The contracts for the large new electric and bi-mode fleets now being built for the IEP, Thameslink and Crossrail projects contain strong incentives for still higher levels of reliability, requiring state of the art monitoring systems and extensive system redundancy.
129. The Fleet Challenge Steering Group sets five-year targets for reliability improvement, using a combination of top-down and bottom-up inputs. Results available at December 2017 indicate that the industry is likely to fall short of its target of a 20% improvement over the course of CP5. The improvement target for CP6 has not yet been determined, but it is possible to extrapolate significant improvement of the total national MTIN over time, as the composition of the national fleet changes as forecast in the RSS and other reliability initiatives take effect.

**Figure 7 – Fleet Reliability Projection**



Source: Rail Delivery Group

130. Such initiatives with the existing fleets include:
- managing the impact of technical incidents;
  - weather resilience, for summer, autumn and winter;
  - making best use of remote condition monitoring and diagnostics;
  - improvements to depot facilities;
  - collection of data to achieve better timetables and to enable improved interfaces with operations management.
131. Experience has shown that the most effective forms of remote condition monitoring and diagnostics are systems that can provide operational data as well as technical data, and which are fed to staff in real time in the TOC's control office. This allows decisions to be made that can reduce the impact of a technical problem on a particular train, and also to identify operational errors for which additional training may be required. These have greater overall value compared with the remote diagnostic systems that are typically specified by train builders for their own development-related requirements. What is critical is the ready availability and timely translation of a myriad of interacting data into useful management information on which action can be based.
132. It can be difficult to make the business case for such systems, unless additional funding is provided, as was the case in CP4 via the Network Rail administered Performance Fund. The short-term nature of some franchises has also made it more difficult for TOCs and ROSCOs to make the business case for some reliability improving modifications, particularly when the future of the fleets concerned is uncertain, but this does depend on individual circumstance and commitment.
133. While new fleet introduction or heavy refurbishment is expected to bring significant long term reliability improvement, short term risks at introduction require intensive proactive management, such as that identified in the 20-Point Plan. The industry has demonstrated that through close collaboration between parties and robust contractual incentive regimes, it can successfully manage these risks and deliver improved customer satisfaction from very early days of service, especially when replacing life-expired fleets. The avoidance of unexpected contract variations by the client is key to ensuring the risk balances and delivery obligations in the contract are maintained.
134. Long term vehicle reliability requires effective maintenance regimes, for which a high quality of depot facilities and staffing is essential. Technology in this area has increased as quickly as on the vehicles themselves, but there is frequently a sharp contrast in the quality of facilities between the new, manufacturer-built and operated depots, and the numerous BR legacy facilities that still exist. This issue will be addressed in RDG's new "Passenger Depot & Stabling Strategy" to be published in 2018.

## K. Sustainable Development, Technology and Standardisation

135. The industry adopted ten Rail Industry Sustainable Development Principles (SD Principles) in the ISBP for CP5 and has committed to embed them. The SD Principles are also supported by DfT and are a core element of the current franchising programme. Through franchising, operators are required to meet ambitious environmental and social goals in which rolling stock has an important role to play.
136. The industry outlined its traction carbon ambition for CP5 in the ISBP and developed a CP6 ambition, based on the RSS, which was put forward in the IIA. A number of key energy efficiency interventions such as energy metering and Driver Advisory Systems can reduce both carbon and cost, and are expected to continue to be mandated by the franchising authorities in new franchise specifications. Life extension and power system replacement may also have net carbon benefits compared with the disbenefit associated with the manufacture of new vehicles.
137. However, the biggest opportunities for improving the sustainability of rolling stock are at the design stage and given the volumes of new rolling stock that are needed, embedding the SD Principles in rolling stock procurement is critical. Future rolling stock procurement and leasing exercises should take due account of worldwide best practice and emerging results from research and development (R&D) in sustainable rolling stock design and operation. There is some good practice, with the new rolling stock generally offering significant efficiency gains, but wider delivery is uneven. Ambitious improvements in energy efficiency should be a key requirement in all future specifications, with opportunities existing for technology transfer from other sectors, such as automotive and aerospace. Innovation in self-powered vehicles is likely to be a key issue for the future as is the efficient use of capacity throughout the day.
138. The freely available **Key Train Requirements** document (see paragraph 142 below) includes guidance to assist the industry supply chain in delivering products and services with optimum environmental credentials, including the undertaking of whole life environmental impact assessment. Further information is provided on traction energy carbon emissions, material sourcing, recyclability, providing accessibility to an increasingly ageing and diverse population, and the management of depots (see Section L below). The informed procurement, manufacture and operation of rolling stock can also have a positive social impact, with consideration given to local regeneration, skills and the role of the SMEs in the supply chain.
139. RSSSG has discussed, at a strategic level, the potential advantages and drawbacks of increasing the degree of standardisation of trains and their subsystems. On the one hand, greater standardisation could potentially make it easier to move trains around the network at franchise re-let points, to achieve economies of scale in production, technical support and maintenance, to increase infrastructure cost efficiency and, potentially, to increase the number of suppliers of important train subsystems. On the other hand, it could inhibit technical innovation and significantly constrain the options open to bidders for franchises, which are important means to promote efficiency. RSSSG recognises that this issue, which is inherent to a fragmented railway, can lead to negative perception of the industry. The rail industry has measures in place (such as Systems Interface Committees (see paragraphs 142 and 143) that address these issues – and is working to assure the franchising authorities that this issue is being effectively managed.

