Department for Transport

Network Modelling Framework (NMF) and Appraisal for HLOS

The Evidence Pack

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SECTION 1: THE NETWORK MODELLING FRAMEWORK (NMF)

1.1 Background to Model Development

1. In order to inform the Secretary of State's HLOS commitments and provide a clear understanding of the relationship between outputs and cost and benefits in the context of growing demand, a programme of work was set up to develop a strategic forecasting and appraisal model, thereafter referred to as the Network Modelling Framework (NMF).

2. The process of constructing the model started with identifying the expected requirements of the HLOS and involving the stakeholders (especially the Office of Rail Regulation – ORR- and Transport Scotland – TS, and Network Rail - NR) who would be making use of the model or whose inputs were essential to its development. The aim was to develop a single model rather than to encourage each organisation to develop separate approaches, especially for a common approach to appraisal.

3. Given that the ownership of data, models, and expertise lies in the hands of many of the stakeholders, a co-operative approach was crucial to ensure that any rail model incorporates all the elements seen by stakeholders as relevant to the operational delivery of a plan and its value for money.

4. The Department's NMF Team consists of a combination of senior economists and senior transport modellers. The NMF team, in collaboration with the relevant stakeholders scoped the requirements for the model building, and contracted the services of consultants who designed and implemented a model agreed by all the stakeholders.

5. A close liaison with Network Rail was essential because Network Rail was developing an infrastructure cost model (ICM) to inform their business

planning. This ICM was to become a component of the NMF and link with other parts of the NMF, in particular the part that represents the services run and train types which operate those services. Network Rail was also responsible for developing the performance module using the knowledge it has gained in delivering industry wide performance targets. NR also provided support through its programme of work on the Route Utilisation Strategies and the Regional Planning assessments, which provided key information which later informed the options tested as part of HLOS (see later sections for a more detailed discussion).

6. At the same time RSSB (The Rail Safety and Standards Board) were developing their safety risk and precursor models, and these too were identified as meeting the needs of the NMF and integrated into the framework. RSSB undertook further development of these models in order to meet the Department's requirements.

7. Below is a high level timescale for the NMF development:

White Paper (the Future of Rail) **15 July 2004** section 3.2.6: 'The Secretary of State for Transport will take responsibility for setting the national-level strategic outputs for the railway industry, in terms of capacity and performance'
Railways Act 2005 (Royal Assent - **7 April 2005**) sets out in schedule 4 and sections 3(8)(d) and 3(11)(b) what the Secretary of State has to deliver, the process, and in accordance of which **July 2007** was set as the Publication date for HLOS.

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DfT Rail Group (now R&NN) set up in the **summer of 2005**

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June 05 –DfT started scoping the model, engaging with Stakeholders, and agreeing on project funding.

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Terms of Reference/ITT for scoping issued in **August 05** – 'Scoping Study' let to SDG/DeltaRail(then AEA)

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DfT Seminar on the conclusions of the scoping study **21 September 05**

↓

ITT to further develop the NMF Model Specification as per the scoping study proposals (or to develop something different) December 05

↓

DfT seminar on the proposed structure (named prototype Version 0) **March 06**

↓

Development and delivery of Version 1 – **July 06**

↓

Delivery of V1.2 to include additional functionalities in the model including third party modules on performance, infrastructure costs etc. – **November 06**

↓

Generation of options **November - May 07**
↓
Delivery of version 1.2.1 of the model **– February 2007**
↓
Update of baseline to integrate in new model version (1.3) – **April 07**
↓
Delivery of v1.3 **– May 07**
↓
Coding and Analysis of HLOS Options – **May/June/July 07**
↓
Publication of HLOS **July 07**

8. The NMF has been developed to provide the evidence base for linking decisions about expenditure on the railway to the outcomes that this expenditure can deliver. It represents a clear shift away from decisions which were in the main concerned only with the size of the budget, to a focus on what the railway can deliver for the passenger and for the taxpayer.

1.2 NMF Model Overview

9. The NMF is a strategic modelling tool designed to support DfT, ORR and Transport Scotland (the Client Group) in testing schemes or options as part of defining the High Level Output Specification (HLOS and SHLOS). While the model is not intended to provide detailed analysis of demand or crowding on specific section of rail routes, it is able to produce high level forecast of demand; and, average crowding, performance and safety changes following a change in the network.

10. The model covers the whole of Great Britain, comprises a number of modules, and integrates these in a complementary manner by providing a common base and allowing interaction between them.

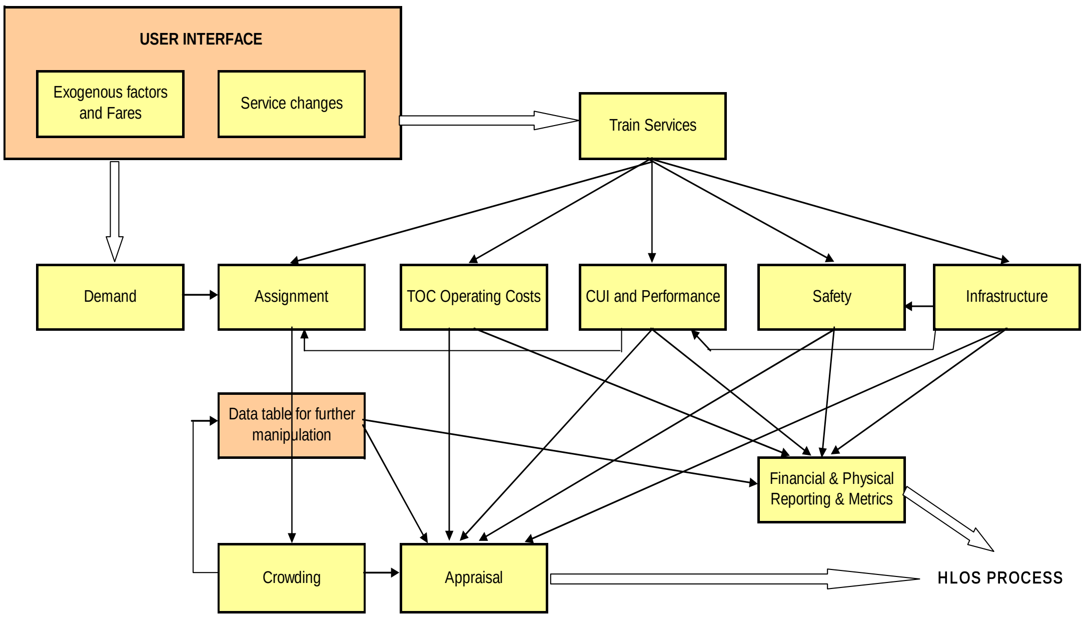
11. Since the NMF comprises a number of modules, some of which were not developed specifically for the NMF, the model was built using Oracle databases and Excel. The outputs are all provided in Excel format.

12. Figure 1shows the NMF model structure. The User Interface allows the user to adjust the key drivers of demand (exogenous factors, fares and the timetable)

and also allows the user to adjust some operating costs. The appraisal and financial and physical reporting is also called from this location.

13. The timetable specification drives changes in all modules, some of which are also inter-linked. For example, a change in the number of trains operated affects performance, changes in performance impact upon demand and changes in infrastructure affect safety and performance. All modules feed the financial and physical, metrics and appraisal reporting.

Figure 1: NMF High Level Model Structure



14. For a detailed description of the model, its component modules, and interactions between the modules, see the NMF Background Document at: http://www.dft.gov.uk/about/strategy/whitepapers/whitepapercm7176/railwhitepapersupportingdocs/pdfnetowrkmodelframe1 .

1.3 NMF Model Audit

15. Over the period 23 April to 25 June, the consultants ARUP conducted an audit of the NMF technical documentation and of the model functionality. While a number of recommendations were proposed, no significant model error was uncovered that would significantly change the HLOS metrics or the VfM

assessments. This gives confidence to the stakeholders that this strategic model is performing as expected. (However, it is to be noted that some errors uncovered as part of this audit, such as in the application of the crowding curve methodology, did provide the basis for a review of the model's functionality and provided an enhancement to the model.)

16. However, as part of the future use and development of the model, ARUP's recommendations will be important to help scope further enhancements and to improve current model functionality.

SECTION 2: MODELLING THE BASELINE AND THE HLOS

2.1 The Baseline Timetable

17. In order to analyse the HLOS options or schemes, a baseline had to be constructed. Such a counterfactual scenario is used to inform what would happen without the proposed HLOS interventions; and is useful in analysing schemes that add to or subtract from the baseline.

18. NMF starts from a base timetable - May 2005 - and then incorporates committed timetable changes to produce a revised baseline that will operate prior to the HLOS period. Full details of changes implemented can be found at: http://www.dft.gov.uk/about/strategy/whitepapers/whitepapercm7176/railwhitepapersupportingdocs/pdfnmfspecimenhlos . The May 2005 timetable applies for services for which no changes are expected prior to the HLOS period or where firm changes have not been agreed as at May 2007.

