



Long Term Passenger Rolling Stock Strategy for the Rail Industry

February 2013





Foreword by the Right Honourable Simon Burns MP, Minister of State for Transport

I am very pleased to see this example of proactive cooperation across the rail industry to develop a first 30-year strategy for passenger rolling stock.

The Government is proud of its record in securing investment to provide capacity for the continuing growth in demand for rail travel. We are determined that this combination of strong growth combined with reducing levels of costs will continue to enable a programme of progressive investment in rail infrastructure and rolling stock. This will bring many benefits to passengers, to the national economy, to the communities served by the railways, and to the environment.

With the programmes for Thameslink, Crossrail, electrification and other route capacity enhancements including HS2, we are laying the foundations for a world class railway network. This report gives a first indication of the potential requirements for additional rolling stock in the next thirty years. We welcome the commitment to continued development and annual updating of this Rolling Stock Strategy, so enabling all industry parties including suppliers and investors to plan for the future with confidence. The Government recognises that a reinvigorated franchising programme is necessary to play its part in delivering this Strategy, while securing value for taxpayers.

We are now taking the necessary steps to enable us to resume the franchising programme with the confidence of the rail industry. We will set out our future franchising programme in full in the spring.

A handwritten signature in blue ink, appearing to read 'S. Burns', followed by a period.

Simon Burns MP

Executive Summary

This report summarises the emerging conclusions from the initial phase of work to develop a high level national passenger Rolling Stock Strategy. This is the first time since privatisation that the industry has joined together to work towards a comprehensive, market-led, strategy for passenger rolling stock and we welcome the endorsement which Government has given to this approach.

The first objective has been to model and document scenarios for the size and composition for the national passenger fleet over a 30-year horizon in the context of demand growth, infrastructure enhancements including electrification and HS2, and the need to achieve better value for money from the rail industry.

The Strategy is not a cascade plan for the deployment of rolling stock. It is intended to help inform Government on potential approaches to rail strategy and to stimulate the industry to develop and deliver optimised whole-life, whole-system, rolling stock investments. We believe that the best way of achieving the latter is through the franchising process as this should provide market-driven solutions, procured in a competitive environment, growing the long-term value generated by these businesses.

Forecasts for route-specific peak period passenger growth have been taken from the most recent Route Utilisation Strategies, and are consistent with DfT and Industry-wide growth assumptions. Whilst it is not yet possible to forecast the extent, pace and sequence of a continuing programme of electrification, illustrative prioritised scenarios for a future rolling programme beyond the present committed projects in Control Period 5 (CP5, 2014-2019) have been developed.

A comprehensive spreadsheet model has been developed to construct three composite scenarios, reflecting a range of outcomes for passenger growth and train utilisation, and for the extent of future electrification. This model will facilitate further development and annual updating of the Strategy.

The work done to date indicates that the national fleet size could grow by between 53% and 99% over the next 30 years. These figures reflect different scenarios and further work will be required to understand the infrastructure implications of accommodating this growth in fleet deployed on the rail network. We envisage the industry planning processes, together with the franchising process, will use and refine these figures to establish how best to combine infrastructure, fleet, timetables and other interventions to meet future demand and deliver value for money.

The proportion of the fleet that comprises electric vehicles is forecast to rise from 68% today to 80% in 2019, as a result of committed projects. This might rise to over 90% over the period of the Strategy, in all scenarios, as a consequence of the growth and electrification assumptions modelled. This assumes that the track mileage that is electrified would rise from 40% today to 50% as committed by 2019 and to a minimum of 60% thereafter. The capital cost of such an electrification programme is estimated to be around £3 billion per five-year Control Period.

Electrification will enable relatively new and mid-life DMUs to be transferred to non-electrified routes where growth has been constrained in the past by lack of sufficient diesel vehicles. Electrification will therefore benefit many communities served by both the electrified and non-electrified routes.

Initial calculations suggest that the modelled combinations of electrification and growth can produce a reduction in rolling stock costs per passenger mile for leasing, maintenance and energy combined of more than 30% in all scenarios. Electrification will also produce journey time improvements, route capacity benefits, revenue increases, and substantial carbon reduction advantages.

The modelled scenarios indicate that between 13,000 and 19,000 new electric vehicles will be required by 2042, an average build rate of between 8 and 12 electric vehicles per week over this period. The total could be higher, depending on individual decisions by franchise bidders and funders about the relative merits of life extension and replacement for individual fleets. Requirements for new non-electric vehicles will be small by comparison, possibly as few as 400 to 800 vehicles over this 30-year period.

Early commitments by Government to electrification beyond CP5 could unlock improved supply side efficiency, and encourage confidence in the train leasing markets. This report also outlines other areas of opportunity which could generate further improvement in overall value for money from the rolling stock fleets. Additional work will be undertaken to quantify these in 2013.

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A. Introduction - Goals and Scope

1. This report summarises the emerging conclusions from the initial four months of work towards the development of a first high level national passenger Rolling Stock Strategy. This is the first time since privatisation that the industry has committed to develop a collaborative, industry-led Strategy for passenger rolling stock. It is also the first time that the long-term rolling stock implications of growth, electrification, HS2 and other major projects have been modelled and considered together.
2. The need for a high-level, long-term Rolling Stock Strategy as a way of helping shape future expectations on fleet was articulated by ATOC in its discussion paper 'Rolling Stock and Value for Money' published in December 2011. That paper set out a number of proposals for delivering better value for money from rolling stock and was welcomed in the March 2012 Government Command Paper on rail. Amongst its recommendations were that putting train operators, rather than DfT, in the lead for planning and delivering rolling stock was the best way forward and that development of a long-term rolling stock strategy would help shape expectations, allowing manufacturers and suppliers to gear up accordingly.
3. Since then, the proposal for a Rolling Stock Strategy has been developed by a cross-industry Steering Group, chaired by Richard Brown, and comprising ATOC, Owner Groups, Network Rail and the three principal train leasing companies (ROSCOs), who are jointly funding the work. DfT attends the Steering Group meetings as an observer. The approach has been to work from the perspective of long-term passenger demand and its implications for different types of rolling stock. This in turn has enabled the Steering Group to develop a number of scenarios for future fleet size. The preliminary results have been discussed with the Rail Industry Association's (RIA) rolling stock members, and discussion with individual manufacturers is continuing. The Rail Delivery Group, who sponsor the rail industry's Planning Oversight Group, has been briefed on development of the Strategy and the work has also fed into the Industry Strategic Business Plans, published at the start of January.
4. The fundamental aim of the Strategy is as follows:

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

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

5. The Strategy will add value through:
 - Providing a backdrop for longer term planning, in particular by train builders and their suppliers, ROSCOs, and Network Rail;
 - Identifying opportunities to smooth peaks and troughs of workload;
 - Highlighting priorities for further Value for Money (VfM) work;

- Facilitating a whole system approach to strategy, bringing together infrastructure, demand growth, train services and fleet scenarios;
 - Assisting investors understand the longer term prospects and opportunities for the industry.
6. The next stages of work on the strategy will aim to:
- Develop industry and DfT thinking on opportunities to deliver greater rolling stock VfM in areas beyond electrification;
 - Review and update the scenarios modelled for the Strategy in the light of broader considerations, such as infrastructure capacity, fares policy and crowding standards;
 - Consider options for Government and ways in which the franchising and network planning processes can work better together to find good value for money solutions.



B.The Approach Adopted for the Strategy

7. Scenarios for fleet size have been modelled by five-yearly Control Period for the whole of the 'main line' passenger fleet including Scotland, LOROL, Crossrail, and HS2 but not the light rail, LUL, or international fleets.
8. Each of the existing 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 mph capability);
 - G. Very High Speed Electric (140 mph and above, for domestic services on HS1 and HS2).
9. Individual Class numbers have not been used in the associated analysis. The Strategy is not a 'cascade plan' for the deployment of rolling stock, nor is it in any way prescriptive. 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 at the time.
10. To develop these scenarios, we have started with expectations for growth in peak period passenger demand, for which the long-term forecasts contained in the latest 'Generation 2' Route Utilisation Strategies (RUSs) published by Network Rail in 2011 have been used. These forecasts are consistent with those in the recent Industry Strategic Business Plans (ISBPs). We have then incorporated the effect of electrification scenarios by examining the various options listed in the 2009 Electrification RUS and prioritising them. To do this, we have drawn on the methodology used in that RUS and concentrated principally (but not solely) on those route sections where electrification would permit more efficient operation of passenger trains.
11. Using these inputs three composite scenarios have been defined and modelled as follows:
 - 'Low' - Low growth combined with a good level of capacity utilisation efficiency growth (this is the relationship between peak passenger demand growth and fleet size growth, see paragraphs 19 and 23 below) and a low level of future electrification;
 - 'Medium' - Medium growth combined with a medium level of capacity utilisation efficiency growth and a medium level of future electrification;
 - 'High' - High growth combined with a poor level of capacity utilisation efficiency growth and a high level of future electrification.
12. At the heart of the Strategy, and facilitating its future updating, is a spreadsheet model. The RUS-based peak period 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). For each TOC, the total fleet size has been determined for each of the three composite scenarios in the year 2042, and the implications for each of Control Periods CP5 to CP8 have then been determined by working backwards from that date.

13. These forecasts and scenarios for long-term passenger growth, fleet utilisation efficiency growth and electrification cannot of course quantify unpredictable external factors (e.g. oil/ energy shortages), or options for future Government policy e.g. in relation to ticket pricing policy, investment in rail infrastructure, policies on crowding, road pricing etc. The Strategy has taken some account of such uncertainties by developing these three composite scenarios and by treating the Strategy as a living entity which will be updated annually to reflect industry developments including the franchising programme and emerging Government policy.
14. The electrification programmes considered and modelled are illustrative, subject to consideration in Network Rail's refresh of the Electrification RUS in 2013, and to development and analysis of the business case for electrification of each route.
15. The 2011 RUSs contain many route-specific infrastructure and timetable options for increasing capacity over the next 15-20 years, and the CP5 Strategic Business Plan, Thameslink, Crossrail and HS2 projects will provide additional capacity well beyond these timescales. On some routes, it will be possible to lengthen trains or run more trains within the existing infrastructure. On others, schemes beyond those proposed for CP5 or included in the RUSs would be needed to provide sufficient paths, stations capacity and depots. The costs and benefits of such schemes have not been established. We expect that the industry's planning processes, through successive HLOSs, RUSs and franchise bids will address this issue progressively. Train operators, ROSCOs and Network Rail work through these processes to help find good value for money outcomes, mindful of the need to improve industry efficiency and the need to bring subsidy levels down over time.
16. Making progress on the franchising programme is essential to taking forward the approach set out in this document. We believe that the DfT's role on rolling stock should be reduced significantly when compared to recent years and, in particular, that the identification of potential cascade and new build options should be addressed through the franchising bidding process, involving ROSCOs and Network Rail, rather than through an internal DfT plan. Asking bidders to identify options for delivering improved value for money by reviewing fleet deployment, diagramming, maintenance, life extension and new build options should be an integral part of the franchising process, so that the best ideas win through. Improvements have been made in recent years (as a result of changes to franchise ITTs, encouraging Alliancing and allowing Rolling Stock Plans in franchise bids to become less hard-wired) to the way in which bidders, ROSCOs and Network Rail work together whilst bids are being constructed to avoid some of the pitfalls of the earlier rounds of franchising. Options for financing new build are also part of this process, given the range of funding sources potentially available in the market.

C.Planning for Growth – Sources of the Assumptions Adopted

17. Overall ‘all-day’ 30-year passenger mile rates of growth forecast by Network Rail are shown in Table 1 below. These figures include exogenous factors (GDP, employment etc) and also the growth in demand that the CP5 projects will stimulate, but do not include the impact of longer term capacity improvements such as HS2 or other capacity enhancements that might be implemented beyond CP5.