140. Supported by RSG and RDG, RSSB launched its twelve-point Rail Technical Strategy Capability Delivery Plan (CDP) in February 2017. The CDP identifies areas of improvement and the coordination required across the industry to create a railway to meet long term future passenger demands in a safe, affordable and sustainable manner. The approach of the CDP looks at the railway as a whole system driven by its markets, hence there is no rolling stock section; but as a core component of rail travel there are multiple areas of capability ambition involving rolling stock, particularly in the field of intelligent vehicles. The CDP focuses on how innovation may be facilitated, such as the provision of technology test trains to provide a bridge from enhanced university research programmes to the operational environment without impacting passenger service vehicles in traffic.
141. The launch of the CDP was also linked with the relaunch of SPARK, an open library of national and international rail industry knowledge and experience. SPARK contains the RSSB's entire research portfolio, from human factors to climate change, and will be continuously updated in a move to speed up and facilitate innovation. SPARK contains nearly 10,000 papers appertaining to rolling stock design, and operation.
142. RDG with the **Vehicle/Vehicle Systems Interface Committee (V/V SIC)**, on which the whole industry including suppliers is represented, has published **Key Train Requirements** for rolling stock. These requirements are distilled from collective experience of procuring new trains and refurbishing existing trains by TOCs and ROSCOs over many years. They comprise a library of advice and best practice for procurement and refurbishment in areas that are not covered by mandatory standards, which the whole industry and other bodies contemplating these activities are encouraged to follow.
143. The **Vehicle/Track Systems Interface Committee (V/T SIC)** follows a similar process to V/V SIC to develop a better understanding of the interaction between train and track represented in the **Vehicle Track Interaction Strategic Model (VTISM)**, which has been used to support a number of recent train procurements; and also the **Vehicle/Structures Systems Interface Committee (V/S SIC)** which is currently looking at options around standardised gauges and train-platform clearances.
144. As route capacity has become more constrained, the **Route Planning Process** and Route Studies and Route Strategic Business Plans are playing an increasingly important role in setting wider expectations for rail in the economy, and in consequence, the kind of future roles and demands that rolling stock will be required to meet. The process effectively sets high-level output requirements (e.g. for speed, acceleration, train length and door positions) for the rolling stock that might be deployed on each route, reflecting the fact that capacity on a route is maximised when the various train types that use it have similar path-occupancy characteristics. For example, the fast pair of tracks on the Great Western, West Coast, Midland and East Coast Main Line routes are now (or may in future be) used by a mix of modern electric trains operating at 110mph and 125mph. Any new rolling stock is likely to be required to meet or exceed the performance of other trains already on the route, and the Route Studies give a good guide in this regard. However, they are not definitive specifications, and other factors such as power supplies – or even a large-scale replacement of a whole fleet as in the EA competition – may give rise to alternative solutions.

145. European TSIs, which apply to new vehicles and to significant modifications of existing ones, have progressively introduced standards that are designed to remove country-based technical differences to allow suppliers to achieve economies of scale and to make it easier to operate and move trains across international borders. After Brexit, the UK may no longer be legally bound by the European TSI legislation, but at least until such times as the UK has left the EU, suppliers to the UK market have been advised that they should continue to treat EU TSI compliance as a UK requirement. While the UK rail industry will continue to contribute to, and seek benefit from, EU rail initiatives up to the point of exiting the EU, the detail and transition arrangements are not yet clear. However, it is quite likely that given the international nature of the market for trains, neither funders nor manufacturers would wish to ignore the TSIs and their supporting Euronorms which are becoming the de-facto international standards. The UK government has already confirmed that the Shift2Rail Joint Technology Initiative (in which €450 million of European Commission funding will be matched by a similar sum from the rail industry for rail research and innovation in rolling stock, infrastructure, and traffic management and control systems), should progress on the understanding that government support will be maintained. Alstom, Bombardier, Siemens and Network Rail are all founding members of Shift2Rail.