2.2 HLOS Optioneering

19. Route Utilisation Strategies (RUSs), RPAs, work conducted by Transport for London, and model runs using the PLANET model (which is owned by DfT), were all instrumental in providing an initial assessment of where stresses (crowding) exist on the network, and provided an initial understanding of where additional capacity might be required. The use of the NMF baseline forecasts (mapped using GIS software, designed to work with NMF) was an important part of the development of specimen options tested as part of HLOS.

20. Most HLOS schemes were developed around train lengthening (rolling stock capacity enhancements) to deliver improvements in peak crowding. A few options reflected journey time improvements.

21. The full list of HLOS options or schemes tested could be found at: http://www.dft.gov.uk/about/strategy/whitepapers/whitepapercm7176/railwphlsospecimen.

22. Over the period April – June 2007 around 30 schemes were coded and tested in NMF. A number of variants of such schemes were also tested using NMF. The Thameslink project was coded and tested in NMF as an option (rather than in the baseline since time constraints prevented a full update to the baseline to reflect timetables which were not in final stages of development). Including Thameslink was essential in order to capture the interactions with other services in the London and South East area.

2.3 Implementing and Analysing Schemes in NMF

23. The schemes analysed in HLOS are coded in NMF using a procedure similar to MOIRA[1] (timetable editor). The Financial and Physical module and the Appraisal module in NMF summarises the outputs from model runs, and these allow an analysis of the load factor, passenger demand, safety, and reliability changes which then informed the metrics used in HLOS. It is also important to note that the Appraisal module also allows for an assessment of the Value for Money (VfM) of each scheme or packages of schemes.

2.4 HLOS Packages

24. Schemes such as those in the London and South East were packaged together, to reflect some important interactions between schemes. Similar such interactions exist elsewhere on the rail network. For example, separate schemes for the Transpennine (TPE option) and Manchester may generate different costs and benefits when modelled together, since a part of the infrastructure costs may be shared between the two sets of services. So, in the presentation of the final packages, the grouping of schemes avoided the double counting issue. This raises another point which is discussed later relating to

[1] MOIRA is a rail industry model and allocates passenger to trains using pre-defined demand profiles, and is an instrument used by the whole industry.

the Value for Money of individual schemes. Some (infrastructure) costs could be shared between schemes but the interactions also work on the demand side since passengers can choose to travel on alternative train services when such opportunities exist.

SECTION 3: DEMAND FORECASTS AND ASSUMPTIONS

3.1 The Forecasting Methodology

25. The HLOS period (2009-2014) necessitates forecasting demand and crowding in the baseline and in the do-something scenarios (the HLOS interventions). Determining the future level of demand in the NMF starts with some industry accepted practices and assumptions, as defined by the Passenger Demand Forecasting Handbook (PDFH)[2]. These are implemented in RIFF-Lite[3] in NMF. The full documentation on demand and assignment processes used in NMF is published at: http://www.dft.gov.uk/about/strategy/whitepapers/whitepapercm7176/railwhitepapersupportingdocs/

26. The rail network is disaggregated into about 560 demand zones (each demand zone comprises one or more stations) and forecasts are produced for passenger demand for travel between demand zone pairs. Passenger demand forecasts are obtained by looking separately at the impact of external factors, fares, rail generalised journey time, performance and crowding. The forecast procedure involves mainly six stages:

I. A base journey information matrix is used as the starting point. This is part of the NMF database. This is derived from industry sources (LENNON[4]) and supplemented with additional data (as in-fills) where full travel details are not available. This procedure is described in the Demand and Assignment Module.
II. RIFF-Lite is used to produce the forecasts. This forecasting tool contains exogenous (GDP, population and employment, diversion factors – 'other modes' cost) drivers of demand and fares.
III. The model uses an elasticity approach and calculates the impact of exogenous factors and fares on the number of journeys/passengers for each demand zone.

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[2] PDFH refers to the Passenger Demand Forecasting Handbook and is owned by the Passenger Demand Forecasting Council. This document is copyrighted and DfT are not able to release any details regarding parameters or elasticities that it contains.
[3] Stands for Rail Industry Forecasting Framework, and is used to forecast rail demand.
[4] Latest Earnings Networked Nationally Over Night. A ticket sales database, which contains for all flows the corresponding demand.

IV. The resulting journey/passenger (unconstrained) forecast is adjusted for changes in rail generalised journey time and then allocated to individual trains according to predefined demand profiles (assignment) using the MOIRA model (in NMF a national MOIRA is used);

V. Individual trains and corresponding passengers are then aggregated into links, whereby a link is a combination of demand section, time of arrival/departure and service code;

VI. The number of journeys/passengers on each link is finally adjusted for the impact of performance and crowding. This is to reflect the constrained demand that the network is assumed to be able to carry.

27. Revenue forecasts are based on a procedure similar to the one used for forecasting demand, but in this case it applies an average fare to convert demand into revenue. Such forecasts are produced up to the year 2030.

28. The elasticities used in stage (III) are taken from version 4 and 4.1 of the Passenger Demand Forecasting Handbook (PDFH). Forecast for the external factors are based on DfT data. All fares are assumed to increase at RPI+1%. The current functionality in the model makes it difficult to use alternative fares changes, especially for unregulated fares.

29. The HLOS options tested in NMF produced the following set of demand forecasts:

Table 1: Annualised NMF Forecast Demand Growth 2006/07 through 2013/14

Sector	Annual passenger km in 2006/07 (millions)	Annual passenger km forecast in 2013/14 (millions)	Annualised growth rate
Intercity	14,167	18,487	3.9%
London & South-East	21,125	25,233	2.6%
Regional	8,382	9,375	1.6%

For the purpose of this table, TOCs included in each sector are:

- Intercity: Virgin West Coast, GNER, Midland Mainline, FGW
- London & South-East: Chiltern, SWT, Silverlink, Southern, Gatwick, FCC, IKF, C2C, One
- Regional: Central, TPE, ATW, Northern, Merseyrail, Virgin Cross Country

These forecasts seem reasonable for the parameters and PDFH elasticities used.

3.2 Evidence to Support the Use of Standard (PDFH) Assumptions

30. The elasticities used to calculate the impact of external factors and fares on demand for rail travel are taken from versions 4 and 4.1 of the Passenger Demand Forecasting Handbook (PDFH) in line with standard DfT practice. The decision to use standard PDFH parameters is supported by two recent studies commissioned to investigate the ongoing relevance of PDFH elasticities.

31. The first study was carried out by MVA on behalf of DfT and was intended to identify short term improvements to current elasticity based forecasting methodologies and to consider areas where further research is needed. Firstly, whilst the study suggested revisions to some of the GDP elasticities, there is some concern that the proposed new parameters may also be picking-up the effect of socio-demographic changes over the estimation period. Without validation against more recent data the existing elasticities are considered preferable. A new approach to estimating the impact of fare changes was also suggested but no work was carried out to calculate new parameters.

32. The second study was carried out by Steer Davies Gleave (SDG) on behalf of the Passenger Demand Forecasting Council (PDFC). This study was commissioned to understand the reasons for the rapid growth in rail demand that has been observed across the network in 2006/2007, and to assess whether the growth was in line with what would be expected based on PDFH recommended parameters. In conclusion the study found that over the long run PDFH could explain most of the observed growth in demand once allowance is made for lagged effects of earlier service and performance improvements. This includes a bounce-back in demand following the Hatfield incident and more recent London bombings. SDG are progressing this work further but it is unlikely that the additional research will change the conclusions on the basis of which PDFH parameters are considered preferable for the purpose of RIFF-Lite forecasting in NMF. However, this conclusion should be read in conjunction with the section below on the use of non-PDFH parameters for some cities of major conurbations.

3.3 Non-Standard Demand Assumptions

33. When implementing the PDFH assumptions in NMF the forecast growth rates observed for some areas, namely for the major conurbations, appeared low relative to recent experience. Additionally, Route Utilisation Strategies (RUS), which contain more detailed analysis and forecasts of demand, indicated that the demand in the major conurbations were higher than the PDFH forecasts. If the recent rapid growth continues in the future, it may be likely that PDFH parameters may have to be revisited or re-estimated.

34. As a consequence of the more rapid growth, unexplained by PDFH parameters, and in the light of NR's more detailed analysis especially for the GMPTE (Greater Manchester PTE) area, a growth overlay was applied in NMF (namely, in RIFF-Lite) for these areas for the years 2006 to 2018. This overlay was applied to match the observed growth rate derived from Lennon data, and summarised in table 2 below (except for Nexus which was based on recent counts data). This overlay was assumed to decline over time and the forecast to converge to PDFH in 2018.