Table 1 – 30-Year Forecasts of Passenger Miles Growth

Market	Passenger Miles Growth 2009-2039	Average Rate per Year
L&SE	+103%	2.4%
Long Distance	+104%	2.4%
Regional (England & Wales)	+161%	3.3%
Scotland	+103%	2.4%
Total	+111%	2.5%

Source – Network Rail 2011 RUSs and ‘Planning Ahead’

18. By comparison, total passenger miles grew by 91% in the 16 years between 1995/6 and 2011/12, an average compound rate per year of 4.1%. Even in the last two years of low economic growth to 2011/12, the average annual growth in passenger miles has been 5.5%. This indicates that the rail industry has successfully increased volumes through actions such as capacity improvement, marketing and new trains. This generates more revenue, which helps pay for the very substantial investment programme that the industry is undertaking in CP4 and CP5. The same opportunity exists in future to help pay for capacity investment.
19. To assess the implications for the number of vehicles needed in future, we have looked at the long-term relationship between demand and passenger fleet size. The 91% increase in passenger miles to 2011/12 has been achieved with an increase of just 12% in the total national fleet size. This major increase in fleet utilisation efficiency since privatisation has resulted from the following factors:
- Replacement of Mark 1 EMUs and DMUs and Mark 2 coaching stock with sliding-door vehicles, which provided more capacity ;
 - Introduction of trains with metro-style interiors for many inner suburban services south of the River Thames;
 - Elimination of most locomotives and non-passenger carrying vehicles for the Virgin West Coast and CrossCountry TOCs;
 - Achievement of higher levels of fleet availability, and of higher average train speeds on some routes;
 - Introduction of automatic passenger load weighing and counting technology on many fleets (which has led to more efficient diagramming of rolling stock);
 - Achievement of higher off-peak load factors, through marketing, yield management and internet sales.
20. We have not used the overall all-day growth figures shown in Table 1 in our fleet size growth analysis. The RUS growth forecasting methodology adopted focuses primarily on route-specific

peak passenger volumes and peak capacity, since that is what determines strategic level planning of railway infrastructure, rolling stock and timetables.

21. The Medium fleet size growth forecasts are based directly on the route-specific forecasts of long-term growth in peak period rail passenger demand that are included in the 2011 RUS documents, extrapolated to 2042. Our resulting forecasts of fleet size growth for individual routes in the Medium scenario range from +132% for the longer distance routes into London Paddington and +104% for the principal cities served by Northern Rail, to +23% for the routes served by Southeastern (excluding HS1).
22. The Low and High growth forecasts represent a range of possible outcomes for future rolling stock capacity requirements. For all routes, these Low and High forecasts of future fleet capacity have been modelled as 0.7 and 1.3 respectively (i.e. $\pm 30\%$) of the Medium forecast of the required fleet capacity in 2042, this being judged to be a reasonable range of likely outcomes making allowance both for uncertainties in future peak growth and in future capacity utilisation efficiencies.
23. Growth in peak demand of higher than the Medium case may occur, as each additional (presently uncommitted) future route enhancement or service enhancement will itself produce some additional peak period growth. Conversely, the franchise bidding process can unlock opportunities to improve capacity utilisation further. This would 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 19 above. The easiest of such opportunities have already been implemented, but more can be achieved through the effective specification and management of franchises. This can be facilitated by:
 - Continuing improvements in timetable patterns;
 - Introduction of more vehicles with 'metro'-style interiors for short-distance services;
 - Introduction of new industry-wide metrics for and benchmarking of peak capacity utilisation, as an aid to effective management of capacity;
 - Changing the profile of peak demand;
 - Replacement over time of many or most of the remaining trains formed of Mark 3 and Mark 4 rolling stock which have non-passenger carrying vehicles (locomotives, power cars and driving trailer vehicles).
24. We have also included estimates of fleet requirements for HS2 based on publically available information from HS2 Ltd and a discussion with them about options for growth after initial service introduction. We have adopted a range of assumptions in the three scenarios for the rolling stock volumes that will be required to operate high speed and intermediate services on the existing long-distance routes where capacity will be released by HS2.

D. Electrification – Prioritisation and Analysis

25. The present total national Network Rail track mileage is 19,469 single track miles (referred to in this report as ‘track miles’ - source Network Rail Annual Return 2012). Of this, 7,824 track miles (40%) are electrified and 11,645 track miles (60%) are non-electrified. With completion of the 1,900 track miles to be electrified in CP4 and CP5, 50% of total track miles will be electrified.
26. Although DfT cannot yet commit to a rolling programme of electrification beyond CP5, the direction of Government policy is to continue such a programme into CP6 and beyond. Views are already being sought by DfT, who have suggested that the programme should include the Derby – Birmingham – Bristol route as well as freight connectivity in South Yorkshire. Similarly, Transport Scotland’s CP5 HLOS already contains a specific objective of a rolling programme of electrification amounting to approximately 60 single track miles per annum, following the completion of the Edinburgh to Glasgow Improvements Programme electrification.
27. The 2009 Electrification RUS listed 131 route sections as candidates for future electrification. Each route was rated by Network Rail in the RUS in relation to four separate criteria:
 - a) Facilitating efficient operation of passenger services;
 - b) Facilitating efficient operation of freight services;
 - c) Providing diversionary routes for electric trains; and
 - d) Facilitating new electrified passenger services.
28. For ranking in terms of ability to facilitate efficient operation of passenger services, Network Rail calculated a metric for each route section of the total number of annual passenger vehicle-miles which might be converted from diesel to electric operation, divided by the number of track miles requiring to be electrified in that route section (with a higher number indicating a probable better case in that the cost of electrification does not greatly increase with usage of the route).
29. Taking account of this data, and the extent to which electrification would release good mid-life diesel units to increase capacity where needed on other non-electrified routes, and also taking some regard of the other ranking factors of paragraph 27 above, we have produced an indicative ranking of route sections that might be electrified in CP6 and beyond (subject to business case development, affordability and negotiation of satisfactory commercial terms).
30. Low, Medium and High scenarios for electrification have been constructed as shown in Table 2 below. This is a strategic view only, designed to give a potential sense of scale for the electrification programme beyond CP5. The timing and phasing of electrification of individual routes are clearly subject to further refinement. The scoping of electrification schemes provides a pool of possible projects from which a long-term rolling programme could be constructed. This report is intended to illustrate and quantify the implications which such a rolling programme might have for the Rolling Stock Strategy.