*All change - Class 172 DMUs in new and old livery*

## L. Improving Value for Money from the Rolling Stock Fleets

146. In the first and subsequent editions of the RSS, RSSSG estimated the cost per vehicle mile of similar new EMU and new DMU vehicles, derived from several TOC and ROSCO sources, the confidential data being merged and anonymised. In doing so RSSSG considered and tabulated typical costs per vehicle mile for the following:
- Fleet maintenance;
  - Capital leases;
  - Energy;
  - Track maintenance; and
  - Electrification fixed equipment.
147. No new DMU vehicles were ordered for British TOCs between 2008 and 2016. The fleets of comparable new Type B DMUs and Type E EMUs to be built by CAF for the ARN and West Midlands franchises could provide an updated comparison on the costs of these different types, but it would be inappropriate to publish figures for these fleets in isolation.
148. In practice the costs per vehicle mile for new pure electric, pure diesel and bi-mode fleets will vary for each contract, depending on factors including:
- how development costs have been amortised;
  - the cost of capital at a particular time;
  - the annual mileage and duty cycle of each fleet;
  - maintenance arrangements; and
  - other factors included in the commercial terms of the contracts, e.g. performance incentive regimes.
149. If any electrification projects are to be progressed following the English government policy change, it is clear that business cases will need to be very strong – with the implication that given the emerging traction technologies and the flexibility of bi-mode vehicles, only the busiest of routes or critical sections are likely to be able to generate the benefit required, both operationally and to the passenger, to justify the investment.
150. Even if opportunities are limited by commercial constraint, RSSSG stands by its original statement that (other matters being equal), the requirement for subsidy per passenger mile can be reduced (or the net premium per passenger mile can be increased) through the expansion of the electrified network on a business case led basis. Once a route is electrified, electric traction remains inherently more efficient and reliable to operate than diesel – particularly on intensively-used routes.
151. Bi-mode vehicles offer the flexibility to capture the benefits of electric traction, but due to the duplicated traction systems and associated additional maintenance requirements, they are more expensive to buy, maintain and operate. Bi-mode trains are also heavier than single power source trains, giving rise to higher track access charges. However, bi-mode vehicles are operationally flexible, and transcend the constraints of overhead power provision, which is particularly attractive when power provision does not match passenger route flow demand.

152. The average price paid by TOCs for traction electricity per vehicle mile continued to be significantly less than the cost of diesel per vehicle mile in 2016/7. Significant falls in oil prices in 2014 and 2015 saw prices hit lows of around \$30/barrel, bringing down both diesel and wholesale electricity costs, though some recovery since that time has seen prices stabilise at around \$60/barrel. TOCs are able to forward hedge diesel and electricity prices, which smoothes some of the inherent volatility in the markets. The overall cost of electricity is being increasingly driven by charges for renewable policies and network upgrades, which in 2016/17 amounted to the same as the wholesale electricity cost. These additional charges are rising every year in line with government's energy policy objectives, causing some narrowing of the gap between overall electricity and diesel prices. However, there is no certainty that oil prices will stay at their relatively low levels in coming years. Decisions on further electrification would, amongst other factors, always need to be taken based on a long term view on the difference between diesel and electricity prices.
153. In the fourth edition of the RSS, attention was drawn to work undertaken by RSSSG to establish opportunities for increasing value for money from the rolling stock fleet during CP5 and CP6. Investigation concluded that opportunities of basic cost reduction are near exhausted, and the industry is now moving toward longer term, whole-system optimisation. Changes to the franchise models, coupled with predictability of the franchising process are facilitating the development of longer term initiatives, even when these commence part-way through a franchise term. Increased visibility of long term industry planning increases investor confidence in the rolling stock supply chain.
154. The proliferation of successful working groups outlined in Section K above is evidence of the effort being applied by the industry to develop cooperatively and spread knowledge. While there will always be perturbations, the increased stability and visibility of the franchising programme promotes industry confidence and with recent initiatives in the transfer of residual asset value at franchise end points, some key barriers to investment have been removed.
155. Whole system optimisation is seen as the way forward, but there are difficulties in delivering this in a fragmented industry. The development of game-changing systems such as ERTMS have the potential to provide efficiency and capacity across the industry, but even when the system is considered technically feasible, the identification and delivery of benefit requires the cooperation of all involved. No single party can construct a viable business case, and the commercial challenges to the delivery of such projects will require the positive engagement of all parties. However, in December 2017, Network Rail, with funding from the DfT's National Productivity Investment Fund agreed funding of up to £150m for the fitment of ETCS Level 2 Baseline 3 to 745 diesel locomotives in the UK freight fleet. This will allow freight operations to continue nationwide as ETCS technology is rolled out across the network and removes one of the largest operational barriers to the spread of the system across the network.

## M. Conclusions

### **The Size and Composition of the Future National Fleet**

156. The forecasting methodology for this sixth edition of the RSS has been refined but the long term conclusions are largely unchanged. The combination of exogenous growth, growth resulting from investment in new and upgraded railway infrastructure, and growth stimulated by TOC initiatives will require a major change in the size and composition of the national passenger fleet over the next three decades. With the assumptions and scenarios modelled in this RSS, the total size of the national fleet is forecast to grow by between 40% and 85% over 30 years, while the proportion of electric (and bi-mode) vehicles would rise from 72% today to between 81% and 86% over the same period.
157. Whilst the economic impact of the decision to leave the EU is uncertain, the medium to long term drivers of rail growth remain fundamentally robust. RDG continue to forecast a doubling of passenger demand over the next 30 years and the franchising authorities are all continuing to invest in the network to meet current and future demand. Further growth can also be expected from projects such as HS2 and Crossrail, and as the result of improvements to be secured through the franchising process and delivered by train operators.
158. Short term demand remains steadfastly positive outside London and the South-East, but there is concern that since 2016 the London commuter market has faltered. Physical passenger counts reveal that demand growth continues, but results derived from ticket revenue data show a slower growth. RSSSG believes that while economic uncertainty around Brexit is influencing demand during this time, passenger travel patterns in the South-East are being influenced by changes to TfL ticketing (including C-PAY and the daily/weekly cap) and that the demand outlook remains positive. The three growth scenarios contained in the RSS cater for this perturbation and while the situation will continue to be monitored, there is currently no reason to adjust long term forecasts.
159. The consequence of the modelled scenarios is that between 10,600 and 15,000 new electric and bi-mode vehicles will be required over the next 30 years, taking account of growth, electrification, HS2, and the replacement of most BR-procured vehicles.
160. The total number of new vehicles committed for delivery in CP5 and in the early years of CP6 is now 7,187, compared with the 6,010 reported in the fifth edition of the RSS, at a capital cost of more than £13 billion. International interest in manufacturing and leasing new trains for the UK market has grown over the last four years, but around 50% of these new vehicles will be built in Britain.
161. New train orders in CP5 and CP6 are at historically high levels. The total order of nearly 7,200 vehicles is put in context when compared with the current total UK fleet of 14,025 vehicles. Many older vehicles will be retired, and the average age of the UK fleet is expected to fall to 15 years by 2021. There is however a risk that this peak of orders will reinforce the historic cyclical pattern of new vehicle construction for the British market that has been a regular feature over the last 30 years.
162. A completely steady new build programme for rolling stock is unlikely ever to occur. Further peaks in demand for new build vehicles will arise in consequence of refranchising timescales, where decisions to procure new rolling stock will in many cases be triggered by franchise award. Nevertheless, the forward projections of rolling stock fleet sizes offered by this RSS should provide a greater degree of predictability for new vehicle orders.