Table 2: Alternative (Non-PDFH) Growth Forecasts

<table>
<tr><td colspan="7">Forecast growth rates for semi-unconstrained demand into each city centre in the 3 hour AM peak (7am to 10am) on an average weekday</td></tr>
<tr><td>Year</td><td>Centro</td><td>Metro</td><td>GMPTE</td><td>SYPTE</td><td>Nexus</td><td>Cardiff</td></tr>
<tr><td>2006</td><td>4.8%</td><td>12.4%</td><td>5.4%</td><td>12.7%</td><td>13.1%</td><td>4.9%</td></tr>
<tr><td>2007</td><td>3.9%</td><td>8.4%</td><td>4.2%</td><td>8.9%</td><td>8.5%</td><td>5.2%</td></tr>
<tr><td>2008</td><td>3.7%</td><td>7.8%</td><td>4.0%</td><td>8.2%</td><td>7.8%</td><td>4.9%</td></tr>
<tr><td>2009</td><td>3.6%</td><td>7.2%</td><td>3.9%</td><td>7.6%</td><td>7.2%</td><td>4.7%</td></tr>
<tr><td>2010</td><td>3.5%</td><td>6.7%</td><td>3.7%</td><td>7.0%</td><td>6.8%</td><td>4.5%</td></tr>
<tr><td>2011</td><td>2.6%</td><td>2.9%</td><td>2.6%</td><td>2.9%</td><td>1.5%</td><td>PDFH</td></tr>
<tr><td>2012</td><td>2.5%</td><td>2.8%</td><td>2.5%</td><td>2.8%</td><td>1.5%</td><td>PDFH</td></tr>
<tr><td>2013</td><td>2.4%</td><td>2.7%</td><td>2.4%</td><td>2.7%</td><td>1.4%</td><td>PDFH</td></tr>
<tr><td>2014</td><td>2.4%</td><td>2.6%</td><td>2.4%</td><td>2.6%</td><td>1.4%</td><td>PDFH</td></tr>
<tr><td>2015</td><td colspan="5" rowspan="3">overlay to decline to zero by 2018</td><td>PDFH</td></tr>
<tr><td>2016</td><td>PDFH</td></tr>
<tr><td>2017</td><td>PDFH</td></tr>
<tr><td>2018</td><td>PDFH</td><td>PDFH</td><td>PDFH</td><td>PDFH</td><td>PDFH</td><td>PDFH</td></tr>
</table>

35. To implement these changes in NMF, in order to achieve the growth rates in the table above, a dummy driver was created in RIFF-Lite at Origin-Destination level and assigned the values in table 3 below in each area. Table 3 provides the details of the dummy drivers for each of the PTEs for each of the year under consideration. For Cardiff, the numbers used in the semi-constrained demand growth were agreed with the Welsh Assembly Government. The Capacity metric determined by DfT covers England and Wales only; consideration of adjusting Scottish flows was left to Transport Scotland.

Table 3: Overlay in RIFF-Lite Applied to the PTE Areas and Cardiff

Values assigned to RIFF-Lite dummy driver in each area						
Year	***Centro***	***Metro***	***GMPTE***	***SYPTE***	***Nexus***	***Cardiff***
2006	3.0%	16.0%	8.0%	36.5%	56.5%	6.5%
2007	3.5%	12.3%	4.3%	17.5%	14.0%	6.5%
2008	3.0%	9.8%	3.7%	13.9%	10.8%	6.5%
2009	2.5%	7.4%	3.0%	10.4%	7.7%	6.5%
2010	1.8%	4.9%	2.1%	6.8%	3.9%	6.5%
2011	1.1%	1.8%	1.5%	1.8%	-0.2%	0.0%
2012	1.1%	1.8%	1.5%	1.8%	-0.2%	0.0%
2013	1.1%	1.9%	1.5%	1.9%	-0.2%	0.0%
2014	1.1%	1.9%	1.6%	1.9%	-0.1%	0.0%
2015	0.8%	1.4%	1.2%	1.4%	-0.1%	0.0%
2016	0.6%	0.9%	0.8%	0.9%	-0.1%	0.0%
2017	0.3%	0.5%	0.4%	0.5%	0.0%	0.0%
2018	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

36. The specific RIFF-Lite O-D flows to which the above values have been applied are listed in the table 4 below

Table 4: RIFF-Lite Flows Applying Non-PDFH Growth Factors

Urban area	**Origin Zone**	**Destination Zone**
Cardiff	Rest of South Wales	Cardiff
	Cardiff	Cardiff
	Avon & Wiltshire	Cardiff
	Bristol	Cardiff
Centro	Rest of West Midlands	Central Birmingham
	Hereford & Worcester	Central Birmingham
	East Midlands 1	Central Birmingham
	Birmingham Airport	Central Birmingham
	North Wales	Central Birmingham
	East Midlands 2	Central Birmingham

GMPTE	Rest of Manchester	Central Manchester
	Cheshire	Central Manchester
	North Lancashire	Central Manchester
	Rest of West Yorkshire	Central Manchester
	Rest of Merseyside	Central Manchester
	Manchester Airport	Central Manchester
Metro	Rest of West Yorkshire	Leeds
	North Yorkshire	Leeds
	Rest of South Yorkshire	Leeds
Nexus	Tees-side	Newcastle
	Northumberland	Newcastle
	Cumbria	Newcastle
	North Yorkshire	Newcastle
	Rest of Tyne & Wear	Newcastle
SYPTE	Rest of South Yorkshire	Sheffield
	East Midlands 2	Sheffield
	Sheffield	Sheffield
	Eastern	Sheffield
	Rest of Manchester	Sheffield
	Rest of West Yorkshire	Sheffield
	Central Manchester	Sheffield
	Leeds	Sheffield
	North Yorkshire	Sheffield
	Humberside	Sheffield

37. To implement the overlays in RIFF-Lite, the appropriate route sections on which to apply the overlays had to be identified. This was done on the basis of selecting the O-D flows which are significant in terms of the perceived extra growth for mostly short-distance trips (for which there are significant season ticket usage). The choice of routes was based on O-D flows with a level of season ticket usage above 1% of the total season ticket usage for each area in the financial year 2005/06. Once this selection is made, the overlays were applied to all the ticket types in RIFF-Lite for the relevant PTE area or major conurbation.

3.3 Additional Overlays Implemented in NMF - Inputs and Outputs

38. The NMF output (passenger journeys and kilometres) was further adjusted to account for the following factors

1. Intrazonal trips (which are not reflected in the demand uplifted in RIFF-Lite)
2. Available count data (to reflect the latest actual demand data)

3. National Rail Trends Statistics
4. Extension of the East London Line
5. Domestic services into St. Pancras International

39. Intrazonal trips: flows into Cardiff, Liverpool, Sheffield and Nottingham have been uprated by 5% to account for Intrazonal trips lost as a result of the aggregation of stations within NMF zones. The 5% figure is used based on some previous comparisons between NMF base demand and actual numbers. This uplift applies to all modelled years.

40. Count data: An adjustment to NMF estimates of demand (for the AM Peak) was also made for the following areas: Cardiff, Leeds, Manchester, Fenchurch Street and Liverpool Street, in order to match the levels recorded in recent counts data. This uplift is not implemented in the RIFF-Lite but implemented in the final NMF outputs. The uplifts used are summarised in table 5 below.

Table 5: Demand Uplifts Based on Latest Counts Data

3 hour peak	Uplift
Fenchurch Street	1.11
Liverpool Street	1.10
1 hour peak	Uplift
Fenchurch Street	1.10
Liverpool Street	1.09
1 and 3 hour peak	Uplift
Leeds	1.02
Manchester	1.11
Cardiff[5]	0.88

41. It should be noted that

- count data refer to one or a few specific weekdays of a given week (or a given few weeks) of the year;
- NMF data shows estimates of usage for an average weekday, taking into account all weekdays of a given year (bank holidays included).

[5] The uplift for Cardiff has been applied after the 5% uplift was applied to this area to account for Intrazonal trips.

42. National Rail Trends Statistics: For the Capacity Metric provided in Table A3 of the appendix to the White Paper, we rebased NMF outputs so that they matched the National Rail Trends data for 2006/07 on a TOC-by-TOC basis.

43. Extension of the East London Line (not modelled in NMF through RIFF-Lite): to account for abstraction from the extension of the East London Line, the estimated number of passengers arriving into London Bridge on an average weekday in the one hour AM peak has been reduced by 1,400 (by 2,800 in the three hour AM peak). This adjustment has been applied to every year from 2009/10 onwards.

44. Domestic services into St. Pancras International: to account for domestic services into St. Pancras International, additional capacity (seats plus standing) was included in the flows into St. Pancras for the years 2010 and 2014. The details are shown in table 6 below (see paragraphs 76 and 77 for further details).

Table 6: Adjustments to Demand and Capacity for Domestic Services into St Pancras

Year	2010		2014	
	passengers	capacity	passengers	Capacity
AM 1 hour peak	2,229	3,536	2,413	3,536
AM 3 hour peak	4,458	10,608	4,825	10,608

SECTION 4: ECONOMIC ANALYSIS

4.1 Definitions and Assumptions

45. This section describes the assumptions used in NMF to define capacity for the purpose of economic appraisal and VfM assessments.

4.2 Rolling Stock Capacity and Proxy Seating

4.2.1 NMF ROLLING STOCK CAPACITIES

46. In order to model the impact of crowding and to understand the capacity provided by each train service the NMF needs to understand the passenger carrying capacity provided by each vehicle using the network. Since the network consists of a large range of vehicle types; carriages of different length, different seating layout, different arrangements for standing, etc., it was necessary to arrive at some relatively straightforward (or generic) train capacities to reflect both the total number of seats as well as the total number of standing capacities. Both these capacity measures are needed for modelling crowding or over-crowding on trains. This section describes the assumptions used to estimate the vehicle capacities.

