Long Term Passenger Rolling Stock Strategy for the Rail Industry

Fifth Edition, March 2017

EVERSHOLT RAIL GROUP

angel Trains

porterbrook

SMBC LEASING (UK) LIMITED

Rail Delivery Group

National Rail

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 Executive Team
- SMBC Leasing
- Stagecoach

Cover Photos:
One of the first new Hitachi Class 800 IEP trains expected to enter service during 2017; a Class 168 Chiltern DMU built in 2000; and two SWT Class 458/5 Juniper units, recently rebuilt as 5-car units.

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

We are pleased to be publishing this fifth annual edition of the Long Term Passenger Rolling Stock Strategy. This is intended to bring some clarity to the planning of the railway of the future. Modern, comfortable and reliable trains are key to improving the experience of rail passengers, and this strategy portrays a welcome picture of the private sector and government working together to invest in the nation's future.

With rolling stock orders now at an historically high level, the capability of the industry to build, deliver and introduce reliable new trains to service is of critical importance. We recognise and the industry as a whole will be addressing the key issues that will accompany such a tremendous investment. Since 2014, over £10bn has been committed on orders for over 6,000 new rail vehicles for UK train operators. Some of these trains are already in service, and in the next few years the benefit of this massive investment will become evident across the country.

We particularly welcome the innovation taking place in the rolling stock arena and are determined that these investments will reduce the carbon footprint of train travel, while retaining flexibility and convenience for passengers. Efficient, quiet electric trains will replace many older diesels on our newly electrified lines, and an increasing number of bi-mode trains will be capable of running beyond the electrified network, reaping the benefit of infrastructure investment while reducing the need for passengers to change trains on longer journeys. This flexibility is just one example of the industry responding to passenger and market demands, and innovating with trains that will contribute to the delivery of a high quality, affordable network.

We are pleased that new suppliers have entered this successful market over the past year and hope that this strategy will assist others in understanding how they may contribute and to share in its continuing growth.

Malcolm Brown
CEO, Angel Trains

Hugh Clancy
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A GWR InterCity 125 High Speed Train from the late 1970s

Executive Summary

This fifth 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 2046. It continues to draw on outputs from the rail industry's Long Term Planning Process but has also considered recent developments, including the reduced pace of electrification and the as yet undetermined impact (positive or negative) of Brexit.

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 total 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 6,010, with a capital cost of more than £10 billion. Around 50% of these new vehicles will be built in Britain, and the average age of the national fleet is estimated to fall from 21 years to 15 years by March 2021. The total national fleet size is now increasing faster than at any time in recent decades. The numbers of vehicles in service will grow by 15% by 2019, and by a further 5% to 10% by 2024.

Pure electric vehicles now comprise 71% of the national fleet, and comprise 78% of the committed new vehicles. The delayed delivery of the committed electrification programmes has resulted in increased interest in bi-mode vehicles. These are electric vehicles that are able to operate from an external source of electricity and also with power generated by on-board diesel engines. 1,054 such vehicles are now on order from three suppliers for six train operators. Bi-mode trains offer residual risk benefits compared to older diesel-only options, can facilitate infrastructure cost savings and operational flexibility during the roll-out of electrification and enable trains to serve communities beyond the core electrified routes. However, they have higher capital and maintenance costs than pure electric trains, and are typically less powerful when working in diesel mode than when working on the electrified network.

New rolling stock introduction is likely to peak with the delivery of current orders, but the long term outlook for new build remains positive. Almost 4,000 of the 6,010 new vehicles referred to above will be financed by parties other than the original three principal train leasing companies, and competitive manufacturing and financing markets are keeping prices keen – evidenced by a total fleet replacement with more than 1,000 new vehicles for the recently awarded East Anglia franchise. The new trains will displace vehicles with significant remaining life, creating opportunities for leasing to other operators. While some of these vehicles are of relatively recent build, value for money refurbishment will be required to bring older vehicles up to standards that meet ever-increasing stakeholder expectations.

The model underpinning this RSS has been enhanced and rebased, but the long term outlook remains unchanged with a national fleet increase of between 41% and 89% forecast over the next 30 years. Brexit impacts remain unknown, but the scenarios covered by the "worst case" industry modelling already cater for impacts much worse than the Office of Budgetary Responsibility predictions for Brexit. The proportion of electric vehicles (including bi-modes) is forecast to rise to over 85% by 2034, and the analysis indicates that between 11,000 and 16,000 new electric vehicles will be required over the 30 years to 2046. A further 800 to 2,300 new vehicles capable of running off the electrified network will be required over the same period. The strategy emphasises the resulting benefits to passengers and the wider community, including improvements to capacity, punctuality, reliability, passenger facilities and the environment.

A. Introduction – Goals and Scope

1. This is the fifth 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. RSSSG is co-chaired by Malcolm Brown, CEO of Angel Trains, and Hugh Clancy, Commercial Director Rail, FirstGroup. Joint meetings are held between RSSSG and senior members of the Department for Transport (DfT) Rail Group.

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 introduced and more recently revised and updated its "Rolling Stock Perspective" document, in which it seeks to explain 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. 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.

4. 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.

5. 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. RSS forecasts continue to be used by the Rail Supply Group (RSG) as an input to its rail industry sector strategy, published in February 2016 as 'Fast Track to the Future'. The forecasts are viewed by the supply chain as a critical part of providing greater visibility of potential investments. The forecasts have also been 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. This analysis has in turn been used by the Government to inform the Transport Infrastructure Skills Strategy, published in January 2016, and by investors to inform rolling stock investment decisions.

6. The RSS is fully consistent with the industry's Long Term Planning Process (LTPP). This fifth edition of the RSS has been developed in parallel with and has 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. It is currently assumed that this will be developed further for:
   - The High Level Output Specifications (HLOSs) and Statements of Funds Available (SoFAs) expected to be published in the Spring of 2017; and
   - The Route Strategic Business Plans (RSBPs), replacing the previous Industry Strategic Business Plans (ISBPs), expected to be published in December 2017.

7. 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:
   - 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.

8. 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;
   - the continuing high levels of growth in peak period and all-day passenger demand;
   - the Market Studies and Route Studies published by Network Rail since 2013;
   - the Rail Industry Sustainable Development (SD) Principles; and
   - Network Rail's Enhancements Delivery Plan and its updates.

9. 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.

10. 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 RSG Sector Council has cited the RSS as an example of the benefits of 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.

B. Principal Changes Incorporated in this Fifth Edition of the RSS

11. It might be thought that the greatest change in this fifth edition of the RSS might arise from consideration of possible changes to assumptions about economic growth and employment following the decision that the UK will leave the European Union ('Brexit'). However, 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 post-Brexit assumptions of the Office of Budget Responsibility (OBR) and other analysts. It can therefore be argued that the consequences of Brexit for the RSS are contained within the envelope of forecasts outlined in this updated RSS, and may be considered to impact the likelihood of certain scenarios rather than the RSS scenarios themselves.

12. 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.

13. The rail industry does, however, anticipate a slower pace of growth in the very short term which RSSSG recognises will have implications for the process of rail franchising and may place some pressure on the overall funding envelope for rail investment in CP6. Passenger demand growth slowed during 2016 as a result of several factors, notably the decline in the punctuality and reliability of rail services and more generally the increase in economic uncertainty. With macro-economic forecasters continuing to revise their forecasts for 2017 following the EU referendum, the net impact on rail revenue remains uncertain, but the medium to long term drivers of rail growth remain fundamentally robust and within the scope of the Low, Medium and High scenarios outlined in this RSS.

14. The committed components of railway route enhancements have been forecast by Network Rail to generate up to nine billion more rail passenger kilometres per year by the end of CP6 - an increase of up to 15 per cent on today's total – with major schemes such as HS2 and Crossrail 2 to be delivered beyond this. 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 are expected to make a substantial contribution to demand and revenue growth during CP6, potentially doubling the level of demand growth delivered by 'external' factors only.

15. 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 89% compared with 99% in the fourth edition. The total national fleet size forecast in the High scenario of this updated RSS for 2046 is 24,943. This compares with 25,521 in the High Scenario of the fourth edition, for 2045 – a change of 578 vehicles – or just 4% of the March 2017 fleet size of 13,377. The reduction in the "headline" percentage fleet size growth figure also results from the fact that the railway is now in a period of several years where the total national fleet size will grow more rapidly than at any time in recent decades. The national fleet size has grown by 3% in 2016/17. It is forecast in this RSS to grow by 14-15% over the next two years to the end of CP5, and by a further 5-10% in CP6. (See Table 3 in Section G below).

16. 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.

17. 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.

18. 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.

19. 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 6,010. International interest in manufacturing and leasing new trains for the UK market has grown over the last four 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 less 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. However, while bi-mode trains offer improved operational flexibility, it should be noted that they currently have lower installed power when operating off the electrified network, additional complexity and higher initial capital and maintenance costs than pure electric trains. Hence 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.

20. A prime example of the welcome and growing influence of quality and capacity in the evaluation of new franchise bids by DfT, combined with growing international interest in the UK rolling stock market from train builders and lessors, is the complete fleet replacement with 1,043 new vehicles contracted for the new Abellio East Anglia (AEA) franchise last year. It is clear that manufacturers and financiers were able to construct innovative proposals that were more attractive to bidders, and consequently to government, than both evolutionary change and transformational refurbishment could achieve. A new supplier, Stadler Rail of Switzerland, has entered the UK market with an order for 378 electric and bi-mode vehicles for AEA, while Bombardier is to build 665 electric vehicles, in Derby, based on its Aventra platform. Funding will be provided by Rock Rail and Angel Trains respectively. While it is known that DfT was seeking a significant improvement in customer perceptions and capacity of the rolling stock fleets on this franchise, and were willing to place significant value on these factors, such a large scale change - including displacement of some relatively recently built vehicles - would indicate that competitive pressure and innovation are effectively reducing costs while increasing quality and capacity. An updated table of all of the confirmed rolling stock orders is included as Appendix 5 of this RSS.