163. It is apparent that the difference in the net cost of ownership of new and life-extended EMUs has closed in recent years, due principally to a reduction in the manufacture and finance cost of new vehicles. Refurbishment of existing rolling stock can still provide a cost-effective way of enhancing the passenger experience and retaining capacity but rolling stock manufacturers and lessors are now responding to opportunities in the market with extremely competitive products.
164. Updated fleet size forecasts show the electric and bi-mode fleet totals increasing by a net figure of between 855 and 1,530 over the course of CP6 in the three scenarios. These figures reflect two opposite movements. There has been a downward adjustment reflecting the slower delivery and reduced scope of Network Rail's electrification programme, but an upward adjustment created by the significant new build orders of over 2,800 vehicles of these types arising from recent franchise competitions. This compares with a net increase of approximately 2,700 electric and bi-mode vehicles from the delivery of just under 4,000 vehicles over the course of CP5.
165. Recent new build orders, coupled with the English government strategy change in respect of electrification have resulted in nearly 4,000 serviceable vehicles being displaced and without future lessees, in the next 4 years (at the time of writing of this RSS). While circa 2,500 of these are over 30 years old, the number includes over 600 vehicles that are less than 20 years old. While this situation has the potential to create a competitive market in future competitions, it also means there is significant investment and asset value on which no return is being made. This is unlikely to contribute to an efficient rolling stock market in the long term.
166. The likely constitution of the UK rolling stock fleet between self- powered, bi-mode and electric power in 2047 has become extremely hard to predict. While the Scottish government has maintained a steady position on electrification over the year, the English government has announced far reaching strategic changes. A reduction in planned electrification of the network, coupled with calls for more bi-modes, hydrogen powered trains and the elimination of diesel engines on trains by 2040 (the same date set for the automotive industry) will necessitate rapid and extensive change. The rate of innovation, development and commercial exploitation of new, sustainable traction power solutions will be instrumental in delivering these goals. While there is a light rail tram network in China that operates with catenary power on just 10% of its network, there is no currently no operational heavy rail alternative that can match the performance of the diesel engine without an external electric power supply.
167. In the medium and long term, the revision in scope of the electrification programme in England and Wales has resulted in changes to the forecast for self-powered vehicles. By the end of CP7 in 2029 it is forecast that this factor alone will increase demand for self-powered vehicles by approximately 500 vehicles, with a corresponding decrease in electric and bi-mode vehicles compared with our forecasts in the fifth edition of the RSS.
168. The additional demand for self-powered vehicles in the medium term poses particular issues for rolling stock owners and manufacturers. A vehicle bought new in 2029, in line with our forecasts, will have significant remaining life in 2040, the date proposed for all diesel traction to be withdrawn. The pricing of asset life risk on such vehicles will bring increasing pressure on manufacturers to develop trains that have sufficient power source flexibility to enable them to be commercially attractive even if innovative technology has not provided totally sustainable solutions.

169. On many routes, meeting the demand growth projections of this RSS will require complementary infrastructure improvements. The industry's Long Term Planning Process will progressively shape how such infrastructure schemes might be developed and delivered, but these schemes will need to be considered alongside measures such as shoulder peak pricing to spread the peaks and shift demand toward available capacity.

