High Speed Two
Atkins Model Development Report - PFMv3.0-PFMv4.3

HS2 Ltd

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Plan Design Enable

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1. Introduction

In 2009, Atkins was appointed to develop a demand forecasting framework for High Speed Two (HS2) Ltd to model and appraise options for a high speed rail link between London and the West Midlands. Outputs from that study were published in March 2010, along with a suite of technical documents describing the modelling approach[1]. During 2010, the modelling framework was updated and the outputs were used to deliver the analysis behind the February 2011 consultation[2]. Documentation describing model development was published as the Model Development and Baseline Report in April 2011[3].

Since then, further analysis and model development work has been undertaken to help inform the Secretary of State's decision in January 2012 on whether to take HS2 forward. This was published as the Model Development and Baseline Report in April 2012[4]. This additional work was undertaken to improve the robustness of the modelling and appraisal, and update assumptions underlying the forecasts to reflect political and economic changes.

In March 2012 the Office of Budgetary Responsibility (OBR) released updated growth forecasts for the UK economy. As economic growth plays a major part in the demand forecasts, and the business case for High Speed Two (HS2), the growth forecasts and business case were be revised to take account of the update whilst at the same time including some further amendments to the modelling framework. This work was reported in the Baseline Forecasting Report (August 2012). This work was undertaken using the PLANET Framework Model (PFMv3) model which has been developed as part of the assessment of the Leeds and Manchester extensions to HS2 with the resulting model being termed PFMv3.0.

This report describes further development of the PFM model to create a revised version of the model which is termed PFMv4.3. The updates to the model included:

- Updates to the base year rail, highway and air matrices to include revisions to the journey purposes in the rail matrices, the development of new highway matrices derived from the DfT's Long Distance Model and revised air matrices from the DfT's Aviation Model. These matrices were also developed in Production/Attraction format (PA) to allow for potential changes to the PFM demand model;
- Updates to the demand forecasts to reflect revised OBR growth forecasts. This was part of a wider package of model development that included moving to using revised forecasting parameters from the Passenger Demand Forecasting Handbook v5 (PDFHv5) and updating the PLANET South matrices;
- Updates to the rail, highway and air networks to reflect latest assumptions;
- An update to the crowding methodology to incorporate the latest guidance found in PDFHv5;
- Other model developments including introducing the method of successive averages (MSA) to the mode choice algorithm in PLANET Long Distance and moving PFM to the EMME3 software; and
- Adjusting appraisal values to ensure consistency with the latest OBR growth forecasts used to develop the demand forecasts.

Section 2 of the report describes the development of the revsied base year rail matrices, whilst sections 3 and 4 describe the revised highway and air matrices respectively. The new growth forecasts are described in section 5 and the revised networks in section 6. Section 7 describes the update to the crowding, and the other model developments are detailed in section 8. Finally the changes to the appraisal values are described in section 9.

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1 http://webarchive.nationalarchives.gov.uk/+/http://www.dft.gov.uk/pgr/rail/pi/highspeedrail/hs2ltd/demandandappraisal/

2 http://webarchive.nationalarchives.gov.uk/20110720163056/http://highspeedrail.dft.gov.uk/library/documents/economic-case

3 http://assets.hs2.org.uk/sites/default/files/inserts/hs2%20model%20development%20and%20baseline%20report%20-%20a%20report%20for%20hs2%20ltd%20by%20mva.pdf

4 http://assets.hs2.org.uk/sites/default/files/inserts/Model%20Development%20and%20Baseline%20Report_Jan2012.pdf

2. Rail Base Year Matrices

2.1. Introduction

This section describes the work undertaken to enhance the base rail matrices for the PLANET Framework Model (PFM) as part of the development of PFM from v3.0 to v4.3. The enhancements introduced in the development of the base year rail trip matrices are described, together with the impact these enhancements have had on region to region movements in the base year matrices and the numbers of rail trips by purpose. The rail fares matrices are derived from the same dataset and have therefore also been updated in a similar manner.

The PFM incorporates four separate PLANET models: the all day PLANET Long Distance (PLD) model and the morning peak period (07:00-10:00) PLANET South (PS), PLANET Midland (PM) and PLANET North (PN). The enhancements detailed below are for the PLD and PS matrices; no changes were made to the base year PM and PN matrices between PFMv3.0 and PFMv4.3.

The principal enhancements introduced to the base rail trip matrices are:

- Revised trip purpose definitions – education trips are included with leisure not commuting and commuting trips over 80 miles are no longer reclassified as leisure);
- Revised process to segment trips by journey purpose – to provide improved representation of observed journey purpose data;
- Revised allocation of trips from station to station pairs to zone pairs – taking into account variations by types of trip and increases in car ownership; and
- Associated changes to the annualisation process used in the calculation of annual demand, benefits and revenue.

The above enhancements have been focused upon the trip matrices for the Planet Long Distance (PLD) element of PFMv4.3. Changes have also been made to the trip matrices for the Planet South (PS) regional model to ensure that these use consistent data sources to those for PLD and to improve the representation of trips within the London Travelcard area. The process of constructing these matrices is described in section 2.2.

The enhancements to the trip matrices have been designed to ensure that best use is made of the available data sources for rail matrix development. These sources are summarised below and are discussed in more detail in section 2.4.4:

- The rail industry ticket database LENNON – comprises details of all national rail tickets sold in Great Britain and continuous data is available for any time period since 2001. LENNON provides the basis for the development of base station to station rail matrices and the fares matrices;
- The National Rail Travel Survey (NRTS) – this dataset published by DfT provides further details (such as journey purpose) for a large sample of weekday rail trips based on surveys undertaken throughout Great Britain;
- The National Passenger Survey (NPS) – this dataset published by Passenger Focus comprises periodic surveys designed to collect information on satisfaction with rail services and includes details such as journey purpose; and
- The National Travel Survey (NTS) – this is a continuous household survey designed to provide personal travel information and surveys travel patterns for all modes and distances nationally.

The following sections consider each group of enhancements in turn and describe the previous PFMv3.0 methodology, the reasons for the enhancements, the methodology adopted for PFMv4.3 and the impact of the modifications on the resulting trip matrices.

The structure of this section is as follows:

- Section 2.2 – overview of the matrix building process with details of where enhancements have been introduced;
- Section 2.3 – revised trip purpose definitions

- Section 2.4 – revised allocation of trips to journey purposes;
- Section 2.5 – revised allocation of trips from station pairs to zone pairs;
- Section 2.6 – revised car ownership growth;
- Section 2.7 – revised annualisation factors;
- Section 2.8 – revisions to rail fares matrices;
- Section 2.9 – update of PLANET south matrices;
- Section 2.10 – cumulative effect of the above enhancements on the trip matrices; and
- Section 2.11 – summary of the model enhancements and their effects.

2.2. Overview of PLD rail matrix building process

2.2.1. PFMv3.0

The matrices in PFMv3.0 were developed during 2011 and were an update to replace the previous 2007/08 matrices with those for a 2010/11 base year. These matrices were developed from LENNON ticket sales data for the 2010/11 financial year.

The LENNON matrices were firstly disaggregated by car availability and distributed from origin/destination station to origin/destination zone to reflect the true start or end of journey location. This followed the same process used to develop the 2007/08 matrices.

A set of de-annualisation factors were then applied by ticket type, to obtain the weekday matrices required for the PLD model. These factors came from the ORCATS (Operational Research Compute Allocation of Tickets to Services) system which was developed to allocate revenues from ticket sales to individual train operators.

The next step was to disaggregate the matrices from ticket type to journey purposes. Between 2007/08 and 2010/11 there had been significant changes to the balance in journeys by ticket type, in particular a significant increase in the proportion of use of single advance purchase tickets and a general down-trading of tickets during the recession, suggesting increased number of business trips using standard class tickets. It was therefore not felt to be appropriate to use the same factors to convert ticket type to journey purpose in 2010/11 as were used in 2007/08, and instead it was decided to adjust the journey purpose splits to be identical (on a journey-pair basis) to those in the 2007/08 base year matrices. There was no evidence to suggest that journey purpose had shifted significantly in either direction between the two years.

An overview of the main steps in the PLD rail matrix building process for PFMv3.0 is shown in Table 2-1 below.

Table 2-1 Overview of previous PLD matrix building process in PFMv3.0

Step		Package / tool
1	Read in LENNON data	SPSS syntax
2	Convert joint codes to particular stations	
3	Develop zonal distributions from NRTS (National Rail Travel Survey) to allocate trips from/to stations to origin and destination zones - for car owning and non car owning separately and % car owning by station	
4	Apply zonal distributions to station to station matrices to produce zone-zone flows for car owning and non car owning	
5	Aggregate results to origin-destination (OD) combinations (for car owning and non car-owning)	
6	De-annualise to average weekday (24 hour)	
7	Convert to journey purpose based on ticket type	
8	Write out to Excel for conversion to EMME format	
9	Apply mask to obtain zone pairs for PLD	EMME
10	Convert to ODs for assignment	

2.2.2. PFMv4.3

The revised PLD matrix building process in PFMv4.3 is summarised in Table 2-2 below, with the steps that have changed from PFMv3.0 shaded in the table.

Table 2-2 Overview of revised PLD matrix building process PFMv4.3

Step		Package / tool
1	Read in LENNON data	SPSS syntax
2	Convert joint codes to particular stations	
3	Develop zonal distributions from NRTS (National Rail Travel Survey) to allocate trips from/to stations to origin and destination zones - for short, medium and long trips, car owning and non car owning separately and % car owning by station	
4	Apply zonal distributions to station to station matrices to produce zone-zone flows for short, medium and long trips, car owning and non car owning	
5	Aggregate results to OD combinations (for car owning and non car owning)	
6	De-annualise to average weekday (24 hour)	
7	Convert to journey purpose using NRTS on a geographical basis	
8	Write out to Excel for conversion to EMME format	
9	Apply mask to obtain zone pairs for PLD	EMME
10	Convert to ODs for assignment	

Whilst the overall methodology generally followed the same process as that for PFMv3.0 significant changes were made to the methodology within each of the steps identified above. The changes detailed in the following sections can be summarised into three areas:

- **Station access distance and car ownership (steps 3 and 4)** - analysis of the NRTS data showed that the average access distances to stations increased with rail journey length. Hence the catchment areas of stations for longer journeys are larger than for shorter trips. Although the station to zone allocation methodology was not revised the process is now carried out separately for short, medium and long distance rail journeys, based on the different catchment areas obtained from the NRTS data for each category of trip;
- **Car ownership (steps 3 and 4**) - the proportions of car owning/non-car owning trips were updated to reflect recent values taken from TEMPRO; and
- **Journey purpose (step 7)** - the process for segmenting the trips into journey purposes has been revised using the same NRTS dataset as previously, but applying the transformation on a geographical basis (treating the locations with the highest numbers of rail journeys separately from the remaining region to region movements) rather than using a ticket type to purpose mapping process. In addition trip purposes were redefined for commuting and leisure trips at this stage.

The sections below describe the individual changes in more detail with a description of the assumptions in PFMv3.0, the reasons for the changes made, the methodology followed and the impact of these changes.

2.3. Revised definition of trip purpose

2.3.1. Trip purpose definitions in PFMv3.0

There are three journey purposes defined in the PFMv3.0 PLD matrices:

- Commuting - but with commuting trips of more than 80 miles classified as leisure trips. The commuting category also includes trips for educational purposes which is consistent with the treatment in Passenger Demand Forecasting Handbook v5 (PDFHv5);
- Business - with home based and non-home based trips being combined; and
- Leisure - also with home based and non-home based trips being combined and including commuting trips of more than 80 miles as noted above.

The rail trip matrices are constructed using the LENNON ticket sales dataset. For PFMv3.0 purpose factors based on ticket types were derived from NRTS on a national basis and applied to the ticket types identified in the LENNON data, this is discussed in more detail in section 2.4.

2.3.2. Reason for change in input definitions

A review of purpose definitions and the treatment of education trips was undertaken to ensure the most appropriate definitions are adopted for commuting, business and leisure trips, taking particular account of the values of time associated with different trip types. Following this review two changes in definition were identified:

- Reclassifying education trips as leisure rather than commuting - Education trips are typically much shorter than commuting trips and the values of time for children/students are more akin to leisure travel than work-based commuting travel; and
- Removing the reclassification of commuting trips of more than 80 miles to leisure trips, so that commuting trips of all lengths can exist.

2.3.3. Impact on matrices

The two changes are introduced in separate sequential steps. Table 2-3 below shows the separate effects on the PFMv3.0 matrices of reclassifying the education trips and removing the 80 mile limit on commuting trips together with the cumulative effect of both changes. This shows that the largest effects occur as a result of the reclassification of education trips, the removal of the 80 mile commuting trip limit having a limited effect. The cumulative effect is that commuting trips have a net decrease, leisure trips a net increase, and business trips are unchanged.

Table 2-3 Impact of reclassifying trips by purpose on PFMv3.0 matrices

Purpose	Incremental change in trip proportions		Cumulative change in trip proportions
	Education trips from commuting to leisure	Remove 80 mile limit for commuting trips	% change
Commute	-12.4%	+2.0%	-10.6%
Business	0%	0%	0%
Leisure	+29.1%	-3.2%	+24.9%

2.4. Revised segmentation of matrices into trips by purpose

2.4.1. Segmentation of trips by purpose in PFMv3.0

The rail trip matrices are constructed using the LENNON ticket sales dataset. For PFMv3.0 purpose factors based on ticket types recommended by PDFHv4 and derived from NRTS were applied to the ticket types identified in the LENNON data. Ticket types were aggregated into 4 groups, as recommended in PDFHv4:

- Full fare;
- Reduced fare;
- Season; and
- Travelcard.

For each of these ticket types national factors based on NRTS were developed so that trips for each of the four aggregate ticket types could be apportioned to the three journey purpose types. For example, full fare tickets were allocated to journey purposes in the following proportions:

- Business - 51%;
- Commuting – 20%; and
- Leisure – 29%.

The use of national factors in the ticket type to journey purpose conversion process does not reflect variations that will occur at a geographic level due to journey length or the nature of the locations being served. This is demonstrated by Table 2-4 below which shows observed journey purposes from NRTS for a sample of city to/from London movements together with the journey purposes from PFMv3.0. This table and all subsequent tables in this section relating to journey purpose use the revised definitions of journey purposes described in section 2.3 above unless stated otherwise.

Table 2-4 Journey purpose proportions (percentages)

Journey	Commuting		Business		Leisure	
	NRTS	PFMv3	NRTS	PFMv3	NRTS	PFMv3
London-Leeds	3	16	70	26	27	57
Leeds-London	4	17	51	29	45	54
London-Manchester	5	16	64	26	32	58
Manchester-London	5	28	61	23	34	50
London-Sheffield	6	16	64	26	30	58
Sheffield-London	6	39	57	20	38	41

This table shows that for these movements to/from London the journey purpose allocation process in PFMv3.0 under-represents the proportion of business trips and over-represents the proportions of commuting and business trips.

2.4.2. Reason for change in segmentation by journey purpose

The process of rail matrix segmentation by journey purpose in PFMv3.0 was dependent upon the use of factors derived from the NRTS data. The NRTS dataset was collected in 2004/5 and thus it is important to understand whether changes have occurred that may affect the use of this data set. The two potential areas of change are:

- Changes in the proportions of trip purposes across rail travel as a whole; and
- Changes in the correspondence between ticket type and journey purpose, particularly given known changes in ticket types since 2004/5.

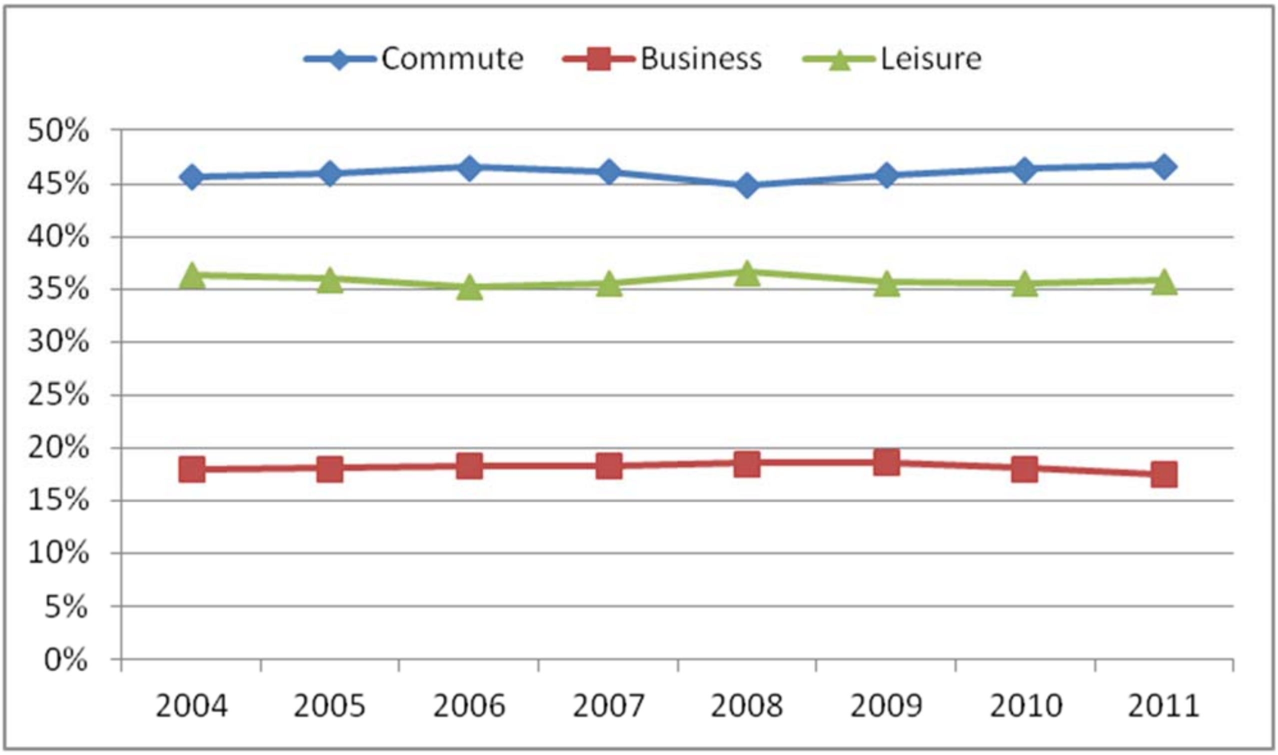
2.4.2.1. Observed changes in trip purpose through time

The National Passenger Survey (NPS) dataset, collected by Passenger Focus, was used to examine the profile of rail trip purposes over time. The NPS provides a sample of rail travellers across the entire week on all ticket types from Autumn 1999 to Autumn 2011 and thus differs from NRTS through the inclusion of weekend and holiday periods. These samples of passengers are then expanded to reflect all rail travellers. Two waves of surveys are carried out each year in the spring and the autumn.

Figure 2-1 shows the trip purpose proportions from the expanded NPS weekday data sets between 2004 and 2011 for the three journey purposes represented in the PFM model (revised purpose definitions). Data before 2004 is not shown as the trip purpose definition changed in the survey in 2004 when commuting and education trips were separated. The figure shows that the split of rail trips across the three journey purposes has remained relatively constant since the collection of the NRTS data in 2004/5.

Comparing the NPS data in Figure 2-1 with the NRTS data in Table 2-3 show that NPS contains a lower proportion of commuting trips (around 46%) than NRTS (around 55%) and correspondingly higher proportions of leisure and business trips. This is likely to be due to the different sampling structure for NPS, which is designed to monitor customer satisfaction by train operating company rather than sample rail travel as a whole.

Figure 2-1 Proportion of trips by purpose through time (NPS expanded trips on weekdays)



Thus the use of NRTS for journey purpose allocation remains appropriate as NRTS provides the most comprehensive rail data available for the definition of trip purpose and purpose splits have not changed materially since the NRTS was undertaken.

2.4.2.2. Observed changes in ticket type through time

The NPS data was also used to examine changes in the ticket types used through time. This analysis showed that:

- The ticket types changed significantly around 2008/09;
- The introduction of Oyster cards in London has led to further changes with usage of Oyster and other travelcards continuing to increase through time; and
- Journeys using single tickets are not differentiated from those using return tickets in NPS.

The change in ticket types over time revealed by the NPS data makes the use of the NRTS data to convert between ticket type and purpose problematic. Transformation needs to be carried out at an aggregate level of ticket type to minimise differences caused by definition changes rather than trends over time. To minimise the impact of ticket type changes an aggregation to full fare, reduced fare, season tickets (over a period) and Travelcards (for a day) was generated from the NPS data to match those aggregate ticket types in PDFH (versions 4 and 5). The aggregation adopted for this analysis is shown in Table 2-5.

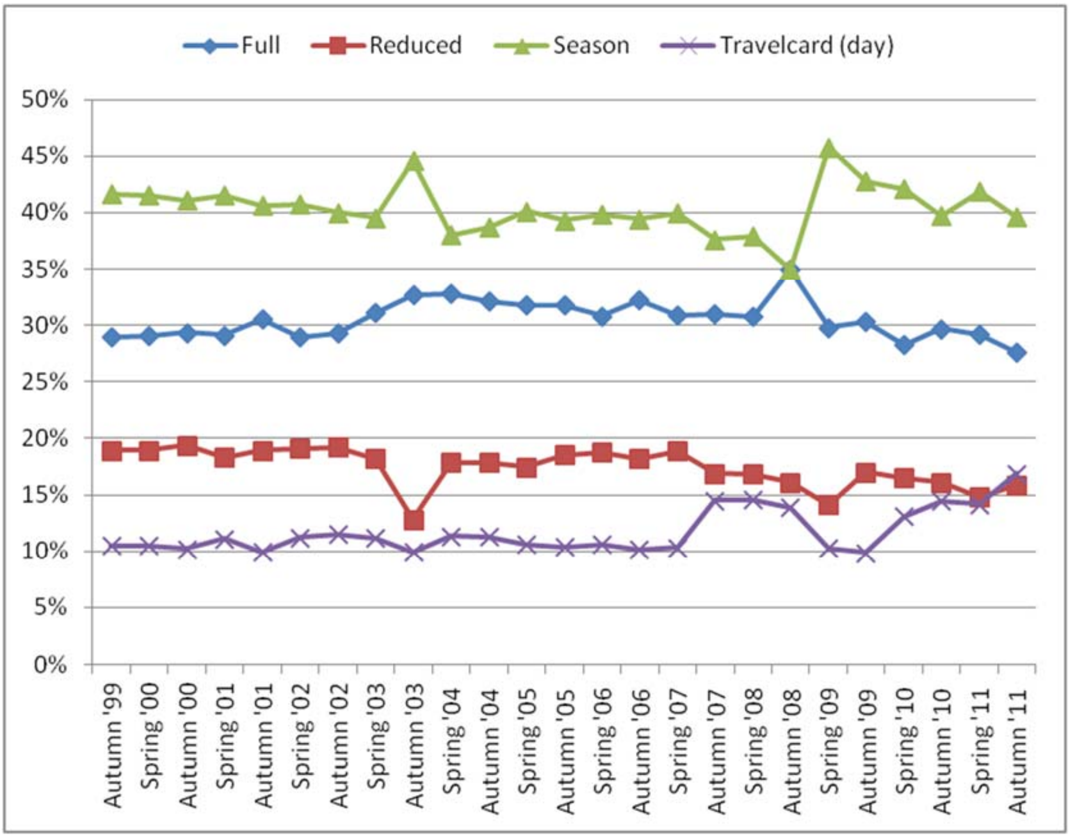
Table 2-5 Aggregation of NPS ticket types for analysis though time

NPS Ticket Type	Years for which data exists	Aggregate Type
Anytime single/return	2009-11	Full
Anytime day single/return	2009-11	Full
Off-peak/super off-peak single/return	2009-11	Reduced
Off-peak/super off-peak day single/return	2009-11	Reduced
Advance	2009-11	Reduced
Day Travelcard	All	Travel card
Oyster pay as you go	2009-11	Travel card

NPS Ticket Type	Years for which data exists	Aggregate Type
Weekly or monthly season (including Travelcard & Oyster Travelcard	2009-11	Season
Annual season (including Travelcard & Oyster Travelcard	2009-11	Season
First class single/return	2000-08	Full
Standard single/return	2000-08	Full
First class season ticket	2000-08	Season
Standard season ticket	2000-08	Season
Cheap day single/return	2000-08	Reduced
Saver/supersaver	2000-08	Reduced
Awaybreak/stayaway	2000-08	Reduced
Apex/super apex	2000-08	Reduced
Special promotion ticket	All	Reduced
Holiday package/tour ticket	2000-08	Reduced
Rail staff pass/Privilege ticket/Police concession	All	Season
Group saver ticket	Autumn 2002-08	Reduced
Oyster	2007-08	Travel card
Free travel pass (e.g. Freedom pass)	Autumn 2007-11	Season
Other	All	Reduced

Figure 2-2 shows that whilst this aggregation of the NPS data minimises many of the changes introduced by new ticket types, there are clear changes around 2008/09 when the most significant revisions to the ticket types were made. The figure also shows increasing use of day Travelcards since 2009 (particularly related to the use of Oyster cards in London) with a corresponding reduction in the use of season and other ticket types.

Figure 2-2 Change in use of ticket types through time (weighted weekday NPS data)



2.4.3. Alternative methodologies for journey purpose allocation in PFMv4.3

The preceding sections have shown that whilst journey purposes have remained stable, use of ticket types changed significantly in 2008/9 and further changes have continued a result of a steady increase in travelcard usage. Further, the use of national factors in the ticket type to journey purpose conversion methodology used in PFMv3.0 has been shown not to reflect adequately journey purposes for individual movements.

In particular, journey purpose splits in PFMv3.0 for movements between London and cities in the north of England show a significant under representation of business trips. This will be due to the PFMv3.0 methodology not taking account of variations in the mapping of journey purpose to ticket type for different trip lengths or different trip origins and destinations. Thus an enhanced methodology was sought to address the issues of changing use of ticket types and lack of representation of route by route variation in journey purpose splits.

2.4.3.1. PDFHv5

The process of relating trips by ticket type to trips by journey purpose was addressed in the updating of PDFH to PDFHv5. Tables of ticket type to trip purpose conversions are provided in PDFHv5 (PDFH Tables B0.5 and B0.7) and recommended for use as sources of data for modelling by the DfT's guidance (TAG unit 3.15.4) "unless there is sufficient good-quality evidence to suggest otherwise".

In order to ascertain whether the PDFHv5 approach would provide an improvement to the PFMv3.0 methodology, the split of rail trips by purpose (commuting, business and leisure, defined as described in section 2.3) between the four cities shown in Table 2-4 were derived from LENNON ticket types using the PDFHv5 methodology and compared with the observed split by purpose in the NRTS dataset and the results from the PFMv3.0 methodology (with the revised purpose definitions) as shown in Table 2-6.

Table 2-6 Journey purpose proportions (percentages, revised purpose definitions)

Journey	Commuting			Business			Leisure		
	NRTS	PFMv3	PDFH5	NRTS	PFMv3	PDFH5	NRTS	PFMv3	PDFH5
London-Leeds	3	16	4	70	26	42	27	57	54
Leeds-London	4	17	5	51	29	46	45	54	49
London-Manchester	5	16	4	64	26	42	32	58	55
Manchester-London	5	28	16	61	23	38	34	50	46
London-Sheffield	6	16	4	64	26	42	30	58	54
Sheffield-London	6	39	27	57	20	36	38	41	37

Table 2-6 shows that:

- Both the existing PFMv3.0 and PDFHv5 methodologies significantly under-represent the proportion of business trips for all journeys in the table;
- The PDFHv5 approach better reflects the observed NRTS purpose splits for commuting, provides some improvement for business trips and a small improvement for leisure trips; and

Both the PFMv3.0 and PDFHv5 approaches do pick up some variation in trip purpose profile for the different movements based on the different ticket types being used. The PDFHv5 method generally better matches the observed NRTS pattern (but not necessarily the levels) of variation.

The main conclusion from the analysis was that neither the existing PFM v3.0 method nor the PDFHv5 method recommended by WebTAG produced an adequate representation of observed journey purposes for these movements of key relevance to HS2, with significant under-representation of business trips in particular.