21. The 6,010 new vehicles already delivered or now committed for delivery will increase the total active national fleet by 2,500 to 3,000 vehicles by 2024. As a direct consequence of this, it can be concluded that some 3,000 to 3,500 existing vehicles will no longer be required by their present TOCs during this time, and will therefore come off lease (although some of these may find new uses during this period). The displaced vehicles will include:
    - around 1,600 Type A, C, D and F vehicles, comprising many of the oldest passenger vehicles in the national fleet;
    - around 1,400 Type E and Type F vehicles built in 1981 to 1995, mostly comprising middle distance EMUs, the majority being built by 1990;
    - around 300 Type B and Type E vehicles that were built after 2002.

    Further orders for new trains resulting from competitions for new franchises may increase these numbers of displaced vehicles.

22. All other sections of this RSS have been comprehensively revised and updated as necessary.

A Virgin Trains East Coast first class Mk4 coach newly refurbished by Yellow Rail in 2017

C. The Approach Adopted for the Strategy

23. 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.

24. 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 (diesel, generally with 75 mph maximum speed);
    B. Middle Distance Self-Powered (diesel, with 90/ 100 mph capability);
    C. Long Distance Self-Powered (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).

25. 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.

26. The RSS originally used demand forecasts published in the Network Rail Route Utilisation Strategies (RUSs) in 2011. Projections have been 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.

27. Using these inputs, three composite scenarios have been defined and updated as follows.
    - 'Low' - Low growth combined with a relatively low level of future electrification.
    - 'Medium' - Medium growth combined with a medium level of future electrification.
    - 'High' - High growth combined with a higher level of future electrification.

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 2046. 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 policy, investment in rail

infrastructure, or road pricing, etc). The RSS has taken account of such uncertainties by developing the three composite scenarios and by treating the RSS as a living entity. As is demonstrated by the fact that this is now the fifth 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.

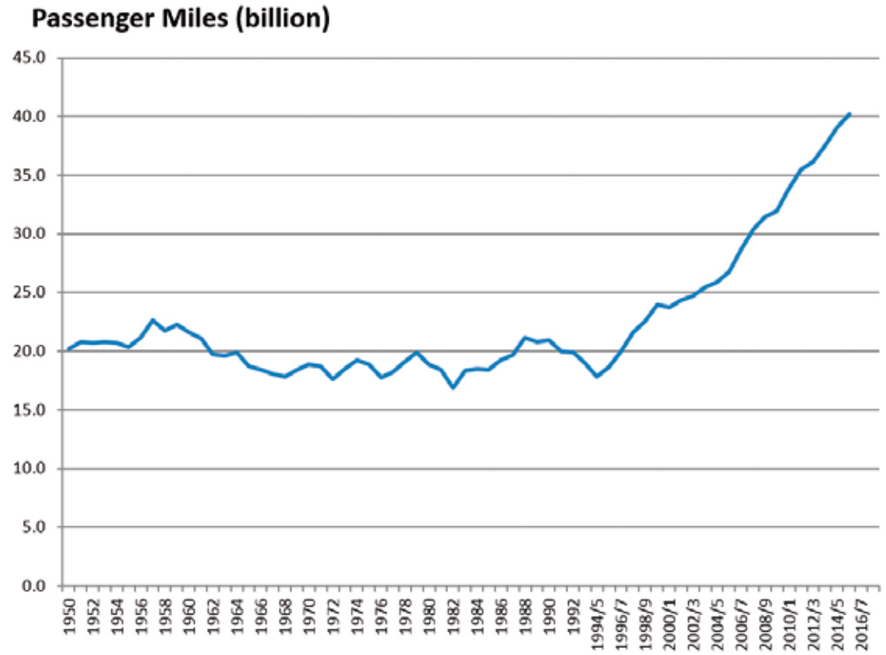
30. The Route Studies contain, and the future RSBPs will update, many route-specific infrastructure and timetable options for increasing capacity beyond CP5. Some of the presently committed enhancements including the IEP, main line electrification, Thameslink, Crossrail, and HS2 projects will provide additional capacity well beyond these timescales. On many routes it will 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, repeated and updated on a five-year cycle or as necessary. 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.

London Midland Class 350 EMUs at Siemens' Northampton depot

D. Planning for Growth – Sources of the Assumptions Adopted

31. Total passenger miles grew by 116% in the 20 years between 1995/6 and 2015/16, an average compound rate per year of 3.9%. (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. The sustained rate of passenger mile growth seen over the last 20 years 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 2016. There is evidence of some softening in the levels of growth in passenger journeys and passenger revenue since that date, for which the reasons are still being analysed. 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)

32. Various studies have attempted to determine why this unprecedented period of sustained growth (including through the recent recession), had not been predicted. 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.

33. The changes in the rail sector have included:
    - 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.

34. National rail passenger revenue has more than doubled in real terms from £4.1 billion to £9.3 billion between 1995/6 and 2015/16 (at 2015/16 price levels; source ORR revenue data and ONS RPI 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.

35. 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).

36. In spite of these changes, peak period crowding has become an increasing problem on many routes. This 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.

37. 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 form a key input to the twelve Route Studies now being produced by Network Rail, seven of which have been published in final form with one other being available in draft form.

38. 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’.

39. 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 is nevertheless significant and is continuing to grow. For example, in the last four 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 3.1% per year. Both of these compound annual growth rate figures are higher than the respective figures quoted in the fourth edition of the RSS. (Source: DfT data).

40. For this fifth edition of the RSS the fleet size growth forecasts have been further enhanced in order 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 now use the Market Study scenarios, adopting their associated overall range of growth. The methodology by which the analysis takes account of present non-compliant levels of crowding on some peak flows into London and other cities has also been enhanced, using DfT data.

41. 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 35 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 AEA franchise.

42. The Market Studies and Route Studies include forecasts for morning peak passenger demand growth for all of 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.

43. This shorter-term focus has been strengthened further in this fifth edition of the RSS. 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 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) 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 electrification and/or 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 comprise Arriva Trains Wales (ATW), East Midlands Trains (EMT), London Midland Railway (LMR) and South West Trains (SWT).

44. The estimates of fleet requirements for Crossrail and for Phases 1 and 2 of HS2 are based on the latest available information from Crossrail and from HS2 Ltd, and discussions with them about options for growth after initial service introduction.

45. Estimating future rolling stock requirements for Open Access operators is difficult as their long-term strategic plans are not in the public domain, and also 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.

One of the new Siemens Class 700 EMUs that entered service with GTR on Thameslink services in 2016

E. Electrification – Prioritisation and Analysis

46. Electrification offers 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, Network Rail has experienced difficulties in delivering its extensive commitments to electrification in CP5 on time and on budget.

47. The present total national Network Rail track mileage is 19,383 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 2016). Of this, 8,117 STMs (42%) are electrified and 11,266 STMs (58%) are non-electrified. 18 STMs of new electrification were completed in 2015/16, compared with 91 STMs of new electrification in 2014/15 and 204 STMs in the five years of CP4.

48. The electrification programme authorised in the CP5 HLOS amounted to some 1,850 track miles. Completion of this programme would increase to 51% the proportion of total track mileage that is electrified, and permitting 75 per cent of passenger traffic to be electrically operated (source: Network Rail). Network Rail subsequently announced that it would be unable to complete this programme, and its other enhancements, within the budget and completion dates previously determined. The revised completion dates for all of the committed electrification schemes in CP5 and CP6 are shown in the Timelines contained in Appendices 1 to 3, based on the report by Sir Peter Hendy published in November 2015, and as clarified and amended further in Network Rail's revised CP5 Enhancements Delivery Plan published in December 2016.

49. The DfT has not committed to a rolling programme of electrification beyond that included in the Hendy Report. Some elements of these projects have now been deferred (e.g. on the Great Western routes), and others may be at risk of deferral or cancellation. The business case of some projects has been weakened by a combination of the current high level of capital costs, and the perceived flexibility of bi-mode trains. Projects proposed for CP6 must now be justified on a case-by-case basis, supported by a sound business case, and proof of affordability and delivery.

50. In 2009, Network Rail published the "Network RUS: Electrification Strategy". This RUS found a strong case for electrification of a number of routes, and was followed by a commitment from government to fund a number of schemes, which are now in various stages of delivery and development. Recognising the difficulties which have been encountered in delivery of the current programme, and the resetting of the portfolio encapsulated in the Hendy Review, Network Rail continues to assess the case for further electrification of the network.

51. Network Rail acknowledges the development of alternative forms of electrification, including bi-mode, battery-assisted or other novel forms of non-diesel traction (see paragraphs 58 and 59 below). These could in some cases strengthen the case for electrification by reducing the capital costs of new infrastructure, but elsewhere can have the opposite impact.

52. Against this background of uncertainty, RSSSG has decided to amend its assumptions for future electrification beyond CP5 in this RSS to incorporate a significantly lower annual rate of electrification, a smaller total programme, and particularly in the Low scenario, a longer overall timeframe. RSSSG has modelled this programme in order to determine the likely impact on the potential requirements for both electric (including bi-mode and battery-assisted) and self-powered vehicles.

53. Low, Medium and High scenarios for electrification have been constructed as shown in Table 1 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 edition of the RSS are also shown for comparison.

Table 1 – Illustrative Electrification Scenarios (Track Miles that might be Electrified)

% Electrified	Low	Medium	High
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

54. 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. The challenges in delivering the CP5 programme have in part resulted from there not being a longer term strategy to electrify the rail network over the last 30 years.