47. The NMF has over 500 different classes and subclasses of rolling stock in its database, and these are likely to change over time. Not all of these different types are necessarily used in the baseline or option timetable although capacity assumptions are made for all of them.

NMF Seating Capacity

48. The estimates of seating capacity were derived from a number of sources and assumptions. The first step was information downloaded from the *Genius*[6]

[6] This database (which is a system for handling on the day hiring of vehicles) is linked to another database – Gemini - which is a cross industry rolling stock asset management system. Gemini provides an information base on asset location, faults and running maintenance.

database over a number of days derived from the base timetable (i.e. actual running timetables as recorded in Genius). Where this information downloads left gaps given some new rolling stock types may not be fully recognised in the download process, this was supplemented by the DfT's Green Book counts. For any remaining gaps in total seated capacity Delta Rail made some estimates, informed by number of sources including web searches and the Rolling Stock books ("British Railways Locomotives and Coaching Stock").

NMF Standing Capacities

49. The total standing capacity was calculated by DfT using an interpretation of the PDFH assumption of total capacity (which is, generically, total capacity = 1.4 *times* total seated capacity), but adjusted in some cases to reflect the configuration of the rolling stock.

50. For some rolling stock classes (predominately **London and South East** commuting type stock) information on the standing space was available owing to the existence of the PIXC regime (Passengers in Excess of Capacity). DfT provides estimates of these for the purpose of implementing the PIXC arrangements. There are, of course, a number of assumptions on which such estimates of capacity are based:

- Calculate the total available floor area (including where there are seats)
- Determine the total (seats + standing) capacity using 0.45 m^2 per person. However, for Metro stock 376s and SWT's refurbished 455s the assumption made was 0.35 m^2 person
- No matter how many seats in the train, the total capacity would be the same.

51. For all **intercity type rolling stock** the standing space was defined as 20% of the standard class seating space. In other words, *total capacity = 1.2 times total seated capacity*.

52. For all other rolling stock for which there was no information on floor space the standing space was assumed to be 40% of the standard class seating space, i.e., *total capacity = 1.4 * total seated capacity*.

4.2.2 Proxy Seating

53. NMF uses PDFH crowding penalties and parameters, which are based on seated capacities. This posed a problem for NMF in modelling crowding to account for differences in seating densities.

54. In order to estimate the crowding effect of different seating densities so that PDFH parameters and values could still be used, a methodology was developed using a proxy value of seating capacities (a full description is provided in NMF documentation – Demand and Assignment Module). In NMF the proxy seating functionality can be switched off if required.

4.3 The Crowding Methodology in NMF

55. The impact of crowding on demand (to generate constrained demand) was estimated by using a model functionality that was specifically developed for the NMF. This crowding methodology deviates from PDFH in that it uses time crowding penalties - which were derived from PDFH monetary crowding penalties - and bespoke estimates of journey time elasticities. This approach yields a set of mappings (crowding curves) between constrained and unconstrained demand that are applied to each peak link in NMF. The mappings vary according to TOC type, peak type and percentage of commuters travelling along each link.

56. The crowding impact is modelled on a link by link basis, for different peak types. Where crowding exists on the network it affects some shorter distance passengers for their entire journey, but it also affects longer distance passengers for part of their journey. The NMF crowding module assesses the impact on key demand sections based on the total number of passenger (from all O-D flows) assigned to that particular link.

4.4 The Appraisal of Benefits and Costs

57. The NMF appraisal module (which is fully documented in the published NMF documentation at: http://www.dft.gov.uk/about/strategy/whitepapers/whitepapercm7176/railwhitepapersupportingdocs/nmfappraisabackgro.pdf), calculates the Value for Money (VfM) of schemes or options against a counterfactual scenario (base case). The appraisal module consists of input parameters that are consistent with WebTAG (www.webtag.org.uk) guidance. Similarly, the methodology used and the calculations executed in NMF are consistent with WebTAG guidance.

4.4.1 Benefits

58. Table 7 presents the TEE (Economic Efficiency of Transport System) table for the HLOS run for all the specimen schemes combined (which is the combined model run conducted as part of the HLOS modelling for the capacity metric). This table contains a description of the components of benefits included in the assessment.

Table 7: Analysis of Monetised Costs and Benefits (AMCB) for HLOS Mega-Run Excluding Thameslink

Analysis of Monetised Costs and Benefits (AMCB)

	TOTAL £M	
Noise		
Local Air Quality	-£37	
Greenhouse Gases	-£80	
Relief of Crowding	£5,937	
Accidents	-£74	
Consumer Users	£437	
Business Users and Providers	£626	
Reliability	-£30	
Option Values		
Present Value of Benefits (see notes) (PVB)	£6,778	
Public Accounts	£4,443	
Present Value of Costs (see notes) (PVC)	£4,443	
OVERALL IMPACTS		
Net Present Value (NPV)	£2,336	*NPV = PVB - PVC*
Benefit to Cost Ratio (BCR)	1.526	*BCR = PVB / PVC*

Note: This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

59. Wider economic benefits (WEB) of the HLOS options have not been included in the value for money assessment.

60. The environmental impacts have been estimated using the environmental module, as discussed in the next section of this evidence pack.

4.4.2 Estimation of Costs

61. NMF has the functionality of estimating both the train operating companies' costs (TOC) as well as the infrastructure costs associated with a timetable or a timetable change. The TOC cost module is fully detailed in the following NMF documentation: http://www.dft.gov.uk/about/strategy/whitepapers/whitepapercm7176/railwhitepapersupportingdocs/nmftoccostmoduleb1.pdf .

62. The main components of costs that feed into the appraisal module are:

- Staff costs
- Rolling stock costs
- Traction costs (including EC4T)
- Commission payments
- Performance payments
- ‘Other’ costs (a residual cost calculated in the model).

(However, not all these modelled costs were used in the final appraisal, since some overlays were required, as discussed in paragraph 66 below.)

63. This module uses a fairly simple approach of taking unit rate costs for line items (such as maintenance costs, staff costs, etc), and uprating them by the appropriate variable (unit hours, train hours, etc). For leasing costs (capital and non-capital) the unit cost values are uprated using peak unit hours. This is generally a reasonable assumption, but in some cases where rolling stock changes are not made equally between peak and off peak periods this may lead to some inaccuracies.

64. Therefore, to improve the quality of our cost estimates for the purpose of HLOS we employed the estimates used to determine the SoFA. One likely area of focus in developing the NMF will be on how to further develop our understanding of the determinants of TOC costs.

65. The infrastructure cost module (ICM) is also part of NMF. This model is briefly described in the NMF overview document (http://www.dft.gov.uk/about/strategy/whitepapers/whitepapercm7176/railwhitepapersupportingdocs/pdfnetowrkmodelframe1). This module has been developed by Network Rail.

66. This module takes as an input a timetable from the NMF, and estimates the Operations, Maintenance and Renewals (OMR) costs associated with this train service specification. Enhancement costs are not calculated in the ICM

(examples could be platform lengthening, additional depots etc), and are brought in off-line from the model. The ICM also produces estimates of track defect rates which are used by other NMF modules. Network Rail is currently developing a new version of the ICM, which will be incorporated into the NMF when it is made available by Network Rail.

67. For our VfM analysis the OMR costs were estimated offline, due to the way the ICM estimates long run (+30years) changes in these costs. On the TOC cost side, some of the staff cost numbers had to be adjusted for the fact that in most cases train lengthening was not considered to add to this cost component. Since the NMF is built on a per unit cost approach, driver cost, for example, would rise with train lengthening. The overlay applied in appraisal was to set these changes to zero. Additional to these overlays, the variable track access charges were also overlayed in the appraisal, since ICM did not produce sufficiently robust forecasts for use in the 30 year and 60 year analyses.

4.4.3 Value for Money (VfM) Assessments of HLOS Schemes

68. In the process of developing options, a consideration has been the VfM implications of the schemes that were tested in NMF. The benefit-cost-ratios used to judge the VfM of a scheme may overstate the costs in some instances where these costs could be (or are) shared with other schemes. For example, infrastructure costs following one scheme may benefit another scheme running in parallel. However, two schemes sharing infrastructure costs may also share demand and this will impact on the user benefits, and the benefits of individual schemes may be overstated, unless modelled as a package.

69. The overall BCR for the HLOS schemes was 1.71. This includes the impact of the Thameslink project (BCR of 2.0). These figures exclude wider economic benefits.

70. The London and South East schemes offer medium to high VfM, while some of the regional schemes tend to indicate lower BCRs. This is understandable given the nature of crowding in London and the South East (with a wider spread around the one hour AM peak) compared to the rest of the country (where the peak is for a shorter period).

71. NMF tends to underestimate the benefits of adding capacity to crowded suburban services on routes where intercity services also operate. This is due to the nature of zoning of demand in NMF, whereby some small stations have been grouped with larger ones, and hence the demand assignment will choose the faster intercity service rather than the suburban services in order to allocate demand. This mis-assignment of demand is due to the zoning and the aggregation procedure currently carried out in NMF, and further improvements in the model will be required if more detailed analysis of localised services are to be analysed.