Given the ongoing process of change in use of ticket types and the lack of correspondence between observed and modelled journey purposes for either the existing PFMv3.0 or PDFHv5 methodologies, it was decided to develop a methodology to derive trip purpose splits on a geographic basis. This would:

- Remove the need for any process for correspondence between ticket type and purpose type, thereby avoiding the issues of changes in use of ticket types over time; and
- Provide better representation of the variation in journey purpose splits on a route by route basis.

2.4.4. Data sets

The rail industry ticket database LENNON remains the most suitable basis for the development of the rail trip matrices for PFMv4.3. LENNON comprises details of all national rail tickets sold in Great Britain and thus provides the totality of ticket sales on a station to station basis and thus enables the construction of complete station to station trip matrices with no factoring process required. LENNON also provides the basis for the development of the fares matrices. LENNON cannot identify actual trips made using travelcards or season tickets and does not provide additional trip details such as final origin and destination or journey purpose.

There are three sources of data that identify journey purposes for rail journeys on a national basis, these are:

- The National Rail Travel Survey (NRTS) – this dataset published by DfT provides details, including journey purpose, for a large sample of rail trips based on surveys undertaken throughout Great Britain. NRTS comprises the London Area Travel Surveys conducted in 2001 with additional surveys outside London conducted in 2004 and 2005. The NRTS database contains some 436,000 records which are expanded to represent the daily trip total of around 2.7 million. NRTS provides details of individual trips including true origin and destination and journey purpose and represents a very large sample. However NRTS provides a 'cross-sectional' sample representing a single point in time (2004/5 for trips outside London) and is now relatively dated;
- The National Passenger Survey (NPS) – this dataset published by Passenger Focus comprises periodic surveys designed to collect information on satisfaction with rail services and includes details such as journey purpose. NPS provides a smaller and differently structured sample from NRTS but has the advantage that, being periodic, it can provide time series data that can be used to monitor change trends. NPS also provides details for individual trips but represents a smaller sample than NRTS and is less well structured to represent travel across Great Britain as a whole; and
- The National Travel Survey (NTS) – This is a periodic household survey designed to provide personal travel information and surveys travel patterns for all modes and distances nationally. NTS is conducted annually and uses a mix of interviews and travel diaries. NTS is useful for looking at patterns of demand between weekday and non-weekday travel, and data can be broken down into different journey purposes. However, the sample size is small, 8200 households in 2012, and the low frequency of rail travel (3% of trips) result in NTS providing a limited sample of rail movements.

The most suitable of the above data sources for the segmentation of the LENNON rail trip matrices by journey purpose is NRTS as:

- NRTS provides the largest sample and thus the highest level of statistical reliability;
- The sample is structured to give a good representation of rail trips on a national basis and thus will retain good statistical reliability at a geographically disaggregate basis; and
- Journey purposes have been shown to be stable since the time of the NRTS surveys (2004/5) and thus the data remains representative.

NPS is less suitable than NRTS as it has a smaller sample and would thus have a lower level of statistical reliability than NRTS. NPS is designed to examine customer satisfaction and thus is structured to deliver samples by rail operator and would provide lower levels of statistical reliability than NRTS when used on a geographically disaggregate basis.

NTS has a limited sample of rail movements and its use would not provide adequate statistical reliability.

2.4.5. Methodology for PFMv4.3

A methodology has been designed to use the NRTS dataset on a geographic basis to allocate trip purposes to the station to station matrices constructed from the LENNON data.

The first step is to derive the purpose splits from the NRTS for each region to region movement for eleven regions as defined in Table 2-7 and apply these to the LENNON matrices. Given the observed stability in trips by purpose demonstrated by the NPS data, this results in a good representation of the overall numbers of trips by purpose, but does not capture the variations for specific major stations used for long distance travel.

Table 2-7 Eleven regions used for journey purpose segmentation

Region
East Midlands
East of England
London
North East
North West
Scotland
South East
South West
Wales
West Midlands
Yorkshire & Humber

To further improve the geographic representation to take account of journey purpose variations for major stations, the NRTS data has been analysed to identify the major movements by examining the local authority districts which have the greatest number of rail trip ends. As the focus of the enhancements is on long distance travel and trips likely to be affected by the HS2 services, the locations of interest are primarily those outside the South East of England (where commuting to London is more dominant). Eleven authorities have been identified which had more than 21,000 trip ends per annum as shown in Table 2-8.

Table 2-8 Local authority districts (outside London and the South East) with highest volumes of trip ends in NRTS

Local Authority district	Annual trip ends
Glasgow City	133,696
Birmingham	111,063
Liverpool	78,893
Leeds	73,646
Manchester	66,180
Edinburgh City	47,811
Cardiff	34,612
Bradford	34,135
Sefton	30,982
Wirral	30,049
Sheffield	23,381

The NRTS data is therefore aggregated to twenty two sectors differentiating these eleven local authorities and what remains of the eleven regions once the local authority districts have been extracted (e.g. Scotland minus Glasgow City and Edinburgh City). The volumes of trips in the resulting NRTS dataset for the twenty two sector matrix are then reviewed. A few combinations (particularly Cardiff / Wales – Scotland / Edinburgh / Glasgow) have very few trips in the NRTS.

Where a sector pair has less than 200 trips, the NRTS data is used at the more aggregate region to local authority, local authority to region or region to region level to ensure adequate data is used on which to base the purpose split. To make the NRTS dataset as robust as possible symmetry is imposed, for example the average of the daily profiles for London to the North West and the North West to London is used for both directions.

2.4.6. Impact on matrices

This revised geographical definition (regional/local authority district) has the advantage of avoiding the inconsistencies in ticket type definitions between the LENNON and NRTS datasets and allows the exact purpose definition to be specified for movements of key relevance to HS2 based on the observed origin and destination purposes within the NRTS. The overall results from the revised PFMv4.3 matrices are shown in Table 2-9 where they are compared with the PFMv3.0 matrices (with revised purpose definitions). This shows that the PFMv4.3 matrices have an increase in leisure trips, a small increase in business trips and a decrease in commuting trips when compared with the PFMv3.0 matrices.

Table 2-9 Impact of applying NRTS twenty two sector purpose mapping

Purpose	PFMv3.0	PFMv4.3
Commute	62%	54%
Business	12%	13%
Leisure	26%	33%

At the region level the changes in business trips compared to PFMv3.0 are shown in Table 2-11, with changes of more than 500 trips shaded separately for increases and decreases. The net increase in business trips using this approach compared to the existing model is the result of a reduction in shorter intra-regional business travel and increases in business travel to and from London.

Table 2-11 shows that the revised geographical use of NRTS provides significant increases in business trips for the longer distance movements to and from London compared with the original PFMv3.0 approach (shading for changes more than 1,000 trips). This confirms that the revised approach has improved the under-representation of such trips in the original model shown in Table 2-6. This is further demonstrated in Table 2-10 below, which compares the journey purposes in the revised matrices against those observed in NRTS for key movements to and from London of relevance to HS2.

It should be noted that the matrices will not precisely match the NRTS data as the NRTS proportions relate to station to station movements and the matrices relate to zone to zone movements. Table 2-10 shows that the revised geographically based methodology for PFMv4.3 provides a good representation of the journey purpose splits for movements of key relevance to HS2 and addresses the under-representation of business trips for these movements in PFMv3.0.

Table 2-10 Journey purpose proportions (percentages)

Journey	Commuting		Business		Leisure	
	NRTS observed	PFMv4.3	NRTS observed	PFMv4.3	NRTS observed	PFMv4.3
London-Leeds	3	4	70	56	27	40
Leeds-London	4	4	51	56	45	40
London-Manchester	5	5	64	64	32	31
Manchester-London	5	5	61	64	34	31
London-Sheffield	6	5	64	65	30	30
Sheffield-London	6	5	57	64	38	31

2.5. Station to zone allocation

2.5.1. Station to zone allocation in PFMv3.0

LENNON provides station to station matrices whereas PFM (all versions) requires matrices with actual origin and destination. Distribution of station trip ends to origin and destination zones was undertaken in PFMv3.0 using NRTS data, which provides true origin and destination for trips together with station used. Origins and destinations in NRTS were identified using postcode information.

Table 2-11 Impact of using NRTS geographic purpose profile on business trips (PFMv4.3 vs. PFMv3.0)

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	-1,249	26	3,219	63	-125	9	159	-18	-3	228	156	**2,463**
East of England	-6	-3,149	8,316	115	-16	-49	515	44	36	113	104	**6,023**
London	2,476	4,245	-16,267	707	3,511	64	13,373	3,300	577	3,572	2,219	**17,775**
North East	63	119	750	-766	171	227	29	2	-6	19	174	**782**
North West	-202	-11	3,518	163	-9,883	-110	-3	83	-20	555	582	**-5,328**
Scotland	7	-46	51	219	-106	-3,278	-48	-24	-11	-26	-23	**-3,285**
South East	146	524	22,867	27	1	-47	-10,252	534	-7	494	113	**14,401**
South West	-17	54	3,913	2	92	-24	637	-2,111	-63	200	70	**2,753**
Wales	1	43	743	-5	103	-9	7	24	-2,913	-146	0	**-2,152**
West Midlands	69	118	3,868	14	526	-28	470	158	-182	-3,419	83	**1,679**
Yorks & Humber	94	113	2,292	121	663	-20	115	66	-6	89	-3,947	**-422**
Grand Total	**1,381**	**2,035**	**33,268**	**659**	**-5,062**	**-3,264**	**5,003**	**2,059**	**-2,598**	**1,677**	**-469**	**34,690**

2.5.2. Reason for change

Subsequent to the development of PFMv3.0, the DfT agreed that NRTS data could be released with an additional character of postcode data, without violating the Data Protection Act. This allowed ultimate origins and destinations to be identified with greater resolution at postal sector level and thus more accurate determination of station access distances.

2.5.3. Methodology for PFMv4.3

2.5.3.1. Relationship between rail journey length and station access distance

The greater geographical resolution provided by the enhanced NRTS postcode data enables differentiation of the types of journeys in the station to zone allocation process on the basis that access distance to the station is likely to be linked to the length of rail journey being undertaken. Those trips undertaking longer distance journeys or along key routes are likely to be prepared to travel further to a major station in order to access a higher quality of service than those travelling on more local routes or for shorter distances. The NRTS data has been analysed to examine the relationships between the journey purpose, travel/ride distance, access distance (to the station) and the egress distance (from the station). The analysis considered two aspects:

- Whether access/egress distances vary by the travel purpose. For instance whether people on business trips are willing to travel further to stations (to get the better train service than for more local travel) as opposed to people travelling on a leisure trip; and
- Analyse whether access/egress distances vary by the actual travel distance. For instance whether access distance for daily commute differs from the access distance for a long distance trip.

This analysis shows that there is a significant link between rail journey length and access distance to station but that this relationship does not vary significantly by journey purpose. Specifically the analysis shows that for all journey purposes there are three rail journey distance bands for which the majority of trips have a station access distances in a defined band:

- Short rail journeys less than 20kms/12.5 miles in length have short access distances of less than 5km for the majority of trips;
- Medium rail journeys between 20kms/12.5 miles and 40kms/25 miles in length have access distances of between 5km and 10km for the majority of trips; and
- Long rail journeys more than 40kms/25 miles in length have access distances of more than 10km for the majority of trips.

This analysis demonstrated that access characteristics of rail trips differ based on the rail journey distance and that it is possible to improve the accuracy of allocation of trips from stations to zones by taking into account the length of the rail journey being undertaken.

2.5.3.2. Station to zone allocation process in PFMv4.3

Within the NRTS data, the top fifteen unitary/local authority districts producing originating rail trips for each station are identified. For all but the largest stations, this threshold (15) accounts for all originating journeys. A lower threshold of ten districts is applied to outward egress to the ultimate destination, as distances tend to be shorter with use of the household car precluded. This process is carried out separately for trips from car owning and non-car owning households.

A small minority of observations to/from London have ultimate origins and destinations transposed, such that an out-and-back rail trip from Manchester Piccadilly to Euston might be shown as produced in Westminster and attracted to Salford. To remove such cases from the analysis of access and egress zonal distribution, a distance cut-off of 80 miles is imposed. This value has been chosen as it prevents transposition of districts/zones in the key West Midlands to London market.

The spatial allocation from station to origin or destination zone is carried out for all trip ends to/from that station irrespective of the journey purpose of the trip. Station-to-station journeys within a given market segment are then divided between the 150 (15 access x 10 egress) combinations of trip-producing and trip-attracting districts. The results are aggregated from districts to the 235 PLD zones to give journeys by zone-to-zone pairings.

The NRTS data is used to classify rail trips into the three distance bands, where the distances are crow fly (straight line) distances based on grid reference co-ordinates.

- short < 20kms/12.5 miles
- 20kms/12.5 miles≤medium<40kms/25 miles
- Long≥40 kms/25 miles

In the small number of cases where the NRTS data does not provide an origin postal sector for an origin station, or a destination postal sector for the destination station, it has been assumed that the trip started/ended in the district containing the station.

In addition, having segmented the NRTS data into six categories, short, medium and long for car owning and non car owning, it was found that there were a number of smaller stations which had no data in one or more of the data sets. In these cases it is assumed that all the journeys to/from that station started/ended in the district within which the station is located. This is not an issue with major stations since these have significant volumes of trips and the NRTS data set is able to provide access/egress profiles. For the smaller stations affected it is likely that the catchment area for the station is relatively small and hence the assumption made should be reasonably realistic and by definition only affects a small volume of trips.

Having segmented the NRTS data into the three distance bands, the LENNON trips are then segmented into the same three distance bands and for each band the NRTS data is used to allocate LENNON trips of that distance amongst appropriate origin / destination zones.

2.5.4. Impact on matrices

The station to zone allocation enhancements have been introduced with the journey purpose definitions described in section 2.3 already revised, namely education reclassified as leisure and the 80 mile commuting cut off removed. Due to improved treatment of missing data[5], there are slightly more trips in the resulting base rail matrices than previously. This small change results in a 0.3% increase in trips and affects all purposes similarly as shown in Table 2-12.

Table 2-12 Impact of reclassifying revising station to zone allocation on trips by purpose

Purpose	% difference
Commute	+0.3%
Business	+0.4%
Leisure	+0.4%
All purposes	+0.3%

The main impact is on the spatial patterns of travel. Table 2-13 shows the change in numbers of rail trips at the aggregate region pair level (shading for changes more than 500 trips). It should be noted that at an aggregate level the changes are generally very small, with the total change of 5,925 trips only representing 0.3% of the matrix. Most of the increases in trips are for intra-regional travel and for trips to/from Wales and Scotland. These are the regions most affected by the limited data where there are smaller stations with less frequent rail services in rural areas. The spatial patterns are similar for all trip purposes as the allocation process does not vary by purpose.

[5] For PFMv3.0 any NRTS records missing information on either the origin or destination were omitted. Similarly where a smaller station was not present in the NRTS data, no station to zone allocation rules existed and the trips from the LENNON data were omitted. For PFM v4.3 missing NRTS origins and destinations were infilled assuming the trip started / ended in the district containing the station. In addition, having segmented the NRTS data into 6 categories: short, medium and long for car owning and non car owning, there were more small stations which had no NRTS data in one or more of the categories. In these cases it was again assumed that all the journeys to / from that station started / ended in the district within which the station is located.

Table 2-13 Impact of station to zone allocation enhancements on Region to Region matrix

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	89	-88	295	9	-146	10	-25	8	14	-61	-49	**55**
East of England	-88	4,089	-2,644	-6	-24	-5	-174	-3	4	-59	-16	**1,074**
London	295	-2,644	6,222	-2	-76	9	-3,528	179	130	45	3	**632**
North East	9	-6	-2	371	-5	-13	-3	0	3	-1	-109	**244**
North West	-146	-24	-76	-5	498	-11	-19	-6	774	-86	-190	**707**
Scotland	10	-5	9	-13	-11	1,646	0	1	9	1	3	**1,650**
South East	-25	-174	-3,528	-3	-19	0	7,804	-147	18	-41	-6	**3,880**
South West	8	-3	179	0	-6	1	-147	481	12	-70	-1	**453**
Wales	14	4	130	3	774	9	18	12	1,335	-19	17	**2,296**
West Midlands	-61	-59	45	-1	-86	1	-41	-70	-19	1,124	-15	**817**
Yorks & Humber	-49	-16	3	-109	-190	3	-6	-1	17	-15	404	**41**
Grand Total	**55**	**1,074**	**632**	**244**	**707**	**1,650**	**3,880**	**453**	**2,296**	**817**	**41**	**11,850**

2.6. Growth in car ownership

2.6.1. Car ownership in PFMv3.0

The rail matrices in PFM (all versions) are divided into trips from car-owning and non car-owning households. This is required for the forecasting stages of the model as trips from these two groups will exhibit different characteristics when responding to changes in travel supply. For example, rail trips from car-owning households may choose to travel to a non local station in order to access a faster or more frequent service, whereas the non car-owning households will have a more restricted choice of stations as they will use the station(s) they can access without a car.

PFMv3.0 implicitly assumes that car ownership remains constant at the level identified in NRTS for 2004/5.

2.6.2. Reason for change

Household car ownership is changing over time with fewer households without cars today than in 2004/5 when the NRTS data was collected (2001 for London). It is thus desirable to take the changes in car ownership into consideration as this provides a more accurate proportion of car owning households in the base model. The car ownership data from NRTS has therefore been updated to represent the levels and regional variations in car ownership for the 2010/11 base year.

2.6.3. Methodology

The NRTS data available is either 2001 (from the LATS surveys for London and South East regions) or 2004 (for the rest of UK). An adjustment factor to take into consideration the percentage change in the car ownership is required to update the NRTS data and feed into the station to zone allocation process matrix. The National Car Ownership Model output (available in the NTEMv6.2 dataset) has been used to estimate the number of households owning none and one or more cars for the years 2001, 2004 and 2010. Review of the changes at different levels of spatial detail: Region, County, local authority and NTEM zone indicated that sufficient spatial variation occurred to warrant applying differential growth rates by district.

The growth in car ownership has been implemented by applying the percentage growth in car owning households to the percentage share of rail trips which were car owning, based on the location of the station from which the trip was made. Since the NRTS data uses LATS for the London and South East areas these data are older (2001) than the data outside London (2004/5) and hence growth factors for London and the South East apply over a longer period.

Thus if the NRTS data shows that 80% of trips from Station X in the NRTS data were made by people from car owning households and car ownership has increased by 5% then 84% (80%*1.05) are assumed to be car owning in the update of the matrices for PFMv4.3. The percentage car owning was capped at 100% and the revised proportion of trips by non car owners was calculated as 100% minus the car owning percentage.

2.6.4. Impact of changes

As this enhancement has been introduced at the same time as the station to zone allocation, detailed results isolating this effect are not available. However, testing demonstrated there was no impact on journey purpose, only on how the trips were segmented into car owning and non-car owning and hence how they were allocated from stations to zone as described previously.

The overall impact on the proportions of rail trips from car owning and non-car owning households in the base matrices is shown in Table 2-14. This shows that the proportion of rail trips which are from car owning households increases from 80% to 82%.

Table 2-14 Impact of growth in car ownership

Car ownership	Trips with revised purpose definitions	Trips with revised station to zone allocation & increased car ownership	% difference
Car owning	80%	82%	+3.0%
Non car owning	20%	18%	-10.0%

2.7. Revised annualisation factors

2.7.1. Deannualisation and annualisation in PFM (all versions)

The PFM (all versions) requires processes for both deannualisation and annualisation of trip information. These are required as follows:

- A **deannualisation** process is necessary to convert the annual data contained in the LENNON database into the single weekday data required for the PFM (all versions). Thus the LENNON data has to be deannualised to represent a single weekday, removing the effects of weekends and public holidays; and
- An **annualisation** process is necessary for appraisal purposes to enable the weekday demand and revenue from the PFM (all versions) to be expanded to represent annual demand and revenue, including weekends and public holidays. The annualisation process has to take account of the variation in journey purposes between weekdays and non-weekdays to ensure the correct annual proportions for each journey purpose. The inclusion of journey purpose means that the annualisation is not simply the reverse of the deannualisaton. The annualisation process permits calculation of annual benefits arising from changes in the transport system together with annual revenues from rail fares.

This deannualisation process in PFMv4.3 is unchanged from that for PFMv3.0, which uses factors from ORCATS which provides factors to derive demand for train travel by time of day and day of week.

As the deannualisation process is unchanged, the remainder of this section focuses on changes made to the annualisation process as part of the enhancements for PFMv4.3.

The PLD element of PFM (all versions) models travel costs across an average day. For the annualisation process it is assumed that the relative benefit per affected rail trip for a given trip purpose is the same on a weekday and a non-weekday. Therefore, the key calculations required are to determine the proportion of demand for each journey purpose that occurs on a weekday compared to a non-weekday. These proportions are then converted into ‘annualisation factors’ for each purpose to provide an estimate of annual demand, benefits and revenues from the weekday demands and revenues from PFMv4.3.

2.7.2. Reason for revised annualisation factors

As described earlier in this section, the enhancements to the rail matrices include the journey purpose splits being applied on the basis of geographically disaggregate purpose data from the National Rail Travel Survey. This methodology replaces the process of correspondence between ticket type and purpose used in PFMv3.0. As a result of this methodological change, the annualisation factors in PFMv3.0, which had been developed on the basis of the previous approach to deriving demand matrices by purpose, are no longer consistent with the PFMv4.3 matrices.

2.7.3. Calculation of Annualisation Factors

A key requirement for the revised annualisation factors is that they are internally consistent with the process used to generate the weekday rail demand matrices.

In order to derive journey purpose specific annualisation factors, there needs to be an estimate of the level of non-weekday demand by journey purpose. Ideally this would be produced in the same way that weekday demand is disaggregated to each journey purpose by using NRTS data. However, NRTS data cannot be used for disaggregating non-weekday demand since it is a weekday only survey.

This means it is necessary to use an alternative data source to identify the purpose split for non weekday demand. There are two sources of such data:

- **National Travel Survey (NTS)** – The NTS surveys travel patterns for all modes and distances nationally. The survey design makes it ideal for looking at patterns of demand between weekday and non-weekday travel, and data can be broken down into different journey purposes; and
- **National Passenger Survey (NPS)** – A survey of rail passengers, the NPS is mainly designed to record passenger satisfaction and journey experiences and is structured to give samples relating to train operators. As part of the survey, day of travel and journey purpose are recorded, which makes the survey potentially useful for deriving annualisation factors.

It is considered that the NTS offers the most suitable basis on which to form annualisation factors, as whilst it has a smaller sample than NPS it is structured for the examination of rail travel as a whole rather than on an operator basis. The NPS is used within the process of deriving factors in order to provide a cross-check.

The NTS data from 2006-2010 was used at a national level to examine evidence on variation of journey purpose splits between weekday and weekend. While further geographical disaggregation was desirable, it was felt the sample size within the NTS was not sufficient to support this. In any case, analysis of the NPS data suggests there is relatively limited difference in purpose splits between weekday and weekend for different movements geographically, particularly for business and commuting journey purposes.

It is assumed that, on average, there are 245 working week days per year based on 260 calendar weekdays per year, eight bank holidays and an additional reduction to account for atypical, reduced demand in the Christmas and New Year period, particularly in the week between the two holidays. This factor was used in the approach used to de-annualise LENNON data by ticket type and thus maintains consistency with the deannualisation process.

The NTS data can be used to directly derive annualisation factors using estimates of weekday and non-weekday demand captured within the survey itself. However, there is no guarantee that these estimates are in line with actual levels of demand observed in LENNON. As such, using these annualisation factors could over- or under-estimate demand across the year. Thus the adopted approach is to apply NTS derived journey purpose splits for non-weekday demand to estimates of total non-weekday demand derived from the LENNON de-annualisation process used in developing the PFMv4.3 rail demand matrices. The annualisation factor A for journey purpose j is thus derived as follows:

$$A_j = 245 * \frac{D_{wd}S_{j,wd} + D_{we}S_{j,we}}{D_{wd}S_{j,wd}}$$

Where D_{wd} = Total weekday demand for all purposes derived from LENNON deannualisation

D_{we} = Total non-weekday demand for all purposes derived from LENNON deannualisation

$S_{j,wd}$ = Share of weekday demand for journey purpose j (derived from NRTS data as part of PLANET matrix development)

$S_{j,we}$ = Share of non-weekday demand for journey purpose j (derived from NTS)

Using these annualisation factors, the sum of annualised demand will equal the total demand reported in the LENNON database.

The process was filtered to remove trips under 50 miles and trips within the regional models from the derivation of the annualisation factors to ensure that the factors derived were appropriate for the longer distance trips in the PLD matrices and thus the movements of most relevance to HS2.

The resulting annualisation factors are shown in Table 2-15 together with the factors used for PFMv3.0. The factors for business and commuting trips for PFMv4.3 are significantly lower than for PFMv3.0, reflecting the changes in the base matrices and journey purpose splits for weekday demand. The factor for leisure trips increases correspondingly.

Table 2-15 Annualisation Factors

	Annualisation Factors		
	Business	**Commute**	**Leisure**
PFMv3.0	301	270	314
PFMv4.3	256	254	416

2.8. Revisions to base rail fares matrices

2.8.1. Fares matrices in PFMv3.0

Fares matrices are required for the base year for use in the demand modelling and the appraisal processes. The fares matrices for PFMv3.0 were derived in parallel to the base year passenger trip matrices from the LENNON revenue data. The average fares were obtained by processing total revenues in the same way as total trips, then dividing the total revenues by the volumes. The approach adopted up to PFMv3.0 used the LENNON ticket types mapped to journey purposes via the same NRTS based mapping as described previously for trips in order to calculate separate fares for each trip purpose and zone pair.

2.8.2. Reason for revised fares matrices for PFMv4.3

It is important to ensure consistency between the approach to develop the trip matrices and fares matrices. However, the revised approach to defining trip purposes means that trips between a zone pair are split into commuting, business and leisure with a set of geographically based proportions. If the revenues were processed in the same way the ratio of revenue to trips would be the same for each purpose – so there would be no fares differentiation by purpose. Much of the differentiation by purpose is due to the different mix of purposes travelling at weekends and in the peak and off-peak periods and is thus related to ticket type. Three options have been considered:

- Having a single fares matrix (no differentiation by purpose);
- Leaving the fares matrices as they were in 2011 based on the earlier PFMv3.0 specific NRTS based ticket type to journey purpose mapping; and
- Updating to a revised ticket type to purpose mapping such as that adopted in PDFHv5.

A single fares matrix is not considered an acceptable approach. The analysis of trip data and journey purposes for the base rail passenger matrices indicates some significant shortcomings with the PFMv3.0 NRTS based ticket type to purpose mapping – primarily in relation to trips to/from London compared with other journeys as a result of no geographical variation. Thus the third option using PDFHv5 for the purpose split is considered the most appropriate way forward.

As the correspondence between ticket type and purpose in PDFHv5 includes a geographical breakdown, this was found to be an improvement on the previous approach and PDFHv5 is a recognised industry standard. For the requirements of PFMv4.3 there are however some shortcomings with the PDFHv5 approach relating to the definition of commuting (including education trips) and the standard mappings being adjusted for an average day (rather than weekday). In addition, PDFHv5 is not used for the processing of the trip matrices as explained previously.

Thus the specific methodology for purpose segmentation to produce the fares matrices differs from the trip purpose segmentation methodology, but this is necessary to ensure that there is fares differentiation by trip purpose. Most of the other enhancements to the trip matrices reported in this section are incorporated in the update of the fares matrices, as follows:

- The revised definition of trip purpose with education trips moved from commuting to leisure and the 80 limit on commuting trips removed;
- The enhancements to the station to zone allocation process; and
- Increased car ownership.

2.8.3. PDFHv5.0 based ticket type to purpose factors

Section C0 of Part C of PDFHv5 (version dated March 2011) is used to obtain the ticket type to purpose conversions for the geographic areas covered by the PLD element of PFMv4.3 – i.e. not for travel within London or the South East. For each market segment two tables are presented in C0: an unadjusted set of factors based on NRTS data for weekdays and an adjusted set of factors for an average day (or week) with an adjustment for long distance commuting (including travel to university accommodation) reclassified as leisure travel.

For the PLD element of PFMv4.3 the factors would ideally be based on weekdays and have all education related travel reallocated to leisure trips. Since this is not possible the weekday “unadjusted” factors are used with the long distance commuting/university education travel reallocated to leisure.