55. Conversion of DC-electrified routes to AC or to dual-voltage capability has been ignored for the purpose of this analysis. The route between Basingstoke and Southampton had been proposed for such conversion but this is not being developed at present.

A ScotRail Class 170 DMU on the newly reopened Borders Railway

F. The Present Fleets and Future Capability Requirements

56. Details of the composition of all of the existing fleets, and of committed changes to the end of March 2017 are summarised in Table 2 below, using the definitions in paragraphs 23 and 24 above (see also Appendix 4). The totals here and elsewhere in the RSS include both passenger-carrying and associated non-passenger carrying vehicles in passenger trains (the latter including locomotives, power cars and driving trailer vehicles).

Table 2 – Present Fleet Composition (including Committed Changes to March 2017)

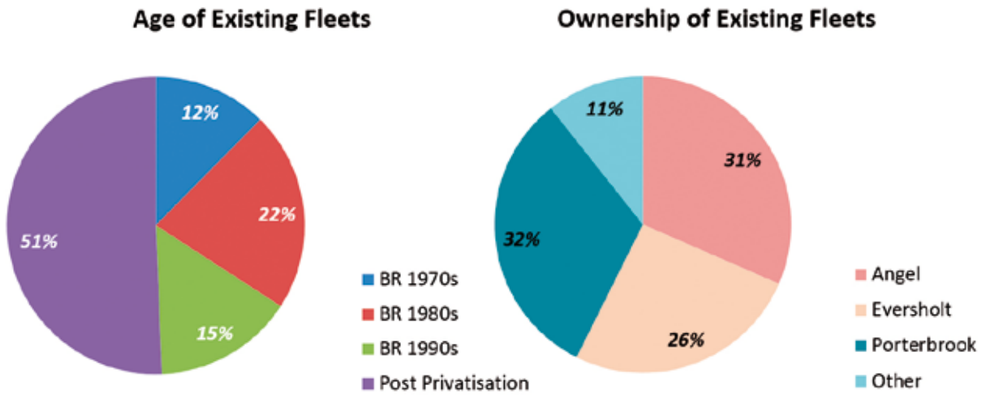
Generic Type	Total Vehicles, March 2017
A. Shorter Distance Self-Powered (diesel, generally with 75 mph maximum speed);	1,057
B. Middle Distance Self-Powered (diesel, with 90 or 100 mph capability);	1,367
C. Long Distance Self-Powered (diesel, with 100 or 125 mph capability);	1,500
D. Shorter Distance Electric (generally with 75 mph maximum speed);	2,461
E. Middle Distance Electric (with 90/ 100/ 110 mph capability);	5,670
F. Long Distance Electric (with 100/ 125/ 140 mph capability);	1,148
G. Very High Speed Electric (140 mph and above)	174
TOTALS	13,377

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

57. Figure 2 on the next page shows that, of these 13,377 vehicles:
    - 6,778 (51%) have been built since privatisation, in the last 20 years; and
    - 1,425 (11%) are owned by parties other than the three largest ROSCOs.

Southeastern Class 465 EMUs - before and after refurbishment to provide better disabled access

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 March 2017

58. 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 AEA) which can both collect power when in motion from an overhead or third rail source, and also generate power from an on-board source. Bi-mode trains can also be created by the fitment of diesel-generator sets to existing EMUs, a first example being the 'Class 319 Flex' units to be provided by Porterbrook for the ARN franchise.

59. 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 first project was the fitment of an additional battery pack to a standard Class 379 EMU to give 60km of independent running, this being known as the Independently Powered EMU (IPEMU). As a result of this project, Bombardier has an IPEMU available in the market, though it has yet to be introduced by any TOCs in Britain. Further innovative traction solutions being progressed to demonstrator stage include a digitally controlled hydraulic displacement transmission, multi-fuel engines capable of running on natural gas and diesel, and energy storage using flywheels. A Very Light Rail Vehicle is being developed by a consortium led by Transport Design International and Warwick Manufacturing Group.

60. 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, it is unlikely that a business case can be made at present to retro-fit a Stage IIIB compliant diesel engine (or engines) to any of the existing British DMU types. The D-Train project being developed by Vivarail is however intended to demonstrate the feasibility, reliability and business case of fitting pairs of smaller Stage IIIB compliant automotive diesel engines beneath former LUL vehicles. The 'Class 319 Flex' units are to be fitted with Stage IIIB compliant engines.

61. 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.

62. As mentioned in paragraphs 49 and 51 above, the perceived flexibility of bi-mode trains has brought significant pressure on some electrification business cases. Other new power technology can also be expected to evolve into rail applications, as in the Alstom 'Coradia iLint' hydrogen fuel cell powered train expected to enter service later this year in Germany. Trains have inherently long service lives. The creation of rail vehicles that can evolve flexibly and utilise these new technologies has the potential to significantly change plans for expansion of the electrified network in the UK, and in consequence, the previously envisaged profile of diesel replacement.

63. The development of the new technologies mentioned above also brings issues for financiers and asset owners. With rail vehicle asset lives typically in the range of 30 to 35 years, 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 three 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 design life.

64. 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 of the industry. Here the outlook now appears weaker than previously, following the relatively large amount of modification work that must be completed by December 2019 in order to comply with the legislation for Passengers of Reduced Mobility (the PRM-TSI requirements). Many new vehicles are on order, but the potential cascade of displaced vehicles, and particularly for this sector, the future of those vehicles past half-life, has yet to emerge. 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.

A South West Trains Class 159 DMU, manufactured in 1992

G. Fleet Sizes and Compositions to 2046

65. As described in paragraph 27 above, the three growth scenarios have been combined with three electrification scenarios to obtain three composite scenarios within the spreadsheet model to 2046, for each TOC. The aggregated results are summarised in Figure 3 and Table 3 below.

66. The key developments over 30 years highlighted in Table 3 are:
- an overall increase of 41-89% in the size of the total national passenger fleet;
- the electric fleets rising from 71% of the national fleet to over 85% or more by 2034; and
- the self-powered fleets falling from 29% of the national fleet to 15% or less.

67. It can be deduced that in the Low scenario, a minimum of 11,000 new electric and bi-mode vehicles would be required by 2046, from today's base position. This figure comprises the sum of:
- 7,000 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 50 years old in 2046).

In the Medium and High scenarios, this minimum total of 11,000 new electric vehicles to be constructed by 2046 would rise to 13,000 and 16,000 respectively.

68. It can similarly be deduced from Table 3 that 800, 1,300, or 2,300 new self-powered vehicles would be required to be built over 30 years, in the three scenarios, assuming the replacement of all of the 2,600 BR-procured diesel vehicles.

Figure 3 – Fleet Size and Composition (Medium Scenario)

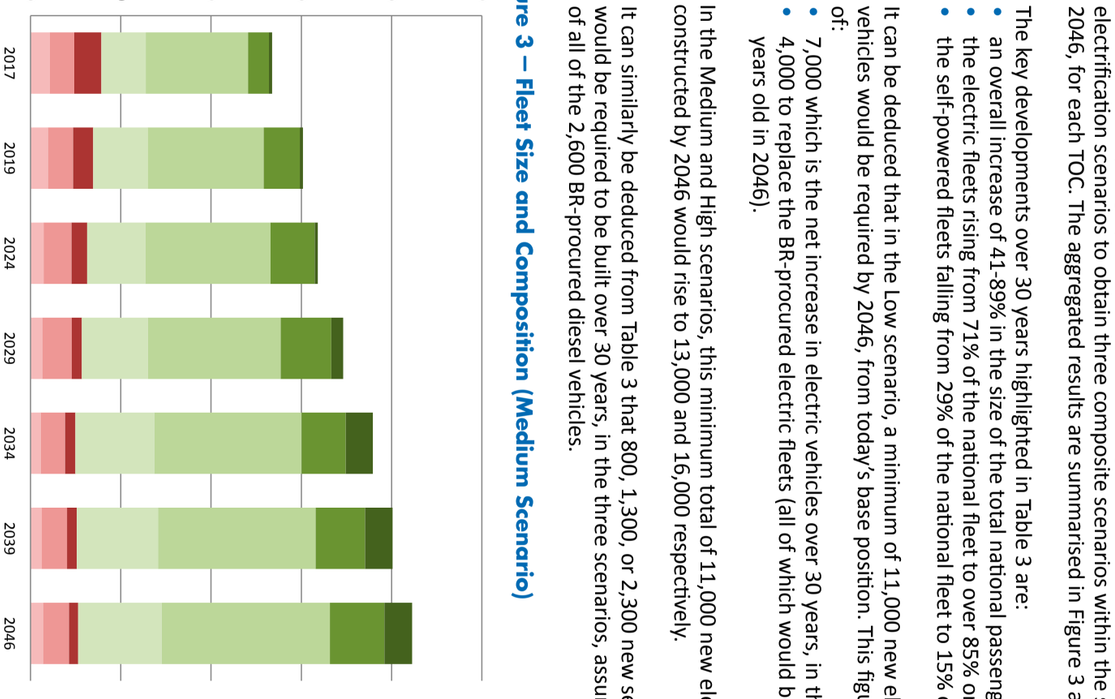


Table 3 – Aggregated Results of Fleet Size Changes for the National Passenger Fleets to 2046 (Low, Medium and High Scenarios)