4.5 Appraisal Assumptions

Appraisal Period

72. Given the mixture of schemes we have tested in HLOS, including a number them involving infrastructure investments (for e.g. track improvements, and platform lengthening), we have used a 60 year appraisal period. This is consistent with standard DfT guidance (www.webtag.org.uk).

NMF Years and Interpolation

73. In order to meet the requirement to develop a model that can run in a matter of hours rather than days, it has not been possible to model every forecast year explicitly (however, the model has the capability to do this, with extended run times). As the NMF models each year independently, as long it models in detail those years for which significant changes are expected (for example changes to timetables or exogenous demand growth) the error introduced through this

approach should be small. Typical NMF modelled years are: 2004/05, 2006/07, 2008/09, 2009/10, 2013/14, 2019/20, and 2029/30. To determine the values for intermediate years, NMF outputs are interpolated on the basis of constant growth rates between modelled years.

Diversion Factors

74. To assess the impact changes in rail services may have on other modes applied diversion factors to capture abstraction from the bus and highway network. Given the focus of HLOS on increasing commuting capacity transfers from air have been ignored. Abstraction rates were derived from the National Transport Model (NTM). Detail of the NTM can be found on the DfT website (http://www.dft.gov.uk/pgr/economics/ntm/), and details of the numbers used can be found in the NMF appraisal documentation. In the VfM calculations changes in levels of congestion for car users, and safety benefits through the removal of car kilometres from the highway network, were included.

Optimism Bias

75. We have followed standard DfT guidance in taking account of capital cost optimism bias. This is available at www.webtag.org.uk (guidance document 3.13.1, section 3.8.4).

4.6 Use of Overlays in NMF

Overlays in the NMF: CTRL Domestics

76. The approach used to calculate demand in the NMF was to take a base level of demand between particular origins and destinations, and then grow this demand over time through changes in exogenous demand and service changes. For most analysis this approach works well, but fails for cases where there is no base demand to gross up, for example through new lines. Due to the new link to St Pancras for CTRL-D, we needed to take demand forecasts from elsewhere and 'overlay' these onto the standard NMF outputs.

77. The introduction of CTRL-D services would be expected to have two effects: a generation of demand along the new line, and an abstraction of demand from existing services. In both cases these demand changes were sourced from the work undertaken for the SRA (Strategic Rail Authority) on the CTRL-D business case in September 2004. The abstraction indicated in table 6 was applied through Riff-Lite for full, reduced and seasons ticket.

SECTION 5: THE ENVIRONMENTAL ASSESSMENT OF HLOS

5.1 The NMF Environmental Module

78. As part of the NMF development, AEA Technology (and DeltaRail and Paul Watkiss Associates) was contracted to produce the 'environmental module' in August 2007. The project was to provide physical and monetary values of the environmental (emissions and noise) damage costs associated with rail transport, so that these could be incorporated into the NMF. A copy of the full report could be found at: http://www.dft.gov.uk/about/strategy/whitepapers/whitepapercm7176/railwhitepapersupportingdocs/nmfenvironmentalmodule.pdf. A summary of the model functionality is provided below.

79. The environmental module has been designed as a spreadsheet (MS Access) model of the rail environmental externalities, allowing the climate change, air pollution, and noise externalities associated with routes within the NMF to be calculated. The module consists of two separate models - an emissions model and a noise model.

80. As an overview of the models, the following flow charts summarise the processes, and describe the requirements of the models to produce monetised environmental impacts of timetable changes. Essentially, the model uses an NMF timetable and it calculates the emissions impacts based on train speed, stopping patterns, rolling stock types, fuel use. It then calculates the damage costs from such emissions. The noise pollution is also calculated but using a different process as described in the flow chart below.

Figure 2: Flow chart describing emissions modelling process

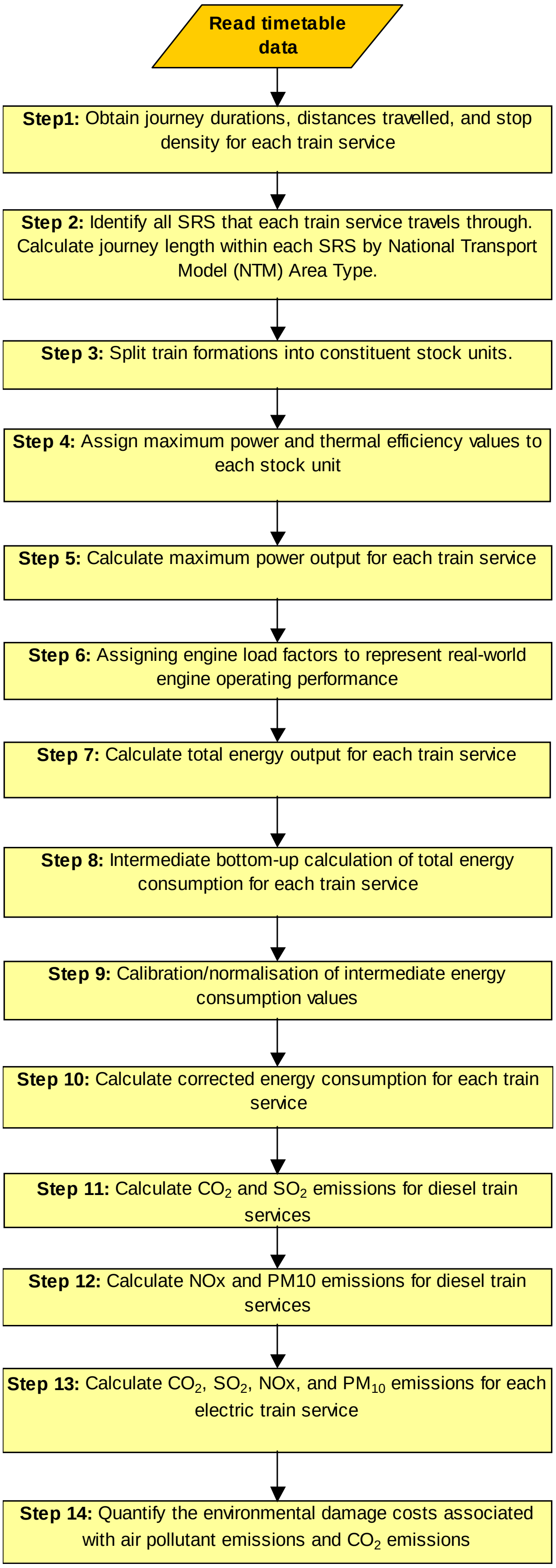
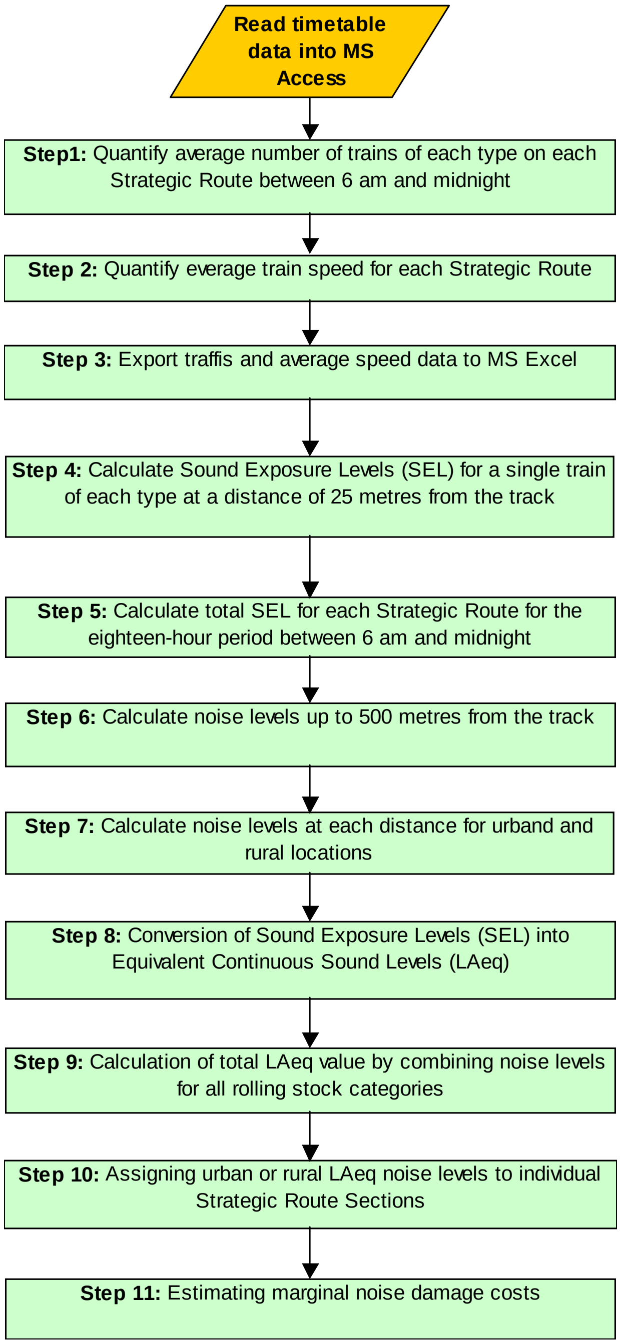


Figure 3: Flow chart describing noise modelling process



81. The model estimates the atmospheric emissions associated with train services for any year up to 2068, with the ability to disaggregate model outputs by Strategic Route, Strategic Route Sections, and the DfT's National Transport Model (NTM) area type, and individual train services.