PDFHv5 details four adjustments to be made to the “unadjusted” tables. These take account of trips for students and workers who stay near their workplace during the week but return home at weekends, these being coded as commuting trips in NRTS but treated as leisure trips in PDFHv5. The adjustments contained in PDFHv5 are:

- Table C0.9 – commuting demand using off-peak tickets reduced by 75%;
- Table C0.13 – commuting demand using off-peak tickets reduced by 75%;
- Table C0.15 – commuting demand using off-peak tickets reduced by 75%; and
- Table C0.15 – leisure demand using season tickets reduced by 75%.

Having made these adjustments to the tables the figures are normalised to bring the sum over purposes and ticket types back to 100%. The split into commuting, business and leisure for each ticket type (full, reduced and season) are then derived. The resulting figures are shown in Table 2-16 below.

Table 2-16 Ticket type to purpose factors based on PDFHv5.0 (March 2011)

	PDFH Source table and ticket type			PDFH Source table and ticket type		
	C0.3: Rest of South East to/from London			C0.7: Outside South East to/from London <100 miles		
Purpose	Full	Reduced	Season	Full	Reduced	Season
Commute	44.86%	33.44%	92.76%	40.17%	32.24%	92.59%
Business	34.58%	23.08%	4.21%	36.75%	24.01%	4.31%
Leisure	20.56%	43.48%	3.03%	23.08%	43.75%	3.10%
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
	C0.9: Outside South East to/from London 100+ miles			C0.11: Outside South East <20 miles (excl within PTE areas)		
Purpose	Full	Reduced	Season	Full	Reduced	Season
Commute	6.09%	3.34%	73.53%	66.79%	48.63%	91.85%
Business	76.73%	40.84%	16.67%	7.50%	7.98%	2.82%
Leisure	17.17%	55.82%	9.80%	25.71%	43.39%	5.33%
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
	C0.13: Outside South East 20–100 miles			C0.15: Outside South East 100+ miles		
Purpose	Full	Reduced	Season	Full	Reduced	Season
Commute	43.93%	11.89%	92.34%	8.70%	3.76%	19.05%
Business	22.59%	19.46%	3.83%	44.35%	22.64%	38.10%
Leisure	33.47%	68.65%	3.83%	46.96%	73.59%	42.86%
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

2.8.4. Processing of revenue and trip matrices for fares

The straight line distances between station pairs are calculated to derive the appropriate distance banding as shown in Table 2-17. Trips to/from PLD zones 117 to 123 inclusive are defined as trips to/from London, the rest as Non London.

The rules set out below are then used to determine the appropriate set of PDFHv5 based ticket type to purpose mappings to apply for combinations of origin/destination and trip length.

The purpose splits from PDFHv5 are applied to **both** the numbers of journeys and the total revenue for each ticket type (full/reduced/season) and zone pair for the CA trips[6]. The results are aggregated to give the total revenue and total trips by purpose for each zone pair.

[6] The processing of the trip matrix is carried out for car owners and non car owners separately. To use the same processing tools, the car owning stage (being the majority of the trips) is run for revenue as well as trips to derive the fares for all trips whatever their car ownership.

Table 2-17 PDFHv5 source table of purpose split for zone pair and trip length combinations

Origin / Destination London	Trip length	Source PDFH Table
To/From London	0 to 50 miles	C0.3
To/From London	50 to 100 miles	C0.7
To/From London	100 to 200 miles	C0.9
To/From London	200+ miles	C0.9
Non London	0 to 20 miles & unknown distance	C0.11
Non London	20 to 100 miles	C0.13
Non London	100 to 200 miles	C0.15
Non London	200 miles+	C0.15

2.8.5. Calculation of fares from revenues and trips

The fares are calculated by dividing the total revenue by the total number of trips and relate to the cost/revenue for a single journey/OD trip. However, a series of checks and adjustments are made to avoid extreme fares where there are insufficient observations or the implied fare is significantly different from the average.

The average yield per kilometre (total revenue/total trips/distance) is calculated for each zone pair and trip purpose. The set of zonal values are then used to give an average and acceptable range (min/max) for the yield per kilometre for each purpose as follows:

- Average: median yield per kilometre for purpose across all zone pairs for purpose; and
- Minimum/maximum yield per kilometre: median ± standard deviation of yields per kilometre across all zone pairs for purpose.

A series of thresholds were also defined:

- Small flows <0.05 trips per weekday for zone pair (summed across all trip purposes);
- Large flows >50 trips per weekday for zone pair (summed across all trip purposes); and
- Minimum fare: £2.00.

The fares are then calculated, following the same approach as had been used to develop the fare matrices found in PFMv3.0, and this approach is shown below:

- For zone pairs with large flows (>50 trips/weekday) and intra regional flows (wholly within GORs):
  - Fare = Maximum (Total revenue/total trips, £2.00)
- For all other zone pairs (inter regional with flows ≤ 50 trips per weekday):
  - If average yield per kilometre not within defined range, or volume of trips is small or initial fare is less than minimum (£2.00): Fare = Maximum (average yield per kilometre * distance for OD, £2.00)
  - Otherwise: Fare = Maximum (Total revenue / total trips, £2.00)

2.9. Update of PLANET South Matrices

2.9.1. Background

The 2011 model update to develop PFMv3.0 saw the model base year moved from 2007/08 to 2010/11. In the PLANET South (PS) matrices, trips with one or both ends outside London were adjusted using factors derived from LENNON data based on changes in trip ends at the point of trip production. For trips wholly within London, TfL supplied a separate global factor of 11.5%.

For PFMv3.0 the LENNON data used to calculate the uplift factors was ‘post-allocation’ journey data where the movements had been allocated to individual Train Operation Company (TOC) Service Codes. The uplift calculations were restricted to full and season tickets, as PS represents an AM (07:00-10:00) peak period where other ticket types would not be expected to be present.

The use of post-allocation data, intended to identify the demand associated with each of the TOC Service Codes, introduced the possibility that timetable changes could have affected the uplifts. The receipt in October 2011 of pre-allocation LENNON data for use in PLD (PFMv3.0) allowed a comparison against the post-allocation data used in PS. Although this suggested no widespread or systematic bias in the PS uplifts, to ensure consistency the PS matrices were rebased using the pre-allocation data. This ensured that the PS and PLD matrices in PFMv4.3 had been derived using consistent LENNON data.

In addition, instead of using one global factor to uplift all trips wholly within London, a more disaggregate approach was developed using data from TfL's Rolling Origin Destination Survey (RODS) and the Office of Rail Regulation (ORR). These new growth factors replaced the existing global factor applied within London.

2.9.2. Data sources

This section briefly describes the sources of data considered for the update of the PS matrices, and discusses their strengths and weaknesses.

2.9.2.1. Pre-allocation LENNON Journey Data

LENNON is the rail industry's central ticketing system, and holds information on all national rail tickets purchased in Great Britain. It contains sufficient data for growing demand within the South East and to/from London and the South East. However, as LENNON data does not capture Travelcard and Oyster Pay As You Go trips it has inherent weaknesses within the London Travelcard area.

The LENNON data received from DFT incorporated a list of National Rail stations with the total number of journeys that originated and ended at each station.

2.9.2.2. ORR data

Delta Rail collated ORR's station usage data that consisted of estimates of the total numbers of people entering, exiting and interchanging at stations. The underlying matrix of ticket sales and associated journeys and revenue came from LENNON with an infill for London Travelcard usage as an estimate of the missing demand.

The ORR station usage data received incorporated a list of National Rail stations with the total number of journeys that originated and ended at each station.

2.9.2.3. RODS data

Rolling Origin Destination Survey (RODS) data for 2008 and 2011 was received from TfL for use in the growing of demand within the London Travelcard area. Unlike LENNON and ORR data, it was based on counts at stations, rather than based on ticket sales, and therefore did not share the same limitations concerning Travelcard usage. However, the RODS data only covered London Underground stations and did not include National Rail stations, and therefore only provided partial coverage of the London area.

The RODS data received consisted of the number of boarders and alighters at each of the stations across the LUL network.

2.9.3. Methodology

This section describes how the uplift factors were derived to develop the 2010/11 PFMv4.3 PS matrices.

The factors to update the 2007/8 PS matrices to 2010/11 matrices were derived and applied differently for the three identified flow categories:

- Southeast to Southeast (i.e. not London Travelcard area) flows
- Southeast to/from London Travelcard area flows
- Within London Travelcard area flows

2.9.3.1. South East to South East flows

The NR station origin and destination information that LENNON provides was allocated from each station to a PS zone using GIS mapping software. Several PS zones had no NR station, and hence no boardings/alightings data, allocated to them. These remaining zones took the growth factors from adjacent stations which were allocated based upon the zone-station links in the PS model. Using the assigned demand from the PS model allows the weighting of the boardings/alightings data associated with the chosen stations.

Uplift factors from 2007/8 to 2010/11 were then produced for all journey purposes, for origin stations and destination stations. Vector matrices of the uplift factors were then produced in EMME/2 format.

Within EMME/2, the 2007/8 base PS matrices were divided into vector matrices, and the base vector matrices were factored up by the uplift vector matrices respectively. Finally the 2010/11 vector matrices were Furnessed within EMME/2 to create the full PFMv4.3 matrices for Southeast to Southeast flows.

Figure 2-3 shows the proportionate growth in origins of demand between 2007/8 and 2010/11. Where a zone shows no growth (coloured white) there are no South East to South East trips contained in the PS matrices. The figure shows that there is an increase in origins of demand particularly concentrated in the southwest, southeast, and north east of London. Some origin zones do decrease though, and these are mainly concentrated in the south east and the north of London.

2.9.3.2. South East to/from London Travelcard Area Flows

The limitations of LENNON data in the London Travelcard area (the ticket data does not cover Travelcard and Oyster Pay As You Go) preclude uplifting on an origin destination basis the flows to/from the London Travelcard area, as well as flows entirely within. Therefore, the approach for trips between the Southeast and the London Travelcard area was based on national rail station origins only i.e. the Southeast, not London, end of the trip.

The collated LENNON data, allocated to PS zones was used to produce the uplift factors. However, this time only an origin matrix was produced and this was then used to factor the 2007/8 base matrices. Although this method provides no indication of differential patterns of growth at the attractor end of the trips it was assumed that over the three years between 2007/8 and 2010/11 employment growth patterns between different parts of Central London did not change significantly and so would not impact on the distribution of trips in the London area.

Figure 2-4 shows the proportionate growth in origins of demand between 2007/8 and 2010/11. Where a zone shows no growth (coloured white), there are no South East to London Travelcard trips contained in the PS matrices. As would be expected Figure 2-4 shows that there was a broadly similar increase in origins of demand in this flow category as for Southeast-Southeast, with growth concentrated in the southwest, southeast, and north east and decreases in the south east and the north.

2.9.3.3. Within London Travelcard Area Flows

The weakness of the LENNON data for ticket sales in London meant it was not felt to be appropriate to use this data for creating the 2007/8 to 2010/11 uplift factors for the ‘within London Travelcard area’ flow group. Instead ORR data was used for National Rail stations in London with TfL’s RODS data used for London Underground stations.

Consideration was given to the level of disaggregation to be used in the calculation of the uplift factors with matrices being prepared using factors derived at a PS zone level and alternatively at a London Borough level. These showed that when the factors were derived at a zone level the Furnessing process used to apply the growth factors to the 2007/08 matrices led to a reduction in demand in zones which contained no LUL or NR station.

To get round this issue, and also to ‘smooth’ out any outliers in the data, the boarding/alighting data was allocated at a borough level instead of a zone level. For both sets of data (RODS and ORR), the PS zones were grouped into the London Boroughs in which they are located, and the total boarders and alighters for each borough was calculated, and the uplift factors produced.

Figure 2-5 shows the proportionate growth in origins of demand in the PS matrices between 2007/8 and 2010/11, using RODS data to construct the uplift factors by borough and ORR data for any boroughs not covered by RODS. Figure 2-6 shows the proportionate growth in destinations of demand.

Note that there is no differentiation between the journey purposes for the derivation of uplift factors and so these were applied uniformly by purpose.

Figure 2-3 2010/11 vs 2007/8 Total Demand by Origin Zone, South East-South East

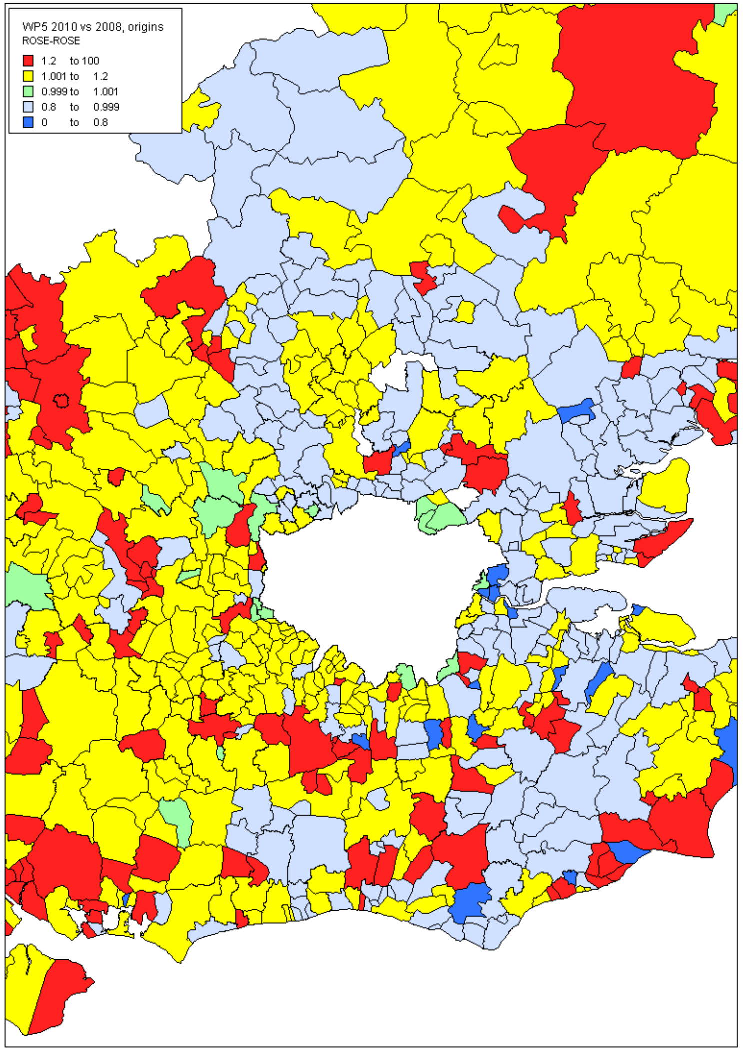


Figure 2-4 2010/11 vs 2007/8 Total Demand by Origin Zone, South East-London Travelcard Area

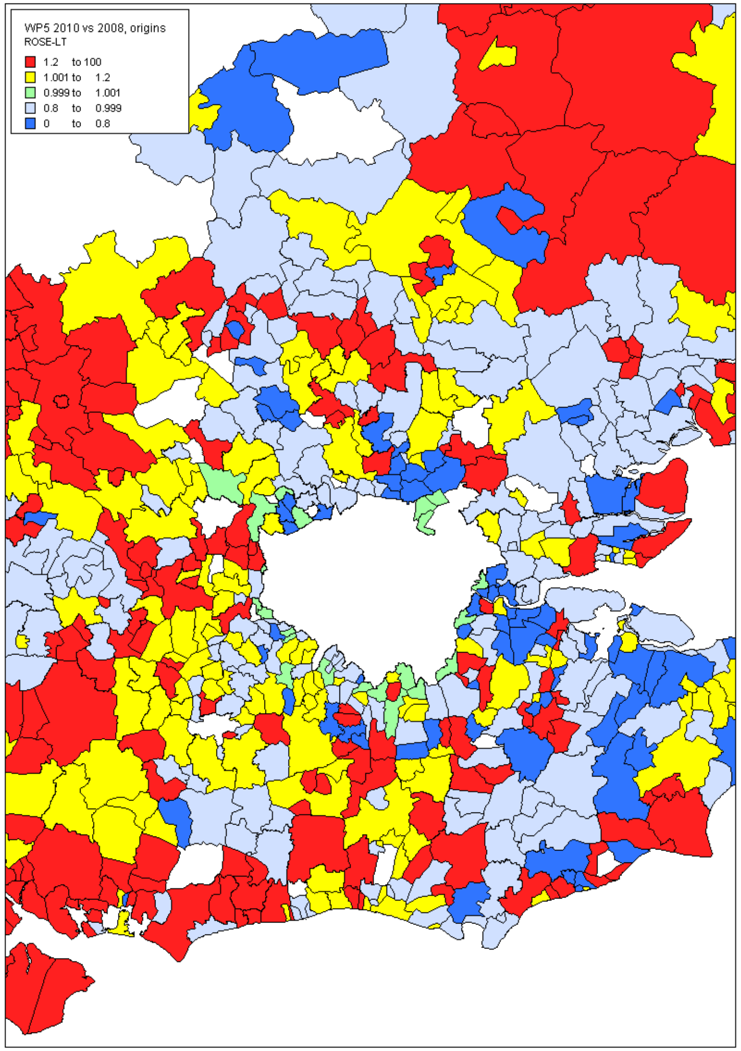


Figure 2-5 2010/11 vs 2007/8 Origins of Demand, LT-LT (RODS & ORR, Borough Level)

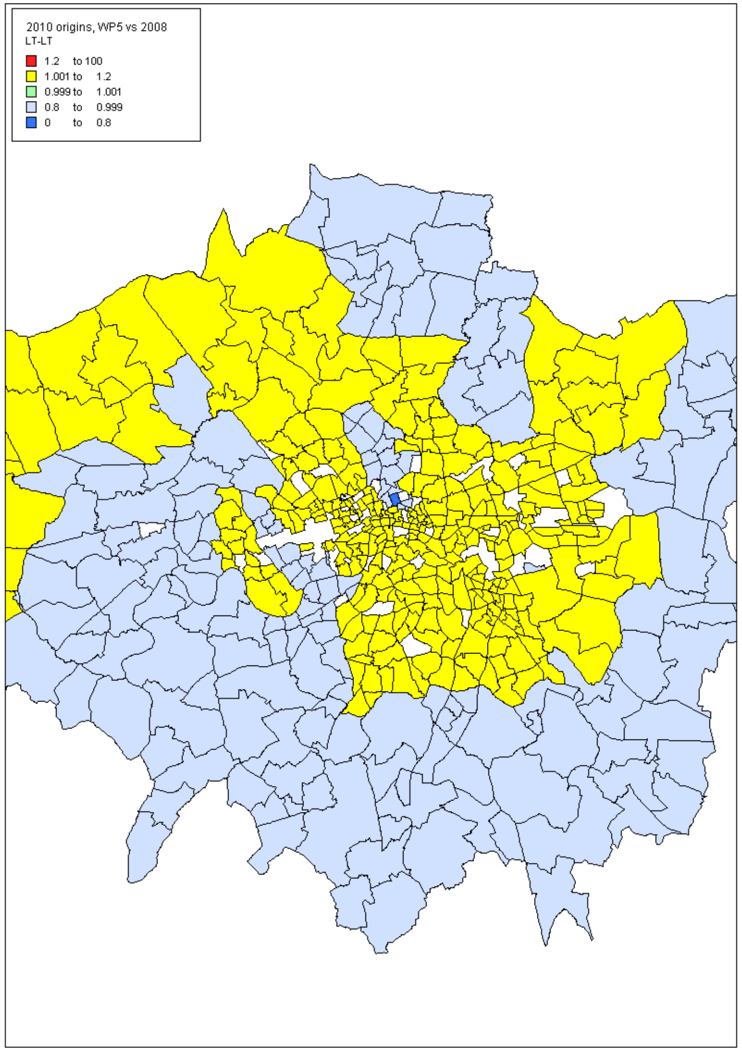
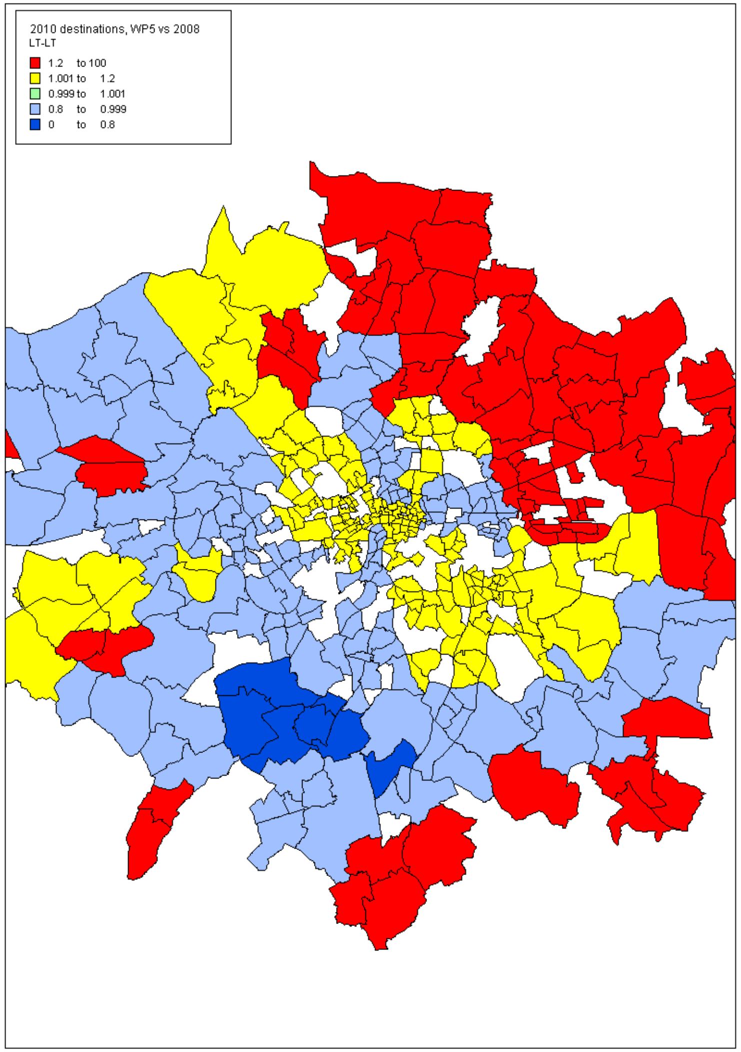


Figure 2-6 2010/11 vs 2007/8 Destinations of Demand, LT-LT (RODS & ORR, Borough Level)



2.9.4. Impact on PS Demand

Table 2-18 shows the impact of the revised methodology on the three groups of trips within the PS matrices; Rest of Southeast-Rest of Southeast, Rest of Southeast to/from London, and London-London trips.

Table 2-18 Matrix Totals by Flow Group

Flow group	2007/08	2010/11 November PFMv3.0	LENNON Data PFMv4.3	RODS + ORR PFMv4.3
ROSE-ROSE	118,255	123,020	123,224	-
ROSE-LT	308,049	315,847	327,945	-
London Travelcard Area	1,093,934	1,218,236	-	1,107,961

Between PFMv3.0 and PFMv4.3 the ROSE-ROSE flow group have slightly increased by 204 trips (0.2%) whilst the ROSE-LT flow group has by increased by 12,098 trips (3.8%). The largest change is for trips internal to the London Travelcard area where there is a reduction of 110,275 trips (9.1%). This large change is due to the adoption of a revised methodology which used alternative data to that used to develop the PFMv3.0 matrices (which had been derived by applying a global factor to the 2007/08 matrices).

2.9.5. Impact on Model Validation

To understand the impact of the revised PS matrices on the model validation they were incorporated in to the PFMv3.0 base year model which was rerun. Whilst the focus of the validation exercise was on PLANET South, the impact on the other models was also looked at to ensure model validation had not worsened elsewhere. Note that this model run is not the PFMv4.3 base year model run as this included the changes to networks, matrices and other part of PFM which are detailed elsewhere in this report

2.9.5.1. PLANET South

Table 2-19 shows that the update to the PLANET South base matrices has not significantly affected the validation of the model. The pass/fail status has not changed for any of the counts. At a total level, the validation of the model has slightly improved (-10% to -9%)[7].

Table 2-19 Impact on PLANET South Validation

Route/Count Point	Observed (PIXC counts 2010/11)	PFMv3 Base	% Difference	Pass/Fail	PFMv3 Base – PS Update	% Difference	Pass/Fail
Great Western Main Line (Paddington)	28,275	22,776	-19%	Pass	22,431	-21%	Pass
Chiltern Main Line (Marylebone)	11,546	7,260	-37%	Fail	7,683	-33%	Fail
West Coast Main Line (Euston)	22,603	19,667	-13%	Pass	19,852	-12%	Pass
Midland Main Line (St Pancras)	23,144	27,144	17%	Pass	28,285	22%	Pass
East Coast Main Line (Finsbury Park)	35,939	33,010	-8%	Pass	32,275	-10%	Pass
Total	121,508	109,857	-10%	Pass	110,526	-9%	Pass

7 WebTAG validation guidance states that 25% is the limit for an individual link, and 15% for a screenline as a whole.

2.9.5.2. Other PLANET models

The validation of the other regional PLANET models in the Framework (Midlands & North) did not change; the majority of passenger volume counts on links in the regional models showed zero change. There were some changes in the PLD validation and these are shown Table 2-20.

Table 2-20 Impact on validation in PLANET Long Distance

Table Ref & Description	Station & Direction	Observed	PFMv3 Base	% Difference	PFMv3 Base – PS Update	% Difference
London Termini Screenline – MOIRA Flows	Euston (Outbound)	28,739	33,504	17%	34,090	19%
London Termini Screenline – MOIRA Flows	Euston (Inbound)	28,537	34,942	22%	35,570	25%
London Termini Screenline – MOIRA Flows	St Pancras (Outbound)	17,542	11,502	-34%	11,850	-32%
London Termini Screenline – MOIRA Flows	St Pancras (Inbound)	15,344	11,221	-27%	11,587	-24%
London Termini Screenline – MOIRA Flows	Kings Cross (Outbound)	21,180	18,817	-11%	19,243	-9%
London Termini Screenline – MOIRA Flows	Kings Cross (Inbound)	17,654	18,168	3%	18,602	5%
South of Midlands Upper Screenline	Bicester North N/B	4,020	2,672	-34%	2,859	-29%
South of Midlands Upper Screenline	Bicester North S/B	4,095	2,768	-32%	2,980	-27%
South of Midlands Lower Screenline	Milton Keynes (N/B	28,397	33,895	19%	34,471	21%
South of Midlands Lower Screenline	Milton Keynes S/B	28,537	35,331	24%	35,959	26%
South of Midlands Lower Screenline	Bicester North N/B	5,209	3,893	-25%	4,346	-17%
South of Midlands Lower Screenline	Bicester North S/B	5,275	3,902	-26%	4,340	-18%
South of Midlands Lower Screenline	Oxford N/B	4,165	3,441	-17%	3,714	-11%
South of Midlands Lower Screenline	Oxford S/B	3,538	3,320	-6%	3,586	1%
Bedford South Screenline	Bedford N/B	12,732	10,868	-15%	11,316	-11%
Bedford South Screenline	Bedford S/B	11,991	10,852	-9%	11,283	-6%

The table shows that the links that showed the largest differences in passenger volume counts were those closer to London; this is intuitive as these are the links that are more susceptible to changes in the PLANET South model, due to the pre load process. Despite the changes in some of the passenger volumes in PLD, there was a very small impact on the validation of the model overall.

2.10. Cumulative impact of enhancements to trip matrices

2.10.1. Enhancements introduced

The preceding sections of this section have described a series of enhancements that have been introduced to the base rail trip matrices for PFMv4.3. These are:

- Revised trip purpose definitions – education trips included with leisure not commuting and commuting trips over 80 miles retained (previously reclassified as leisure);
- Revised process to segment trips by journey purpose using NRTS data on a geographic basis to provide improved representation of observed data;
- Revised allocation of trips from station to station pairs to zone pairs – taking into account variations by types of trip;
- Revised car ownership growth; and
- Associated changes to the annualisation process used in the calculation of annual demand, benefits and revenue.

This section describes the cumulative impacts of the enhancements on the base rail matrices for the PLD element of the model.

2.10.2. Impacts of enhancements on base matrices

This section summarises the main impacts of the enhancements made to the base year matrices. The global impacts are considered first then the spatial changes are presented.