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

Control Period	Low	Medium	High
CP4 & CP5	1,895	1,895	1,895
CP6	2,136	2,136	2,136
CP7	0	1,778	1,778
CP8	0	0	1,060
TOTAL	4,031	5,809	6,869
% Electrified	61%	70%	75%

Source – Analysis based on data provided by Network Rail

31. The capital cost of the CP5 electrification programme is estimated to be in the region of £3 billion (source: Network Rail), and similar expenditure would be required in CP6 and CP7.

32. Conversion of DC-electrified routes to AC has not been included in the above table, with one exception, this being the HLOS scheme between Basingstoke and Southampton. Such conversion elsewhere, if and where there is a business case, is likely to lead to (in the inner suburban areas) replacement of the existing BR-procured DC rolling stock or retrofit of newer 3rd rail vehicles. Given that examination of the business case for more widespread DC to AC conversion is still at early stage, we have not made allowance for any early replacement or modification of these fleets. The analysis assumes that DC to AC conversion will not lead to an increase in total vehicle numbers beyond that which would be required for growth.



E. The Present Fleets and Future Capability Requirements

33. Details of the composition of all of the existing fleets (in use, rather than stored), and committed changes to the end of CP4, are summarised in Table 3 below, using the definitions of paragraphs 7 and 8 above. These are not rigid categorisations: it is of course possible that, for example, Long Distance Self-Powered trains could in some cases be used on services currently covered by Middle Distance Self-powered trains if that is the most economical option.

Table 3 – Present Fleet Composition (showing also Committed Changes to the End of CP4)

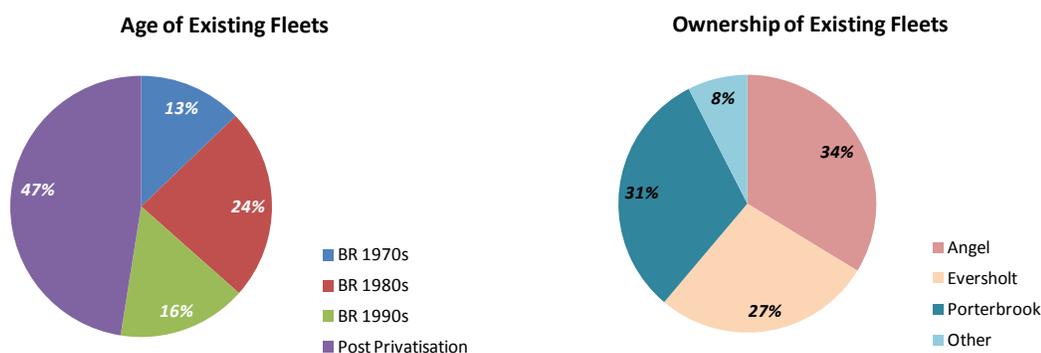
Generic Type	Total Vehicles, Period 6, 2012/13	Total Vehicles, Period 13, 2013/14
A. Shorter Distance Self-Powered (diesel, generally with 75 mph maximum speed);	1,055	1,055
B. Middle Distance Self-Powered (diesel, with 90/ 100 mph capability);	1,334	1,342
C. Long Distance Self-Powered (diesel, with 100/ 110/ 125 mph capability);	1,515	1,515
D. Shorter Distance Electric (generally with 75 mph maximum speed);	2,336	2,336
E. Middle Distance Electric (with 90/ 100/ 110/ 125 mph capability);	4,832	5,138
F. Long Distance Electric (with 100/ 110/ 125 mph capability);	1,105	1,131
G. Very High Speed Electric (140 mph and above, for domestic services on HS1 and HS2).	174	174
TOTALS	12,351	12,691

Source: Analysis confirmed by the ROSCOs

34. Figure 1 shows that, of the 12,691 vehicles:

- 6,025 (47%) will have been built since privatisation, and the remaining 6,666 during the BR era prior 1994.
- 954 (8%) will be owned by parties other than the three ROSCOs (e.g Voyager Leasing), principally in categories C, D and E.

Figure 1 Age and Ownership of the National Passenger Rolling Stock Fleet



Source: Analysis as at the end of CP4 in March 2014

35. 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 fuel cell with some form of electrical or mechanical energy storage. 'Electric' units include not only straight-electric but also 'bi-mode' trains (such as Hitachi's Super Express Trains) which may both collect power when in motion from an overhead or third rail source, and also generate power from an on-board source.
36. It is widely expected that present and future EC legislation regarding emissions from diesel engines (Directive 97/68/EC and its subsequent amendments, implemented in Great Britain as the Non-Road Mobile Machinery (Emission of Gaseous and Particulate Pollutants) Regulations 1999, known as NRMM) will increasingly make it difficult or even impossible to procure and operate new DMUs having underfloor diesel engines, with an affordable business case. Indeed, EU consultation on possible tightening of the rules is now underway. Existing diesel trains can continue to operate for as long as necessary thanks to an amendment agreed in 2011.
37. Some overlap is already occurring in the distinction between Categories E and F. On the south end of the West Coast Main Line, and on other principal electrified (and to be electrified) main lines, maximum route capacity and revenues will most probably be achieved if high capacity, high performance electric trains (in some cases with a maximum speed of 110 or 125 mph) are introduced for middle distance flows.



F.Fleet Sizes and Compositions Calculated for each Scenario

38. As described in paragraph 11 above, the three growth and capacity utilisation scenarios have been combined with the three electrification scenarios to obtain three composite scenarios within the spreadsheet model, for each TOC, for each Control Period to 2042. The aggregated results are summarised as Table 4.