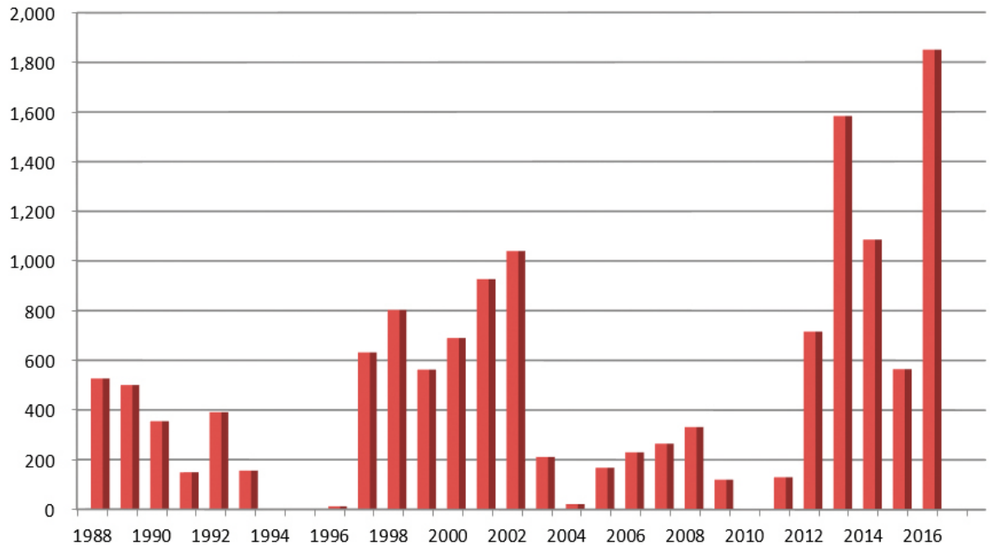
	Committed	Forecast CP5, March 2019			Forecast CP6, March 2024			Forecast CP7, March 2029			Forecast CP8, March 2034			Forecast CP11, March 2046		
Sub-Group	**Total Vehicles**	**Total Vehicles**			**Total Vehicles**			**Total Vehicles**			**Total Vehicles**			**Total Vehicles**		
	Period 13, 2016/17	**Low**	**Med,**	**High**	**Low**	**Med,**	**High**	**Low**	**Med,**	**High**	**Low**	**Med,**	**High**	**Low**	**Med,**	**High**
A, Shorter Distance Self-Powered	1,057	941	957	973	714	722	794	583	646	771	473	563	742	517	690	944
B, Middle Distance Self-Powered	1,367	1,367	1,399	1,436	1,505	1,548	1,692	1,519	1,635	1,864	1,256	1,355	1,583	1,286	1,436	1,724
C, Long Distance Self-Powered	1,500	1,063	1,111	1,162	949	869	910	471	562	721	472	574	851	330	514	986
D, Shorter Distance Electric	2,461	3,012	3,021	3,030	3,182	3,227	3,282	3,478	3,655	3,860	4,114	4,363	4,648	4,232	4,628	5,126
E, Middle Distance Electric	5,670	6,430	6,430	6,438	6,826	6,930	7,147	7,093	7,359	7,804	7,636	8,156	8,914	8,282	9,315	10,764
F, Long Distance Electric & Bi-Mode	1,148	1,999	1,999	1,999	2,293	2,446	2,489	2,591	2,802	2,956	2,060	2,446	2,752	2,438	3,021	3,611
G, Very High Speed Electric	174	174	174	174	174	174	174	613	663	746	1,427	1,511	1,758	1,443	1,532	1,787
TOTALS	**13,377**	14,986	15,091	15,212	15,643	15,916	16,488	16,348	17,322	18,722	17,440	18,969	21,248	18,527	21,136	24,943
Fleet Size Growth from Sept. 2016	2%	14%	15%	15%	19%	21%	25%	24%	31%	42%	32%	44%	61%	41%	60%	89%
Self-Powered Totals	3,924	3,371	3,467	3,571	3,168	3,139	3,397	2,573	2,843	3,356	2,202	2,492	3,176	2,132	2,640	3,654
Electric & Bi-Mode Totals	9,453	11,615	11,624	11,641	12,475	12,777	13,091	13,776	14,480	15,366	15,238	16,477	18,072	16,395	18,496	21,288
% Electric & Bi-Mode %	71%	78%	77%	77%	80%	80%	79%	84%	84%	82%	87%	87%	85%	88%	88%	85%

Source: Analysis as in Table 3.

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

69. The historically high volume of orders for new trains in the last five 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 4 below). This is discussed further in Section H below.

Figure 4 – Orders Placed for Mainline Passenger Rolling Stock (exc. LUL and Light Rail)



Source: Railway Industry Association.

A new Class 345 Bombardier Aventra train, soon to be operating on TfL's Crossrail services

H. Rolling Stock Requirements in CP5 and CP6

70. In previous editions and again for this fifth 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 seven years. This has formed a key input to the IIAs for CP6 to be published in the spring of 2017, and to the RSBPs for CP6 which it is expected will be published in December 2017.

71. It had previously been thought that a 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 some additional new self-powered vehicles would be required. Delays in electrification programmes, together with continuing high rate of growth of passenger demand have resulted in the higher numbers now declared in paragraph 68 above. In the ARN franchise, the DfT's decision to eliminate the 214 Pacer vehicles mandated the construction of some new DMUs. In the new Caledonian Sleeper, ARN, TPE and AEA franchises, two new suppliers, CAF of Spain and Stadler Rail of Switzerland, have entered the UK market with a range of EMU, DMU, loco-hauled and bi-mode products. The creation of these new fleet types broadens the range of certified new vehicles available to the wider British market, and may encourage further orders of this kind from these and other manufacturers for other franchises. This is clear evidence of the market responding to a challenge and utilising new technology to produce incremental benefits.

72. As outlined in Appendix 5, our updated analysis indicates that 3,189 new pure electric vehicles, 772 bi-mode vehicles, 141 loco-hauled coaches and 93 pure diesel vehicles (including 14 diesel locomotives) are now committed for delivery in CP5 (for England, Wales and Scotland, and including TfL's rail concessions). The total figure to be delivered in the five years of CP5 is 4,195 new vehicles. This total may be compared with the figure of "up to 4,150" new vehicles forecast to be delivered in CP5 as quoted in early editions of the RSS. This is a very large requirement for new vehicles in a single five-year period, and can be compared with the total of 1,055 new electric and diesel vehicles delivered in CP4. Furthermore, a total of 1,496 pure electric, 258 bi-mode vehicles and 61 pure diesel vehicles have already been committed for delivery in the early years of CP6, a total of a further 1,815 new vehicles. The forecast delivery dates of committed new rolling stock in CP5 and early CP6 are shown in the Timelines contained in Appendices 1 to 3 of this RSS.

73. The total number of new vehicles committed for delivery in CP5 and in the early years of CP6 is therefore now 6,010, compared with the figures of 3,800 and 4,500 reported in the third and fourth editions respectively of the RSS. These new vehicles will have a capital cost of around £10 billion. Around 50% of the new vehicles will be built in Britain. Almost 4,000 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.

74. The total replacement of all vehicles in the AEA franchise with new rolling stock has generally been welcomed by stakeholders and passengers. Quality, capacity and deliverability were an important focus of the competition, and this procurement indicates that the DfT has government support for significant improvement in the rolling stock base. The procurement will displace some ex-BR rolling stock and also some relatively recent EMU and DMU vehicles, for which no plans exist at present. It is notable that various alternative rolling stock solutions, including heavy refurbishment and life extension, were not contracted for the full franchise period in the winning bid. The displaced rolling stock from AEA, including some recently built vehicles, may be required to go into storage, joining vehicles displaced by the new Thameslink fleets in particular. Network Rail's delayed and potentially de-scoped electrification programme has reduced the opportunities to return displaced rolling stock to operation, and a number of vehicles, many of which have significant remaining life and value, are facing an uncertain future. It falls to the vehicle owners to manage the financial impacts brought about by this unprecedented rolling stock market liquidity.

75. Our updated fleet size forecasts contained in Table 3 of this RSS show the electric and bi-mode fleet totals increasing by a net figure of between 860 and 1,450 over the course of CP6, in the three scenarios. This compares with a forecast net increase of approximately 2,900 electric and bi-mode vehicles over the course of CP5 (April 2014 to March 2019). It is not possible to predict how many older electric vehicles will be permanently retired during these control periods, and also how many EMUs which may temporarily be off-lease at the end of 2019 may move back into operational use during CP6. Nevertheless, it appears probable on the basis of the assumptions contained in this analysis that the total number of new electric and bi-mode vehicles required to be delivered in CP6 will be less than in CP5.

76. The over-riding reason for this is that the Thameslink and Crossrail projects, and replacement of many of the InterCity 125 trains (HSTs) built in the 1970s, all represent major investments which had long gestation periods and are due to come to fruition in CP5. Earlier editions of the RSS had forecast that there would be few orders of 600 or more vehicles for a single TOC in subsequent years but the orders for the AEA franchise have proved this to be incorrect. (HS2 is forecast to require around 500 new vehicles in CP7, with a further 700 to 800 in CP8).

77. In the latest DfT franchise replacement programme, there are eight franchises planned to be let in the next three years (see Appendices 1-3). These franchises currently contain over 2,000 BR-procured vehicles (excluding those vehicles for which replacement plans already exist). These will be 25-40 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 in CP6 may be expected.

78. 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. The contract for the replacement of trains on the Piccadilly, Central, Bakerloo and Waterloo & City lines, commencing in the early 2020's, is expected to be announced in autumn 2017 and will require similar total numbers.

79. 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.

80. The new liquidity in the EMU market referred to above is not replicated for DMUs. All of 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 in the next 10 years to 2027, all being 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 be operating beyond that date, if environmental legislation and the supply of engines permit this, but the trend of cross-party political ambition to improve the quality of environment and facilities offered to passengers across the country shows no sign of abatement. Refurbishment and modernisation will be required if older stock is to be retained, and in the EA competition, it would appear that manufacturers were able to offer new vehicle packages that were more attractive.