Table 2-21 shows the composition of the rail trips by trip purpose for PFMv3.0 and PFMv4.3 together with the observed proportions from the NRTS data (all using the revised purpose definitions). This shows that commuting accounts for 54% of the rail trips in PFMv4.3 and PFMv3.0 compared with 55% for the NRTS observed data. Business trips in PFMv4.3 have a slightly increased share at 13% and leisure trips reduced slightly to 33%.

Table 2-21 Comparison of purpose split in PFMv4.3 PLD matrices with PFMv3.0 and observed NRTS data (revised purpose definitions)

Overall purpose split	Commute	Business	Leisure
PFMv3.0 PLD matrices	54%	12%	34%
Output PFMv4.3 matrices	54%	13%	33%
NRTS data set (observed)	55%	12%	33%

The impacts on trip purpose brought about by the enhancements for PFMv4.3 are shown in Figure 2-7 and Figure 2-8 by purpose and car ownership. The PFMv3 column in Figure 2-7 uses the original journey purpose definitions. These figures show the incremental effects of each of the main enhancements described in the preceding sections together with the cumulative effects of all the enhancements. The main change on the overall volume of trips by purpose was caused by the redefinition of the education trips as leisure which resulted in nearly 30% more leisure trips. It is important to note that this change will not significantly affect the final PLD matrices for PFMv4.3 as trips wholly within the PLANET regional models are removed and as education trips are typically short distance they will be removed for these areas.

The 8% gain in business trips is expected to feed through to the final PLD matrices since it was found that these trips are typically the longer distance movements to/from London that were previously under-represented in the PFMv3.0 model.

Figure 2-7 Change in trips by purpose and car ownership

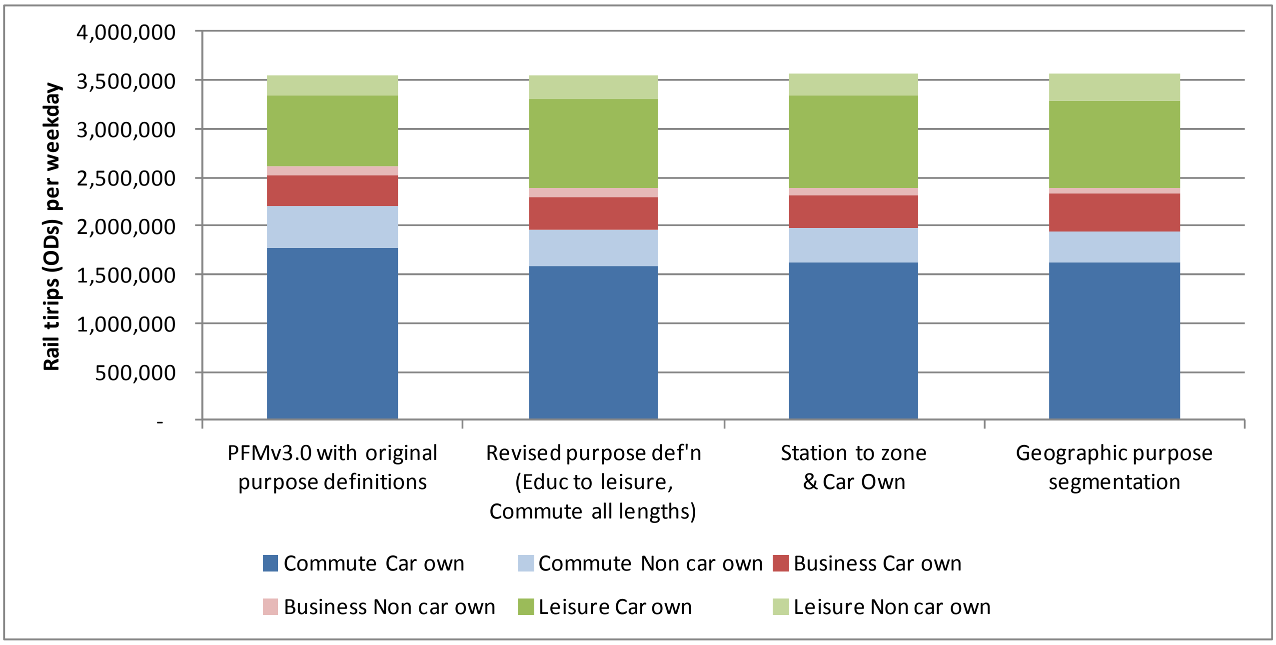
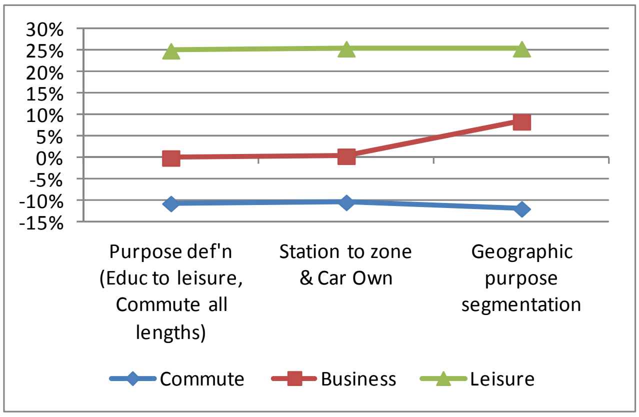
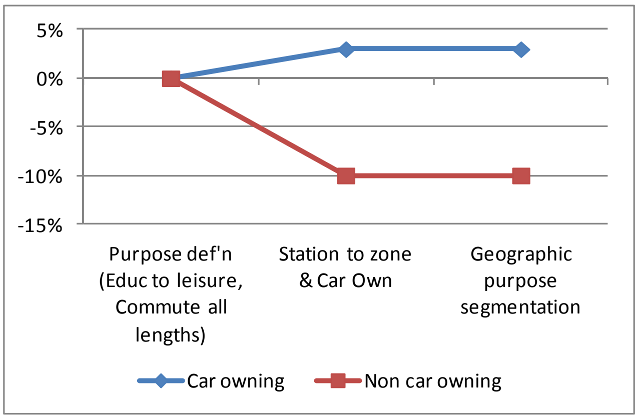


Figure 2-8 Percentage change in trips by purpose (left) and car ownership (right)





A summary of the impact on OD trips of all these enhancements by trip purpose is shown in Table 2-22, this table also shows the incremental effects of each of the main enhancements together with the cumulative effects of all the enhancements. As has been seen the most significant impact on OD trips is the change in purpose definition for education trips. There is a modest increase in business trips as a result of the change to geographically based purpose segmentation.

Table 2-22 Impact of changes on OD trips by purpose

Purpose	Proportion of trips by purpose			
	PFMv3.0 (original purpose definitions)	Purpose definition (Education with leisure & commute all lengths)	Stations to zones & car ownership increase	PFMv4.3 (Geographic purpose segmentation)
Commute	62%	54%	55%	54%
Business	12%	12%	12%	13%
Leisure	26%	34%	33%	33%
Purpose	**Percentage change in trips from PFMv3.0**			
	PFMv3.0 (original purpose definitions)	Purpose definition (Education with leisure & commute all lengths)	Stations to zones & car ownership increase	PFMv4.3 (Geographic purpose segmentation)
Commute	-	-11%	-10%	-12%
Business	-	0	0	+8%
Leisure	-	+25%	+25%	+25%

The effect of the rail matrix enhancements for each journey purpose for movements of key relevance to HS2 as shown in Table 2-4 and Table 2-10 are brought together in Table 2-23 below together with data for additional major cities to/from London. It should be noted that the matrices will not precisely match the NRTS data as the NRTS proportions relate to station to station movements and the matrices relate to zone to zone movements. The table shows that PFMv4.3 matrices are providing a much better replication of NRTS observed journey purpose splits than the PFMv3.0 matrices, particularly for business trips where PFMv3.0 was typically under-representing trips for these movements by 50% or more.

Table 2-23 Journey purpose proportions (percentages)

Journey	Commuting			Business			Leisure		
	NRTS Obs.	PFM v3.0	PFM v4.3	NRTS Obs.	PFM v3.0	PFM v4.3	NRTS Obs.	PFM v3.0	PFM v4.3
London-Leeds	3	16	4	70	26	56	27	57	40
Leeds-London	4	17	4	51	29	56	45	54	40
London-Manchester	5	16	5	64	26	64	32	58	31
Manchester-London	5	28	5	61	23	64	34	50	31
London-Sheffield	6	16	5	64	26	65	30	58	30
Sheffield-London	6	39	5	57	20	64	38	41	31
London-Birmingham	8	17	15	65	26	56	27	57	29
Birmingham-London	8	26	15	63	25	56	29	49	29
London-Liverpool	4	16	12	58	26	48	38	58	40
Liverpool-London	3	16	12	54	26	48	42	57	40
London-Newcastle*	1	16	6	65	26	53	34	58	41
Newcastle*-London	1	16	6	59	27	53	40	57	41
London-Glasgow	7	16	7	25	26	31	68	59	62
Glasgow-London	7	16	7	25	26	31	69	59	62

*** Notes:**
Newcastle is the whole of Tyne & Wear for PFMv3 and PDFHv5 approach (based on zone pairs)
NRTS data is based on station to station movements

Table 2-24 shows the impact on the overall OD trip matrices aggregated to region pairs. As expected the change in total trips is small and is the result of the revised station to zone allocation process and the improved handling of missing station / local authority combinations in the NRTS dataset.

Table 2-25 and Table 2-26 show the equivalent impacts on for commuting and leisure trips. These are again for daily OD trips for the whole of the country (not just those masked zone pairs used in PLD).

Commuting and leisure show similar but opposite changes with the intra regional reduction in commuting leading to an increase in leisure primarily due to the education trips. Longer distance gains in commuting trips as a result of removing the previous trip length cut-off are small and fewer longer distance trips are defined as commuting and leisure – particularly to/from London.

Table 2-27 shows the changes in pattern for business travel showing more trips to and from London and fewer occurring wholly within each Region. This is primarily due to the change in how trip purpose is defined using the NRTS directly rather than the previous ticket type to purpose mapping.

2.11. Summary of effects of improvements to rail matrix development

2.11.1. Overview

This section has described a number of enhancements made to the processes for developing rail matrices for the PLD element of PFMv4.3. As discussed in the introduction to this section, the processes have been designed to deliver improvements to the matrices through best use of the available data sources.

The work has focused upon those trips of most relevance to HS2, in particular longer distance trips between London and the north. In general the changes to the rail matrices introduced by the improvements are relatively modest, particularly when viewed at an aggregate level.

2.11.2. Revised segmentation to journey purposes

The most significant changes to trips of most relevance to HS2 arise from the revised process for segmenting trips to journey purposes. The existing PFMv3.0 methodology and the PDFHv5.0 methodology recommended by WebTAG are both shown to significantly underestimate the proportion of business trips between London and cities in the north of England. These are movements of key relevance to HS2 and the scale of the underestimation, typically in the region of 50%, required the development of an improved methodology.

A process using NRTS data on a geographic basis was developed as an alternative to the ticket type based methodologies previously used in PFMv3.0 and separately detailed in PDFHv5.0. The success of this revised process is illustrated in Table 2-23 above which compares observed (NRTS), PFMv3.0 and PFMv4.3 journey purposes for key movements to and from London. This table shows that PFMv4.3 provides a much improved representation of journey purposes for the movements of most relevance to HS2.

2.11.3. Effect of other enhancements to matrix development methodology

As noted above, the effects of the other enhancements to the matrix development methodology upon trips of most relevance to HS2 are more modest than those introduced by the improvements to the journey purpose segmentation. In summary these enhancements and their effects are:

- Revised definition of trip purposes through re-allocation of education trips from commuting to leisure and removal of 80 mile cut-off for commuting trips. Whilst this results in an overall reduction in commuting trips of 10% and an increase in leisure trips of 25% the changes are concentrated upon intra-regional trips and shorter distance trips to and from London; and
- Revised station to zone allocation and car ownership growth. These enhancements result in small overall changes of less than 1% to trips by journey purpose. In spatial terms the changes are concentrated upon intra-regional and rural trips with little change to longer distance trips to and from London.

Table 2-24 Region to region: change in all rail trips (PFMv4.3 vs. PFMv3.0)

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	89	-23	936	8	52	13	7	5	6	107	59	**1,258**
East of England	-153	4,089	2,115	-16	-33	-10	-178	-16	-7	-69	-32	**5,690**
London	-347	-7,402	6,222	-36	-89	22	-13,577	-296	-45	-243	-68	**-15,858**
North East	10	4	33	371	6	14	1	0	1	5	-32	**412**
North West	-344	-16	-63	-16	498	-22	-18	-16	511	-126	-319	**68**
Scotland	7	0	-5	-39	0	1,646	0	1	4	1	-1	**1,614**
South East	-57	-170	6,521	-6	-20	0	7,804	-383	-26	-46	-8	**13,610**
South West	11	10	654	0	4	1	89	481	-153	-27	4	**1,073**
Wales	22	15	304	5	1,036	13	62	178	1,335	87	27	**3,083**
West Midlands	-229	-50	332	-8	-45	1	-37	-114	-126	1,124	-24	**825**
Yorks & Humber	-157	0	74	-185	-61	8	-3	-6	7	-5	404	**74**
Grand Total	**-1,149**	**-3,543**	**17,123**	**77**	**1,347**	**1,685**	**-5,850**	**-166**	**1,509**	**808**	**8**	**11,850**

Table 2-25 Region to region: change in commuting rail trips

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	-4,142	-490	-54	37	-629	25	-396	4	4	-1,294	-1,169	**-8,104**
East of England	-490	-9,082	-8,734	31	77	33	-1,171	28	15	-102	5	**-19,390**
London	-54	-8,734	12,454	160	926	100	-31,691	687	244	30	392	**-25,487**
North East	37	31	160	-1,814	-213	68	21	13	26	7	-329	**-1,994**
North West	-629	77	926	-213	-28,398	-37	63	23	-437	-1,521	-2,419	**-32,566**
Scotland	25	33	100	68	-37	-27,596	12	4	49	33	103	**-27,206**
South East	-396	-1,171	-31,691	21	63	12	-39,592	-2,633	4	-732	74	**-76,040**
South West	4	28	687	13	23	4	-2,633	-5,737	-597	-372	9	**-8,571**
Wales	4	15	244	26	-437	49	4	-597	-13,960	-598	7	**-15,243**
West Midlands	-1,294	-102	30	7	-1,521	33	-732	-372	-598	-25,185	-184	**-29,918**
Yorks & Humber	-1,169	5	392	-329	-2,419	103	74	9	7	-184	-12,877	**-16,388**
Grand Total	**-8,104**	**-19,390**	**-25,487**	**-1,994**	**-32,566**	**-27,206**	**-76,040**	**-8,571**	**-15,243**	**-29,918**	**-16,388**	**-260,906**

Table 2-26 Region to region: change in leisure rail trips

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	5,480	441	-2,228	-91	806	-22	244	20	5	1,173	1,072	**6,898**
East of England	342	16,320	2,534	-161	-94	6	478	-88	-58	-80	-141	**19,057**
London	-2,768	-2,913	10,035	-902	-4,526	-142	4,741	-4,282	-866	-3,846	-2,678	**-8,146**
North East	-89	-146	-877	2,951	47	-281	-50	-16	-19	-20	123	**1,623**
North West	487	-81	-4,507	34	38,779	125	-79	-122	968	840	1,518	**37,961**
Scotland	-26	13	-156	-325	142	32,520	35	21	-33	-6	-82	**32,105**
South East	193	476	15,346	-54	-84	35	57,648	1,716	-23	193	-196	**75,250**
South West	24	-72	-3,946	-15	-111	20	2,085	8,328	507	145	-75	**6,891**
Wales	17	-43	-684	-17	1,371	-27	51	750	18,208	832	21	**20,478**
West Midlands	996	-66	-3,566	-29	950	-5	225	100	654	29,728	76	**29,064**
Yorks & Humber	918	-117	-2,610	22	1,695	-75	-192	-81	7	90	17,228	**16,884**
Grand Total	**5,573**	**13,813**	**9,342**	**1,412**	**38,974**	**32,154**	**65,187**	**6,346**	**19,350**	**29,049**	**16,865**	**238,066**

Table 2-27 Region to region: change in business rail trips

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	-1,249	26	3,219	63	-125	9	159	-18	-3	228	156	**2,463**
East of England	-6	-3,149	8,316	115	-16	-49	515	44	36	113	104	**6,023**
London	2,476	4,245	-16,267	707	3,511	64	13,373	3,300	577	3,572	2,219	**17,775**
North East	63	119	750	-766	171	227	29	2	-6	19	174	**782**
North West	-202	-11	3,518	163	-9,883	-110	-3	83	-20	555	582	**-5,328**
Scotland	7	-46	51	219	-106	-3,278	-48	-24	-11	-26	-23	**-3,285**
South East	146	524	22,867	27	1	-47	-10,252	534	-7	494	113	**14,401**
South West	-17	54	3,913	2	92	-24	637	-2,111	-63	200	70	**2,753**
Wales	1	43	743	-5	103	-9	7	24	-2,913	-146	0	**-2,152**
West Midlands	69	118	3,868	14	526	-28	470	158	-182	-3,419	83	**1,679**
Yorks & Humber	94	113	2,292	121	663	-20	115	66	-6	89	-3,947	**-422**
Grand Total	**1,381**	**2,035**	**33,268**	**659**	**-5,062**	**-3,264**	**5,003**	**2,059**	**-2,598**	**1,677**	**-469**	**34,690**

2.11.4. Associated changes

The enhancements to the development of the trip matrices have necessitated corresponding changes to the development of the fares matrices and the annualisation process required to develop annual values for demand, benefits and revenues. These can be summarised as follows:

- **Revised fares matrices** – a revised methodology has been developed to ensure that the segmentation of the fares matrices by trip purposes reflects the fares differentiation that occurs between trip purposes. The other enhancements to the trip matrices reported in this section are incorporated in an equivalent manner in the update of the fares matrices; and
- **Annualisation factors** – revised annualisation factors have been developed that provide internal consistency with the enhanced process to segment the trip matrices by journey purpose on a geographic basis.

3. Highway Base Year Matrices

3.1. Introduction

This section describes the work undertaken to enhance the base highway matrices for the PLANET Long Distance (PLD) model as part of the development of PFM from v3.0 to v4.3. The PLD highway model covers the whole of Greater Britain, and has a base year of 2010. The PFMv3.0 highway person demand represents an average 16 hour weekday (Monday to Friday), for three trip purposes, namely employer's business, commuting, and other (N.B. education trips in PFMv3.0 were included in 'commuting'). The demand is built in OD format and used in the PLD demand model and highway assignment, after converting into hourly demand and adjusting by car occupancy to convert person into vehicle trips.

The PFMv3.0 car trip matrices were developed from a number of regional multi-modal models which are now out-of-date and so the matrices required updating using more recent data. Furthermore, the only validation of the PLD car trip matrices was through ensuring that the assigned volumes were less than observed flows on links with no checks being made of the trip length distributions (TLD) or sector to sector movements.

The objective of the update to the PLD highway matrices for PFMv4.3 was to:

- Update the existing long distance car passenger matrices with the best and most reliable information available;
- Rebase the matrices to a base year of 2010, and produce them for a 24 hour average weekday, instead of the current 16 hours;
- Use 50 miles as the distance threshold for highway matrices in PLD except for nine specific urban areas;
- Move education trips from 'commuting' to 'other' as described in section 2;
- Produce the matrices in PA format for the PLD demand model; and
- Produce a set of factors to convert the PA matrices to OD format for the PLD assignment model.

In order to derive PA format matrices, the home based (HB) trip purposes must be distinguished from non home based (NHB) purposes.

Undertaking surveys of long distance car travel was not feasible due to the scale of the surveys that would be required. Reliance was thus placed on existing data sources and models, and the challenge was to select the most reliable of these sources from which the updated matrices are built. The sources considered were:

- National Transport Model (NTM);
- Long Distance Model (LDM);
- National Travel Survey (NTS); and
- Regional multi-modal models.

This section establishes the principles of the preferred approach that was adopted to develop the car trip matrices and the reasons for selecting the data sources and models that were used.

The structure of this section is as follows:

- Section 3.2 discusses changes to the distance definition for including trips in the highway matrices;
- Section 3.3 examines each of the data sources in turn with the strengths and weaknesses of each source discussed;
- Section 3.4 summarises the assessment of 'fitness for purpose' of the data and describes the overall approach which was adopted in building the matrices;
- Section 3.5 compares the final PFMv4.3 PLD highway matrices with the LDM and NTS data used in their construction; and
- Section 3.6 describes the final PFMv4.3 PLD highway matrices with comparisons with the previous PFMv3.0 matrices.

3.2. Distance Threshold

The PFMv3.0 PLD highway matrices include trips greater than 25km (15.5 miles), but before those matrices are input into the demand model or assigned, they are 'masked' to take out any trips within the travel-to-work areas in major cities (Sheffield, Leeds, Liverpool, Manchester, Birmingham and East Midlands), and short distance trips within strategic rail corridors . The resulting masked matrices (that are of interest as they are input into the PLD demand model and are assigned) end up with no trips less than 30km (18.6 miles).

For the PFMv4.3 update to the PLD highway matrices it was decided only to include trips longer than 50 miles (80km) for the following three reasons:

- Generally trip lengths below 50 miles (80km) are not in scope or within the HS2 catchment and are thus not of relevance to HS2;
- Increasing the threshold from 30 km to 50 miles (80km) would reduce the number of trips in the matrices which were not relevant and which can cause 'model noise' impacting on the analysis; and
- As will be seen, the development of highway car trip matrices was heavily reliant on updating the existing Long Distance Model (LDM) demand with the outputs from National Travel Survey (NTS) dataset, and both these sources define long distance movement as being greater than 50 miles.

Although PFMv4.3 PLD therefore generally represents long distance trips of more than 50 miles in length, there are some zone pairs that lie within the HS2 catchment, for which car passengers may shift mode to rail when HS2 is introduced. Trips for those zone pairs need to be included in the matrices although the distance between them is 50 miles or less.

3.3. Review of Data Sources

3.3.1. The NTM

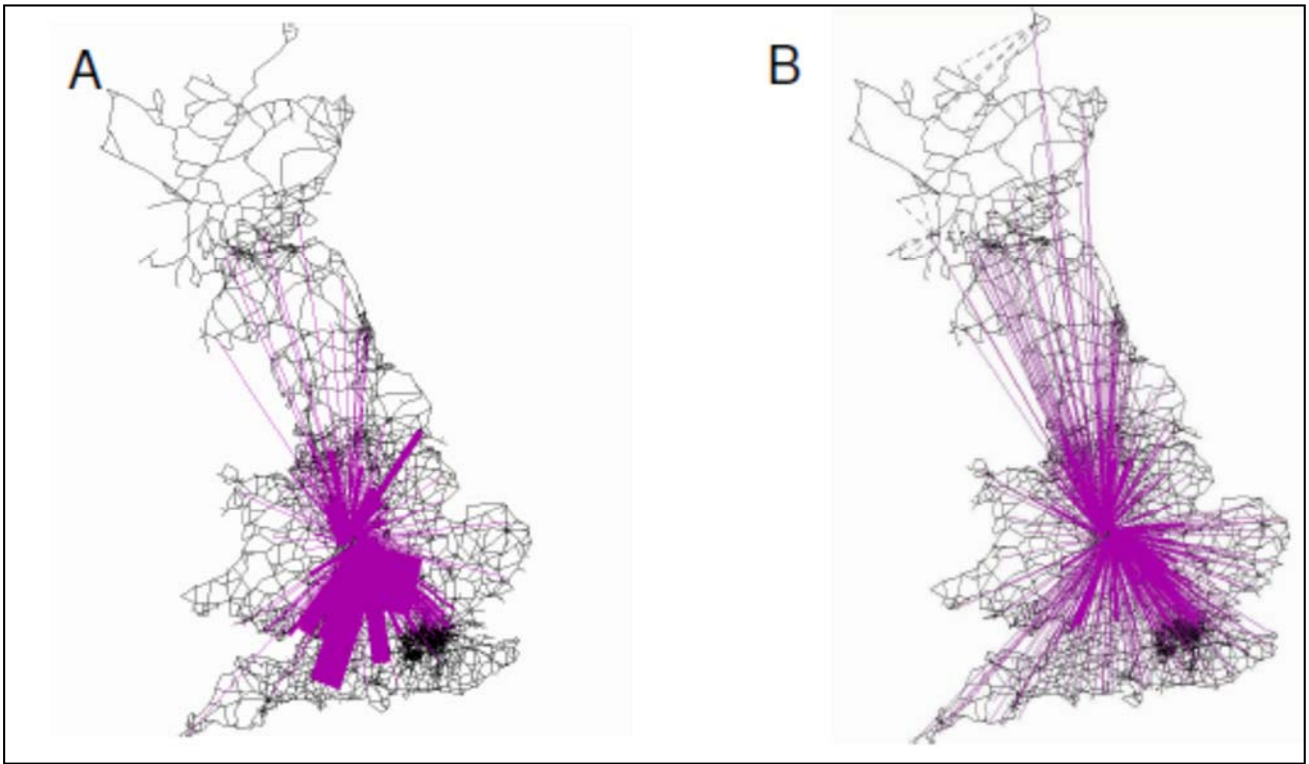
The National Transport Model (NTM) was developed by the DfT and provides a systematic means of assessing the impact of alternative national transport policies or widely-applied local transport policies, as well as taking into account the major influences affecting future patterns of travel.

The NTM produces a fully synthetic car trip matrix which has been calibrated to the NTS trip length distributions and validated against traffic data (vehicle-km) by region, area type and road type (but not against traffic flows at link level). Given this level of validation, it may be argued that aggregate sector to sector movements from NTM should be plausible as a source of data for such movements. However, getting the correct traffic levels by trip distance does not necessarily ensure reliable sector pair movements as there could be compensating errors.

During the development of the LDM the plausibility of the NTM trip matrices was explored. For example the NTM and LDM (synthetic) trip patterns between Birmingham and other areas were compared and this showed that the NTM patterns were quite 'lumpy' compared to LDM patterns, and were sometimes counterintuitive. It would have been expected that the models would be more consistent, both being synthetic and calibrated using NTS data. This comparison is shown in Figure 3-1.

This analysis provides evidence that the NTM is unlikely to provide a useful database for long distance travel by car. It was thus concluded that the NTM matrices were not a suitable starting point from which the matrices can be built.

Figure 3-1 Birmingham distributions - commute (A=NTM, B=LDM)



3.3.2. The LDM

The LDM was developed jointly by URS (formerly Scott Wilson) and RAND Europe for the DfT as a 'mode neutral' model to examine traveller behaviour making long distance journeys at a national level.

The LDM zoning system is at the 406 district level. On the supply side, the highway network includes motorways and A classified roads, providing a reasonable representation of link coverage at the strategic level. The highway demand comprises short and long distance demand, each with four purposes, namely, commuting[8], employers business, visiting friends & relatives (VFR) and other.

In summary, base year LDM highway trip matrices for the AM and IP periods were created as follows:

- the Long Distance Demand Model (LDDM) was used to synthesise 24-hour tours of person trips by car longer than 50 miles, by trip purpose, and for an average day (including weekends);
- the resulting synthetic tour matrices were then adjusted, so that the trip length distributions in six distance bands matched those derived from the NTS;
- the resulting synthetic average day 24-hour matrices of person tours by car in PA format were converted to average weekday, average morning peak hour and average inter-peak hour car trip matrices in OD format;
- the resulting matrices of car trips of more than 50 miles were combined with matrices of car trips of 50 miles or less from the National Transport Model (NTM);
- factors were then applied to reduce the NTM demand so that it was more commensurate with the level of detail in the LDM modelled highway network; and
- the resulting matrices were assigned (along with goods vehicle trip matrices) and modified by means of matrix estimation so that they matched traffic counts at individual locations on the main road network represented in the LDM.

In principle LDM therefore provides two sets of matrices, the first are synthetic (PA or OD) daily matrices that have been adjusted to TLD from NTS but not calibrated to screenline or link flows. The second is the AM

8 It is found that the LDM commuting trips contain approximately 4% of education trips. Following PFMv4.3 PLD's matrix purpose definitions, the 4% of the LDM commuting will be merged in the "other" purpose, however, only at daily level.

and IP matrices in OD format, as just described, calibrated to link flows but not compared to TLD from NTS post matrix estimation. Note that PM matrices are not available.