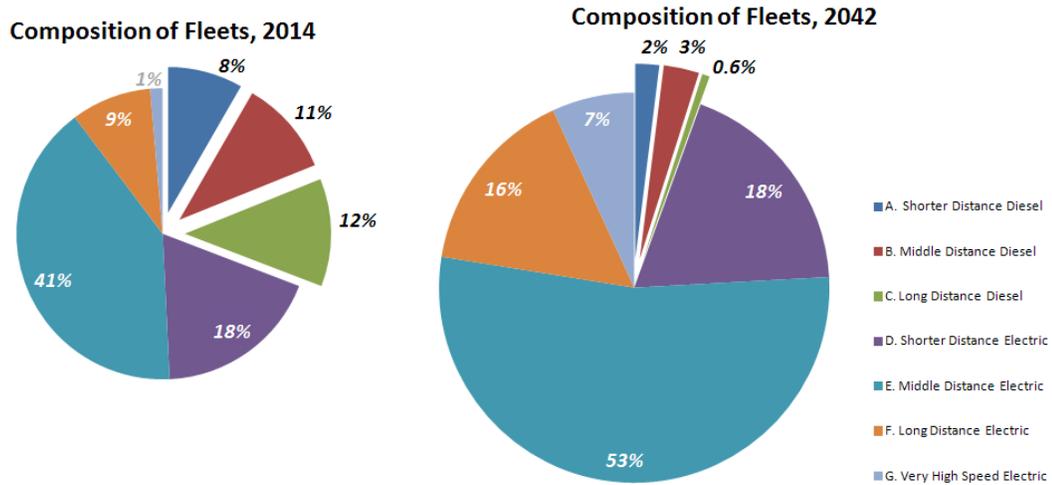
Table 4 – Aggregated Results of Fleet Size Changes for the National Passenger Fleet to 2042 (Low, Medium and High Scenarios)

Sub-Group	Present CP4	Committed CP4	Forecast CP5 to 2019			Forecast CP6 to 2024			Forecast CP7 to 2029			Forecast CP8 to 2034			Forecast CP9/10 to 2042		
	Total Vehicles	Total Vehicles	Total Vehicles			Total Vehicles											
	Period 6 2012/13	Period 13 2013/14	Low	Med.	High	Low	Med.	High									
A. Shorter Distance Diesel	1,055	1,055	756	767	784	527	516	512	514	484	467	503	457	392	489	426	343
B. Middle Distance Diesel	1,334	1,342	1,334	1,366	1,400	942	967	1,038	910	598	687	899	588	651	931	634	728
C. Long Distance Diesel	1,515	1,515	613	640	673	353	373	424	108	137	188	108	137	188	108	137	188
D. Shorter Distance Electric	2,336	2,336	2,915	2,924	2,931	3,101	3,143	3,208	3,300	3,425	3,591	3,547	3,777	4,071	3,720	4,020	4,405
E. Middle Distance Electric	4,832	5,138	6,236	6,465	6,750	7,608	8,076	8,637	8,345	9,342	10,155	9,032	10,542	11,775	9,708	11,551	13,110
F. Long Distance Electric & Bi-Mode	1,105	1,131	2,066	2,177	2,233	2,510	2,665	2,776	2,600	3,018	3,417	2,292	3,030	3,780	2,527	3,381	4,255
G. Very High Speed Electric	174	174	174	174	174	174	174	174	654	662	670	1,373	1,396	1,419	1,433	1,476	1,519
TOTALS	12,351	12,691	14,094	14,513	14,945	15,214	15,915	16,769	16,432	17,666	19,175	17,754	19,927	22,276	18,918	21,624	24,548
Effective Capacity Growth on Period 6 2012/13		3%	14%	18%	21%	23%	29%	36%	33%	43%	55%	44%	61%	80%	53%	75%	99%
Diesel Totals	3,904	3,912	2,703	2,773	2,857	1,822	1,857	1,974	1,532	1,219	1,342	1,510	1,182	1,232	1,528	1,197	1,259
Electric & Bi-Mode Totals	8,447	8,779	11,391	11,740	12,088	13,392	14,058	14,795	14,900	16,447	17,833	16,245	18,745	21,045	17,390	20,427	23,289
Electric & Bi-Mode %	68%	69%	81%	81%	81%	88%	88%	88%	91%	93%	93%	91%	94%	94%	92%	94%	95%

Source: Analysis using route-specific growth and capacity utilisation forecasts and illustrative electrification scenarios as described in this report.

39. Based on these assumptions, the following changes over 30 years can be seen in Table 4:
- Total national passenger fleet, overall increase of 53-99%;
 - Electric fleets, rising from 68% of the national fleet today to 92-95%;
 - Self-powered fleets, falling from 32% of the national fleet today to 5-8%.
40. It can be deduced that in the Low scenario, a minimum of 13,000 new electric vehicles would be required by 2042, from today's base position. This figure comprises the sum of:
- 9,000 which is the net increase in electric vehicles from 8,447 to 17,390;
 - 4,000 to replace most of the BR-procured electric fleets (all of which will be a minimum of 48 years old in 2042).
- In the Medium and High scenarios, this minimum total of 13,000 new electric vehicles to be constructed by 2042 would rise to 16,000 and 19,000 respectively. This equates to a construction requirement for electric trains averaging approximately 8, 10 or 12 vehicles per week respectively in the three scenarios over 30 years. This would be a significant increase over the average rate of construction of new electric and diesel vehicles during CP4 of around 4 vehicles per week.
41. It should also be noted that the near-committed construction of new vehicles for the Thameslink, Crossrail and Super Express Train (IEP) projects is around 2,400 vehicles in CP5 i.e. an average of nine vehicles per week in CP5 for these projects alone (all of these being electric or bi-mode vehicles). In addition the ISBP suggests that up to 1,000 additional new electric vehicles will be required for growth and electrification on other routes (e.g. the Midland Main Line), with the possibility of further new construction (suggested in the ISBP to be up to 750 new vehicles) to replace older vehicles where successful franchise bidders can make a business case for this. Hence the requirement for construction of new vehicles in CP5 could average up to 15-16 vehicles per week, rather higher than the long-run modelled figure of 8-12 vehicles per week.
42. This illustrates that a completely steady new build programme is unlikely to occur. Further peakiness of demand for new build vehicles will occur as a direct consequence of refranchising timescales, where decisions to procure new rolling stock will, in the main, be triggered by franchise award. Nevertheless the forward look on rolling stock offered by this Strategy, combined with a commitment to a rolling programme of electrification should provide a greater degree of predictability about orders for new electric vehicles beyond CP5. This can help manufacturers optimise production capacity and associated costs.
43. The projected changes in the size and composition of the national passenger fleet for the Medium Scenario are shown in Figure 2.

Figure 2 – Change in National Passenger Fleet Size and Composition (Medium Scenario)



Source: The figures are as in Table 4. The two circles are approximately to scale, with the reduction in the diesel fleets being shown highlighted.