### **Electrification, Cost Reduction and Value for Money**

170. Rolling stock-related costs per vehicle mile can be reduced in real terms as a result of electrification because the manufacturing, leasing and maintenance costs for new electric vehicles are substantially lower than the costs for comparable new diesel vehicles. The costs for older electric vehicles are also significantly less than for comparable older diesel vehicles. However, the cost of extending the overhead line to power these trains has risen sharply in recent years, making the commercial business case for expansion of the overhead network harder to deliver. Where overhead network extension can be justified, it remains the preferred source of traction energy, but it is recognised that increasing cost helps drive the search for alternative sustainable energy sources.
171. As pressure to move from diesel to more sustainable energy sources increases, innovative new technologies are being developed. Prototype developments have demonstrated that electricity for traction motors can be derived from sources including hydrogen power cells and batteries, and not just diesel generators and overhead wire. The English government has challenged the industry to actively encourage these technologies, with aspirations for hydrogen trains to operate on the network "as soon as possible", and diesel engines to be removed from rail passenger vehicles by 2040. The real question is no longer "diesel or electric", but "what is to be the energy source that will feed the electric traction motor". Factors such as fuel pricing differential between electric and diesel vehicles now appear to be very short-term arguments, as the removal of oil-based fuel from the transport sector gathers pace.
172. Innovative technology is already coming to fruition on the network through the use of bi-mode trains, but these currently employ diesel engines for the generation of power to enable operation beyond the electrified network. This operational flexibility allows operators to meet one of rail passengers' strongest demands – end to end journeys without changing trains. Operators can optimise the use of overhead power where it exists, but this no longer defines the seamless journeys that can be offered to the passenger. However, while the current bi-mode trains still have diesel engines, it is highly likely that the next generation will utilise more sustainable alternative power sources.
173. Following the recent change of strategy by the English government, the presently committed programme of electrification will take the proportion of track mileage that is electrified from 42% to 48% - down 10% from the RSS forecast last year. The Scottish government has left its electrification strategy unchanged this year and continues to progress schemes in accordance with strategic goals and commercial justification. In consequence of scope revisions, the "High" electrification growth scenario has been removed from the RSS model as this is now considered very unlikely, and the "Medium" scenario has been revised to 50% by 2039, containing only schemes still identified as under consideration by any government.
174. If the extent of ongoing electrification assumed in this updated RSS were to prove to be too optimistic, then the most likely change is that more of the uncommitted new vehicles (required both for ongoing growth and to replace the ageing ex-BR fleets) would be built as bi-mode trains or self-powered trains, depending on the rate of traction technology development.

175. The commitment to a rolling programme of electrification beyond existing schemes would enable the rail industry to continue to develop its skills and capacity to deliver, potentially offering efficiency savings over a more ‘stop-go’ approach, but such a scenario now appears unlikely. With Sheffield now included on the HS2 network, commercial justification for continuous electrification of the Midland MainLine appears unlikely. The Scottish government strategy includes having 35% of its network electrified by 2032, and so long as electrification costs can be contained, the pattern of gradual expansion of the network looks set to continue.
176. Opportunities for commercially viable, easy efficiencies in the field of rolling stock are now the exception. Examples of successful initiatives are plentiful, but newer initiatives frequently require greater investment in innovative technology, often coupled with cross-party working between the key stakeholders. The proliferation of successful working groups under RSSB is evidence of the effort being applied by the industry to develop cooperatively and spread knowledge. Excepting occasional perturbations, the increased stability and visibility of the franchising programme promotes industry confidence and with recent initiatives in the transfer of residual asset value at franchise end points, some key barriers to investment have been removed.
177. Whole system optimisation is seen as the way forward, but delivery across a fragmented industry can be challenging. The development of game-changing systems such as ERTMS have the potential to provide efficiency and capacity across the industry, but even when the system is considered technically feasible, the identification and delivery of benefit requires the cooperation of all involved. It is hard for single parties outside Network Rail or government to construct a viable business cases for such large, widely scoped projects, but where strategy is aligned, progress can be made. In December 2017, Network Rail, with funding from the DfT’s National Productivity Investment Fund agreed funding of up to £150m for the fitment of ETCS Level 2 Baseline 3 to 745 diesel locomotives in the UK freight fleet. This will allow freight operations to continue nationwide as ETCS technology is rolled out across the network and removes one of the largest operational barriers to the spread of this system across the network.

### **Passenger Benefits and Fleet Reliability**

178. The direction of travel described in this RSS reflects the change in English government policy on electrification and the issues the rolling stock side of the industry is now managing. However, from a passenger perspective, new vehicles will continue to be delivered onto a network that is undergoing enhancement in line with forecast demand. The many benefits for passengers will include:
- improved fleet reliability, producing improvements in punctuality;
  - train capacity and route capacity, hence a reduction in crowding levels;
  - shorter journey times and station dwell times;
  - on-train ambience;
  - reduction of noise, vibration and emissions;
  - improved facilities for passengers with reduced mobility;
  - on-train communications and Wi-Fi.

179. The reliability of the total national passenger fleet as measured by the MTIN MAA benchmarking data has been rising continuously over several years, but has flattened abruptly over the last year, coinciding with national rail punctuality falling to a 10 year low in February 2017. The root causes of this decline in punctuality are under investigation, but the undertaking extensive modernisation of the network while keeping it largely open for service is believed to be at the heart of the problem. There are two key areas where rolling stock may have impacted this decline:
- Engineering work and route modernisation predominantly take place at night and weekends. This work frequently impacts vehicle access to depots, disrupting maintenance and repair plans and consequently reliability and availability.
  - New rolling stock orders number over 7,000 and delivery schedules are intensive. Operators have to manage the introduction of new vehicles and the associated staff training at the same time as maintaining new and outgoing fleets – often at the same depot. Vehicle reliability of new fleets can initially be poor, especially when they are first of type or entail brand new technology, and it is not uncommon for new incoming fleets to be statistically less reliable than the vehicles they displace during the first months of operation.
180. Furthermore:
- Once introductory issues have been resolved on new build vehicles, strong reliability can be expected to follow. Two modern EMU fleets are achieving average reliability of over 100,000 MTIN MAA, and a further 6 sub-fleets achieving over 60,000 MTIN; and
  - When the performance of different unit types is compared, EMU performance is approximately double that of DMU performance in all categories.