The LDDM is a model of the choices in frequency, mode and destination of long-distance travellers. It was estimated by statistical analyses from NTS data and a 2009 Household Interview Survey which had been conducted alongside a Stated Preference (SP) Survey (used to inform particular elements of the model). Two aspects of the NTS data used for this purpose are noteworthy:

- As part of the NTS, data on trips made are collected by means of both 'recall' and 'diary' surveys. Prior to 2006, the 'recall' period was three weeks and from 2006 onwards it was reduced to one week. The 'recall' data are regarded as less reliable than the 'diary' data; and
- The NTS data used to develop LDDM applied to all days in the week, including the weekends and to both recall and diary records.

The differences between the TLD of the car tour matrices synthesised by the estimated choice models and the TLD from the NTS data used in the estimation were substantial. Hence there was a need to adjust the matrices. Unless specific steps are taken in the estimation of choice models of this nature to ensure that 'observed' TLDs are matched, it is not unusual for there to be a discrepancy between the synthetic and observed TLDs.

Note that the main purpose of the LDDM was to forecast changes in demand (from changes in generalised cost) which were then applied to the base modal matrices. It was not designed specifically as a means of synthesising base year trip matrices for assignment. For this latter purpose, much greater attention would be paid to calibrating a model which reproduced the TLD and sector to sector movements derived from surveys. No steps were taken to validate the movements in the synthetic tour or trip matrices, at either the 24-hour PA stage, or prior to or after the adjustment to ensure a fit to the NTS TLD, or the period OD stage, against data derived from any source.

The factors used to convert from average day 24-hour matrices of person tours by car in PA format to average weekday, average morning peak hour and average inter-peak hour car driver trip (i.e. vehicle) matrices in OD format lacked spatial detail. The conversion from average day 24-hour PA matrices to average weekday period OD matrices used four factors for each purpose varying by distance band. The conversion from person trips to car driver trips used a global occupancy factor for each trip purpose. The resulting average morning peak hour and average inter-peak hour car trip matrices in OD format are thus likely to be approximate.

The factors applied to the NTM data to reduce the number of trips so that the resulting demand was more commensurate with the capacity of the network represented in the LDM were inevitably approximate. Matrix estimation was shown to improve markedly the correspondence between assigned flows and counts at the sites where counts were used as constraints (as would be expected if the matrix estimation process had worked as intended). It was shown that changes in zonal trip ends and zonal level movements were generally small but the changes in the TLD were more marked. No analyses of movements at sector level were presented. It is possible for matrix estimation to modify zonal level matrix cells by only small amounts but for the accumulated sector level movements to show substantial changes though it is not known whether this applied in this case.

Matrix estimation was applied using individual counts rather than counts grouped into mini-screenlines. The latter approach is good practice as it takes account of the inaccuracy of counts (by grouping counts together the confidence intervals are reduced). Moreover, it is less likely to result in matrix adjustments which compensate for network representation errors or simplifications or inaccuracy in the assignment. Matrix estimation was allowed to modify both the long distance movements (synthesised by the LDDM) and the shorter movements derived from the NTM as opposed to being used to modify just the NTM movements.

The above discussion shows that although LDM forms a potential starting point for building the highway matrices, it still has some inherent weaknesses, some of which can be addressed in the development of the PFMv4.3 PLD highway matrices. In particular, a set of PM matrices is required.

3.3.3. The NTS

The National Travel Survey (NTS) is carried out in order to monitor long-term changes in travel patterns and provide a better understanding of the use of transport facilities made by different sectors of the population within Greater Britain.

NTS data are collected annually by means of a diary covering seven days travel together with a face-to-face interview as described in Section 2. The survey has been carried out since 1988, with a consistent sample size since 2002 of around 8,000 households comprising around 19,000 individuals. At the time of writing the standard available data set covered the nine years 2002-2010

There are a number of subsets of the NTS data. The one predominantly used for estimating the LDM is the Long Distance Journey (LDJ) subset which only includes trips longer than a (respondent reported) distance of 50 miles. This subset repeats any diary journeys that are over 50 miles, but also includes other 'recalled' long distance journeys. It has been established that the diary records are less prone to bias than the recall data, and so in our analyses the diary dataset was used on its own whenever possible.

The main issue with the NTS is that the sample size (of around 0.03% by population) is quite small which makes the data unreliable if it is used in a spatially detailed way. This is so even if data for all nine years are combined. The NTS guidance states that a sample of 300 records should be considered as a minimum to ensure the analysis is robust. The NTS data have therefore been aggregated to an appropriate level until this minimum sample size (in terms of trips) has been achieved. This has meant that it was possible to use diary only data for the breakdown of trips by purpose, for the TLD (by purpose), and for car occupancy by purpose.

For movement patterns, it was found that the sample size of the diary records on their own was too small to support much spatial detail. Even when recall and diary records were combined, the data would not yield a reliable complete trip matrix even at the regional level due to the low sample size, except for home based other purpose demand. However, use was still made of the cell values which were based on sufficient records.

The NTS LDJ dataset does not include time of travel information, unlike the NTS Journey database, which records start, mid-point and end times for individual journeys. This information is needed so that the LDM matrices for the PM can be developed. The Journey database contains all trips recorded in the diary. After filtering out the short distance trips, this data was utilised to derive factors to convert AM levels of travel to PM. Due to sample size constraints, this was done at the eleven region sector level.

While the NTS dataset cannot be used on its own to develop complete trip matrices at any level of spatial detail compatible with the requirements of the PLD model, it was nevertheless important for providing the following:

- the split of trips by purpose, and the identification of the percentage of education and NHB trips;
- the relationship between AM and PM levels of travel by purpose;
- the TLDs by trip purpose;
- regional level trip ends by purpose;
- sector to sector movement totals by purpose used as a control for target cells with sufficient NTS data; and
- factors to convert OD to PA.

3.3.4. Regional Models

A number of regional multi-modal models were examined to assess the reliability of the data they contain on long distance travel, to see if they can be used as donor models for building the matrices. These regional models are:

- M1 Junction 28 to 31 ,developed by Atkins for the Highways Agency;
- M6 Junction 11 to 19 ,developed by URS for the Highways Agency;
- M25AM ,developed by Hyder Consulting for the Highways Agency;
- Land Use And Transport Integration for Scotland (LATIS),developed by MVA for Transport Scotland;
- Leeds Transport Model (LTM), developed by AECOM for Metro and Leeds City Council;

- PRISM, developed by Mott MacDonald for the West Midlands metropolitan districts, CENTRO and the Highways Agency;
- SEMMMS, developed by MVA for Transport for Greater Manchester;
- South Yorkshire Strategic Transport Model (SYSTM+), developed by AECOM for the South Yorkshire LTP Partnership and the Highways Agency; and
- East of England Regional Highway Assignment Model (EERHAM), developed by AECOM for the Highways Agency and BAA.

To assess whether or not there was benefit in using data on LD trips from the regional models, a review was undertaken of the available model development reports. The review concluded that:

- In general, the roadside interview surveys on which the regional models were based were unlikely to have intercepted a sufficiently significant number of long distance trips, especially after segmenting by purpose; and
- The calibration and validation of these regional models did not, in general, focus on the long distance trips. In many cases, no attempt was made to validate the long distance elements of the final trip matrices and, in those few cases where such a validation was attempted, the results were poor.

3.4. The Adopted Approach

The conclusions from the above review were as follows.

- The data on long distance movements in the regional models are insufficiently accurate for the purpose of updating the PLD car trip matrices;
- The NTS data provides statistically reliable estimates of a limited number of region to region movements and NTS therefore cannot be used on its own to yield the required matrices at the PLD zoning level; and
- Although the quality of the LDM matrices, as explained above, should be borne in mind, they are the only source of all long distance movements in scope and there is therefore no alternative to using these matrices at this stage. However, they need to be modified to accord better with the NTS trip purpose splits, TLDs and sector to sector movements where the NTS data are sufficiently reliable.

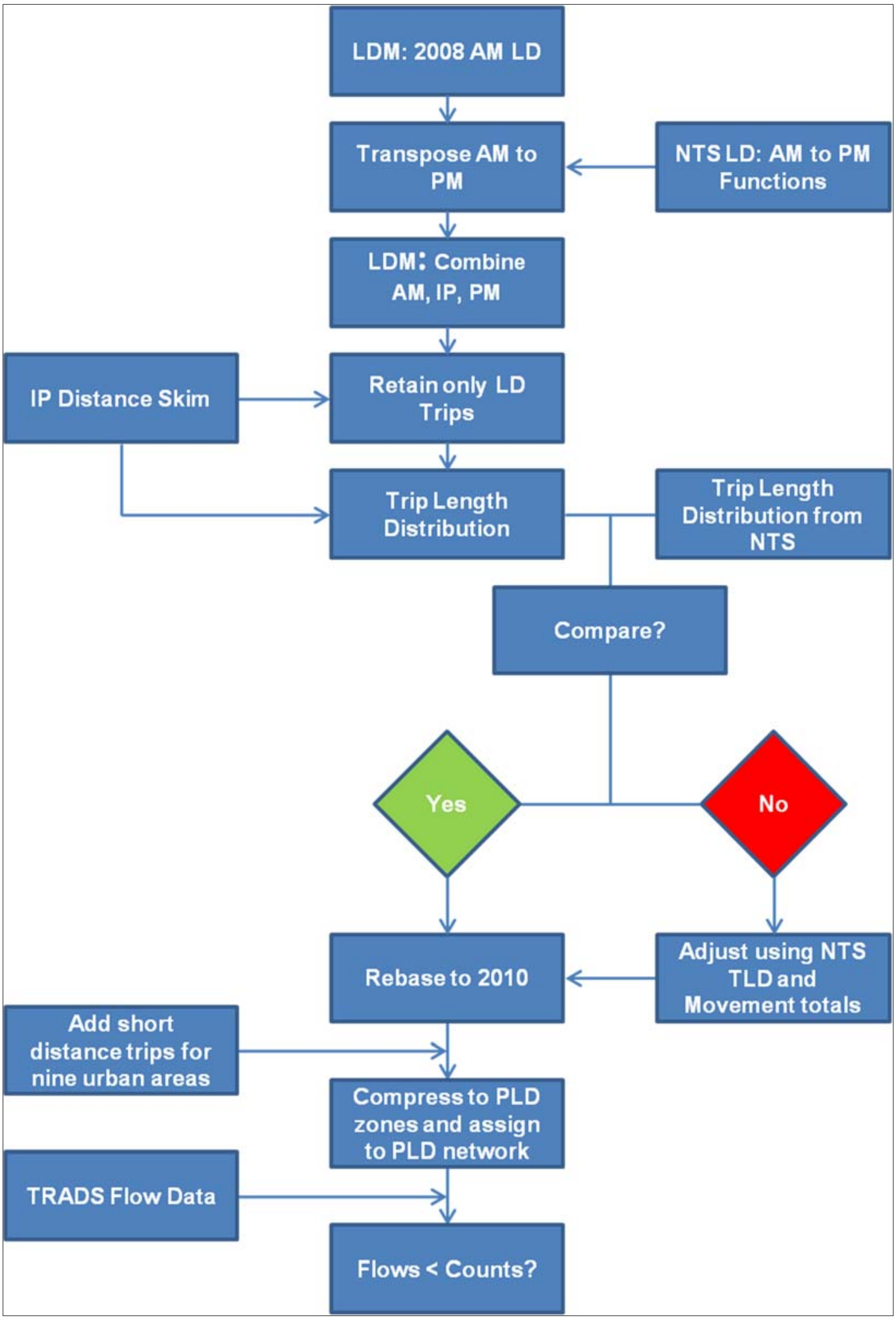
Thus, in outline, the approach adopted was as follows;

- LDM assignment (calibrated) car vehicle matrices for the AM and IP periods were taken as the basis for deriving the updated PLD matrices, and formed the ‘least deficient’ option given available data and models. Using these matrices as the starting point was felt to be more reliable than the daily synthetic adjusted matrices as the period matrices have been calibrated to observed link flows
- The LDM vehicle matrices were converted to person matrices using car occupancy factors at a regional level from NTS;
- Using NTS data, equivalent LDM period person matrices for PM were produced from the AM period person matrices, from which average weekday person matrices in OD format were generated;
- Those matrices were then aligned to NTS data in terms of the following restraints:
    - adjustment factors by distance band, so that the TLDs from LDM were in line with NTS TLDs for four trip purposes (Employer’s business, home based work, home based others and non-home based other); and
    - at either an eleven or seven region level, certain region to region total movements for each of the four trip purposes were used as controls to the LDM matrices (see section 3.5).
- Data from the regional models for trips of 50 miles or less between specified urban areas within the HS2 catchment were added, as there was no other source available for these movements which were:
    - Nottingham-Sheffield
    - Derby-Sheffield
    - Leeds-Sheffield
    - Liverpool-Manchester
    - Preston-Manchester
    - Birmingham-Nottingham;
    - Sheffield-York
    - Sheffield-Manchester; and
    - Glasgow-Edinburgh;
- The final person matrices were converted back into vehicle matrices and assigned and the assigned flows were compared with counts, to check for instances where the former exceeded the latter; and

- OD to PA factors were derived from the LDM synthetic matrices and used to convert the final OD matrices to PA format. The inverse of these factors are used to convert from PA format to OD format when assignment is required.

Figure 3-2 provides a flow chart of the main processes in the matrix build.

Figure 3-2 Matrix build flow chart



3.5. Comparison of PFMv4.3 PLD Highway Matrices with LDM and NTS

Whilst the principal source of the PFMv4.3 matrices was the LDM, NTS was used as a control based upon target cells containing more than 300 trips (the level at which the NTS sample becomes statistically reliable). For the HBEB and HBO purposes there were sufficient target cells at the eleven regional sector level, but for the HBW and NHB purposes there were very few cells with more than 300 trips so sectors were aggregated to a seven sector system from which the target cells were drawn.

It should be noted that only target cells were used as controls so this will affect the degree of match to be expected between NTS and PFMv4.3, the number of target cells by purpose are shown in Table 3-1.

Table 3-1 NTS Target cells used as controls

Purpose	Target cells	Total cells	Proportion of total demand
HBEB	14	121	45%
HBO	49	121	82%
HBW	13	49	79%
NHB	11	49	66%

3.5.1. Comparison with LDM

A comparison between PFMv4.3 and the LDM (prior to any manipulation as part of the PFM matrix development) at the eleven sector level is shown in Table 3-2 as a ratio of the PFMv4.3 cell value to the equivalent LDM cell value. Zeroes are shown for those cells where PFMv4.3 has been fully masked to filter out the trips in the PLANET South area and those cells partially affected by masking in PFMv4.3 are shaded amber, the LDM trips have not been masked.

Whilst it is to be expected that significant variations will occur at a cell level due to the subsequent use of NTS and regional model data in the development of the PFMv4.3 matrices, the comparison shows that the great majority of the cell ratios (unaffected by masking) lie between 0.5 and 2.0, showing that the PFMv4.3 matrices broadly reflect the patterns of movement in the LDM. It can also be seen that the sector trip totals for LDM and PFMv4.3 are very similar, with ratios lying in the range 0.9288 to 1.1013 for those sectors unaffected by masking.

3.5.2. Comparison with NTS

A comparison between PFMv4.3 and NTS at the seven sector level is shown in Table 3-3 as a ratio of the PFMv4.3 cell value to the equivalent NTS cell value. The comparison is based upon NTS data factored to the same overall trip total as PFMv4.3 and is imperfect as the factoring will be affected by the trips partially masked from the PFMv4.3 matrices. Zero is shown for the cell where PFMv4.3 has been fully masked to filter out the trips in the PLANET South area and those cells partially affected by masking have been shaded amber. Cells shaded in green are where the PFMv4.3 matrices contain less than 5000 trips (0.36% of the total matrix).

The factoring of NTS noted above will tend to increase the ratios as can be seen from the column and row totals unaffected by masking which all are greater than 1.0. The comparison does show a relatively close match between NTS and PFMv4.3, excepting the shaded cells the ratios lie between 1.39 and 0.65 with the exception of trips between Scotland and the aggregated regional sector comprising the North East, Yorkshire and Humberside where the ratios are closer to 2.0. This indicates that the PFMv4.3 matrices retain the basic patterns of movement shown in NTS when examined at the seven sector level applied to the use of NTS in the PFMv4.3 matrix development.

Table 3-2 Ratio of PFMv4.3 to LDM at eleven regional sector level

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	0.9214	1.0229	0.5692	1.0739	1.2281	2.4467	0.8599	0.3690	1.3204	0.9570	0.9468	**0.9401**
East of England	1.0728	0.0000	0.0000	0.6352	0.7202	0.9020	0.0000	0.1161	1.5917	0.8268	0.8472	**0.2272**
London	0.5446	0.0000	0.0000	1.4657	0.4922	1.5876	0.0000	0.1009	1.6021	0.7759	0.7452	**0.2102**
North East	1.0192	1.0686	1.7820	0.2520	1.0572	1.8076	0.9325	0.9547	1.7962	0.6065	1.1482	**0.9802**
North West	1.1816	0.7139	0.4701	1.1570	1.1424	1.0285	0.5774	0.5592	0.9960	1.0021	1.0379	**1.0225**
Scotland	1.6564	0.6850	2.2690	1.5777	0.8822	1.0434	0.7637	2.1727	1.0889	1.7799	1.2452	**1.0725**
South East	0.8681	0.0000	0.0000	1.0535	0.5591	0.8480	0.0000	0.0886	0.5098	1.0010	0.7945	**0.1638**
South West	0.3527	0.1150	0.1034	0.6278	0.6618	0.9722	0.0814	0.0976	1.2343	0.8468	0.4288	**0.2717**
Wales	1.2082	1.4283	1.9756	1.7813	0.9700	1.9072	0.5011	1.1565	0.7863	1.3426	1.2435	**1.0177**
West Midlands	0.9648	0.8517	0.7891	0.6289	1.0641	1.8387	0.9872	0.8294	1.2822	0.7991	0.7357	**0.9360**
Yorks & Humber	0.9614	0.8236	0.8883	1.2050	1.0353	1.2677	0.8825	0.5483	1.2920	0.7360	1.1925	**1.0558**
Grand Total	**0.9362**	**0.2261**	**0.2141**	**0.9779**	**1.0227**	**1.1013**	**0.1587**	**0.2647**	**1.0214**	**0.9288**	**1.0387**	**0.6139**

Table 3-3 Ratio of PFMv4.3 to NTS at seven regional sector level

Region	East Midlands & East of England	London & South East	North East & Yorks & Humber	North West	Scotland	South West	Wales & West Midlands	Grand Total
East Midlands & East of England	1.20	0.91	1.09	1.39	2.22	0.28	1.29	**1.12**
London & South East	0.93	0.00	1.25	0.72	1.97	0.12	1.21	**0.67**
North East & Yorks & Humber	1.07	1.22	1.19	1.23	2.08	1.13	1.09	**1.21**
North West	1.36	0.65	1.34	1.26	1.31	0.71	1.28	**1.23**
Scotland	2.05	1.58	1.90	1.18	1.21	8.17	1.67	**1.27**
South West	0.29	0.11	0.78	0.98	1.28	0.11	1.27	**0.34**
Wales & West Midlands	1.25	1.18	1.08	1.27	3.02	1.24	1.15	**1.21**
Grand Total	**1.11**	**0.66**	**1.22**	**1.22**	**1.31**	**0.32**	**1.22**	**1.00**

3.6. Comparison of PFMv3.0 and PFMv4.3 PLD Highway Matrices

3.6.1. Matrix comparison

Table 3-4 shows the difference between the PFMv3.0 PLD highway matrices and the PFMv4.3 matrices disaggregated by trip purpose. These have been masked to filter out those trips wholly within the PLANET South area, some intra-sector trips within the PLANET Midlands area and all other trips less than 80km (50 miles) have been removed from the matrices to provide a consistent basis for comparison. These masked matrices have been used for all comparisons in this section.

These matrix totals are ‘all day’ and in person trips (not vehicles). The new matrices have been built as 24-hour matrices, whilst the old matrices, because they came from a variety of data sources with different time periods, are representative of a 16-hour day.

Table 3-4 shows that there are significant differences between the PFMv3.0 and PFMv4.3 matrices, with a 40% reduction (908,266 person trips) in total trips. The largest differences are for the commuting and business trip purposes.

Table 3-4 PLD highway matrix totals – trips 80+ km (person trips)

Trip Purpose	Highway Matrix totals (PS and PM areas, and ODs < 80km apart masked out)			
	PFMv3.0 Highway Matrices	PFMv4.3 Highway Matrices	Change	% change
Commute	531,058	173,257	-357,801	-67%
Business	694,923	328,799	-366,123	-53%
Leisure	1,054,748	870,407	-184,341	-17%
Total	2,280,729	1,372,463	-908,266	-40%

Figure 3-3 and Figure 3-4 show a comparison of the PLD total highway matrix row and column totals, as the percentage change in the zone trip ends from PFMv3.0 to PFMv4.3. The green areas show where reductions of trips have occurred, the majority of these occur due to reductions in trips wholly within regional sectors in PFMv4.3, as discussed below. It can be seen than the PFMv4.3 matrices have extra trips in some of the peripheral zones (parts of Wales, along the South Coast, parts of East Anglia and the North East). These are the areas with little or no coverage by the regional models used to develop the PFMv3.0 matrices.

3.6.2. Sector comparison

Table 3-5 shows the PFMv3.0 PLD highway matrices and Table 3-6 shows the PFMv4.3 PLD highway matrices aggregated into eleven regional sectors. These have been masked to remove highway trips as detailed above. Table 3-7 and Table 3-8 show the differences between the two sets of matrices as absolute and percentage values respectively.

The largest changes are for intra-sector movements which is consistent with the use of the LDM as the basis for the PFMv4.3 matrix development compared with the use of more spatially detailed regional models for PFMv3.0. Increases in trips can be seen to/from areas such as Wales which is due to the improved geographic coverage of the revised matrices and the lack of regional models for these areas when developing PFMv3.0.

Thus whilst the highway matrices show a 39.8% (908,266 trips) reduction in total trips, the majority of this reduction (29.5% or 630,053 trips) relates to intra-sector trips within the regional sectors which will have little impact on the HS2 assessment. Total trips to and from London increase by 2.3% and 7.6% respectively, showing that the longer distance trips of most relevance to HS2 are subject to relatively small changes.

Figure 3-3 Highway (all purposes, PS and PM masked out, trips>80km) - Comparison of Origin Totals - PFMv4.3 minus PFMv3.0

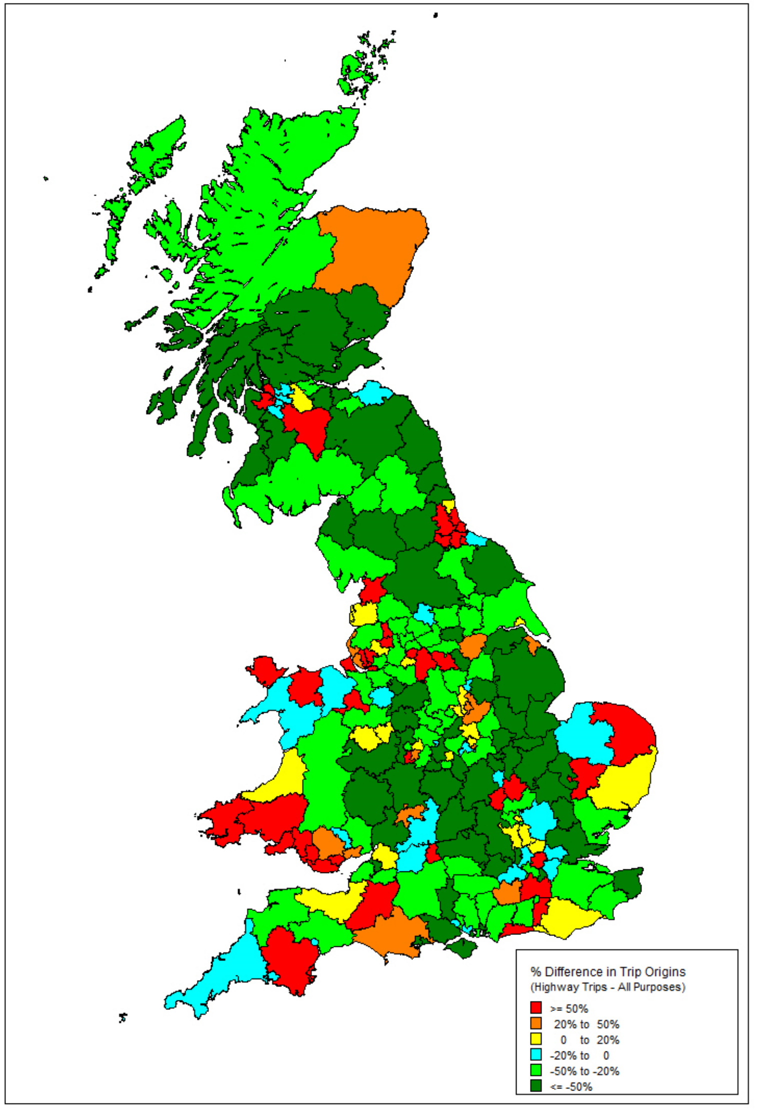


Figure 3-4 Highway (all purposes, PS and PM masked out, trips>80km) - Comparison of Destination Totals - PFMv4.3 minus PFMv3.0

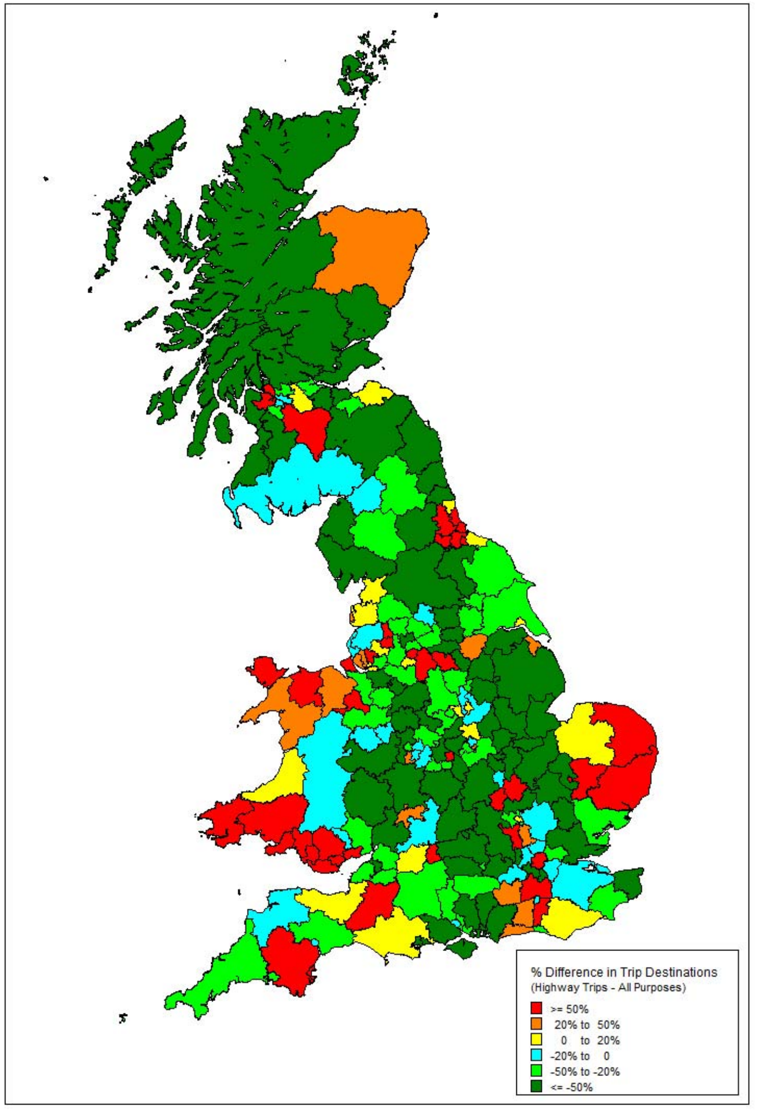


Table 3-5 PFMv3.0 PLD highway matrices

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	90,399	50,322	9,585	3,055	18,140	1,212	32,058	6,179	7,594	48,500	36,323	**303,366**
East of England	59,573	0	0	850	3,905	1,177	0	536	2,109	17,764	6,296	**92,208**
London	10,492	0	0	673	2,621	278	0	999	2,885	11,449	2,868	**32,264**
North East	2,129	552	427	65,119	5,025	20,056	2,391	352	240	2,610	7,427	**106,327**
North West	17,905	3,216	2,050	9,389	97,700	11,049	16,330	3,765	13,634	25,505	35,677	**236,219**
Scotland	2,411	1,462	458	15,808	10,598	408,341	1,972	659	746	6,170	3,875	**452,500**
South East	44,371	0	0	2,049	14,650	2,081	0	2,988	7,108	38,664	13,303	**125,214**
South West	8,115	474	794	630	5,041	969	3,046	8,871	14,690	52,530	2,513	**97,672**
Wales	9,061	3,013	3,056	238	19,053	1,226	7,807	16,001	7,913	21,430	647	**89,445**
West Midlands	48,365	16,137	14,538	2,735	37,381	3,709	45,434	55,469	19,889	165,535	13,434	**422,626**
Yorks & Humber	38,737	6,810	2,784	6,748	37,043	1,784	11,065	3,268	818	11,290	202,543	**322,890**
Grand Total	**331,557**	**81,985**	**33,691**	**107,292**	**251,158**	**451,882**	**120,103**	**99,087**	**77,624**	**401,445**	**324,904**	**2,280,729**