44. The numbers of new electric vehicles required could be further increased beyond those noted above if the costs and capabilities of new electric trains can justify replacement of electric trains built since privatisation.
45. Electrification will produce a steady flow of mid-life DMUs for use on non-electrified routes, (subject to commercial terms). Based on the electrification scenarios in this report and the figures in Table 4 it can be assumed that there will be no requirement for any new diesel or hybrid rolling stock on a significant scale unless or until hybrid technology matures and the business case becomes sufficiently strong, or until such time as new environmental legislation makes the operation of the present diesel-engined vehicles non-viable. Smaller orders of growth stock as part of franchise bids remain possible, however.
46. All of the Type A short-distance DMUs were procured by British Rail between 1985 and 1992. It can be expected that all or most of these will have been withdrawn by 2042, all being 50 years old or more at this time. Based on the figures in Table 4, between 340 and 490 new Type A vehicles may therefore be required by 2042. The number of middle distance Type B DMUs built since privatisation is 780, these being built between 1997 and 2011. Most of these could still be operating in 2042, the number required shown in Table 4 being 630 to 930. It is likely therefore that only 400-800 new Type A and Type B self-powered vehicles may be required to be built in the 30 years to 2042.

G.Improving Value for Money from the Rolling Stock Fleets

47. According to the McNulty Rail Value for Money Study, the annual cost of maintenance and financing of rolling stock in the UK is £1.9 billion (at 2009/10 prices), approximately 15% of total railway operating costs. The total cost of traction energy (electric power and diesel fuel) for the passenger TOCs has been estimated from ATOC data to be £0.55 billion. These costs totalling £2.45 billion p.a. are defined as Rolling Stock Related Base Costs in this section G.
48. The High Level 30-Year Rolling Stock Strategy will, as it develops, quantify many different kinds of opportunity by which costs can be reduced in the short term and over time. Rolling stock costs should not however be seen in isolation, but should be seen in the context of whole-life, whole-system costs, revenues and other benefits.
49. The growth projections quantified in this report mean that a reduction in absolute costs is highly unlikely (given the likely increase in total fleet size), but taken together with the electrification scenarios there is significant scope to reduce unit costs for rolling stock (see paragraphs 51 to 60).
50. Our analysis of potential cost savings is at an early stage of development, and will be refined and updated early in 2013 by the project team working closely with Network Rail in its updating of costs for the Electrification RUS. Nevertheless the requirement for subsidy per passenger-mile should be reduced through this combination of growth, electrification and other changes, provided that the electrification projects are prioritised in respect of their business case, and taking account of incremental revenues and other benefits as well as incremental costs.
51. Typical rolling stock costs (i.e. total maintenance costs, and capital leasing costs) per vehicle-mile of diesel and electric vehicles are compared in Table 5:

Table 5 – Comparison of Diesel and Electric Rolling Stock Costs per Vehicle Mile

Cost per Vehicle Mile (£)	Diesel	Electric	Saving (£)	Saving (%)
Maintenance Cost	£0.80	£0.44	£0.36	45%
Capital Lease Cost	£1.43	£0.97	£0.47	32%
Maintenance and Leasing Sub-total	£2.23	£1.41	£0.83	37%

Source: TOC and ROSCO sources, for new EMU and DMU vehicles, assuming similar annual mileages

52. In general terms, the maintenance costs of diesel vehicles are higher than those of similar electric vehicles because of the additional costs of fuelling, servicing, maintenance and repair of the engines and transmissions of the diesel vehicles.
53. Capital lease costs are higher for new diesel vehicles than for similar new electric vehicles because of the higher initial capital cost, and also because of lessors' concerns about their ability to lease diesel vehicles in the medium to longer term when financial and environmental factors are expected to increase the benefits of electrification as outlined in this Strategy.

54. Other costs for diesel and electric vehicles are compared in Table 6:

Table 6 – Comparison of Other Diesel and Electric Costs per Vehicle Mile

Cost per Vehicle Mile	Diesel	Electric	Saving (£)	Saving (%)
Energy Cost	£0.47	£0.25	£0.22	47%
Track Maintenance Cost	£0.071	£0.068	£0.003	4%
Electrification Fixed Equipment Maintenance Cost	£0.00	£0.012	-£0.012	n/a
'Other' Sub-total	£0.54	£0.33	£0.21	39%

Source: TOC and ROSCO sources, for new EMU and DMU vehicles

55. Future energy costs are very difficult to forecast. Diesel fuel costs may in future rise faster than electricity costs, but the reverse is also possible. Electricity costs are currently rising to help pay for lower carbon sources. It is possible that the cost of fossil fuels used in generation may fall from their current, relatively high, levels.

56. When the annual vehicle miles that might be electrified in each of the illustrative scenarios of this report are combined with the rolling stock related cost savings per vehicle mile from Tables 5 and 6, the gross rolling stock related savings that would result are as shown in Table 7:

Table 7 – Projected Annual Rolling Stock Related Cost Savings from Electrification, by 2042

Annual Rolling Stock Savings from Electrification	£ pa (millions)	% of Total Rolling Stock Related Costs
Annual Saving by 2042 (Low Scenario)	£346	14%
Annual Saving by 2042 (Medium Scenario)	£438	18%
Annual Saving by 2042 (High Scenario)	£479	20%

Notes:

These savings have been calculated from the data in Tables 5 and 6 above.

The annual savings have been presented as a % of the total annual Rolling Stock Related Base Costs for maintenance, capital lease and energy quoted in paragraph 47 above.

57. To get a fuller sense of future impact on fleet unit costs, the savings in rolling stock related costs from electrification, and the costs of greater fleet sizes, have been combined with estimates of total increases in passenger miles to 2042. The results for the total national fleet are shown in Table 8 for the Medium scenario.

Table 8 – Estimated Reduction in Total Rolling Stock Related Unit Costs in 2042 (Medium Scenario)

	2011/12 (Base)	2042 (Medium Scenario)	Change
Rolling Stock Related Costs pa (£ millions)	£2,450	£3,520	44%
Passenger Miles p.a. (billions)	36	80	125%
Rolling Stock Related Costs (£ per thousand Passenger Miles)	£69	£44	-36%

Notes:

The Rolling Stock Related Costs quoted for maintenance, leasing and energy in 2042 have been calculated as (Base Cost – RS Savings from Electrification (from Table 7)) x Increase in Fleet Size (from Table 4).