81. With political and environmental pressure already resulting in the banning of diesel road vehicles from some cities in the world, the pricing of asset life risk on diesel-only rail vehicles is likely to increase and further incentivise the development of other sources of traction power.

82. Based on the figures in Table 3, a total of between 2,100 and 3,600 self-powered vehicles will be required in service in 2046. 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. It is still possible that relatively few new self-powered vehicles may be required to be built in the 30 years to 2046. Alternatively, if environmental legislation were to be strengthened, and/or quality factors were to become dominant, then up to 3,600 new self-powered vehicles might be required. A requirement this high is considered unlikely, particularly with the impact of bi-mode trains discussed above. In summary, the long term market requirement for pure diesel powered vehicles appears relatively small compared with the 11,000 to 16,000 new electric and bi-mode vehicles forecast to be required over this period (see Section G above), and with the opportunities for hydrogen fuel cell powered and hybrid technology.

83. RSSSG has further revised its previous detailed analysis and sensitivity testing of the shorter term requirements for self-powered trains in recent months, in the light of the Hendy Report, Network Rail electrification delivery and recent franchise awards. This indicates a shortage of around 200 Type B self-powered vehicles in the next two years, but that this will be resolved subsequently with the implementation of committed electrification and delivery of new bi-mode and DMU vehicles for the ARN, TPE and AEA franchises. The award of the latter in 2016 saw a commitment to introduce 138 bi-mode vehicles, with the diesel traction supply contained in its own vehicle in the middle of each unit. These units will completely replace the previous DMUs on predominantly rural, non-electrified routes, but the central "diesel power vehicle" will provide a level of future-proofing. These trains could be made pure electric in future, which should be relatively straightforward and cost significantly less than a new build – a feature that makes them flexible and attractive, particularly given the uncertainty over future electrification.

84. There will be some unsatisfied demand for self-powered vehicles in the next one to two years, but RSSSG is confident that the industry (TOCs, train builders and leasing companies) can continue to innovate to provide appropriate solutions into early CP6. Life extension on Chiltern (loco haulage) and ScotRail (HST refurbishment) are two examples, and the Vivarail product is still under development. The creation of the Class 319 Flex bi-mode train in response to pressures brought by delayed electrification on the ARN routes is another innovative solution.

85. 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 of 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 March 2017). 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. Owners did not plan to modify old vehicles that were identified to be cascaded out of service and for which they had received no interest for future leasing by TOCs. The slippage of Network Rail's electrification and other infrastructure programmes will bring risk to these plans if it does not prove possible to operate all of the envisaged new and existing electric vehicles, and hence to achieve the cascades to remove some of the oldest diesel vehicles from service. In response to Network Rail delays, some vehicles have already been identified and added to the programmes for modification (e.g. the CrossCountry HSTs through their new Direct Award) – but careful fleet and infrastructure planning is required to ensure that an unmanageable bow-wave does not develop in the supply chain in 2018/19.

86. 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, by mid-2017. 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.

A ScotRail Class 170 DMU built in 2004

I. Passenger Requirements and Benefits

87. 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. Providing an affordable railway means that the national fleet will comprise trains close to the end of their working lives as well as new trains.

88. 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. 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.

89. 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 wifi 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. 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.

90. 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.

91. RSSSG'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.

92. 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.

93. The setting of aspirations for passenger rolling stock is undertaken by the DfT in its publication 'Rolling Stock Perspectives – Moving Britain Ahead'. This sets out aspirations for passenger rolling stock towards which the industry should work, with particular reference to passenger facilities. 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 wifi, 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.

94. The document also emphasises that "There is a great opportunity for the market in improving the design and styling of trains on the network and to put passengers at the heart of this, both through refurbishing existing stock and in the design of new trains".

95. 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 2016, the average 'satisfied or good' score for 'Overall Satisfaction with the Train' was 80%. 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. Three TOCs on which all or most vehicles have been replaced c2c, London Overground and Virgin West Coast all score 88-89% satisfaction, 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.

96. 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.

97. Future rolling stock design will, as with the Class 378 for London Overground, S-Stock for LUL and Class 345 for Crossrail, and as indicated in the ITT for the new South Western franchise, be influenced by the need to reduce station dwell times as a key component of optimising total system capacity. Vehicle interior configuration, door width, stepping distances, and inter-car gangways are all components of this optimisation process.

98. Statutory requirements for on-train facilities for passengers with reduced mobility are being delivered through the PRM-TSI modifications (see paragraph 85 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.

J. Fleet Reliability

99. 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.

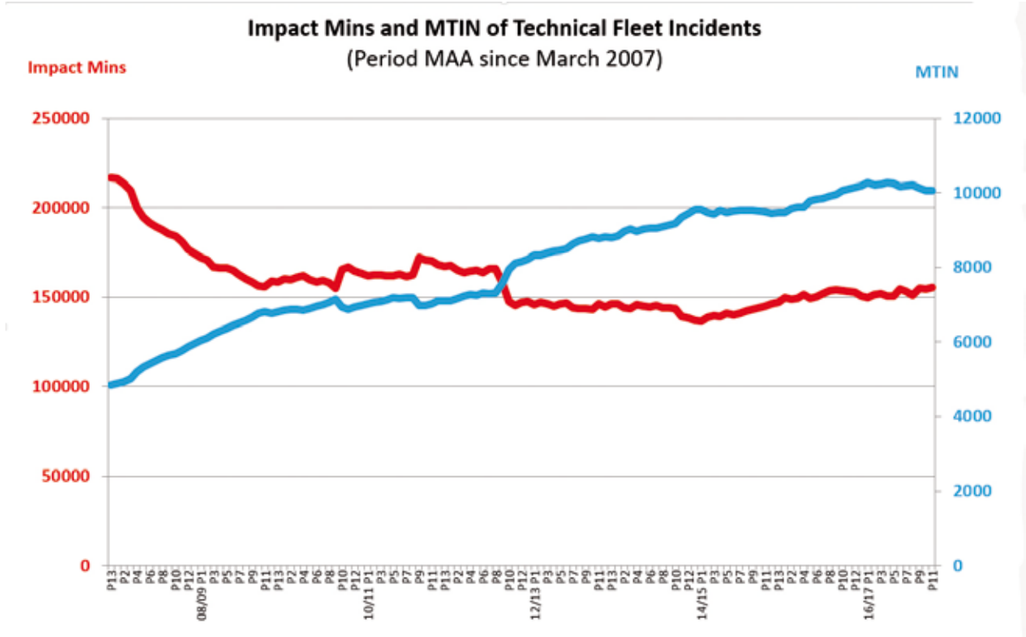
100. Strategic direction in setting the national planned performance levels for punctuality and reliability is provided by the industry's senior performance group, the National Task Force (NTF). The overall national fleet reliability improvement strategy is managed by a Fleet Challenge Steering Group. 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.

101. 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.

102. 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.

103. The moving annual averages of total fleet-related impact minutes and of average MTIN are shown in Figure 5 for the period since March 2007.

Figure 5 – Rolling Stock Reliability Growth since March 2007



Source: RDG and Network Rail, as monitored by NTF

104. In Figure 5 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 2015/16 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.

105. 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 4 – MTIN MAA Miles per Technical TRUST Incident, by Fleet Class Group

Fleet Class Group	MTIN MAA as at Period 9 2016/17
Modern EMU	42,197
Midlife EMU	17,690
Modern DMU	15,642
Other Intercity Traction	15,463
Old Generation EMU	15,194
Midlife DMU	9,608
Old Generation DMU	8,066

Source: TOC Inputs to RDG, used for ReFocus Benchmarking

106. In this Table 4 it can be seen that:
- the 'Modern EMUs' have an MTIN MAA that is two or more times better than any other category of unit; and
- the 'Old Generation DMUs' and 'Midlife DMUs' have significantly the lowest MTIN MAA.

107. Four of the individual 'Modern EMU' sub-fleets are now achieving MTIN MAA figures of more than 90,000, with two others 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.

108. 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.

109. 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 2016 indicate that the industry is on track to meet its target of a 20% improvement over the course of CP5. The improvement target for CP6 has not yet been determined. 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, as electrification progresses and as the proportion of Modern EMUs in the national fleet increases, in addition to the many other initiatives that are being and will be developed to improve the reliability of existing fleets.

110. 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.

111. 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.

112. It can be difficult to make the business case for such systems, unless additional funding is provided, as was the 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.

113. 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.

114. 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. The pan-industry Depot & Stabling Steering Group addresses this issue, and further detail is provided in Section L below.

K. Sustainable Development, Technology and Standardisation

115. 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.

116. The industry outlined its traction carbon ambition for CP5 in the ISBP and is currently developing a CP6 ambition, based on the RSS, which will be included 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.

117. 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.

118. The freely available Key Train Requirements document (see paragraph 115 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.

119. 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 123 and 124) that address these issues – and is working to assure the franchising authorities that this issue is being effectively managed.

120. The rate and degree of change in railway performance required to meet future stakeholder expectations is increasingly difficult to afford and technically challenging to achieve by conventional solutions, and sometimes appears to require trade-offs e.g. between capacity and punctuality. Technology created through R&D enables new value to overcome such challenges. Sustained investment in the creation of new capabilities can bring the railway system to a position where it is possible to simultaneously increase capacity, reduce whole life costs and become more efficient and improve punctuality and the total passenger experience. These capabilities then require rapid application across the whole of the railway system to reap the maximum benefit as swiftly as possible.

121. 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 new 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.

122. 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.

123. 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.

124. 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.