82. Emissions of CO_2 from diesel trains are directly related to the amount of fuel consumed by the trains over their journey. They are related to the carbon contents of the fuel, as all the carbon in the fuel is directly emitted as CO_2, or will ultimately produce this pollutant in the atmosphere. The carbon content parameter does not change much, and is currently set at 0.870. The carbon content of ultra-low sulphur diesel and sulphur-free diesel used in road transport if 0.863. In the model, it has been set at 0.870 for all years between 2005 and 2009 and to 0.863 thereafter.

83. For air pollution, only NO_X (Nitrous Oxides), PM_{10} (particulate matter), and SO_2 (sulphur dioxide) emissions were included in the model. As with carbon, the model relies on the use of emission factor data for a selection of current diesel locomotives and multiple units, as well as data on current and future average emission factors associated with electricity generation. In the model it is assumed that the UK railway will move from using gas oil with a relatively high sulphur content (ca 1490 parts per million) to a low or sulphur-free fuel (10 parts per million) by 2010/11.

84. Emission factors for NO_X and PM_{10} for the current rolling stock are based on analyses of engine manufacturers' type testing data and from in-service test results. There are not significant differences in the factors among engines of different classes. Emission factors for different classes of diesel locomotives falling within the same engine power range (e.g. 560-2000 kW) were averaged. The emission factors are lowered for future stock to the limit values set in the Directive ((Non-Road Mobile Machinery Directive Stage IIIA and IIIB legislative emission classes) with the implementation of the limit values occurring according to the dates set in the Directive for the Stage IIIA differ for different engine size range.

85. The emissions from electric trains are not released to the atmosphere at the point of train use, but at power stations. The model, in this case makes use of the normalised electricity consumption data calculated in Step 10 (in the flow chart above) for each

electric train service and multiplies these data by the appropriate average power station emission factors for each pollutant for the particular year of interest. The report details the assumptions made on the emissions at power stations for power losses on the network and at stations.

86. The monetisation of the calculated impacts uses the latest recommended social cost of carbon for estimating costs of CO_2, and the latest DEFRA's recommendations on damage costs for air quality impacts.

87. The noise model was developed around the Calculation of Railway Noise (CRN) methodology, which is the standard method used in the UK railway scheme appraisal for estimating railways noise impacts. The model makes use of the Dft's WebTAG guidance on quantifying the affected population that would be annoyed by noise. This model was constructed as a stand-alone model, given the MS Access software memory limitations. The flow chart (Figure 3) describes the process for estimating noise impacts from NMF timetables.

5.2 HLOS Environmental Impact

88. The noise impact from the HLOS options were not computed since train lengthening has been modelled and found not to contribute significantly to additional noise from the base timetable (an incremental noise by at least 3 decibels is required for it to be included in the noise model). The cost associated with HLOS is set at zero in the appraisal reporting sheet.

89. The impact for CO_2 has been estimated using the model. The outputs presented below exclude the impact of Thameslink option, since the costs and benefits associated with Thameslink have already taken into account in the business case. Hence, the results below are additional to the Thameslink option.

90. The environmental impact from HLOS has been appraised and the results are shown in Table 8 below. The figures represent net impacts in the sense that they take into account the environmental benefits of diversion from road to rail.

Table 8: Summary of Emissions and Damage Costs from HLOS (60 Year Appraisal)

	CO_2	NO_X	SO_2	PM_{10}
Total Emissions ('000 tonnes)	6,225.3	37.5	3.0	0.8
Present Value of Emissions (2002 Prices) – million £	79.8	18.8	2.3	15.9

SECTION 6: ANALYSIS AND INTERPRETATION OF RESULTS

6.1 NMF Outputs

91. The NMF outputs extracted for the purpose of HLOS include the metrics and the VfM implications of the schemes and the packages. The metrics were in two parts: (1) the passenger kilometres to be accommodated on the rail network and (2) the load factors not to be exceeded by the end of the HLOS period. Section 4 has already covered a number of the considerations relating to the NMF outputs. This section provides some additional materials which informed the HLOS process and the published metrics for both HLOS and the White Paper.

92. Only the capacity metric has been directly derived from the NMF. The other two metrics relating to safety and reliability have been informed by other policy considerations, such as management initiatives that would deliver improvements additional to capacity changes as modelled in NMF.

93. Tables 9a and 9b show the baseline projections of the capacity metrics without the HLOS options (but including the Thameslink project). These tables are important for an economic assessment of the net impacts from HLOS interventions. This table should be compared with Tables 10a and 10b which are the published HLOS capacity metrics.

94. The average load factor for London is 83% in the high peak in the do-nothing scenario and it is 76% in the HLOS scenario. While the policy on this metric is that crowding should not get any worse relative to 2006/7 levels, the analysis shows that the improvement in crowding conditions is reflected in an average load factor reduction of about 7 percentage points.

95. A similar picture emerges when considering the other major cities.

Table 9a: The Base Case Capacity Metric (Without HLOS) for London and South East

	Peak Three Hours			High Peak Hour		
London	2008/09	2013/14	London Maximum Average Load Factor at end CP4	2008/09	2013/14	London Maximum Average Load Factor at end CP4
Blackfriars	21,900	3,100	71%	11,200	900	83%
Euston	23,800	2,000		10,600	800	
Fenchurch Street	26,000	1,700		13,900	800	
Kings Cross	18,300	1,600		8,000	600	
Liverpool Street	74,300	7,200		36,700	3,000	
London Bridge.	127,600	8,400		65,200	4,400	
Marylebone	9,100	800		4,600	300	
Moorgate.	13,000	700		7,400	400	
Paddington	24,100	1,900		11,500	800	
St. Pancras	25,900	10,700		13,100	5,100	
Victoria	58,700	4,400		29,300	2,000	
Waterloo	74,300	6,500		36,800	2,800	

Table 9b: Base Case Capacity Metric for Other Major Cities

	Peak Three Hours			High Peak Hour		
City	2008/09	2013/14	Maximum Average Load Factor at end CP4	2008/09	2013/14	Maximum Average Load Factor at end CP4
Birmingham	32,000	3,300	52%	15,400	1,400	63%
Cardiff	8,500	600	40%	4,000	200	47%
Leeds	23,400	2,700	73%	11,300	1,200	84%
Manchester	22,100	2,400	51%	10,700	1,100	61%
Other urban areas	27,700	2,600	45%	12,300	1,500	52%

Table 10a: HLOS Metrics - London

London Terminus	Peak three hours			High-peak hours		
	Forecast demand in 2008/9	Extra demand to be met by 2013/14	Maximum average load factor at end CP4 (%)	Forecast demand in 2008/9	Extra demand to be met by 2013/14	Maximum average load factor at end CP4 (%)
Blackfriars	21,900	3,500	67	11,200	1,200	76
Euston	23,800	3,400		10,600	1,600	
Fenchurch Street	26,000	2,500		13,900	1,600	
Kings Cross	18,300	2,300		8,000	1,100	
Liverpool Street	74,300	10,600		36,700	4,900	
London Bridge	127,600	12,600		65,200	7,800	
Marylebone	9,100	1,000		4,600	600	
Moorgate	13,000	700		7,400	400	
Paddington	24,100	2,900		11,500	1,400	
St. Pancras	25,900	10,900		13,100	5,700	
Victoria	58,700	5,300		29,300	2,800	
Waterloo	74,300	9,200		36,800	4,900	

Table 10b: HLOS Metrics - Regionals

City	Peak three hours			High-peak hours		
	Forecast demand in 2008/9	Extra demand to be met by 2013/14	Maximum average load factor at end CP4 (%)	Forecast demand in 2008/9	Extra demand to be met by 2013/14	Maximum average load factor at end CP4 (%)
Birmingham	32,000	4,600	48	15,400	2,400	55
Cardiff	8,500	900	39	4,000	600	43
Leeds	23,400	5,100	64	11,300	2,700	70
Manchester	22,100	4,100	45	10,700	2,200	49
Other urban areas	27,700	3,600	41	12,300	2,000	46

6.2 Using Maps to Analyse NMF Outputs

96. A useful tool employed in the analysis of the schemes and in the determination of where additional capacity is required on the network is the GIS mapping of load factors and demand.

97. The NMF is able to produce outputs of the HLOS metrics for each Strategic Route, Strategic Route Section and Demand Section of the network and also by Train Operating Company for some output. This is potentially a lot of data to present and interpret when displayed in tables.

98. For the purpose of mapping of NMF outputs, the ArcGIS 9 software was used with the Network Rail (NR) defined rail network database. Because the NR database is defined in terms of Strategic Routes (SR) and Strategic Route Sections (SRS), DfT commissioned some work to create a Demand Section mapping capability.