### **The Principle of Franchise-Led Procurement**

181. Government policy is that rolling stock procurement should in most cases be franchise-led and the RSS fully supports this principle.
182. RSSSG asserts that:
- the franchising model is an excellent mechanism to deliver value for money rolling stock provision;
  - the new RSBPs represent an opportunity for fleet driven infrastructure requirements to be incorporated into long term strategy in a timely manner;
  - rolling stock provision should be the result of market-driven solutions, procured in a competitive environment; and
  - short term budget constraints should not prejudice the delivery of optimum whole-life, whole-system costs and benefits of rolling stock.
183. RSSSG also asserts that over the last decade, the output-based specifications and consistent strategic direction from franchising authorities has facilitated the provision of efficient rolling stock solutions for the industry. There is concern that when sudden or extreme changes are exerted on the market through policy or strategy, the industry will endeavour to deliver the required outputs, but this may not prove to be the optimal long term solution, and inefficiency and cost may result.

184. Articulating the required outputs and allowing the market to decide the optimal means of delivering these will produce the following benefits:
- Optimised long term, whole-system benefits from investment in and deployment of rolling stock.
  - A spur to investment in innovation.
  - A strengthened supply chain with greater production capacity for both new and life-extended fleets.
  - Reduction in the overall costs of enhancements (e.g. where these can be combined with PRM-TSI modifications, ETCS fitment and/or heavy maintenance).
  - Lower cost of capital and improved value for money.
  - Earlier delivery of passenger benefits, revenue increases, and carbon reduction benefits.
  - Greater value for DfT from future franchise bids.



*Refurbished interior of East Midlands Trains Class 222 Meridian DMU*

## **APPENDICES 1 TO 3: TIMELINES OF KEY ACTIVITIES**

On the three appendices that follow, please note the sources used as follows:

- Franchise dates are the start dates shown on the DfT Franchise Schedule dated July 2017;
- Infrastructure dates are as shown in the Network Rail Enhancements Delivery Plan dated December 2017, quoting when infrastructure is planned to be authorised for passenger use. Dates shown as 'CP6' are subject to confirmation of funding.
- Rolling stock dates are the latest planned date for the first and last unit of each new fleet to be on lease and in passenger service.







## APPENDIX 4, CATEGORISATION OF ROLLING STOCK TYPES

For the purpose of this Rolling Stock Strategy, existing and committed rolling stock classes have been allocated to the generic rolling stock Types A to G as shown in the following table.

Type A (Shorter Distance Self-Powered)	Type B (Middle Distance Self-Powered)	Type C (Longer Distance Self-Powered)	Type D (Shorter Distance Electric)	Type E (Middle Distance Electric)	Type F (Longer Distance Electric)	Type G (Very High Speed Electric)
121	158	180	313	317	390	395
139	159	220	314	318	397	
142	166	221	315	320	IC225	
143	168	222	345	321	800	
144	170	HST	376	322	801	
150	171	Mk5 LHS	378	323	802	
153	172		455	331		
155	175		456	332		
156	185		465	333		
165	195		466	334		
230			507	350		
			508	357		
			707	360		
			710	365		
			717	375		
				377		
				379		
				380		
				385		
				387		
				442		
				444		
				450		
				458		
				700		
				701		
				769		

Unpowered passenger carrying vehicles and the associated locomotives have been allocated in accordance with the service groups on which they are currently deployed.

Class numbers are not yet known for the new Type E and Type F fleets for Abellio East Anglia, and the new Type D fleet for Merseyrail.

See also paragraphs 25 and 26 of the RSS.

## APPENDIX 5, COMMITTED ROLLING STOCK FOR DELIVERY IN CP5 AND CP6

New rolling stock ordered or committed for delivery in CP5 and the early years of CP6 comprises the following:

TOC and Vehicle Class or Type	No. of New Vehicles		Manufacturer	Owner
	CP5	CP6		
<b>Major DfT/ TfL Procurements</b>				
Crossrail Class 345 EMU	504	126	Bombardier	DfT/ TfL
Thameslink Class 700 EMU	1,140		Siemens	Cross London Trains
GWR Class 800 Bi-Mode	369		Hitachi	Agility Trains West
VTEC Class 800 Bi-Mode	167		Hitachi	Agility Trains East
VTEC Class 801 Electric	60	270	Hitachi	Agility Trains East
<b>Subtotal, Major Projects</b>	<b>2,240</b>	<b>396</b>		
<b>Other</b>				
Caledonian Sleepers Mk 5 sleeper train coaches	75		CAF	RBS (owns Caledonian Sleepers Rail Leasing)
TPE, Mk 5A coaches	66		CAF	Beacon Rail
ARN Class 195 DMU	79	61	CAF	Eversholt Rail
ARN Class 331 EMU	66	75	CAF	Eversholt Rail
LMR Class 350 EMU	40		Siemens	Angel Trains
TfL Class 378 EMU	57		Bombardier	Joint Venture between SMBC Leasing & NAB
ScotRail Class 385 EMU	234		Hitachi	SMBC (owns Caledonian Rail Leasing)
GTR Class 387 EMU	116		Bombardier	Porterbrook
Gatwick Express Class 387 EMU	108		Bombardier	Porterbrook
GWR, Class 387 EMU	180		Bombardier	Porterbrook
C2c, Class 387 EMU	24		Bombardier	Porterbrook
TPE Class 397 EMU	60		CAF	Eversholt Rail
SWR Class 707 EMU	150		Siemens	Angel Trains
London Overground, Class 710 EMU	180		Siemens	Joint Venture between SMBC Leasing & RBS
GTR Class 717 EMU	150		Siemens	Rock Rail
GWR, Class 802 Bi-Mode	236		Hitachi	Eversholt Rail
Hull Trains, Class 802 Bi-Mode		25	Hitachi	Angel Trains
TPE Class 803 Bi-Mode		95	Hitachi	Angel Trains
Merseyrail Type D EMU		208	Stadler Rail	Merseytravel
West Midlands Aventura EMU		333	Bombardier	Corelink (JV Infracapital & Deutsche Bank)
West Midlands DMU		80	Stadler Rail	Corelink (JV Infracapital & Deutsche Bank)
SWR Aventura EMU		750	Bombardier	Rock Rail
AEA Aventura EMU		665	Bombardier	Angel Trains
AEA Flirt Bi-Mode		138	Stadler Rail	Rock Rail
AEA Flirt EMU	120	120	Stadler Rail	Rock Rail
c2c, Aventura EMU		60	Bombardier	Porterbrook
<b>Subtotal, Other</b>	<b>1,941</b>	<b>2,610</b>		
<b>TOTALS</b>	<b>4,181</b>	<b>3,006</b>		

**APPENDIX 6, VEHICLES CONTRACTED TO BE DISPLACED BETWEEN 2018 AND 2020, FOR WHICH NO FUTURE LESSEE HAS BEEN SECURED.**

Vehicle Class	Owner	Vehicles	Type	Build Date	Current Lessee	Displacement Date
185	Eversholt	66	DMU	2006	TPE	2019
170	Porterbrook	32	DMU	2002	GA	2019
180	Angel	25	DMU	2001	Hull Trains	2020
156	Porterbrook	18	DMU	1989	GA	2019
153	Porterbrook	5	DMU	1988	GA	2019
142	Angel	158	DMU	1987	Northern	2019
144	Porterbrook	56	DMU	1987	Northern	2019
153	Porterbrook	8	DMU	1988	LoM	2020
150	Angel	6	DMU	1986	LoM	2020
707	Angel	150	EMU	2017	SW	2020
379	Macquarie	120	EMU	2011	GA	2019
350/2	Porterbrook	148	EMU	2009	LoM	2021
360	Angel	84	EMU	2003	GA	2020
365	Eversholt	84	EMU	1995	GTR	2019
319	Porterbrook	96	EMU	1988	GTR	2017
319	Porterbrook	28	EMU	1988	LoM	2021
313	Eversholt	132	EMU	1977	GTR	2018
323	Porterbrook	51	EMU(AC)	1993	Northern	2019
323	Porterbrook	78	EMU(AC)	1993	LoM	2020
321/322	Eversholt	448	EMU(AC)	1990	GA	2020
315	Eversholt	244	EMU(AC)	1981	TfL X-rail	2019
317	Angel	204	EMU(AC)	1982	GA	2020
458	Porterbrook	180	EMU(DC)	2000	SW	2020
442	Angel	30	EMU(DC)	1989	SW	2018
456	Porterbrook	48	EMU(DC)	1991	SW	2020
455	Porterbrook	364	EMU(DC)	1985	SW	2020
HST-PC	Pbk/Angel	77	HST-PC	1982	GW/VTEC	2019
Mk4	Eversholt	302	LHS	1991	VTEC	2019
Mk3	Porterbrook	144	LHS	1988	GA	2019
Sleepers	Porterbrook	53	LHS	1985	Cal.Slpr	2018
Mk3	Pbk/Angel	455	LHS	1982	GW/VTEC	2019
91	Eversholt	31	Loco	1991	VTEC	2019
90	Porterbrook	15	Loco	1990	GA	2019