125. It is not always recognised that the operation of the normal commercial process in franchising, train procurement and leasing since privatisation has, in practice, naturally led to the evolution of several large families of trains whose designs have continued to evolve, most particularly:
- Siemens' Desiro and Desiro City EMUs (16% of the present national fleet);
- Bombardier's Electrostar EMU (16% of the present national fleet); and
- Bombardier's Turbostar DMU (4% of the present national fleet).

126. This may have happened because, once a manufacturer has developed a train type and this has been successfully proved safe and reliable in service on the UK network, barriers to entering the market have been overcome, and that manufacturer may have a commercial edge in competition over a new manufacturer trying to enter the market.

127. As part of the Interoperability Network Study, the UK rail industry is seeking to promote the adoption of standardised passenger rolling stock gauges on the rail network in Great Britain and thereby reduce the requirement for bespoke vehicles and/or infrastructure. This study will identify a baseline for current gauge clearance and a long term aspiration for a gauge cleared network which maximises the ability of rolling stock to operate on as many routes as possible. A wider network on which a vehicle can operate means more operational flexibility and reduced financier residual risk.

128. As route capacity has become more constrained, the Route Planning Process and Route Studies (and future RSBPs) 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.

129. Route Studies have been driven by Network Rail in recent years, with support from TOCs and other stakeholders, which was an appropriate model before Network Rail was taken into government accounts. The relationship between Network Rail and DfT is now becoming much closer in this area, and it is likely that the expectations on the role of rail transport in the economy, and the funding of infrastructure to support that role will become more closely tied, with strong focus to deliver projects on time and budget. Recent new rolling stock procurement has generally met financial targets, but new electrification, power supplies, stabling and other facilitating infrastructure enhancements are still high risk items that threaten the delivery of business plans. Initiatives that assist the industry in the formation of robust and reliable long term views are to be welcomed as they promote confidence, and consequently investment and innovation.

130. 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.

L. Depots, Stabling, Skills and Infrastructure Requirements

131. A number of plans for the additional maintenance depot capacity and berthing sites required for the large expansion of fleet sizes in CP5 have already been delivered, or are well advanced.
- Several new depots have already been constructed or adapted (e.g. at Reading, and Liverpool Allerton).
- Construction is either completed or is well advanced for the other new and reconfigured depots and berthing locations required for the IEP, Thameslink and Crossrail fleets.
- The depot and stabling capacity that will be required for fleet growth in the ScotRail, ARN, TPE and AEA TOCs is committed by the new franchisees.

132. The ORR included a £312 million Depot and Stabling Fund for other depot and stabling enhancements (e.g. for electrification schemes in England and Wales) in its determination of Network Rail's funding requirements in CP5, but subsequent to Network Rail overspends and the Hendy Report, all funds not directly allocated to schemes by autumn 2015 were lost. The last project, a new depot at Banbury, has been curtailed, again due to major Network Rail budget issues. The pan-industry Depots and Stabling Steering Group (DSSG) is delivering the Depots and Stabling workstream for the IIA for CP6. Within the IIA, a further submission for funding will be made in respect of depot and stabling capacity. This is a bottom-up submission, based on the infrastructure picture at autumn 2016.

133. DSSG continues to progress strategic work to give structure to depot and stabling development, while upholding the principle that additional depot and stabling capacity should be franchise bidder-led wherever possible. Good practice is recorded in Design Considerations for Rail Maintenance Depots published by Network Rail in 2012, in Key Depot Requirements published by ATOC in 2014, and the group has prompted RSSB to develop a depot design guidance note in 2017. DSSG has constructed a database of current depots and their key facilities and capacities, and has also developed a basic model to indicate the likely costs of additional depot and stabling facilities. These records are now undergoing their second annual review.

134. DSSG uses inputs from the RSS spreadsheet model to draw forecasts for increased depot and stabling capacity. DSSG is working directly, and through TOCs, to get its forecasts recognised in the RSBPs, and thereby ensure that Network Rail have all they need to manage their property portfolio, and future proof their plans accordingly. Considerations can be wide ranging – from operational development (e.g. lengthening of train formations) to alternative brownfield sites for new depots. This is particularly important as Network Rail is currently under pressure from government to release poorly utilised land for urban housing development. DSSG gives Network Rail sight of new trackside maintenance technology (e.g. trackside acoustic monitoring; monitoring cameras for underframes / gauge / pantographs) and provides information on environmental, social, water and energy considerations.

135. Depots have a significant environmental footprint and the DSSG input to the IIA includes consideration of sustainability best practice in the selection of depot locations, and the design, enhancement and construction of depots. This is also embedded in franchising commitments, with requirements to reduce non-traction energy use, fit water meters and send zero waste to landfill. RSSB is currently developing best practice guidance on building energy efficiency technology for the industry, which will include depots.

136. Significant investment will be required to upgrade older depots which are barely adequate for their present fleets, let alone for the next generation of trains. Furthermore, the need for safe working with 25kV EMUs will necessitate substantial modification to some existing DMU depots if these are to remain in use following electrification. In some locations it will be more cost-effective to construct a new depot on a new site.

137. Depot operation, management and ownership are varied across the UK network, having evolved according to local need since privatisation. TOCs and manufacturers maintain new and older fleets according to franchise preferences; however, the manufacturers' ability to raise capital when introducing large new fleets has meant that most modern hi-tech depots have been custom designed by manufacturers to support particular fleets of rolling stock. Siemens' depot at Northampton and Bombardier's at Central Rivers are notable examples. In this structure the maintenance of a TOC's key asset is contracted out to a committed supplier.

138. Where rolling stock is older, or of a well-proven design, TOCs have generally chosen to maintain these fleets at the BR legacy depot sites which they lease, preferring to take responsibility for managing the risks inherent in these vehicles.

139. There is no single right answer to the maintenance question – and there are all manner of variations to the above two basic structures, all aimed at placing risk in the hands of those who are best placed to manage it. Reliability data shows that each structure is capable of delivering class leading performance. Provision of additional depot and stabling capacity should be franchise bidder-led wherever possible.

140. It is important to emphasise that the adverse consequences of not providing adequate and suitable depot and stabling facilities detrimentally impact the effective and efficient deployment of the national rolling stock fleet. Despite attempts to raise its profile, this area remains under-valued. DSSG will develop a longer-term vision that transcends franchise boundaries and reletting timescales.

141. The scale of future additional berthing required is also indicative of the scale of infrastructure investments that will be required on each of the routes. This requirement is being developed through the industry's LTPP including its Route Studies and RSBPs. These will document a range of route-specific solutions including:

- longer trains;
- increases in the number of trains per hour, produced by:
  - more homogeneity in the performance characteristics of rolling stock types on specific routes;
  - the Digital Railway, including shorter headways between trains produced by changes to signalling, driver advisory systems, ERTMS (initially at Level 2 and subsequently at Level 3), intelligent automated traffic management and centralised train control systems;
- incremental infrastructure – elimination of bottlenecks and the provision of additional running lines; and
- totally new infrastructure.

142. All of these solutions (except ERTMS Level 3) are already being adopted in the investment programmes now committed and being delivered for CP5, and being developed for the CP6 IIAs. All funders have to face strategic options of affordability and value for money in their infrastructure investment programmes. The scale of growth anticipated in this RSS and outlined in the Network Rail Market Studies indicates the need not only for HS2 plus ongoing incremental investment in many routes, but potentially also for additional completely new infrastructure (e.g. Crossrail 2), and other major enhancements for example on the Brighton Main Line and the routes to and from London's Waterloo station. These schemes will need to be considered alongside measures such as shoulder peak pricing to spread the peaks and shift demand toward available capacity.

Skills and Training

143. A skilled and professional workforce is critical to the success of the railway industry, and this is certainly true for rolling stock maintenance. Short franchises have not always given sufficient incentive for TOCs to invest in recruitment, training and development of engineering staff at all levels. The introduction of new fleet types, new technology, larger fleets and electrification must be accompanied by adequate long term investment to provide the skills necessary to underpin the required business results.

144. The National Skills Academy for Rail (NSAR) has an important role in quantifying potential future gaps in engineering skills, and in developing new tools such as 'skills passports' to enable railway staff to work across the industry. The potential "skills gap" is most acute for the traction & rolling stock sector where 14,500 staff are currently employed today for the design, construction, development and maintenance of rail vehicles. (This figure includes freight and LUL). Over the next 10 years, NSAR has estimated that:

- 4,900 new staff will be required to replace retirements;
- 3,300 additional staff will be required for growth in the sector (net of technology changes);
- Hence a total of 8,200 new staff will be required, equivalent to 57% of today's workforce.

145. There will also be a need for a more systematic approach to career development across the industry to ensure that sufficient numbers of high quality engineering managers are available with the leadership and technical skills required for future years. Two major injections of new training resources will come from:

- The National Training Academy for Rail (NTAR) at Northampton. This has been established by Siemens and NSAR, with support from the DfT and the Department of Business Innovation and Skills, (now the Department for Business, Energy and Industrial Strategy (BEIS)) for the rail industry, and is now operational.
- The National College for High Speed Rail, now funded to construct and commission its two sites in Birmingham and Doncaster, with training to commence in the autumn of 2017.

146. The Transport Infrastructure Skills Strategy published in January 2016 has outlined how the Government's commitment to 30,000 apprenticeships in this sector by 2020 is to be achieved.

At Stansted Airport with an AEA Class 379 "Stansted Express" EMU manufactured by Bombardier

M. Improving Value for Money from the Rolling Stock Fleets

147. 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.

148. 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 franchise 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.

149. 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.