99. Passenger Spill (i.e. number of passengers constrained off due to crowding) was also an important output that had to be mapped for the purpose of further analysis. These maps have been effective in communicating in detail, the pattern/distribution of these metrics across the network. This has been helpful in identifying problem points on the network from the baseline case, and has been important in developing the specimen schemes HLOS.

100. The maps have also been useful in identifying gaps and omissions of the NMF assumptions and outputs. For example, ensuring that no demand section is omitted and that stations/demand zones are properly linked. Maps of the output from HLOS options could be compared to the baseline maps to see how well or not an option had improved a given metric.

101. Below are examples of two sets of maps showing Load Factors (defined as passenger numbers *divided by* total capacity) for the 2007 and 2014 baseline cases during the AM Peak Hour period for both national level detail (Figures 4 and 5) and London Area level (Figures 6 and 7). Note that the maps provide load factor details for those sections of the

network where AM peak travel occurs. In the NMF, these are demand sections that have on them, trains arriving at the associated principal station between 8.00AM and 9.00AM.

Figure 4: 2006/07 Baseline AM Peak Loading

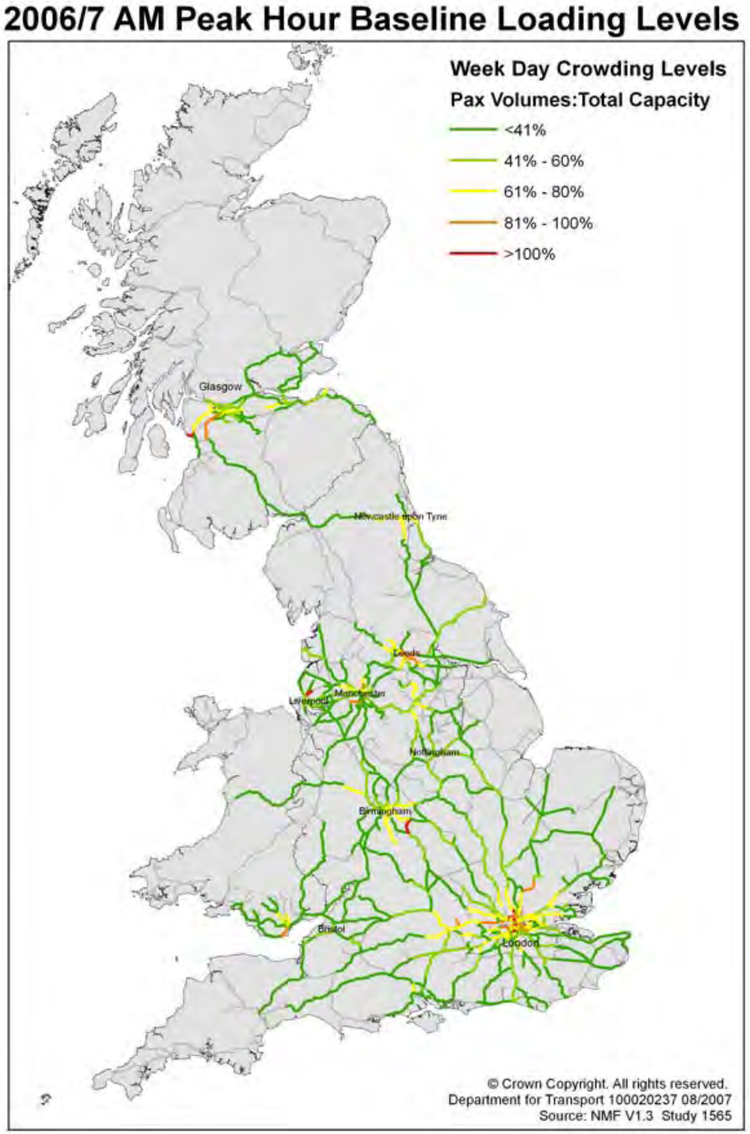


Figure 5: 2013.15 AM Peak Hour Baseline Loading

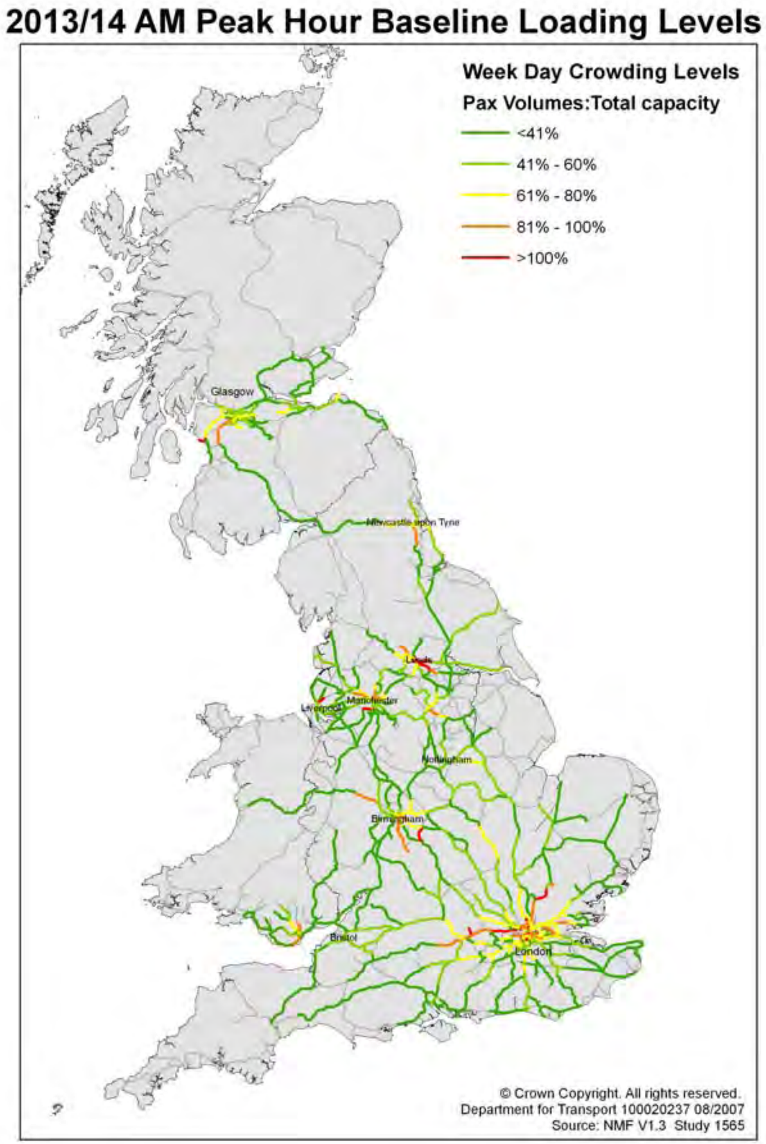


Figure 6: 2006/7 AM Peak Baseline Loading - London

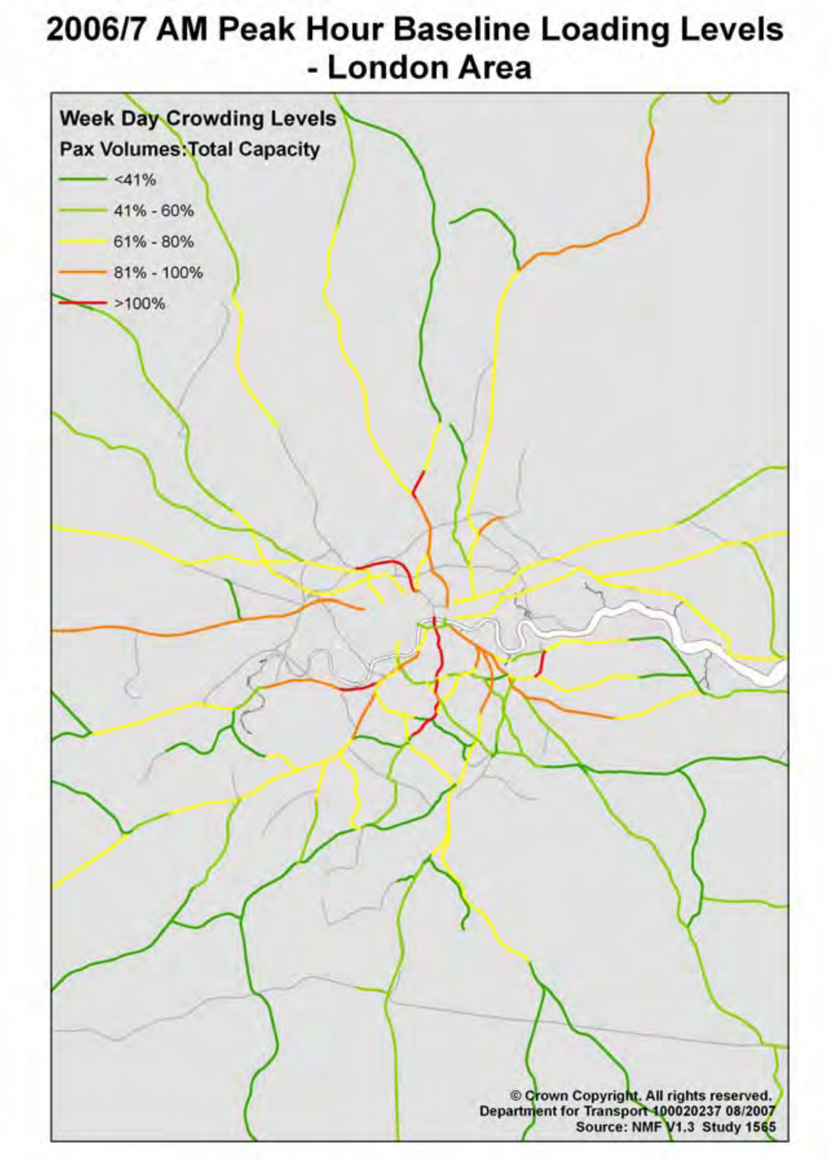
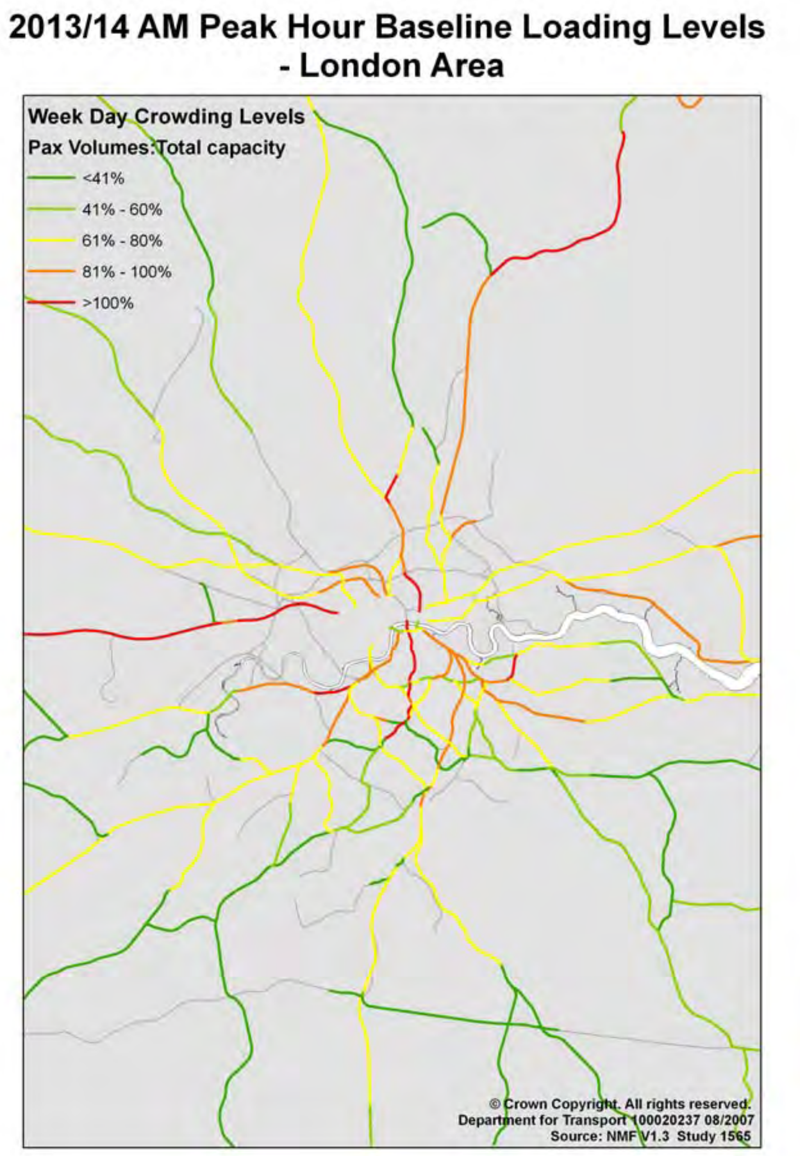


Figure 7: 2013/14 AM Peak Hour Base Loading - London



SECTION 7: SENSITIVITY ANALYSES

102. This section summarises the sensitivity analyses that were carried out on both the HLOS metrics and the BCRs. The results of these sensitivity tests are presented in this section.

103. The metrics for London include numbers of arriving passengers to be accommodated on services into the main London termini and London city maximum average load factors by the end of CP4, on a weekday morning in three hour peak and in the high peak hour. These results are shown in part (a) of tables 11 and 12. For other major cities a similar load factor metric is presented with specific load factors to be achieved for each specified city, and for other cities, an average as per the last rows in tables 11b and 12b.

104. The sensitivity tests on the London metrics show that the high-low forecasts produce the following average load factor range: 66% < 67% < 68%. The central value of 67% appears reasonable in the light of the symmetric 1% divergence on either side from alternative growth assumptions. A similar range around the central value in the case of the peak one hour is observed.

105. Regarding the capacity metrics for the major cities, the sensitivity tests show the similar ranges as the metrics derived for London. This puts confidence in the modelling outputs derived from NMF for the purpose of deriving the metrics for HLOS and the White Paper.