## GLOSSARY

AC	Alternating Current
AEA	The Abellio East Anglia TOC
ARN	The Arriva Rail North TOC
ATOC	Association of Train Operating Companies
ATW	The Arriva Trains Wales TOC
BEIS	Department of Business, Energy and Industrial Strategy
Bi-mode vehicle or train	A electric vehicle or train (see below) whose propulsion is by electric motors and which is able to draw power from an external supply, and also using power generated from an on-board source (this being a diesel engine for bi-mode trains currently being procured). Such trains can also be described as 'electro-diesel' but this terminology is not used in the RSS
BR	British Rail
Brexit	The process by which the UK will leave the European Union
CDP	Capability Delivery Plan
CP	A five-year regulatory Control Period
CP4	1/4/2009 to 31/3/2014
CP5	1/4/2014 to 31/3/2019
CP6	1/4/2019 to 31/3/2024
CP7	1/4/2024 to 31/3/2029
CP8	1/4/2029 to 31/3/2034
CP10	1/4/2039 to 31/3/2044
c2c	The TOC which operates the Essex Thameside franchise
DC	Direct Current
DfT	Department for Transport
DMU	Diesel Multiple Unit
DPI	Delay per Incident
DSSG	The Depots and Stabling Steering Group
EA	The East Anglia Franchise
EC	European Commission
ECML	The East Coast Main Line
EGIP	The Edinburgh – Glasgow Improvement Project
Electric vehicle or train	A vehicle or train whose propulsion is by electric motors and which is able to draw power from an external overhead line or third rail supply
EMT	The East Midlands Trains TOC
EMU	Electric Multiple Unit
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
EU	European Union
Future Railway	A collaboration of Network Rail and RSSB, to accelerate research and innovation
GTR	GoVia Thameslink Railway
GWML	Great Western Main Line
GWR	The Great Western Railway TOC
Hendy Report	The report prepared by Sir Peter Hendy and published in November 2015 regarding the timing and cost of infrastructure enhancements originally included in the HLOS for CP5.
HLOS	High Level Output Specification (expected in future to be re-named as the Rail Investment Strategy)
HST	InterCity 125 High Speed Train
HS1	The High Speed line from London to the Channel Tunnel
HS2	The proposed High Speed line from London to Birmingham, Manchester and Leeds
IC225	The intercity electric trains operated by the East Coast TOC

## GLOSSARY

IEP	The Intercity Express Programme (and ‘Super Express Trains’ to be built by Hitachi)
IIA	Initial Industry Advice – including ‘Scotland’s rail Infrastructure: The rail industry’s advice for 2019 onwards’
IPEMU	An Independently Powered EMU, this being an electric train which also has high capacity batteries or other forms of electrical storage to enable it to operate beyond the limits of the electrified network
ISBP	Industry Strategic Business Plan
ITT	Invitation to Tender
kV	Kilovolts
KPI	Key Performance Indicator
L&SE	London and the South East
LMR	The London Midland Railway TOC
LNW	Network Rail’s London North Western Route
LTPP	The rail industry’s Long Term Planning Process
LUL	London Underground Ltd.
MAA	Moving Annual Average
Mark 1	20-metre slam-door rolling stock built by BR, now all withdrawn
Mark 2	Later 20-metre slam-door rolling stock built by BR, now almost all withdrawn
Mark 3	23-metre rolling stock built by BR, built from the mid-1970s and still in operation
Mark 4	Rolling stock operating in the IC225 trains
MML	Midland Main Line
MTIN	Miles per Technical TRUST Incident
NAB	National Australia Bank
NFRIP	National Fleet Reliability Improvement Programme (now called ‘ReFocus’)
NRPS	National Rail Passenger Survey
NSAR	The National Skills Academy for Rail
NTAR	National Training Academy for Rail
NTF	The National Task Force for the punctuality of the rail network
NW	North West
OBR	The Office for Budget Responsibility
ONS	Office of National Statistics
ORR	Office of Rail and Road
PRM-TSI	Technical Specification for Interoperability, for Passengers of Reduced Mobility
R&D	Research & Development
RDG	Rail Delivery Group
RIA	Railway Industry Association
ROSCO	A company that owns and leases rolling stock
RPI	Retail Price Index
RSBP	Route Strategic Business Plan
RSG	The Rail Supply Group
RSS	The Long Term Passenger Rolling Stock Strategy
RSSB	The Rail Safety and Standards Board
RSSSG	Rolling Stock Strategy Steering Group (see paragraph 1)
RTS	Rail Technical Strategy
RUS	Route Utilisation Strategy
SD Principles	The ten Sustainable Development Principles adopted by the railway industry

## GLOSSARY

Self-powered vehicle or train	Any type of vehicle or train which cannot collect electrical power when in motion, from an overhead or third rail source. This may include classic diesel-powered units and also 'hybrid' units incorporating an internal combustion engine or hydrogen fuel cell with some form of electrical or mechanical energy storage.
SE	The South Eastern TOC and Franchise
SMBC	Sumitomo Mitsui Banking Corporation
SoFA	Statement of Funds Available
STM	A single track mile (e.g. of electrification)
SW	The South Western Franchise
SWR	The South Western Railway TOC
SOBC	Strategic Outline Business Case
TfL	Transport for London
TOC	Train Operating Company
TPE	The TransPennine Express franchise
TRUST	The Network Rail computer system used for monitoring trains and tracking delays
TSI	Technical Specification for Interoperability
TLG	The Technical Strategy Leadership Group, who produce the Rail Technical Strategy
UK	United Kingdom
VfM	Value for Money
V/S SIC	Vehicle/ Structures Systems Interface Committee
VTEC	The Virgin Trains East Coast TOC
VTWC	The Virgin Trains West Coast TOC
VTISM	Vehicle Track Interaction Strategic Model
V/T SIC	Vehicle/ Track Systems Interface Committee
V/V SIC	Vehicle/ Vehicle Systems Interface Committee
XC	The CrossCountry TOC and Franchise



*Passengers on a new Class 800 Bi-mode IEP*

***Back Cover Photo:***  
***A new Class 800 "Azuma" IEP emerges from the factory***