The Passenger Miles quoted for 2042 have been conservatively assumed to be the 2011/12 actual (from ORR) plus 125%, this being the figure of 111% from Table 1 increased for non-committed electrification and non-committed capacity enhancements after CP5, plus the impact of HS2, TOC marketing etc.

58. Similar analysis for the Low and High scenarios to 2042 produces a reduction in rolling stock related costs per thousand passenger miles of 39% and 33% respectively; and similar analysis for the Medium scenario to the end of CP6 in 2024 produces a saving of 20%.

59. Observations relating to Tables 5 to 8 are as follows:

- These estimated operating cost savings, though material, would not in general be sufficient to justify the capital cost of electrification. The business case for electrification is generally founded on a combination of operating cost reductions, revenue increases, capacity benefits, carbon-related benefits and socio-economic benefits. Each such business case is route-specific;
- The estimated savings are preliminary and will require further work for validation. There is a potentially a large range in the values of some of these estimates, affected by the type of service being electrified and the annual mileages of the fleets;
- It is difficult to be precise about the lease costs of new DMUs since no TOC or ROSCO has procured any new DMU vehicles since 2008, since which time residual value concerns about such trains have arisen following the Government’s change of policy regarding electrification, and EC emissions legislation has become more demanding;
- The estimated rolling stock savings ignore real cost increases for the capital leasing costs of new electric rolling stock compared with life-extended diesel rolling stock, on the basis that all or most of the BR-procured fleets will have been withdrawn by 2042;
- The estimated savings in Table 8 do not include track maintenance savings or electrification fixed equipment maintenance costs (see Table 6 above) and many potential cost savings from other rolling stock related initiatives (see paragraph 60 below);

- The estimated savings do not include potential incremental depot costs (see paragraphs 61 to 68 below).

60. Several other ways of improving the VfM from rolling stock have been identified for the Strategy. Further work will be undertaken to quantify these in 2013, working in conjunction with Steering Group members and with DfT and the wider industry as appropriate. These include opportunities arising from:

- Whole-life, whole-system investment decisions (with rolling stock issues being key e.g. weight, asset condition monitoring, ERTMS etc);
- Residual Value mechanisms being properly activated in franchise agreements, with appropriate economic signals from DfT in franchise bid requirements;
- Benchmarking of fleet maintenance costs;
- Innovation and technology change (e.g. Driver Advisory Systems for energy reduction and improved right time running);
- Standardisation of fleet sub-system performance specifications;
- Long-term depot and maintenance strategy decisions (see section H below);
- Greater certainty providing confidence to the train leasing markets;
- Fleet capacity utilisation improvements, assisted by output-based franchise specifications and other changes to load factor regulation from DfT, resulting in optimised fleet size increases over time.



H. Depots, Maintenance and Skills

61. The scale of increase in fleet size outlined in Section F and Table 4 of this report would require additional berthing sites and some new maintenance depots:
 - New or re-configured depots are already committed or planned for CP5, for the Thameslink, Crossrail, and IEP projects;
 - HS2 will require new depots, for Phase 1 and for Phase 2;
 - Electrification of Regional services will prompt TOCs and funders to review depot capability requirements in some cities, where the depots provided by BR for DMUs in the 1980s may in some cases be sub-optimal for the EMUs which will replace them.
62. These increases will be compensated in part by the reduced servicing and maintenance requirements of electric trains compared with diesel trains, and in some cases of new or re-tractioned electric trains compared with older electric trains.
63. Depot and stabling capacity is already an issue in the London area and the scale of fleet expansion to serve the South East means that it may be sensible to attempt a higher level strategic review of possible sites. Some Network Rail-owned sites could be safeguarded for future depot and berthing uses in the longer-term. Other large brownfield sites adjacent to railway lines (and often with present or past rail connections) exist outside railway ownership. Some of these are potentially suitable for new depots or berthing locations. Similarly, there may be opportunities to rationalise depot capacity in some locations, particularly close into London, given high land values.
64. As regards who should provide and manage new depot sites, TOCs or manufacturers, there is no single correct answer, and both are likely to have a long-term role going forward:
 - Crossrail, Thameslink and IEP will increase the extent of manufacturer involvement;
 - Some TOCs who procure new fleets are likely to prefer to be largely responsible for maintenance themselves, especially where these are generic trains with limited technical risk;
 - Where a greater degree of innovation is offered with new fleets, some TOCs may prefer to involve the manufacturer in a medium-term or long-term relationship;
 - In some cases, TOCs may choose a maintenance contract to the manufacturer, but with defined future break-points.
65. It is important that future depot planning addresses not only forecast growth and the shift toward more and longer electric trains, but also addresses depots that are already known to pose significant operational constraints to one or more TOCs.
66. The second Rail Technical Strategy (RTS 2012) published in December 2012 identifies people issues as being critical to success, and this is certainly true for rolling stock maintenance issues. Short-term franchises have not 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.

67. The National Skills Academy for Railway Engineering (NSARE) has an important role in helping to identify potential future gaps in engineering skills, and in developing new tools such as 'skills passports' to enable railway staff to work across the industry.
68. 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.