Table 3-6 PFMv4.3 PLD highway matrices

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	39,318	27,548	5,946	3,471	19,095	2,848	15,854	3,147	4,949	28,861	26,816	**177,852**
East of England	26,250	0	0	1,391	4,697	1,012	0	1,313	5,340	11,988	5,709	**57,700**
London	6,507	0	0	1,432	2,579	743	0	1,910	6,564	11,624	3,352	**34,711**
North East	3,132	1,199	1,267	3,076	11,450	11,493	1,850	758	943	1,298	17,026	**53,492**
North West	19,209	4,875	2,818	12,649	88,869	9,356	5,533	3,859	20,233	29,238	38,539	**235,179**
Scotland	2,430	861	776	10,271	8,130	138,155	1,170	843	1,299	2,410	4,372	**170,718**
South East	17,073	0	0	1,694	5,660	1,227	0	5,560	4,233	23,823	6,618	**65,888**
South West	2,807	1,393	1,966	469	4,912	979	4,872	12,035	20,787	24,495	1,646	**76,362**
Wales	4,869	4,245	6,484	1,140	17,729	1,541	3,989	21,220	33,784	22,354	3,468	**120,822**
West Midlands	28,347	11,575	11,937	1,581	27,034	3,328	23,274	21,531	22,724	22,847	8,255	**182,434**
Yorks & Humber	27,261	5,721	3,285	18,365	37,194	5,844	6,914	2,371	3,606	8,462	78,282	**197,306**
Grand Total	**177,203**	**57,419**	**34,481**	**55,539**	**227,349**	**176,525**	**63,456**	**74,548**	**124,461**	**187,399**	**194,082**	**1,372,463**

Table 3-7 Change in PLD Highway Trips (Absolute Differences): PFMv4.3-PFMv3.0

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	-51,081	-22,774	-3,639	415	955	1,636	-16,204	-3,032	-2,645	-19,639	-9,507	**-125,514**
East of England	-33,323	0	0	542	793	-165	0	777	3,231	-5,776	-587	**-34,508**
London	-3,985	0	0	759	-42	465	0	911	3,679	175	484	**2,447**
North East	1,003	648	840	-62,043	6,425	-8,563	-541	406	703	-1,311	9,599	**-52,835**
North West	1,304	1,659	769	3,260	-8,831	-1,693	-10,797	95	6,599	3,733	2,862	**-1,039**
Scotland	19	-601	319	-5,537	-2,468	-270,186	-801	184	553	-3,760	497	**-281,782**
South East	-27,298	0	0	-354	-8,990	-854	0	2,572	-2,874	-14,841	-6,686	**-59,326**
South West	-5,308	920	1,172	-161	-129	9	1,826	3,165	6,098	-28,035	-868	**-21,310**
Wales	-4,192	1,232	3,428	902	-1,324	315	-3,819	5,218	25,871	924	2,821	**31,377**
West Midlands	-20,018	-4,561	-2,601	-1,154	-10,348	-381	-22,160	-33,938	2,835	-142,688	-5,178	**-240,192**
Yorks & Humber	-11,476	-1,089	502	11,617	151	4,060	-4,151	-897	2,787	-2,828	-124,261	**-125,584**
Grand Total	**-154,354**	**-24,565**	**789**	**-51,753**	**-23,809**	**-275,357**	**-56,647**	**-24,539**	**46,837**	**-214,046**	**-130,823**	**-908,266**

Table 3-8 Change in PLD Highway Trips (Percentage Differences): PFMv4.3-PFMv3.0

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	-56.5%	-45.3%	-38.0%	13.6%	5.3%	134.9%	-50.5%	-49.1%	-34.8%	-40.5%	-26.2%	**-41.4%**
East of England	-55.9%	-	-	63.7%	20.3%	-14.0%	-	145.1%	153.2%	-32.5%	-9.3%	**-37.4%**
London	-38.0%	-	-	112.9%	-1.6%	167.4%	-	91.2%	127.5%	1.5%	16.9%	**7.6%**
North East	47.1%	117.4%	196.5%	-95.3%	127.9%	-42.7%	-22.6%	115.6%	292.8%	-50.2%	129.2%	**-49.7%**
North West	7.3%	51.6%	37.5%	34.7%	-9.0%	-15.3%	-66.1%	2.5%	48.4%	14.6%	8.0%	**-0.4%**
Scotland	0.8%	-41.1%	69.6%	-35.0%	-23.3%	-66.2%	-40.6%	27.9%	74.1%	-60.9%	12.8%	**-62.3%**
South East	-61.5%	-	-	-17.3%	-61.4%	-41.0%	-	86.1%	-40.4%	-38.4%	-50.3%	**-47.4%**
South West	-65.4%	194.2%	147.6%	-25.5%	-2.6%	1.0%	60.0%	35.7%	41.5%	-53.4%	-34.5%	**-21.8%**
Wales	-46.3%	40.9%	112.2%	379.0%	-7.0%	25.7%	-48.9%	32.6%	327.0%	4.3%	435.9%	**35.1%**
West Midlands	-41.4%	-28.3%	-17.9%	-42.2%	-27.7%	-10.3%	-48.8%	-61.2%	14.3%	-86.2%	-38.5%	**-56.8%**
Yorks & Humber	-29.6%	-16.0%	18.0%	172.2%	0.4%	227.6%	-37.5%	-27.5%	340.6%	-25.0%	-61.4%	**-38.9%**
Grand Total	**-46.6%**	**-30.0%**	**2.3%**	**-48.2%**	**-9.5%**	**-60.9%**	**-47.2%**	**-24.8%**	**60.3%**	**-53.3%**	**-40.3%**	**-39.8%**

4. Air Base Year Matrices

4.1. Introduction

This section describes the methodology for developing the domestic air passenger (i.e. excluding interlining trips that are the first leg of an international journey) demand matrices for the PFMv4.3 2010 model base year. The approach is to adopt the DfT Aviation Model forecasts of supply and demand. This ensures a completely consistent approach between domestic air passenger demand and aviation supply in the base year.

Within PFM air is only represented in the PLD model and only includes those trips made exclusively within Great Britain and therefore excludes movements to/from Northern Ireland, Isle of Man etc. It also excludes interlining trips as described above.

The domestic air passenger demand provided by the DfT came from the 'VAL12' (2012 revalidation exercise) and "APF02_1209" generation of forecasts from the DfT Aviation Model. The data was received in the form of an Excel file (*HS2_2010.xls*) which contained end-to-end, non-transfer demand by trip purpose (employers business and other).

This section is structured as follows:

- Section 4.2 presents a review of the 2010 DfT Aviation Model matrix; and
- Section 4.3 presents a review of the changes between this matrix and that taken from an earlier version of the DfT Aviation Model and used to develop the previous PFMv3.0 2010 PLD air matrix.

4.2. DfT Aviation Model

The DfT Aviation Model forecasts the number of passengers passing through UK airports each year and includes trip matrices for UK and foreign residents travelling to, from or within the UK. The internal domestic market sector (excluding interlining trips as described above) required for PLD accounts for approximately 15% of the passengers in the DfT Aviation Model matrices.

The model has a base year of 2008 with forecasts being developed at yearly intervals. To ensure the model is accurately replicating observed aviation activity in those years where data is now available, a present year model validation was undertaken for 2011. Detail on the results of the validation and the wider DfT Aviation Model Framework can be found in *UK Aviation Forecasts, DfT, January 2013*.

4.2.1. Regional Air Demand Review

The first element of the 2010 DfT Aviation Model matrix review was to investigate region to region air demand patterns. When reviewing this demand the key assumptions were that:

- there should be little inter-regional demand;
- there should be little demand between adjacent regions; and
- the majority of movements should be longer distance, typically between Scotland and southern England.

Note that the data supplied from the DfT Aviation Model are annual forecasts of demand with the final PLD air matrices being created by dividing the annual matrices by a de-annualisation factor of 313 to create daily (weekday) demand for assignment. This factor was supplied by the DfT.

Table 4-1 represents the regional origin to destination demand matrices for domestic air passengers with region allocations based on origin/destination zone irrespective of the location of the airport chosen. There is intra-regional demand within the South West (2% of the regions origin trips). Upon investigation trips internal to the South West are to/from the Isle of Scilly. Whilst this is logical, it would not have an impact on HS2 London to West Midlands forecasting.

The matrix also contains some movements between adjacent regions. Focusing on those that are significant (>1% of origin region's demand) reveals movements between the following adjacent regions:

- North East and Scotland (6% of North East demand);
- North West and Scotland (28% of North West demand and 3% of Scotland demand);
- South West and South East (2% of South West demand and 1% of South East demand); and
- Wales and South West (3% of Wales demand).

These movements represent approximately 3% of total domestic movements and typically feature movements between the extremes of adjacent regions.

The proportion of demand between each region is shown in Table 4-2 for all trips and Table 4-4 to Table 4-6 for business and leisure trips. The patterns of movement are very similar for business and leisure passengers. Movements between Scotland and London plus the South East account for approximately 48% of all domestic business and leisure flights; whilst movements that have at least one end of their journey at an airport in Scotland, London or the South East account for approximately 92% of all domestic business and leisure flights.

Table 4-1 Regional demand for Domestic air derived from the 2010 DfT Aviation Model (all trips)

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	0	247	897	597	0	137,066	520	627	1,684	0	0	**141,638**
East of England	166	0	0	40,103	21,828	481,132	0	7,605	398	417	1,318	**552,967**
London	940	0	0	62,275	89,905	1,238,824	0	9,912	2,615	143	8,525	**1,413,139**
North East	504	57,770	63,853	0	0	27,177	114,118	135,756	19,994	7,166	0	**426,338**
North West	0	26,636	89,033	0	0	95,076	63,694	60,772	387	211	0	**335,809**
Scotland	180,856	535,097	1,258,333	29,579	93,367	3,821	820,431	299,226	107,606	253,636	66,013	**3,647,965**
South East	548	0	0	108,445	63,425	791,676	0	12,239	497	716	24,272	**1,001,818**
South West	623	9,944	9,016	121,876	54,354	285,371	12,524	12,106	3,554	728	28,406	**538,502**
Wales	1,744	1,082	4,777	20,250	412	102,852	846	4,080	0	18	427	**136,488**
West Midlands	0	881	162	7,610	125	234,163	425	616	18	0	0	**244,000**
Yorks & Humber	0	1,898	9,852	0	0	67,262	24,232	20,633	470	0	0	**124,347**
Grand Total	**185,381**	**633,555**	**1,435,923**	**390,735**	**323,416**	**3,464,420**	**1,036,790**	**563,572**	**137,223**	**263,035**	**128,961**	**8,563,011**

Table 4-2 Percentage allocation of regional demand for air derived from the 2010 DfT Aviation Model (all trips)

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%	**2%**
East of England	0%	0%	0%	0%	0%	6%	0%	0%	0%	0%	0%	**6%**
London	0%	0%	0%	1%	1%	14%	0%	0%	0%	0%	0%	**17%**
North East	0%	1%	1%	0%	0%	0%	1%	2%	0%	0%	0%	**5%**
North West	0%	0%	1%	0%	0%	1%	1%	1%	0%	0%	0%	**4%**
Scotland	2%	6%	15%	0%	1%	0%	10%	3%	1%	3%	1%	**43%**
South East	0%	0%	0%	1%	1%	9%	0%	0%	0%	0%	0%	**12%**
South West	0%	0%	0%	1%	1%	3%	0%	0%	0%	0%	0%	**6%**
Wales	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	**2%**
West Midlands	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	**3%**
Yorks & Humber	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	**1%**
Grand Total	**2%**	**7%**	**17%**	**5%**	**4%**	**40%**	**12%**	**7%**	**2%**	**3%**	**2%**	**100%**

Table 4-3 Regional demand for Domestic air derived from the 2010 DfT Aviation Model (business annual trip matrix)

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	0	103	757	569	0	111,655	313	230	1,684	0	0	**115,311**
East of England	106	0	0	17,400	12,394	281,229	0	378	194	181	326	**312,208**
London	798	0	0	36,580	65,885	755,459	0	2,070	2,548	56	5,334	**868,730**
North East	444	16,424	36,287	0	0	22,478	54,566	43,450	11,458	6,727	0	**191,834**
North West	0	11,977	66,416	0	0	49,373	46,681	20,250	290	0	0	**194,987**
Scotland	104,598	274,527	764,014	21,637	47,967	1,026	425,773	107,701	30,631	151,072	49,429	**1,978,375**
South East	314	0	0	58,453	46,279	437,758	0	6,826	303	237	13,619	**563,789**
South West	300	421	2,611	48,381	22,011	119,330	7,636	5,595	246	630	10,175	**217,336**
Wales	1,744	166	2,395	12,623	313	34,207	292	205	0	18	357	**52,320**
West Midlands	0	189	89	7,342	0	160,638	251	584	18	0	0	**169,111**
Yorks & Humber	0	430	7,529	0	0	56,225	15,221	9,883	403	0	0	**89,691**
Grand Total	**108,304**	**304,237**	**880,098**	**202,985**	**194,849**	**2,029,378**	**550,733**	**197,172**	**47,775**	**158,921**	**79,240**	**4,753,692**

Table 4-4 Percentage allocation of regional demand for air derived from the 2010 DfT Aviation Model (business annual trip matrix)

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%	**2%**
East of England	0%	0%	0%	0%	0%	6%	0%	0%	0%	0%	0%	**7%**
London	0%	0%	0%	1%	1%	16%	0%	0%	0%	0%	0%	**18%**
North East	0%	0%	1%	0%	0%	0%	1%	1%	0%	0%	0%	**4%**
North West	0%	0%	1%	0%	0%	1%	1%	0%	0%	0%	0%	**4%**
Scotland	2%	6%	16%	0%	1%	0%	9%	2%	1%	3%	1%	**42%**
South East	0%	0%	0%	1%	1%	9%	0%	0%	0%	0%	0%	**12%**
South West	0%	0%	0%	1%	0%	3%	0%	0%	0%	0%	0%	**5%**
Wales	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	**1%**
West Midlands	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	**4%**
Yorks & Humber	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	**2%**
Grand Total	**2%**	**6%**	**19%**	**4%**	**4%**	**43%**	**12%**	**4%**	**1%**	**3%**	**2%**	**100%**

Table 4-5 Regional demand for Domestic air derived from the 2010 DfT Aviation Model (leisure annual trip matrix)

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	0	144	140	28	0	25,411	207	397	0	0	0	**26,327**
East of England	60	0	0	22,703	9,434	199,903	0	7,227	204	236	992	**240,759**
London	142	0	0	25,695	24,020	483,365	0	7,842	67	87	3,191	**544,409**
North East	60	41,346	27,566	0	0	4,699	59,552	92,306	8,536	439	0	**234,504**
North West	0	14,659	22,617	0	0	45,703	17,013	40,522	97	211	0	**140,822**
Scotland	76,258	260,570	494,319	7,942	45,400	2,795	394,658	191,525	76,975	102,564	16,584	**1,669,590**
South East	234	0	0	49,992	17,146	353,918	0	5,413	194	479	10,653	**438,029**
South West	323	9,523	6,405	73,495	32,343	166,041	4,888	6,511	3,308	98	18,231	**321,166**
Wales	0	916	2,382	7,627	99	68,645	554	3,875	0	0	70	**84,168**
West Midlands	0	692	73	268	125	73,525	174	32	0	0	0	**74,889**
Yorks & Humber	0	1,468	2,323	0	0	11,037	9,011	10,750	67	0	0	**34,656**
Grand Total	**77,077**	**329,318**	**555,825**	**187,750**	**128,567**	**1,435,042**	**486,057**	**366,400**	**89,448**	**104,114**	**49,721**	**3,809,319**

Table 4-6 Percentage allocation of regional demand for air derived from the 2010 DfT Aviation Model (leisure annual trip matrix)

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	**1%**
East of England	0%	0%	0%	1%	0%	5%	0%	0%	0%	0%	0%	**6%**
London	0%	0%	0%	1%	1%	13%	0%	0%	0%	0%	0%	**14%**
North East	0%	1%	1%	0%	0%	0%	2%	2%	0%	0%	0%	**6%**
North West	0%	0%	1%	0%	0%	1%	0%	1%	0%	0%	0%	**4%**
Scotland	2%	7%	13%	0%	1%	0%	10%	5%	2%	3%	0%	**44%**
South East	0%	0%	0%	1%	0%	9%	0%	0%	0%	0%	0%	**11%**
South West	0%	0%	0%	2%	1%	4%	0%	0%	0%	0%	0%	**8%**
Wales	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%	**2%**
West Midlands	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%	**2%**
Yorks & Humber	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	**1%**
Grand Total	**2%**	**9%**	**15%**	**5%**	**3%**	**38%**	**13%**	**10%**	**2%**	**3%**	**1%**	**100%**

4.2.2. Asymmetrical Demand

The 2010 DfT Aviation Model matrix represents an average annual demand. As such, the assumption is that regional and district level demand should have similar levels of origin and destination trip totals. The analysis in Table 4-7 shows that whilst most regions have origin and destination trip ends within 10% of each other, the East Midlands has 31% more trip destinations than origins and the East of England has 15% more trip destinations than origins.

Table 4-7 Regional level asymmetrical demand

Region	Origins	Destinations	Difference	% Difference
Scotland	3,647,965	3,464,421	183,543	5%
North West	335,809	323,415	12,393	4%
North East	426,338	390,735	35,603	8%
Yorks & Humber	124,349	128,960	-4,611	-4%
East Midlands	141,638	185,381	-43,742	-31%
West Midlands	243,999	263,036	-19,037	-8%
Wales	136,488	137,223	-735	-1%
South West	538,502	563,572	-25,070	-5%
South East	1,001,818	1,036,789	-34,970	-3%
East of England	552,967	633,555	-80,588	-15%
London	1,413,138	1,435,924	-22,785	-2%
Grand Total	8,563,011	3,464,421	0	0%

District level asymmetry shows some much larger differences in percentage terms with leisure trips (Table 4-8) showing much high levels of district level asymmetry than business trips (Table 4-9). The scale of the issue could be considered quite significant as the ten most asymmetrical districts represent approximately 20% of leisure and approximately 30% of business demand. A concern is that for both business and leisure trips, some of the highest levels of asymmetry occur in Scottish districts.

Table 4-8 Top five (positive and negative differences) district level asymmetry for leisure trips (selection based on absolute difference)

Zone Name	Origins	Destinations	Difference	% Difference
South Cambridgeshire	8,600	33,399	-24,800	-288%
Southend-On-Sea UA	3,979	23,088	-19,109	-480%
Blaby	993	13,679	-12,686	-1278%
Birmingham	19,951	29,974	-10,023	-50%
Rushcliffe	803	8,113	-7,310	-911%
Kirkcaldy	165,955	146,709	19,246	12%
Newcastle Upon Tyne	85,332	61,494	23,838	28%
Glasgow City	172,354	147,737	24,617	14%
East Renfrewshire	69,352	33,910	35,442	51%
Edinburgh, City Of	247,444	210,864	36,579	15%

Table 4-9 Top five (positive and negative differences) district level asymmetry for business trips (selection based on absolute difference)

Zone Name	Origins	Destinations	Difference	% Difference
Edinburgh, City Of	473,064	494,870	-21,806	-5%
Glasgow City	533,726	543,374	-9,648	-2%
Newcastle Upon Tyne	86,919	93,528	-6,609	-8%

Zone Name	Origins	Destinations	Difference	% Difference
Dunfermline	57,407	61,317	-3,910	-7%
Aberdeen City	214,476	218,262	-3,786	-2%
City Of London	107,345	103,701	3,644	3%
Portsmouth UA	17,641	13,202	4,439	25%
Bristol, City of UA	49,348	43,916	5,431	11%
Leeds	34,621	28,989	5,632	16%
Inverness	40,488	33,371	7,117	18%

Evidence of asymmetry selected by percentage difference is shown in Table 4-10 and Table 4-11, although with the exception of East Renfrewshire, the large percentage changes involve relatively small numbers once the demand has been de-annualised to daily demand.

Table 4-10 Top five (positive and negative differences) district level asymmetry for leisure trips (selection based on percentage difference)

Zone Name	Origins	Destinations	Difference	% Difference
Teesdale	1	2,013	-2,011	-170,400%
East Lindsey	2	1,845	-1,843	-78,050%
Rutland UA	47	2,088	-2,041	-4,323%
Kettering	85	2,680	-2,595	-3,053%
St. Edmundsbury	231	5,516	-5,285	-2,284%
Wrexham	2,545	1,198	1,347	53%
Burnley	1,721	791	930	54%
Wear Valley	1,708	686	1,022	60%
Flintshire	3,184	967	2,217	70%
Dartford	4,505	4,401	104	78%

Table 4-11 Top five (positive and negative differences) district level asymmetry for business trips (selection based on percentage difference)

Zone Name	Origins	Destinations	Difference	% Difference
Richmondshire	621	961	-339	-55%
Wear Valley	599	762	-162	-27%
Nairn	1,796	2,261	-465	-26%
Epping Forest	1,583	1,885	-302	-19%
Easington	934	1,081	-148	-16%
South Holland	174	83	91	52%
Adur	676	303	373	55%
Purbeck	341	115	225	66%
West Somerset	222	61	161	73%
Teesdale	466	75	391	84%

To address this asymmetry the original 2010 DfT Aviation Model matrices by purpose were transposed, added to the original matrices and divided by two. This leads to the revised trip ends becoming an average of the existing origin and destination trip ends.

The impact of resolving the asymmetrical demand on regional air demand movements is shown in Table 4-13 and the percentage changes are shown in Table 4-14. Whilst there are a few large percentage changes in regional demand, these are changes between relatively small numbers (for example East of England to

Wales changes from 398 movements to 740 movements, which is an 86% change). There is only a +/-2% change in movements between London and the South East and Scotland.

4.3. Changes in Air Demand between PFMv3.0 and PFMv4.3

4.3.1. Total Matrix Changes

Table 4-12 compares the PFMv4.3 2010 DfT Aviation Model (2012 validation) matrices with the PFMv3.0 2010 DfT Aviation Model matrices.

The PFMv3.0 2010 matrices were developed using forecast matrices from the 2008 base year DfT Aviation Model, assuming growth in demand between 2008 and 2010. As described above, the PFMv4.3 2010 matrices have been developed using base year matrices from the 2010 DfT Aviation model (validated in 2012). UK domestic air travel declined during 2008 and 2009 as a result of the economic recession. The 2010 DfT Aviation model takes account of this decline thus the PFMv4.3 matrices show a reduction in domestic air travel compared with the PFMv3.0 matrices.

The PFMv4.3 2010 DfT Aviation Model matrix shows an overall reduction in domestic passengers of 11.3% compared with PFMv3.0, with the largest reduction being for leisure trips (901,695 trips or 19.1%).

Table 4-12 Comparison of DfT aviation matrices

Description	Business	Leisure	Combined
PFMv3.0 2010 DfT Aviation Model matrix	4,941,613	4,711,014	9,652,627
PFMv4.3 2010 DfT Aviation Model matrix	4,753,692	3,809,319	8,563,013
Absolute Difference	-187,921	-901,695	-1,089,614
Percentage Difference	-3.8%	-19.1%	-11.3%

4.3.2. Region to Region Changes

Changes in regional level trip ends (origin and destination) are shown in Table 4-15. It can be seen that whilst the overall reduction is 11% the differences by region vary significantly. The table also shows that the PFMv3.0 matrices contained asymmetrical trip ends which are removed in the PFMv4.3 matrices.

In this instance:

- West Midlands sees a 36% reduction in origins and a 11% reduction in destinations;
- East Midlands has 46% less origins but only a 2% reduction in destinations;
- North West has a 51% reduction in origins and 50% reduction in destinations;
- South West has a 29% reduction in origins and 25% reduction in destinations;
- Wales has a 37% reduction in origins and 18% reduction in destinations;
- Yorkshire & Humberside has a 34% reduction in origins and 22% reduction in destinations; and
- London sees a 5% reduction in origins but a 4% increase in destinations.

Table 4-16 shows the PFMv3.0 2010 DfT Aviation model matrix (all purposes) and a comparison with the PFMv4.3 matrix can be found in Table 4-17 and Table 4-18. It is understood that the 2012 validation exercise for the DfT Aviation model focused on movements between London and the South East and Scotland. The changes between the two sets of matrices on these corridors are listed below:

- London to Scotland demand increased by 5%;
- South East to Scotland demand decreased by 4%;
- Scotland to London demand increased by 16%; and
- Scotland to South East demand increased by 13%.

Figure 4-1 and Figure 4-2 show the changes in origins and destinations at the PLD zone level between PFMv3.0 and PFMv4.3. Reductions in demand can be seen across most zones.