Table 11a: White Paper Metrics With High Growth (GDP = + 0.25% per year, employment = + 0.125% per year) - London

	Peak Three Hours			High Peak Hour		
London	2008/09	2013/14	London Maximum Average Load Factor at end CP4	2008/09	2013/14	London Maximum Average Load Factor at end CP4
Blackfriars	22,000	3,700		11,300	1,300	
Euston	24,000	3,700		10,600	1,800	

Fenchurch Street	26,000	2,700		13,900	1,700	
Kings Cross	18,400	2,500		8,000	1,200	
Liverpool Street	74,500	11,300		36,800	5,200	
London Bridge.	128,200	13,700	68%	65,500	8,400	77%
Marylebone	9,200	1,100		4,700	700	
Moorgate.	13,100	800		7,400	500	
Paddington	24,200	3,100		11,600	1,500	
St. Pancras	26,000	11,100		13,200	5,800	
Victoria	59,000	5,800		29,400	3,000	
Waterloo	74,700	9,800		37,000	5,200	

Table 11b: White Paper Metrics With High Growth (GDP = + 0.25%, per year employment = + 0.125% per year) - Other

	Peak Three Hours			High Peak Hour		
City	2008/09	2013/14	Maximum Average Load Factor at end CP4	2008/09	2013/14	Maximum Average Load Factor at end CP4
Birmingham	32,200	4,900	48%	15,500	2,600	55%
Cardiff	8,600	1,000	39%	4,000	600	43%
Leeds	23,500	5,300	65%	11,300	2,800	71%
Manchester	22,200	4,400	45%	10,800	2,400	50%
Other urban areas	27,900	4,000	42%	12,400	2,200	47%

Table 12a: White Paper Metrics With Low Growth (GDP = - 0.25% per year, employment = - 0.125% per year) - London

	Peak Three Hours			High Peak Hour		
London	2008/09	2013/14	London Maximum Average Load Factor at end CP4	2008/09	2013/14	London Maximum Average Load Factor at end CP4
Blackfriars	21,800	3,400		11,200	1,100	
Euston	23,600	3,200		10,500	1,500	
Fenchurch Street	25,900	2,400		13,800	1,500	
Kings Cross	18,200	2,100		7,900	1,000	
Liverpool Street	74,100	10,000		36,600	4,700	
London Bridge.	126,900	11,700	66%	64,900	7,400	75%
Marylebone	9,100	1,000		4,600	600	
Moorgate.	12,900	600		7,300	400	
Paddington	24,000	2,700		11,400	1,300	
St. Pancras	25,800	10,600		13,000	5,600	

Victoria	58,400	4,900		29,100	2,600	
Waterloo	73,900	8,500		36,600	4,600	

Table 12b: White Paper Metrics With Low Growth (GDP = - 0.25% per year, employment = - 0.125% pear year) - Other

	Peak Three Hours			High Peak Hour		
City	2008/09	2013/14	Maximum Average Load Factor at end CP4	2008/09	2013/14	Maximum Average Load Factor at end CP4
Birmingham	31,700	4,300	47%	15,300	2,200	54%
Cardiff	8,500	800	38%	4,000	500	42%
Leeds	23,300	4,900	63%	11,200	2,600	69%
Manchester	21,900	3,900	44%	10,700	2,100	48%
Other urban areas	27,500	3,200	40%	12,200	1,900	45%

Sensitivity Analysis of Alternative GDP Growth on BCR

106. Sensitivity analyses were also carried out on the BCRs. Table 13 below summarises the BCRs for the combined specimen schemes (the Mega-Option). Further development of the schemes as part of the implementation of HLOS will very likely lead to different BCRs than the current strategic assessments.

Table 13 : Summary NMF Results (60 year appraisal period; 2002 prices; Excluding Thameslink)

Option	BCR (Central Case)	BCR (Low Growth Scenario)	BCR (High Growth Scenario)
- Mega-Option	**1.53**	**1.41**	**1.65**

Option	PV Benefits	PV Costs	BCR
Mega-Option Central Values	**£6,778m**	**£4,443m**	**1.53**