150. The business case for any electrification project must be based on the specific characteristics of the route and service groups to be electrified e.g. route characteristics such as the number and extent of overhead structures requiring increased clearance for the overhead power supply, and the potential for revenue growth; in addition to the potential for reduction of operating and fleet maintenance costs.

In the drivers seat. A mock-up of the new Hitachi Class 800 IEP cab

151. 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.

152. 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. This feature is particularly important at the extremities of electrification routes, where lower train loadings weaken expensive electrification business cases.

153. 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 2015/16. 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 in 2016 has seen prices stabilise at around $50/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 on the basis of a long term view on the difference between diesel and electricity prices.

154. 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.

155. 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. The increased stability and visibility of the franchising programme promotes industry confidence and coupled to recent initiatives in the transfer of residual asset value at franchise end points, some key barriers to investment have been removed.

156. 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.

N. Conclusions

The Size and Composition of the Future National Fleet

157. The forecasting methodology for this fifth 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 electrified 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 41% and 89% over 30 years, while the proportion of electric (and bi-mode) vehicles would rise from 71% today to between 85% and 88% over the same period.

158. 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. The committed components of railway route enhancements have been forecast by Network Rail to generate up to nine billion more rail passenger kilometres per year by the end of CP6 with major schemes such as HS2 and Crossrail 2 to be delivered beyond this. 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 are expected to make a substantial contribution to demand and revenue growth during CP6, potentially doubling the level of growth delivered by 'external' factors only.

159. The consequence of the modelled scenarios is that between 11,000 and 16,000 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 6,010, compared with the 4,500 reported in the fourth edition of the RSS, at a capital cost of more than £10 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. The average age of the fleet is estimated to fall from 21 years to 15 years by March 2021.

161. Our updated fleet size forecasts show the electric and bi-mode fleet totals increasing by a net figure of between 860 and 1,450 over the course of CP6 in the three scenarios. These figures are smaller than previously forecast because of the slower than anticipated completion of Network Rail's electrification programme. This compares with a net increase of approximately 2,900 electric and bi-mode vehicles over the course of CP5. It appears probable on the basis of the assumptions contained in this analysis that the total number of new vehicles required to be delivered for the franchised TOCs in CP6 will be less than in CP5, but this number may be increased by additional new rolling stock to replace BR-procured vehicles, and this total excludes new vehicles for LUL deep tube routes.

162. The historically high volume of orders for new trains in the last five years reflects the lack of such investment in some previous years, plus the implementation of the Thameslink, Crossrail and IEP projects. There is a 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.

163. 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 about orders for new electric vehicles beyond CP5.

164. It is apparent that the difference in the net cost of ownership of new and life-extended EMUs has closed in the last two years, due principally to a reduction in the 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.

165. As forecast in the fourth edition of the RSS, it is still believed that some further diesel or bi-mode vehicles will be required in early CP6, as a result of:
- the existing levels of crowding and continuing strong growth of passenger demand on some non-electrified routes; and
- the slower than anticipated rate of completion of the committed programme of electrification.

166. RSSSG has updated its previous detailed analysis of the total number of Type A and Type B vehicles likely to be required in each year to 2024. This work indicates a shortage of around 200 Type B self-powered vehicles in the next two years, but that this will subsequently be resolved with the implementation of committed electrification and the delivery of new bi-mode and diesel vehicles for the ARN, TPE and AEA franchises. The diesel vehicles displaced by these new vehicles are of varying age and may also be suitable for cascade, possibly helping to fill some of the envisaged DMU resource gap. In the longer term, based on the amended electrification assumptions adopted for this edition of the RSS, a total of between 800 and 2,300 new vehicles capable of operating off the electrified network will be required over this 30-year period.

167. With political and environmental pressure already resulting in the banning of diesel road vehicles from some cities in the world, the pricing of asset life risk on older diesel-only rail vehicles is likely to increase, further incentivising the transfer of automotive sector power train development into rail applications. This residual risk pressure is less strong for bi-mode vehicles, which are operationally flexible and may operate under externally supplied power where this is available.

168. 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

169. Rolling stock-related costs per vehicle mile can be reduced in real terms as a result of these changes because the cost of leasing and maintenance 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. Future energy costs and the relative costs of diesel fuel and electricity are in contrast very difficult to forecast. Electricity costs are currently rising to help pay for lower carbon sources, while diesel fuel costs have fallen. Decisions on further electrification will always need to consider a long term view on the difference between diesel and electricity prices, including future levies, not just the current market differential.

170. The presently committed programme of electrification will take the proportion of track mileage that is electrified from 42% to 51%. The Low, Medium and High scenarios in this RSS illustrate the consequences of increasing this figure to 58%, 63% or 68% in subsequent years. This is a smaller programme, implemented more slowly, than was assumed in previous editions of the RSS. The adoption of such a programme would be subject to a range of factors including the strength of business cases, the pace of technological development of alternative and more cost-effective electrification solutions, environmental and other priorities, and the availability of funding.

171. 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 rather than as pure electric or pure diesel trains.

172. 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. The challenges in delivering the CP5 programme have party resulted from there not being a longer term strategy to electrify the rail network over the last 30 years.

173. Electrification will produce journey time improvements, route capacity benefits, revenue increases, fleet reliability improvements and substantial carbon reduction advantages. The impact of the RSS is potentially good news for the economy and could offer additional employment and business opportunities – in manufacturing, maintenance, installation and the associated supply chains, for vehicles and electrification; and in programmes for cost-effective life extension and re-tractioning of older vehicles.

174. 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. The increased stability and visibility of the franchising programme promotes industry confidence and coupled to recent initiatives in the transfer of residual asset value at franchise end points, some key barriers to investment have been removed.

175. 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 such projects will require the positive engagement of all parties.

Depots and Berthing

176. The scale of increase in fleet sizes outlined in this RSS will require additional berthing locations and some new maintenance depots. Provision of this capacity for CP5 is already well advanced. Our analysis shows that a further increase in berthing capacity of around 6% will be required to 2024, and 45% to 2046, in the Medium scenario, these increases being relative to total capacity at the end of CP5 in 2019. Provision of additional depot and stabling capacity should be franchise bidder-led wherever possible.

177. Careful management of Network Rail's property portfolio will be required to ensure that land required for future stabling will be available in the required volume and location in the future. Network Rail is under pressure to dispose of under-utilised land under current government policy, and there are industry concerns that critical sites may be under threat. RSBPs are seen as the forums in which an appropriate balance should be found, but the time required to construct and review these key strategy documents poses the risk that depot and stabling issues may not be considered constructively in a timely manner. Current arrangements for the protection of Network Rail owned land adjacent to running lines do not appear to be robust.

178. DSSG's review of depot capability is about to undergo its second review. The database and its associated models are available to those working on remits in this arena. DSSG can also provide support for the introduction of new maintenance technology (in-depot and trackside), and is working to ensure that this equipment features in RSBPs.

179. It is important to emphasise the adverse consequences of not providing adequate and suitable depot and stabling facilities beyond CP5. This could otherwise have a detrimental impact on the effective and efficient deployment of the national rolling stock fleet. Despite attempts to raise its profile, this area remains under-valued. A longer-term vision is needed that transcends franchise boundaries and reletting timescales.

180. A skilled, professional workforce is critical for the safe and effective maintenance of rail vehicles – and following a lull in training activity post privatisation, a number of modern training facilities are now on line to provide over 8,000 maintenance engineers that are forecast to be required over the next 10 years – a number representing 57% of the current workforce. This requirement is in a market where engineers are in demand across the economy; the rail industry needs to prove that it can offer an attractive career proposition. In conjunction with the National Skills Academy for Rail and with government support, Siemens operates the National Training Academy for Rail (NTAR) at Northampton. The National College for High Speed Rail will open two colleges in Birmingham and Doncaster in 2017.

Passenger Benefits and Fleet Reliability

181. The direction of travel described in this RSS, combined with a continuing programme of electrification, will produce many benefits for passengers, including:
- 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 wifi.

182. The reliability of the total national passenger fleet as measured by the MTIN MAA benchmarking data has been rising continuously over several years. It is notable that since March 2007:
- 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 overall rate of progress has however stalled in the last year;
- 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 have increased by 14% between 2007/8 and 2015/16.

183. Furthermore:
- the 'Modern EMUs' now have an MTIN MAA that is two or more times better than that of any other category of unit; and
- the 'Old Generation DMUs' and 'Midlife DMUs' have significantly the lowest MTIN MAA.

The Principle of Franchise-Led Procurement

184. Government policy is that rolling stock procurement should in most cases be franchise-led and the RSS fully supports this principle.

185. 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.

186. 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.

TransPennine Express Class 185 DMU. This is the diesel variant of the Siemens "Desiro" train, built in 2005.