Table 4-13 2010 DfT Aviation Model demand (symmetrical demand)

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	0	206	919	551	0	158,961	534	625	1,714	0	0	**163,510**
East of England	206	0	0	48,937	24,232	508,114	0	8,774	740	649	1,608	**593,260**
London	919	0	0	63,064	89,469	1,248,579	0	9,464	3,696	153	9,188	**1,424,532**
North East	551	48,937	63,064	0	0	28,378	111,282	128,816	20,121	7,388	0	**408,537**
North West	0	24,232	89,469	0	0	94,221	63,559	57,563	400	168	0	**329,612**
Scotland	158,961	508,114	1,248,579	28,378	94,221	3,821	806,054	292,299	105,229	243,899	66,638	**3,556,193**
South East	534	0	0	111,282	63,559	806,054	0	12,382	671	570	24,253	**1,019,305**
South West	625	8,774	9,464	128,816	57,563	292,299	12,382	12,106	3,817	672	24,520	**551,038**
Wales	1,714	740	3,696	20,121	400	105,229	671	3,817	0	18	449	**136,855**
West Midlands	0	649	153	7,388	168	243,899	570	672	18	0	0	**253,517**
Yorks & Humber	0	1,608	9,188	0	0	66,638	24,253	24,520	449	0	0	**126,656**
Grand Total	**163,510**	**593,260**	**1,424,532**	**408,537**	**329,612**	**3,556,193**	**1,019,305**	**551,038**	**136,855**	**253,517**	**126,656**	**8,563,015**

Table 4-14 Percentage change as a result of resolving asymmetrical demand

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	0%	-16%	2%	-8%	0%	16%	3%	0%	2%	0%	0%	**15%**
East of England	24%	0%	0%	22%	11%	6%	0%	15%	86%	55%	22%	**7%**
London	-2%	0%	0%	1%	0%	1%	0%	-5%	41%	7%	8%	**1%**
North East	9%	-15%	-1%	0%	0%	4%	-2%	-5%	1%	3%	0%	**-4%**
North West	0%	-9%	0%	0%	0%	-1%	0%	-5%	3%	-20%	0%	**-2%**
Scotland	-12%	-5%	-1%	-4%	1%	0%	-2%	-2%	-2%	-4%	1%	**-3%**
South East	-3%	0%	0%	3%	0%	2%	0%	1%	35%	-20%	0%	**2%**
South West	0%	-12%	5%	6%	6%	2%	-1%	0%	7%	-8%	-14%	**2%**
Wales	-2%	-32%	-23%	-1%	-3%	2%	-21%	-6%	0%	0%	5%	**0%**
West Midlands	0%	-26%	-6%	-3%	34%	4%	34%	9%	0%	0%	0%	**4%**
Yorks & Humber	0%	-15%	-7%	0%	0%	-1%	0%	19%	-5%	0%	0%	**2%**
Grand Total	**-12%**	**-6%**	**-1%**	**5%**	**2%**	**3%**	**-2%**	**-2%**	**0%**	**-4%**	**-2%**	**0%**

Table 4-15 Changes in regional trip ends in PFMv3.0 2010 matrix and Asymmetry Corrected PFMv4.3 2010 DfT Aviation Model matrix

Region	PFMv3.0 2010 DfT Aviation Model matrix		PFMv4.3 2010 DfT Aviation Model matrix (symmetrical)		Percentage Difference	
	Origin	Destination	Origin	Destination	Origin	Destination
East Midlands	302,923	166,268	163,511	163,511	-46%	-2%
East of England	687,486	465,873	593,260	593,260	-14%	27%
London	1,494,989	1,372,169	1,424,531	1,424,531	-5%	4%
North East	361,998	410,417	408,537	408,537	13%	0%
North West	670,781	653,459	329,612	329,612	-51%	-50%
Scotland	3,396,750	4,217,766	3,556,193	3,556,193	5%	-16%
South East	1,160,408	1,019,769	1,019,304	1,019,304	-12%	0%
South West	773,923	731,077	551,037	551,037	-29%	-25%
Wales	215,934	167,570	136,855	136,855	-37%	-18%
West Midlands	394,306	286,205	253,517	253,517	-36%	-11%
Yorks & Humber	193,130	162,055	126,655	126,655	-34%	-22%
Total	**9,652,628**	**9,652,628**	**8,563,013**	**8,563,013**	**-11%**	**-11%**

Table 4-16 PFMv3.0 2010 DfT Aviation Model matrix (business and leisure)

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	0	221	1,236	834	0	285,470	1,088	11,932	2,142	0	0	**302,923**
East of England	341	0	0	38,299	49,580	537,347	0	54,460	2,808	514	4,137	**687,486**
London	1,327	0	0	78,178	181,456	1,193,736	0	14,333	3,123	271	22,566	**1,494,990**
North East	698	27,157	73,218	0	0	37,719	94,128	100,438	19,387	9,254	0	**361,999**
North West	0	36,914	178,482	0	0	219,985	155,458	79,332	425	186	0	**670,782**
Scotland	158,025	381,966	1,076,604	34,232	185,417	9,221	711,922	361,275	132,327	271,472	74,287	**3,396,748**
South East	1,156	0	0	108,446	156,989	837,086	0	21,776	998	592	33,364	**1,160,407**
South West	2,401	14,760	14,136	116,595	79,235	453,642	20,671	35,565	5,858	3,901	27,159	**773,923**
Wales	2,320	1,360	3,057	23,427	442	177,231	1,146	6,395	0	13	543	**215,934**
West Midlands	0	286	392	10,406	340	376,131	851	5,885	14	0	0	**394,305**
Yorks & Humber	0	3,209	25,044	0	0	90,197	34,506	39,686	489	0	0	**193,131**
Grand Total	**166,268**	**465,873**	**1,372,169**	**410,417**	**653,459**	**4,217,765**	**1,019,770**	**731,077**	**167,571**	**286,203**	**162,056**	**9,652,628**

Table 4-17 Difference between PFMv4.3 2010 DfT Aviation Model matrix (symmetrical) and PFMv3.0 matrix (business and leisure)

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	0	-15	-317	-283	0	-126,509	-554	-11,307	-428	0	0	**-139,413**
East of England	-135	0	0	10,638	-25,348	-29,233	0	-45,686	-2,068	135	-2,529	**-94,226**
London	-408	0	0	-15,114	-91,987	54,843	0	-4,869	573	-118	-13,378	**-70,458**
North East	-147	21,780	-10,154	0	0	-9,341	17,154	28,378	734	-1,866	0	**46,538**
North West	0	-12,682	-89,013	0	0	-125,764	-91,899	-21,769	-25	-18	0	**-341,170**
Scotland	936	126,148	171,975	-5,854	-91,196	-5,400	94,132	-68,976	-27,098	-27,573	-7,649	**159,445**
South East	-622	0	0	2,836	-93,430	-31,032	0	-9,394	-327	-22	-9,111	**-141,102**
South West	-1,776	-5,986	-4,672	12,221	-21,672	-161,343	-8,289	-23,459	-2,041	-3,229	-2,639	**-222,885**
Wales	-606	-620	639	-3,306	-42	-72,002	-475	-2,578	0	5	-94	**-79,079**
West Midlands	0	363	-239	-3,018	-172	-132,232	-281	-5,213	4	0	0	**-140,788**
Yorks & Humber	0	-1,601	-15,856	0	0	-23,559	-10,253	-15,166	-40	0	0	**-66,475**
Grand Total	**-2,758**	**127,387**	**52,363**	**-1,880**	**-323,847**	**-661,572**	**-465**	**-180,039**	**-30,716**	**-32,686**	**-35,400**	**-1,089,613**

Table 4-18 Percentage difference between PFMv4.3 2010 DfT Aviation Model matrix (symmetrical) and PFMv3.0 matrix (business and leisure)

Region	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	0%	-7%	-26%	-34%	0%	-44%	-51%	-95%	-20%	0%	0%	**-46%**
East of England	-40%	0%	0%	28%	-51%	-5%	0%	-84%	-74%	26%	-61%	**-14%**
London	-31%	0%	0%	-19%	-51%	5%	0%	-34%	18%	-44%	-59%	**-5%**
North East	-21%	80%	-14%	0%	0%	-25%	18%	28%	4%	-20%	0%	**13%**
North West	0%	-34%	-50%	0%	0%	-57%	-59%	-27%	-6%	-10%	0%	**-51%**
Scotland	1%	33%	16%	-17%	-49%	-59%	13%	-19%	-20%	-10%	-10%	**5%**
South East	-54%	0%	0%	3%	-60%	-4%	0%	-43%	-33%	-4%	-27%	**-12%**
South West	-74%	-41%	-33%	10%	-27%	-36%	-40%	-66%	-35%	-83%	-10%	**-29%**
Wales	-26%	-46%	21%	-14%	-10%	-41%	-41%	-40%	0%	38%	-17%	**-37%**
West Midlands	0%	127%	-61%	-29%	-51%	-35%	-33%	-89%	29%	0%	0%	**-36%**
Yorks & Humber	0%	-50%	-63%	0%	0%	-26%	-30%	-38%	-8%	0%	0%	**-34%**
Grand Total	**-2%**	**27%**	**4%**	**0%**	**-50%**	**-16%**	**0%**	**-25%**	**-18%**	**-11%**	**-22%**	**-11%**

Figure 4-1 Air Matrix (all purposes) - Comparison of Origin Totals

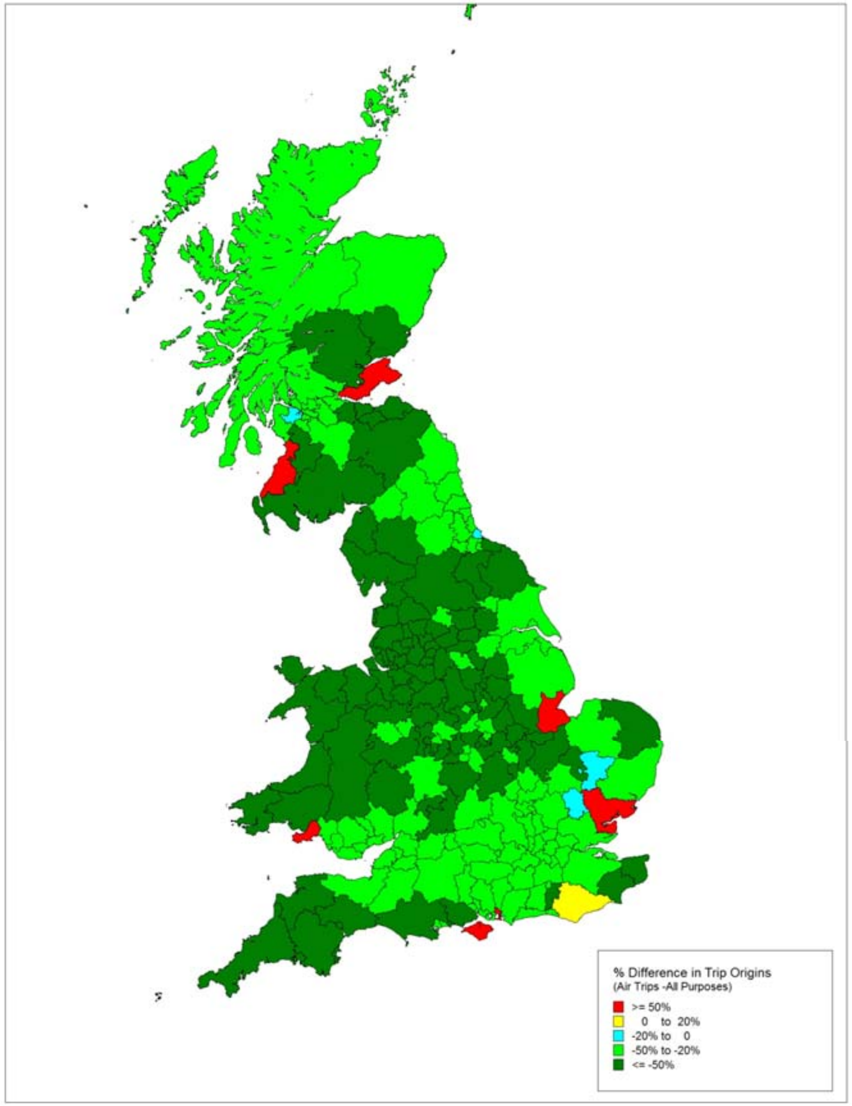
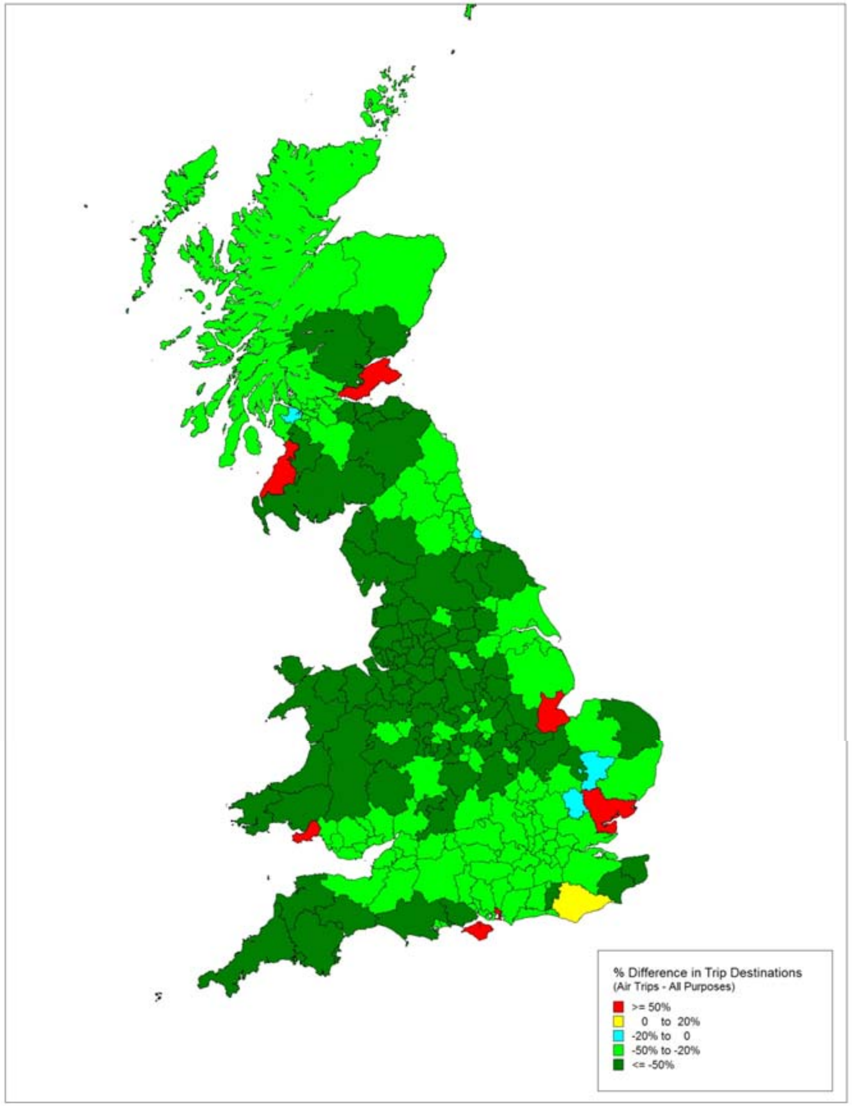


Figure 4-2 Air Matrix (all purposes) - Comparison of Destination Totals



5. Development of New Growth Forecasts

5.1. Introduction

This section describes the development of the revised demand forecasts for PFM 4.3. These incorporated revised growth forecasts for each of the models within PFM (PLD and the three regional PLANET models). For PLD separate forecasts were prepared for the rail, highway and air modes.

Rail forecasts were developed using the DfT's Exogenous Demand Growth Estimator (EDGE) tool, whilst the highway forecasts used data from the DfT's National Trip End Model (NTEM). Air forecasts were taken directly from the DfT's Aviation Model.

This section describes the development of the rail forecasts, followed by those for highway and air.

5.2. Rail Forecasts

5.2.1. Introduction

The development of the new rail growth forecasts not only included changes to the economic parameters to reflect latest advice from the DfT, but they also incorporated changes to the rail forecasting process. These changes were:

- Incorporating PDFHv5 parameters into the forecasting process;
- Revised application of elasticities;
- Revisions to the RIFF/NTEM zone correspondence;
- Introducing differential population growth into the PLANET South EDGE case study; and
- Forecasting from revised based year matrices for PLD and PS.

5.2.2. PDFHv5 Based Forecasts

The parameters used in PFMv3.0 to forecast rail demand came from the Passenger Demand Forecasting Handbook (PDFH) 4.0/4.1 in line with the DfT WebTAG guidance current at the time. The WebTAG guidance (TAG Unit 3.15.4), updated in August 2012, moved to the use of parameters from PDFHv5 for rail demand forecasting.

The changes in PDFHv5 are limited to those for the External Environment and the Ticket Type/Journey Purpose Splits. Although PDFHv5 also provides revised fares elasticities WebTAG recommended that the fares elasticity parameters from PDFHv4.0 should still be used for rail passenger demand forecasting.

5.2.2.1. External Environment

In moving from PDFHv4.1 to PDFHv5 the only elasticities that differ are the London to / from rest of country GDP per capita elasticities, which are generally lower in PDFHv5. Note that this only impacts on non-season ticket elasticities as season ticket demand growth is driven by employment.

5.2.2.2. Ticket type to Journey Purpose Conversion Proportions

The ticket type to journey purpose conversion proportions were taken from PDFHv5 whereas previous WebTAG advice was to use data which had been used to populate the RIFF software.

5.2.3. Other Amendments to the Forecasting Process

5.2.3.1. Elasticities

On the advice of the DfT a number of amendments were made to the application of elasticities in the demand forecasting process and these are described below.

Intermodal Elasticities

Previously elasticities had been used that vary by ticket type for intermodal competition drivers (see PDFHv5, tables B2.1- B2.6). The DfT has highlighted that these elasticities have not been updated to reflect the revised journey purpose to ticket type mapping recommended in PDFHv5 tables B0.1 – B0.10, and given that the original elasticities are disaggregated by journey purpose, these should be used instead (Table B2.7).

Therefore, the elasticities used as inputs to the EDGE forecasting tool were revised so intermodal competition effects vary by journey purpose, as opposed to ticket type.

Population Elasticities

The non-London long distance season ticket population elasticity had previously been set to zero which is contrary to PDFH guidance. For PFMv4.3 this elasticity was changed to a value of 1 (PDFHv5, Table B1.5).

Season ticket fare elasticities

As PDFHv4.0 does not provide fare elasticities for season tickets these were taken from WebTAG 3.15.4 (April 2009 version), Annex A 11.2, Table 30. In PFMv3.0 an elasticity of -0.75 was used for long distance London to rest of country flows. To ensure consistency with the other season ticket elasticities this was revised to -0.70.

Impact of amendments to forecasting process

In order to gauge the level of the impact of the above changes to the forecasting process, three sensitivity tests were carried out on PFMv3.0 but with a version of EDGE that included the use of PDFHv5 parameters. Each sensitivity test incorporated the adjustments described above, incrementally.

The first sensitivity test, which revised the elasticities inputs to the EDGE forecasting tool for intermodal competition to vary by journey purpose as opposed to ticket type, had a small impact increasing total 2026 and 2043 demand by 0.5%.

The second sensitivity test, which set the non-London long distance season ticket population elasticity to 1, had a larger impact on the demand forecasts. The combined impact of the first and second sensitivity tests was to increase the total 2026 demand by 1.7%, and the 2043 demand by 2.8%. The third sensitivity test, which set the long distance London to rest of country fare elasticity to -0.7, had a negligible impact on the demand forecasts.

The combined impact of all three sensitivity tests was to increase the total 2026 demand by 1.7%, and the 2043 demand by 2.8%.

5.2.3.2. RIFF/NTEM zoning correspondence

A review of the RIFF to NTEM zoning correspondence that is used to convert NTEM based demand driver data to RIFF compatible data highlighted a few anomalies. After further investigation it became apparent that the RIFF zoning attempts to represent TOCs (and possibly service levels) in the first instance, rather than geographical areas, and some of the groupings are rather subjective. This explained many of the anomalies, though there were also some correspondence anomalies that could not be explained.

It was decided that, of the subjective groupings which may be due to attempts to represent TOCs rather than geographical areas, only the RIFF zones in and around London would be amended. These amendments can be seen in Table 5-1 below. Additionally to these, there were also two correspondences that were judged simply to be errors. These were Minehead and Watchet which were classified as being in 'Rest of South Wales' and were changed to being in 'Cornwall and Devon'.

Table 5-1 Amendments made to RIFF zoning system

NTEM Zone	NTEM Zone Name	Current RIFF Zone	Current RIFF Zone Name	Proposed RIFF Zone	Proposed RIFF Zone Name
29UK3	Swanley/Hextable	2	South East London	13	South East

NTEM Zone	NTEM Zone Name	Current RIFF Zone	Current RIFF Zone Name	Proposed RIFF Zone	Proposed RIFF Zone Name
43UK1	Caterham and Warlingham	3	South Central London 1	15	South Central
43UH5	Walton and Weybridge(part of)	5	South West London	16	South West (Shorter)
26UE3	Borehamwood(main)	7	North London 1	24	Thameslink
11UC3	Amersham	8	North London 2	22	Chiltern
11UC4	Chesham	8	North London 2	22	Chiltern
26UJ0	Rural	8	North London 2	22	Chiltern
26UJ3	Rickmansworth	8	North London 2	22	Chiltern
26UJ4	Chorleywood	8	North London 2	22	Chiltern
26UJ5	Hillingdon(part of)	8	North London 2	22	Chiltern
22UH1	Loughton	10	North East London	26	West Anglia (Inner)
22UH11	Theydon Bois	10	North East London	26	West Anglia (Inner)
26UB1	Cheshunt	10	North East London	26	West Anglia (Inner)
22UD0	rural	11	East London	29	Anglia (Shorter)
22UH3	Chigwell	11	East London	26	West Anglia (Inner)
00KG0	rural	14	C2C	11	East London
00AR0	rural	14	C2C	11	East London
00AH1	Croydon(main)	15	South Central	4	South Central London 2
00BF2	Croydon(part of)	15	South Central	4	South Central London 2
43UF2	Croydon(part of)	15	South Central	4	South Central London 2
40UF1	Minehead	31	Rest of South Wales	18	Cornwall & Devon
40UF2	Watchet	31	Rest of South Wales	18	Cornwall & Devon

5.2.3.3. Impact of Changes

To understand the combined impact of introducing the PDFHv5 parameters and incorporating the other amendments described above interim forecasts were prepared based on the PFMv3.0 version of the model.

Generally across the four PLANET models the leisure and business demand decreased between PDFHv4 and PDFHv5, whilst commuting demand increased. The decrease in leisure and business demand was due to the revised lower GDP elasticity assumptions and the increase in commuting demand was due to the new ticket type to journey purpose conversion proportions.

The increase in commuting demand is the result of a reduction in the proportion of commuting journeys being grown by the season ticket type growth factors from EDGE. Under PDFHv4 assumptions around 95% of the commuting demand growth comes from season ticket growth, with the remaining growth coming from full and reduced ticket growth, whilst with PDFHv5 assumptions this figure is reduced to around 62%. As the growth rate for full and reduced tickets is higher than for season ticket growth this will lead to an overall increase in commuting demand.

The new assumptions associated with PDFHv5 (different GDP demand drivers and ticket type to journey purpose conversion proportions) have altered the distribution of demand in all of the models. Under PDFHv5 assumptions, there was markedly less demand from the London area; which was due to the lower GDP elasticity parameters for London to/from the rest of the country.

Several areas of the country have more demand originating from them under PDFHv5 assumptions; for example Bedfordshire, Northamptonshire, Milton Keynes and the Highlands. This was caused by the increase in commuting demand, which was in turn caused by the new ticket type to journey purpose conversion proportions. The increase of commuting demand to these cities offsets the longer distance reductions to London, caused by the lower GDP demand elasticities.

5.2.4. PLANET South Differential Growth

5.2.4.1. Background

The PLANET South model is an AM peak (07:00-10:00) model with its key focus being on crowding on commuting services into London. Whilst this demand will not use HS2 services it will benefit from the release of capacity on the West Coast Main Line (WCML) in Phase 1 and the Midland Main Line (MML) and East Coast Main Line (ECML) in Phase 2, which will enable the introduction of additional services which will benefit commuter flows. Analysis of the EDGE population forecasts provided by the DfT implies that these areas are expected to see greater than average levels of population growth which should drive rail demand, thus increasing the benefits from HS2.

The PS EDGE case study did not consider changes in demand for South East to London commuting trips that could result from origin population growth; instead it only considered employment at the destination end of the trip. PDFH is clear that origin growth can be included as a driver but only in relative terms, i.e. if population of an origin area is higher or lower than the average for all areas for commuting into London.

To allow new forecasts to be derived which reflect the differential growth in population a separate driver was included in the PS EDGE case study. This demand driver was to be origin based, and would only affect origins for zones in the South East outside of London but excluding airport zones.

5.2.4.2. Producing New EDGE Demand Driver

The PS EDGE uses the RIFF zoning system, as supplied by the DfT, for its forecasting. In order to produce the relative population growth of the South East zones, growth factors were calculated from 2010 to the various future years for each of the thirteen RIFF zones in the South East.

A growth factor was calculated for the whole of the South East and the growth factor for each South East zone was calculated by dividing by the overall SE growth factor. Table 5-2 shows the relative population growth for each of the thirteen South East RIFF zones (rounded to 2 decimal places).

Table 5-2 Relative Population Growth for the South East RIFF Zones

RIFF Zone	Zone Name	2016	2026	2031	2036	2041	2046
13	South East	1.01	1.01	1.01	1.01	1.01	1.01
14	C2C	0.99	1.01	1.01	1.02	1.02	1.02
15	South Central	0.99	0.97	0.97	0.96	0.96	0.96
16	South West (Shorter)	0.99	0.98	0.97	0.96	0.96	0.96
21	Thames Valley	1.00	0.99	0.99	0.99	0.99	0.99
22	Chiltern	1.01	1.01	1.01	1.01	1.01	1.01
23	Silverlink	1.02	1.04	1.05	1.05	1.06	1.06
24	Thameslink	1.01	1.01	1.02	1.02	1.02	1.02
25	Great Northern	0.99	1.00	0.99	1.00	1.00	1.00
26	West Anglia (Inner)	1.01	1.04	1.05	1.06	1.06	1.06
27	West Anglia (Outer)	1.00	1.02	1.03	1.03	1.04	1.04
28	Anglia (Longer)	1.00	1.02	1.03	1.04	1.05	1.05
29	Anglia (Shorter)	0.99	1.00	1.00	1.01	1.01	1.01

The largest areas of relative population growth are on a key route for the HS2 business case; along the West Coast Main Line. This is a corridor that will be affected by the proposed released capacity timetable, and therefore contains areas where crowding relief benefits can be obtained.

As well as the demand driver, a new demand elasticity file was developed and calibrated to ensure that the relative population growth only affected season ticket growth, and not full or reduced tickets. This was to reflect the fact that the guidance suggests that population growth should only alter the patterns of commuting demand and not leisure or business trips. Season ticket growth was assigned a population growth elasticity of 1.0, which means that season ticket demand grows at the same rate as the relative population growth.

EDGE runs were undertaken to produce new future year demand forecasts based on the new EDGE demand drivers resulting from the relative population growth of South East zones.

5.2.4.3. Impact on PLANET South Demand

Table 5-3 shows the largest increases in origin demand (person trips) as a result of the introduction of the relative population demand driver, by PLANET South zone whilst Table 5-4 shows the largest decreases. These tables compare the 2026 PFMv3.0 PS matrices with those that include differential population growth.

Table 5-3 Largest Increases in Origin Demand by PLANET South Zone, 2026

PS Zone	Zone area	PFMv3.0	PFMv3.0 - Differential Population Growth	Difference
143404	Dacorum	2446.2	2499.9	53.7
146763	East Hertfordshire	2468.1	2521.1	53.0
4665	Watford	2025.7	2070.9	45.1
930161	Cambridge	2599.4	2644.4	45.0
148301	South Bedfordshire	1937.0	1980.9	43.9
4666	Watford	1864.1	1905.6	41.5
134104	Milton Keynes	1590.2	1624.5	34.3
144781	St Albans	3572.3	3603.0	30.7
101964	Sevenoaks	3440.0	3469.1	29.2
106302	Tunbridge Wells	3567.5	3596.2	28.7

Table 5-4 Largest Decreases in Origin Demand by PLANET South Zone, 2026

PS Zone	Zone area	PFMv3.0	PFMv3.0 - Differential Population Growth	Difference
117406	Brighton and Hove	7058.7	6964.4	-94.3
113402	Woking	5504.1	5430.5	-73.6
118101	Crawley	5912.7	5840.6	-72.1
4515	Sutton	5031.9	4963.6	-68.3
6015	Elmbridge	2985.1	2943.0	-42.1
118403	Mid Sussex	2856.1	2814.6	-41.6
6017	Elmbridge	2402.7	2367.9	-34.8
114461	Guildford	2508.0	2476.7	-31.3
125102	Basingstoke and Dean	3007.7	2976.9	-30.8
121305	Surrey Heath	2546.9	2516.8	-30.0

Overall PLANET South demand decreases very slightly when the population demand driver and elasticities were incorporated into the matrix production process. The 2026 demand decreased by 0.03%, and the 2043 demand by 0.1%. This slight disparity in the matrix totals is caused by the fact that whilst relative population is used as the extra demand driver in the production of the new demand matrices, the relative population does not necessarily equal the relative demand from each of the in-scope origin RIFF zones.

5.2.4.4. Impact on P-A and A-P Matrices

PLANET South contains P-A (Production-Attraction) and A-P (Attraction-Production) matrices. The P-A matrices represent a journey made during the AM Peak Period from a ‘production’ zone (e.g. home) to an ‘attraction’ zone (e.g. a place of work). The A-P matrices represent a journey made during the AM peak period from an ‘attraction’ zone to a ‘production’ zone, and could for example represent someone returning home during the AM peak period after working a night-shift. The P-A matrices make up the majority of the total demand in the model.

Analysis of the change in the distribution of trip origins shows that, whilst the largest changes are in trips with origins within the population demand driver scope (i.e. from within the zones identified as in scope), there is also a small change in trips with origins outside of the scope (i.e. central London). The presence of A-P demand in the model causes this seemingly unintuitive impact. When the population demand driver alters the distribution of where people live in the South East, the journeys made by people returning home during the AM Peak Period will be affected accordingly. Therefore, it is correct to observe a slight change in trips made with origins outside of those zones previously identified as in scope.