I. Conclusions

69. This report outlines the emerging conclusions from the initial phase of work to develop a first high level national passenger Rolling Stock Strategy. Through detailed bottom-up scenario modelling it has already provided some new cross-industry insights about the implications of long-term growth in passenger demand, and highlighted benefits that could be achieved through a continuing programme of electrification beyond CP5.
70. The work has already achieved a significant degree of convergence of thinking about these issues among the parties represented on the Steering Group – ATOC, Owner Groups, the three ROSCOs and Network Rail. DfT attends Steering Group as an observer and has had full visibility of the emerging modelling and analysis.
71. Whilst it is not yet possible to forecast the extent, pace and sequence of a rolling programme of electrification beyond 2019, 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 report, the total size of the national fleet could grow by between 53% and 99% over 30 years, while the proportion of electric (and bi-mode) vehicles could rise from 68% today to more than 90% over the same period.
72. The consequence of the modelled scenarios is that between 13,000 and 19,000 new electric vehicles would be required over the next 30 years, taking account of growth, electrification, replacement by 2042 of most BR-procured vehicles, and HS2. This equates to a build rate of between 8 and 12 electric vehicles per week, and may be compared with an average build rate of just four (diesel and electric) vehicles per week in CP4. The total could be higher, depending on individual decisions by franchise bidders and funders about the relative merits of life extension and replacement for individual fleets.
73. On many routes, the growth projections of this report (as extrapolated from the RUSs) would also require potential enhancements to the supporting infrastructure, such as longer platforms, changes to signalling and more tracks. The industry planning process will progressively shape what schemes might need to be considered for funding in future Control Periods to support this. Similarly, changes in areas such as fares policy and crowding standards might be considered by future Governments. This could additionally affect infrastructure and rolling stock requirements.
74. The future relations between forecast peak passenger growth and consequential fleet size growth has not been modelled in a formal way for this exercise because to do so would require extensive analysis for each route similar to that required for a franchise bid. This factor has been judged to be contained within the envelope of the Low and High growth forecasts (see paragraph 22 above). Output-based franchise specifications and other changes to load factor regulation from DfT could result in optimised fleet size increases over time.
75. Assuming that the current policy of a rolling electrification programme continues in CP6, the work to date suggests that no new diesel vehicles (or other self-powered vehicles) would be required to be built in either CP5 or CP6. Many older diesel vehicles would be withdrawn over time, firstly those HSTs which are being replaced by IEP (although some might be used on other

TOCs including open access operators), and then by 2024 potentially 500 (50%) of the shorter-distance 75 mph DMUs procured by British Rail in the 1980s. There would be a smaller reduction in the number of 90 mph and 100 mph DMUs which were built after 1989, as many of these would be redeployed to provide additional capacity on non-electrified routes.

76. The report forecasts that there would be no requirement for any new diesel or hybrid rolling stock other than for limited capacity purposes whilst a long term electrification programme proceeds. It is likely that as few as 400 to 800 new self-powered vehicles may be required to be built in the 30 years to 2042 – probably in the second half of this period – principally to serve routes that are unlikely ever to be electrified.
77. Rolling stock-related costs per vehicle mile can be reduced in real terms as a result of these changes because the cost of leasing, maintenance and energy for new electric vehicles are substantially lower than the costs for comparable new diesel vehicles; also the costs of older electric vehicles are significantly less than for comparable older diesel vehicles. The committed programme of electrification in CP4 and CP5 will take the proportion of track mileage that is electrified from 40% to 50% by 2019. The Low, Medium and High scenarios in this Strategy, based on some initial ranking, illustrate the potential to increase this figure to 60%, 70% or 75% in subsequent years. The capital cost of the CP5 electrification programme is estimated to be about £3 billion and our current working assumption is that similar expenditure would be needed in CP6 and CP7.
78. The Rolling Stock Strategy recommendations would be enhanced if DfT (and Transport Scotland) could make early commitments to a future electrification programme beyond CP5. Ministerial and departmental commitment to a rolling programme of electrification in CP6, of a similar quantum to that of CP5, would greatly help Network Rail and the suppliers of both electrification and rolling stock, to optimise production capacity and associated costs. This would also give confidence to TOCs that a steady flow of good quality diesel trains will become available to meet growth in demand on non-electrified routes, so reducing the need for expensive new diesel vehicles. It would also help Network Rail to combine synergies of electrification with other major route infrastructure renewals.
79. All owners, maintainers, operators and funders of rolling stock and infrastructure should be incentivised to cooperate in working together to adopt a whole-life, whole-system approach to cost reduction and optimisation, as is best practice in other asset based industries. One way in which this could be encouraged would be for DfT (and Transport Scotland) to insist that rolling stock plans in franchise bids should contain explicit forecasts of whole-life, whole-system costs and benefits, and to give credit in the franchise bid evaluation process for such costs and benefits for the lives of these rolling stock assets i.e. beyond the end of the franchise being let.
80. At present, no single party is able to calculate or compare the whole-life whole-system rolling stock related costs (i.e. including maintenance, leasing, energy and track maintenance) of individual rolling stock fleets. As the industry matures one option would be to introduce anonymised benchmarking of whole-life whole-system rolling stock related costs for individual fleets.
81. In each of the three scenarios outlined in this report, our work to date indicates that total rolling stock costs per passenger mile could fall in real terms by more than 30% by 2042. Electrification

will also produce journey time improvements, route capacity benefits, revenue increases, and substantial carbon reduction advantages. The methodology for assessing the costs and benefits of the Strategy is at an early stage of development, and will be refined and updated in 2013. However, the direction of travel reflected in these three scenarios is potentially good news for the economy and potentially offers 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, for achieving compliance with the PRM-TSI regulations for passengers of reduced mobility, and for the fitting of ETCS. Additional production capacity will be required in order to provide sufficient capacity for all of these programmes.

82. The scale of increase in fleet sizes outlined in this report would require additional berthing sites and some new maintenance depots. As regards who should provide and manage new depot sites, TOCs or manufacturers, there is no single correct answer, and both are likely to have a long-term role going forward.
83. The second Rail Technical Strategy, RTS 2012, identifies people issues as being critical to success, and this is certainly true for rolling stock maintenance issues. The introduction of new fleet types, new technology, larger fleets and electrification must be accompanied by adequate long-term investment to provide the leadership and skills necessary to underpin the required business results.
84. The next stages of work on the Strategy will aim to develop and prioritise the several areas of potential that have been identified to deliver greater Value for Money from rolling stock. These are complementary to opportunities contained in RTS 2012. The most promising of these ideas will be developed and quantified during 2013. We will also review and update the scenarios modelled for the Strategy in the light of broader considerations, such as infrastructure capacity, fares policy and crowding standards.
85. The Strategy must be flexible to respond to changes to economic, political and technological factors and therefore will need to be updated annually. The first major annual update of the Rolling Stock Strategy will be undertaken in the last quarter of 2013. A major input to this will be the updating of the 2009 Electrification RUS by Network Rail during 2013.
86. Delivering a substantial fleet investment programme through a reinvigorated franchising programme is the best approach to securing value for taxpayers as this should provide market-driven solutions, procured in a competitive environment, growing the long-term value generated by these businesses.
87. The re-start dates and subsequent order of the franchising programme are important to enable TOCs to procure rolling stock in an efficient way for routes being electrified in CP5, and for other rolling stock investments.