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 December 2016;
- Infrastructure dates are as shown in the Network Rail Enhancements Delivery Plan dated December 2016, 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 1, TIMELINE OF KEY ACTIVITIES RELATING TO LONDON & SOUTH EAST FRANCHISES

Item	Start	Finish	2014				2015				2016				2017				2018				2019				2020				2021				2022				2023				2024			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
SE New Franchise	12/2018																																											
c2c Franchise	9/2014	11/2029																																											
c2c New Class 387 EMUs (24 cars)	11/2016	1/2017																																											
c2c New EMUs (68 cars)	tbc	tbc																																											
GTR Franchise	9/2014	9/2021																																											
GTR New Class 387/1 EMUs (116 cars)	12/2014	7/2015																																											
GTR New Class 387/2 Gatwick EMUs (108 cars)	2/2016	9/2016																																											
GTR New Class 700 EMUs (1,140 cars)	6/2016	12/2018																																											
GTR New Class 717 EMUs (150 cars)	6/2017	9/2018																																											
Thameslink Key Output 2 incl ERTMS 24 tph		12/2018																																											
Crossrail Concession	5/2015	5/2023																																												
Crossrail New Class 345 EMUs (594 cars)	5/2017	7/2019																																												
Crossrail Core and Abbey Wood Services		12/2018																																												
Crossrail to Shenfield		5/2019																																												
Crossrail to Reading		12/2019																																												
AEA Franchise	10/2016	10/2025																																												
AEA New Stadler EMUs and Bi-Modes (378 cars)	7/2018	12/2019																																												
AEA New Aventra EMUs (665 cars)	1/2019	9/2020																																											
Overground New Class 378 EMUs (57 cars)	11/2014	12/2015																																											
Overground Full 5-car Operation		1/2016																																												
Overground New Concession	11/2016																																												
Overground New Class 710 EMUs (180 cars)	1/2018	10/2018																																											
Gospel Oak - Barking Electrification		12/2017																																											
SWT Class 458/5 conversion (180 cars)	3/2014	6/2016																																											
SWT New Class 707 EMUs (150 cars)	4/2017	12/2017																																											
SWT Full 10-car Operation (Inners & Reading)		12/2018																																											
SW New Franchise	8/2017																																												
Chiltern Services to Oxford		12/2016																																											
East West Rail, Oxford - Bletchley/ Bedford		CP6																																											
East West Rail Electrification, Oxford to Bletchley		CP6																																											
Chiltern New Franchise	12/2021																																												

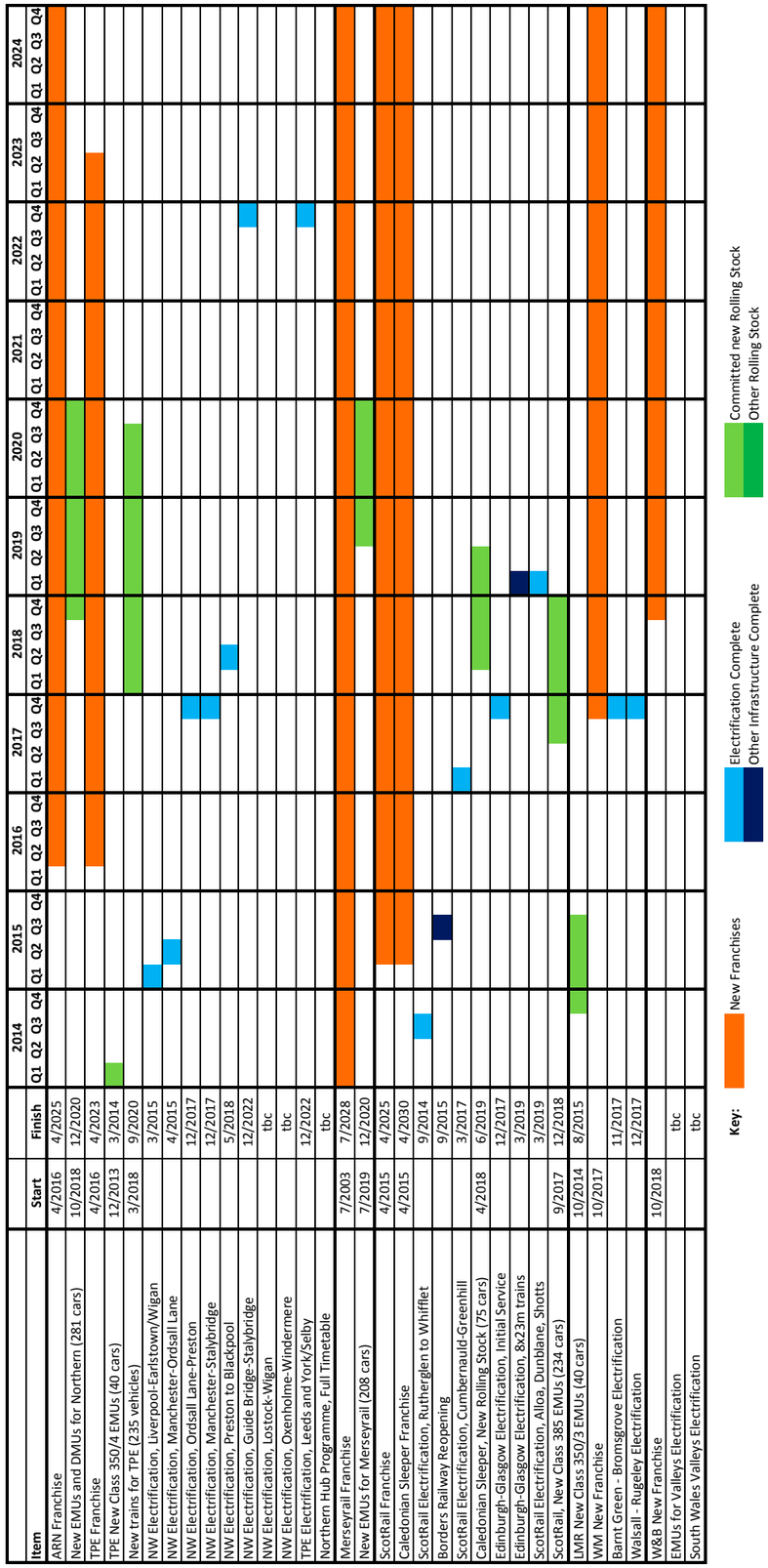
Key: New Franchises; Electrification Complete; Other Infrastructure Complete; Committed new Rolling Stock; Other Rolling Stock

APPENDIX 2, TIMELINE OF KEY ACTIVITIES RELATING TO INTERCITY FRANCHISES

Item	Start	Finish	2014				2015				2016				2017				2018				2019				2020				2021				2022				2023				2024			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GW New Franchise	4/2020																																											
GW New Class 387 EMUs (180 cars)	9/2016	10/2017																																											
GW New Class 800/801 IEP trains (369 cars)	6/2017	7/2018																																											
GW New Class 802 trains (236 cars)	5/2018	3/2019																																											
GW Electrification, Maidenhead-Didcot		12/2017																																											
GW Electrification, Didcot-Cardiff		12/2018																																											
GW Electrification, Reading-Newbury		12/2018																																											
GW Electrification, Thames branches		CP6																																											
GW Electrification, Didcot-Oxford		CP6																																											
GW Electrification, Swindon-Bristol via Bath and Filton)		CP6																																										
GW Electrification, Cardiff-Swansea		CP6																																											
GW Electrification, Reading-Basingstoke		CP6																																											
Western Rail Access to Heathrow		CP6																																											
West Coast Partnership New Franchise	4/2019																																												
VTEC Franchise	3/2015	3/2023																																											
ICEC New Class 800/801 IEP trains, Phase 1 (227 cars)	8/2018	4/2019																																											
ICEC New Class 800/801 IEP trains, Phase 2 (270 cars)	5/2019	4/2020																																											
New Class 802 trains for Hull Trains (25 cars)	4/2019	12/2019																																											
EM New Franchise	7/2018																																												
Rolling Stock for MML Phase 1 Electrification	tbc	tbc																																											
MML Electrification, Bedford-Corby		12/2019																																											
Rolling Stock for MML Phases 2&3 Electrification	tbc	tbc																																											
MML Electrification, Derby, Nottingham, Sheffield		CP6																																											
XC New Franchise	10/2019																																												

Key: New Franchises; Electrification Complete; Committed new Rolling Stock

APPENDIX 3, TIMELINE OF KEY ACTIVITIES RELATING TO REGIONAL FRANCHISES



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	803	
155	175		456	332		
156	185		465	333		
165	195		466	334		
			507	350		
			508	357		
			707	360		
			710	365		
			717	375		
				377		
				379		
				380		
				385		
				387		
				442		
				444		
				450		
				458		
				700		

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 23 and 24 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		
Major DfT/ TfL Procurements				
Crossrail Class 345	504	90	Bombardier	DfT/ TfL
Thameslink Class 700	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	60	270	Hitachi	Agility Trains East
Subtotal, Major Projects	**2,240**	**360**		
Other				
Caledonian Sleepers Mk 5 sleeper train coaches	75		CAF	RBS (owns Caledonian Sleepers Rail Leasing)
TPE, Mk 5A coaches (includes 14 Class 68 diesel locos)	80		CAF	Beacon Rail
ARN Class 195 DMU	79	61	CAF	Eversholt Rail
ARN Class 331	66	75	CAF	Eversholt Rail
LMR Class 350	40		Siemens	Angel Trains
TfL Class 378	57		Bombardier	Joint Venture between SMBC Leasing & NAB
ScotRail Class 385	234		Hitachi	SMBC Leasing (owns Caledonian Rail Leasing)
GTR Class 387	116		Bombardier	Porterbrook
Gatwick Express Class 387	108		Bombardier	Porterbrook
GWR, Class 387	180		Bombardier	Porterbrook
c2c, Class 387	24		Bombardier	Porterbrook
TPE Class 397	60		CAF	Eversholt Rail
SWT Class 707	150		Siemens	Angel Trains
London Overground, Class 710	180		Bombardier	Joint Venture between SMBC Leasing & RBS
GTR Class 717	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
AEA Aventra EMU		665	Bombardier	Angel Trains
AEA Flirt Bi-Mode		138	Stadler Rail	Rock Rail
AEA Flirt EMU	120	120	Stadler Rail	Rock Rail
c2c, Type E EMU	0	68	Under competition	Under competition
Subtotal, Other	**1,955**	**1,455**		
TOTALS	4,195	1,815		

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
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
SWT	The South West Trains 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

Arriva Trains Wales Class 150 Sprinter and Class 143 Pacer trains, both built in the mid 1980s

A Grand Central Class 180 Adelante DMU, built by Alstom in 2000