5.2.5. Revised Rail Demand Drivers

A set of revised demand drivers which reflected the latest OBR forecasts was provided by the DfT. This section describes the demand drivers and provides a comparison of the sources of the previous drivers received in March 2012, and used for the PFMv3.0 forecasts, and those used for the PFMv4.3 forecasts.

5.2.5.1. Demand Drivers

There are a total of fourteen demand drivers which feed into the future year forecasts of rail demand. These drivers can be categorised as follows:

Socioeconomic drivers:

- Population
- Employment
- GDP per capita

Rail policy:

- National Rail fares
- London Underground fares

Intermodal competition drivers:

- Car availability
- Car time
- Fuel cost
- Bus cost
- Bus time
- Bus headway
- Air cost
- Air headway
- Air passengers

The DfT provided a summary of the changes to the sources underpinning the demand drivers since the previous set used in PFMv3.0 in March 2012. These are shown in Table 5-5 below.

Table 5-5 Data Sources (from DfT Supporting Documentation)

Item	March 2012 source – PFMv3.0	October 2012 source – PFMv4.3
Population	ONS national (October 2011), with regional shares based on OEF (March 2012)	ONS national (October 2011, based on low migration variant), with regional shares based on CEBR (July 2012)
GDP per capita and Employment	OBR national (March 2012 for short term forecasts, and July 2011 for long term forecasts) / with regional shares based on OEF (March 2012)	OBR national (March 2012 for short term forecasts and July 2012 for long term forecasts) / with regional shares based on CEBR (July 2012), using the ONS low migration variant numbers for population
National Rail Fares	RPI +3 / for 2013 and 2014, and RPI+1 for all other years (for all fares). RPI forecast	RPI +1 for all years for all fares. RPI forecast based on a mixture of OBR (July

Item	March 2012 source – PFMv3.0	October 2012 source – PFMv4.3
	based on a mixture of OBR (March 2012) and OEF (March 2012)	2012) and CEBR (July 2012)
Underground fares	RPI+2 up to 2016/17 then RPI	As for National Rail Fares
Bus Cost	Now out-of-date	ONS/Local Economics, extrapolation of past trend.
Bus Time	Now out-of-date	Latest National Transport Model runs.
Bus Headway	Now out-of-date	Local Economics (DfT). Extrapolation of recent trends
Air Cost	DfT Aviation Model (2011)	DfT Aviation Model (August 2011)
Air Headway	Now out-of-date	DfT Aviation Model (August 2011)
Air passengers	DfT Aviation Model (2011)	DfT Aviation Model (August 2011)

It should be noted that a separate adjustment of about -0.2% per annum has been made to OBR's published real GDP growth forecasts due to the change to the deflator used by OBR to CPI while the EDGE GDP parameter was estimated using GDP deflated by RPI. The DfT recommended that no further updates were required to the car time, car availability and fuel cost drivers as the latest data was already being used:

5.2.6. Review of Demand Drivers

This section presents the demand growth for each of the drivers received from the DfT and compares these with the previous drivers received for PFMv3.0. The data received from the DfT is labelled as calendar years but relates to financial years, for example, "2010" denotes financial year "2009/10", and hence the growth presented below refers to financial years. Fares are provided in the normal EDGE format, which means the annual year-on-year growth is shown, rather than the cumulative growth.

5.2.6.1. Socioeconomic Drivers

Population

Figure 5-1 below presents the UK population forecast to 2050 supplied by the DfT for use in PFMv4.3 and the equivalent DfT forecast received for PFMv3.0. It can be seen that long term projections of population are lower, with GB population in 2050 predicted to be approximately 72.7 million in the PFMv4.3 forecast, compared with 76 million in the PFMv3.0 forecast.

Figure 5-1 GB Population Forecast

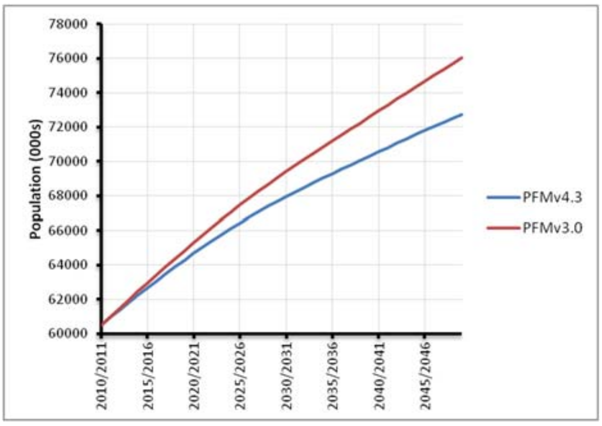


Figure 5-2 and Figure 5-3 present the population forecasts for the Central Birmingham and Central Manchester RIFF zones, as these are two of the key cities outside London on the proposed HS2 network. Population growth in Central Birmingham forecast in PFMv4.3 is faster than forecast in PFMv3.0 until approximately 2033, but then grows at a slower rate in the 2030s. By 2050 the Central Birmingham population is predicted to be approximately 20,000 lower than forecast previously.

It can be seen that the population of Manchester grows in a similar manner up to approximately 2031, but the PFMv4.3 forecast increases at a slower rate than the PFMv3.0 forecast beyond this point. Generally, the population of other areas likely to be served by HS2, such as Leeds, is also lower than previously forecast as can be seen in Figure 5-4. However, Figure 5-5 shows that London population is forecast to be higher initially, before levelling off beyond 2030.

Figure 5-2 Central Birmingham Population Forecast

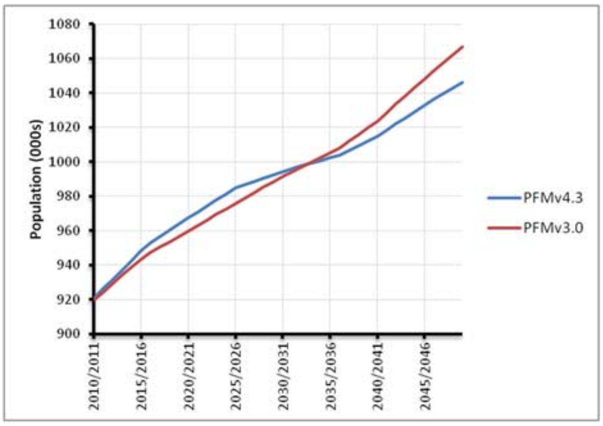


Figure 5-3 Central Manchester Population Forecast

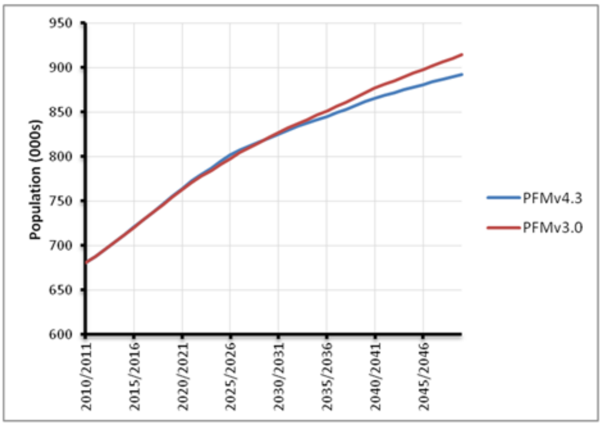


Figure 5-4 Leeds Population Forecast

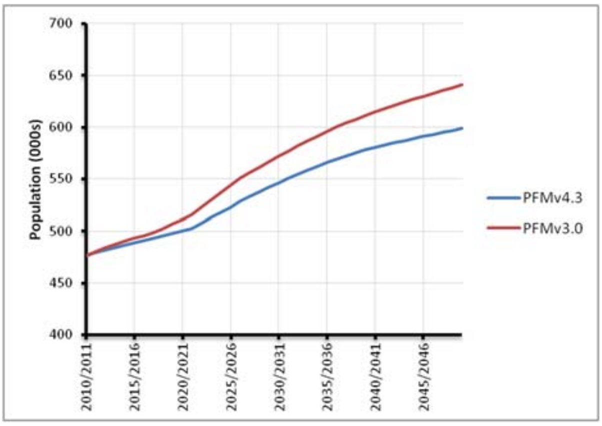
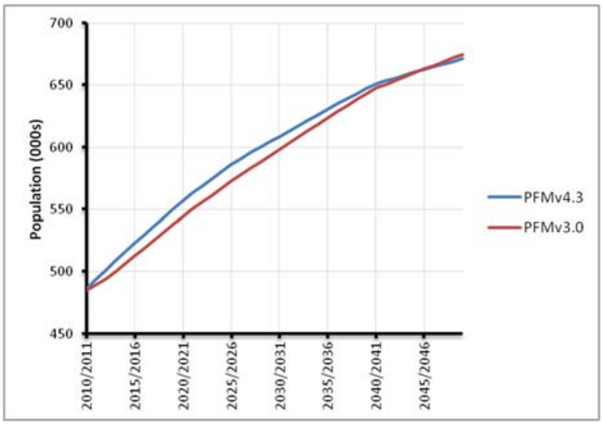


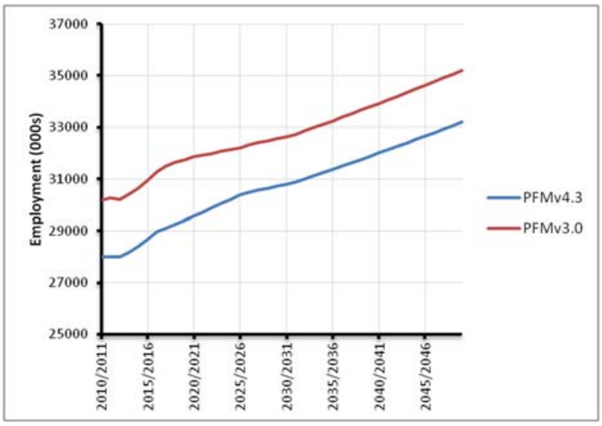
Figure 5-5 Central London Population Forecast



Employment

Figure 5-6 presents forecasts of GB employment for PFMv3.0 and PFMv4.3. It can be seen that GB employment in 2010/2011 is now reported as approximately 2 million lower than previous forecasts, though the profile of growth to 2050 is broadly similar.

Figure 5-6 GB Employment Forecast



A similar pattern is shown for Central Birmingham, Central Manchester, Leeds and Central London employment in Figure 5-7 to Figure 5-10 respectively.

Figure 5-7 Central Birmingham Employment Forecast

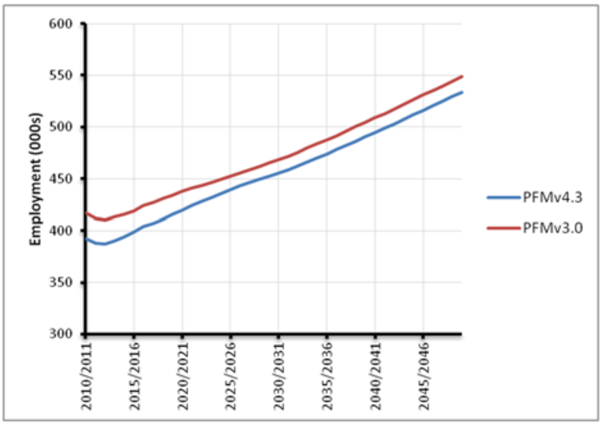


Figure 5-8 Central Manchester Employment Forecast

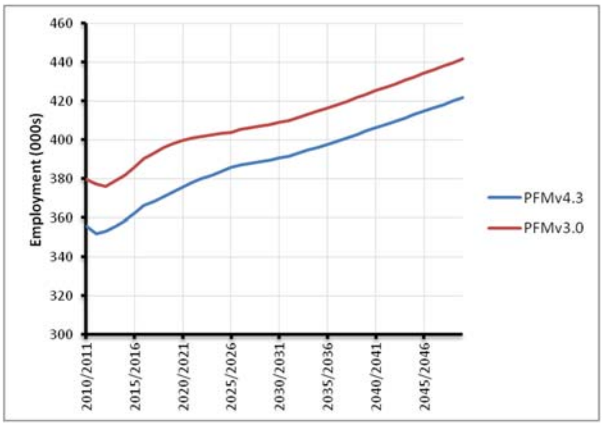


Figure 5-9 Leeds Employment Forecast

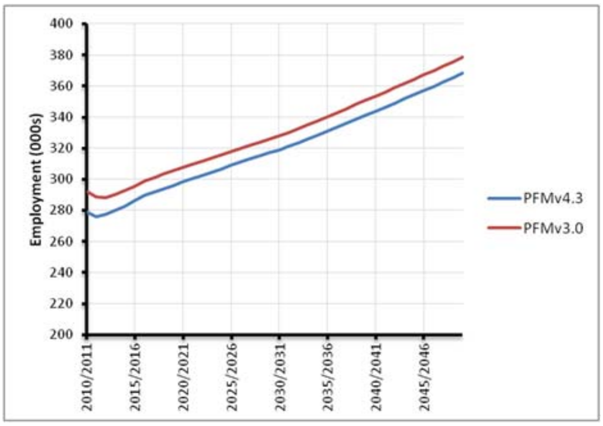
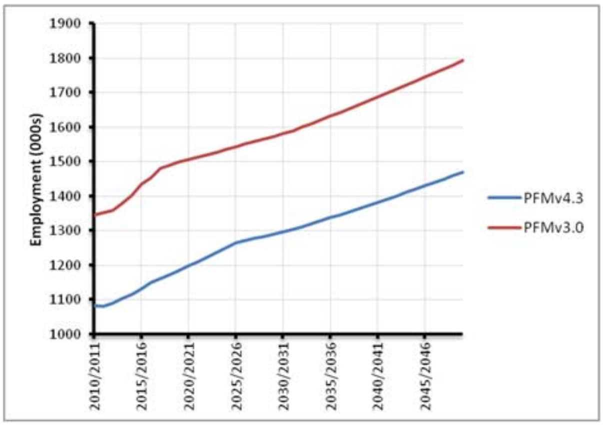


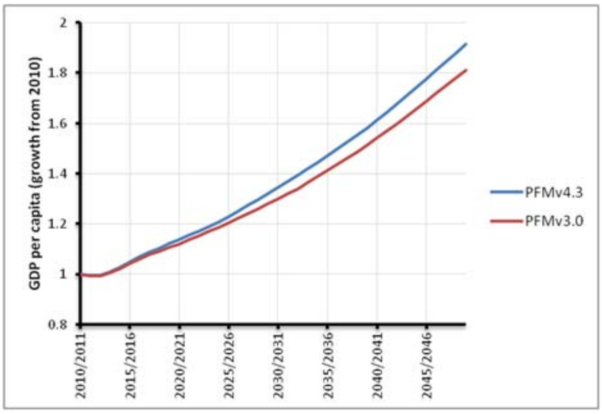
Figure 5-10 Central London Employment Forecast



GDP per Capita

GDP per capita is the most significant driver affecting rail demand on long distance services. For the latest forecasts GDP per capita has been provided as cumulative growth from 2010/2011, disaggregated by Government Office Regions. Figure 5-11 below presents a comparison of the average growth in GDP per capita for GB for the period 2010/2011 – 2049/2050 used in PFMv4.3 with that used in PFMv3.0. The graph demonstrates a similar rate of economic recovery initially, with GDP per capita growing at a faster rate beyond 2015. By 2050, average GDP per capita in the PFMv4.3 forecasts is expected to be approximately 10% higher than in the PFMv3.0 forecasts.

Figure 5-11 GB Average GDP per Capita Growth from 2010/2011



For PFMv4.3, Figure 5-12 and Figure 5-14 demonstrate that GDP per capita growth follows a similar pattern to the GB average in the West Midlands Government Office Region (GOR) and Yorkshire and Humberside GOR, whilst for the North West GOR the growth is consistent with the PFMv3.0 values apart from a slightly higher rate of growth between 2020 and 2030, as shown in Figure 5-13. Growth in the London GOR is shown in Figure 5-15 where it can be seen that it is slower initially than previously forecast, before accelerating beyond 2020.

Figure 5-12 West Midlands GDP per Capita Growth

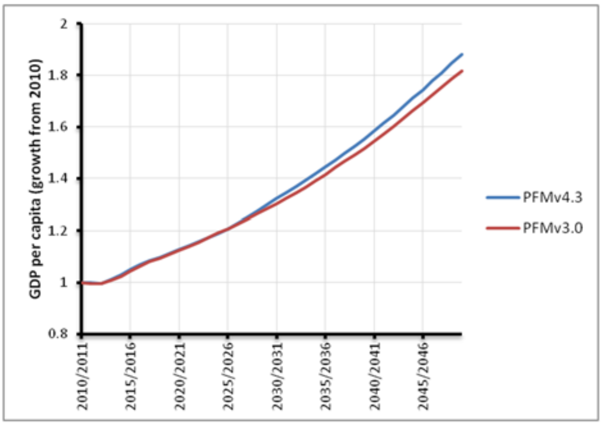


Figure 5-13 North West GDP per Capita Growth

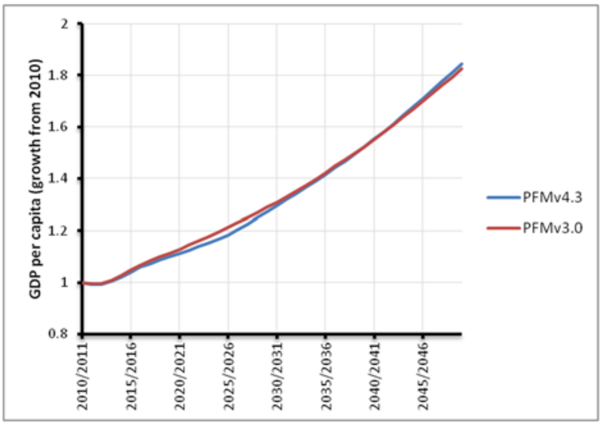


Figure 5-14 Yorkshire & Humber GDP per Capita Growth

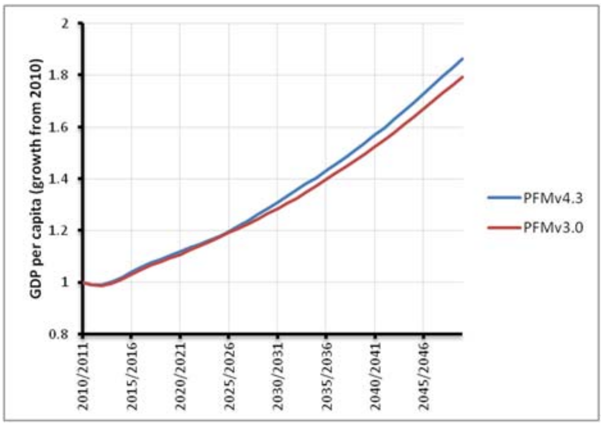


Figure 5-15 London GDP per Capita Growth

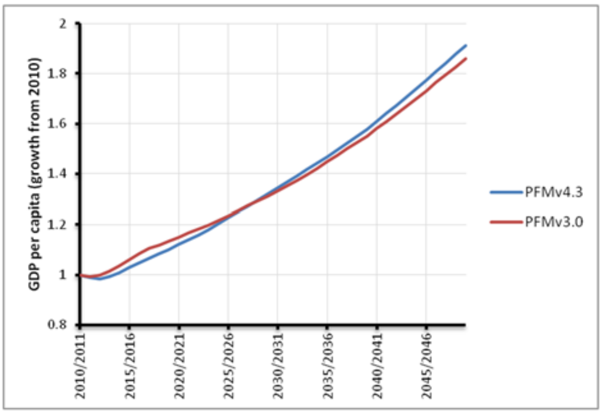


Figure 5-16 GDP per Capita Forecast Change – PVMv3.0 - PFMv4.3 Forecasts (2036)

Figure 5-16 shows the geographical variation by Government Office Region (GOR) of the change in absolute GDP per capita for the year 2036, between the PFMv3.0 and PFMv4.3 forecasts for the same year. It can be seen that GDP per capita is forecast to be higher in all regions compared with the previous forecasts, although the magnitude of this change varies significantly.

GDP per capita is expected to be over 20% higher than the previous forecasts in the South East and East Midlands regions, while in other regions, such as the North West, West Midlands and London, the change in GDP per capita compared with the previous forecasts is anticipated to be less significant.

Summary of Socioeconomic Drivers

As part of the documentation provided alongside the demand drivers, the DfT provided a summary of the growth in socioeconomic demand drivers to 2029/2030 forecast for PFMv4.3 and the equivalent forecasts produced in PFMv3.0, which is summarised in Table 5-6.

Table 5-6 Change in Economic Driver Inputs from 2010/2011 to 2029/2030

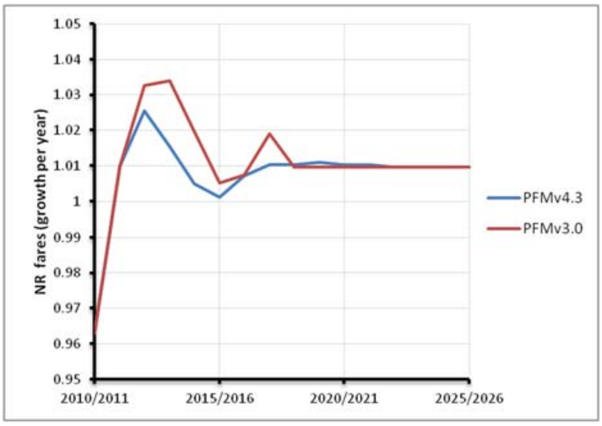
Driver	Central London		West Midlands		Yorkshire and Humber	
	PFMv3.0	PFMv4.3	PFMv3.0	PFMv4.3	PFMv3.0	PFMv4.3
Population	+19%	+21%	+11%	+11%	+15%	+10%
GDP per capita	+31%	+32%	+28%	+30%	+27%	+29%
Employment	+13%	+15%	+6%	+9%	+7%	+9%

5.2.6.2. Government Policy (Rail Fares)

National Rail Fares

National Rail fares growth has been revised since the PFMv3.0 forecasts to take into account changes to RPI forecasts and a change in Government fares policy for the years 2013 and 2014. Previously the Government had announced that fares would rise at a rate of RPI+3% in January 2013 and January 2014. This has since been revised so that fares will grow at a rate of RPI+1% for both of these years. As a result, fares growth is now forecast to grow at a rate of RPI+1% for all years between 2011 and 2050, and this is shown in Figure 5-17 together with the previous forecast.

Figure 5-17 National Rail Fares in-year Growth

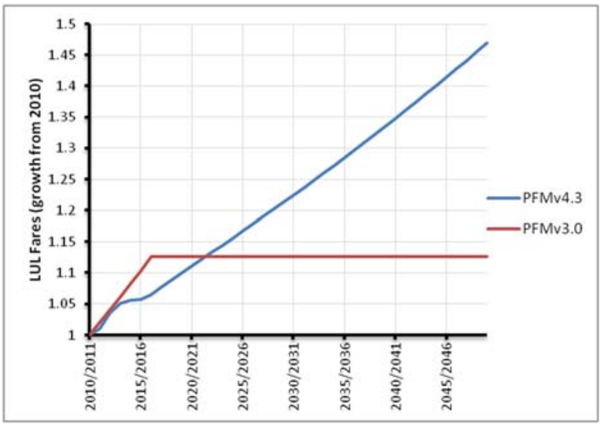


Note that the growth shown is for individual years rather than cumulative, and has been converted to financial years for consistency with the other drivers. It can be seen from the graph that real fares growth forecast in PFMv4.3 is lower than that forecast in PFMv3.0 for the period between 2012/2013 and 2015/2016 due to the change in Government policy. The year-on-year fluctuation in RPI growth is generally lower than previously forecast from 2015/2016 to 2018/2019, with RPI fluctuation forecast to be negligible (i.e. real fares growth at around 1% per annum) beyond that point.

London Underground Fares

London Underground (LUL) fares growth has also been revised since PFMv3.0 and now reflects the same assumptions as those for National Rail fares. This is a significant change from the PFMv3.0 forecasts, as shown below in Figure 5-18. LUL fares were previously forecast to remain the same from 2016/2017 onwards, but in the PFMv4.3 forecasts continue to grow at a rate of RPI+1% until 2050.

Figure 5-18 LUL Fares Growth

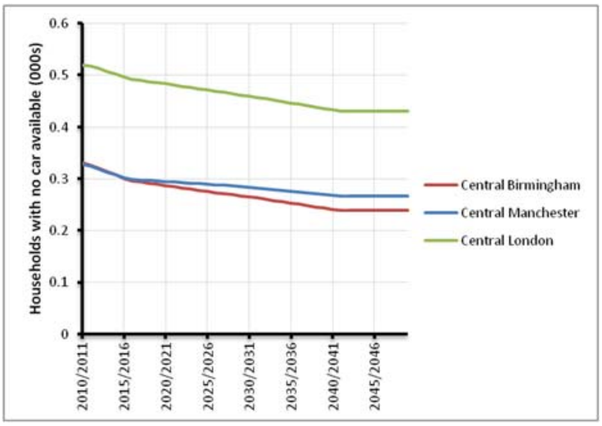


5.2.6.3. Intermodal Competition Drivers

Car Availability

The DfT recommended that the PFMv3.0 forecasts of car availability should still be used and so this results in no impact on passenger demand. Figure 5-19 summarises the car availability drivers for the Birmingham, Manchester and London RIFF zones. This driver represents the proportion of households with no car available. The graph demonstrates that the number of households with no car decreases with time, with no change beyond 2041. It can also be seen that the proportion of households with no car available in Central London is far higher than in Central Birmingham or Central Manchester.

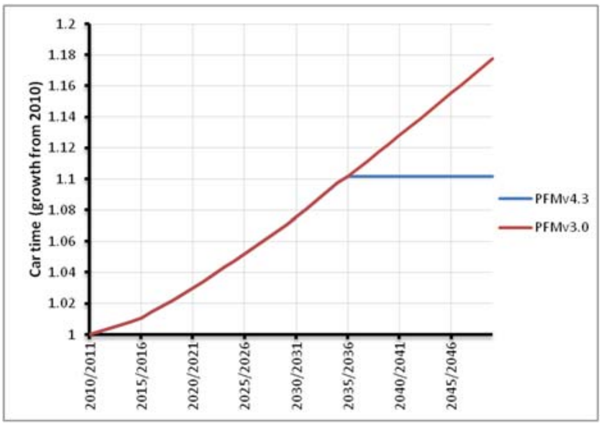
Figure 5-19 Car Availability Forecast



Car Time

The DfT recommended that the PFMv3.0 forecasts of car time should be used in PFMv4.3 so again there will be no impact on demand. However, it should be noted that the drivers received from DfT were adjusted in PFMv3.0 to continue growth beyond 2036 in line with growth in the previous five years. To ensure consistency with the highway demand forecasts it was agreed with the DfT that for the PFMv4.3 forecasts the growth beyond 2036 should not be extrapolated forwards. This is demonstrated in Figure 5-20 where the adjusted forecasts used in PFMv3.0 are compared with the unadjusted forecasts used in PFMv4.3.

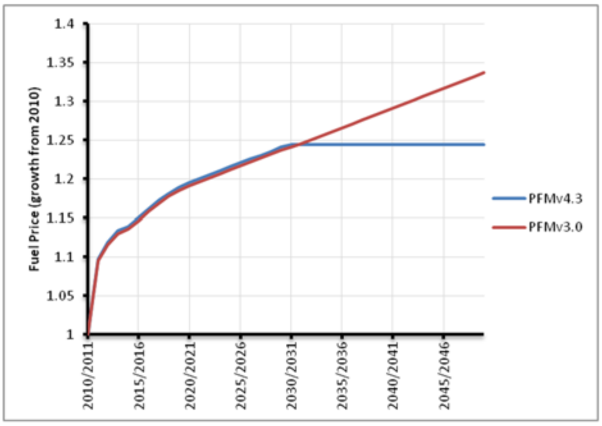
Figure 5-20 Car Time Growth (Rest of Country to London)



Fuel Price

The PFMv4.3 forecasts of fuel price were marginally higher than the PFMv3.0 forecasts as can be seen in Figure 5-21. Both sets of forecasts assumed no growth beyond 2031 but the PFMv3.0 forecasts had been adjusted to continue the average growth from 2026 to 2031 to beyond 2031. It was agreed with the DfT that forecasts should be used as received and not be extrapolated beyond 2031.

Figure 5-21 Growth in Car Fuel Prices

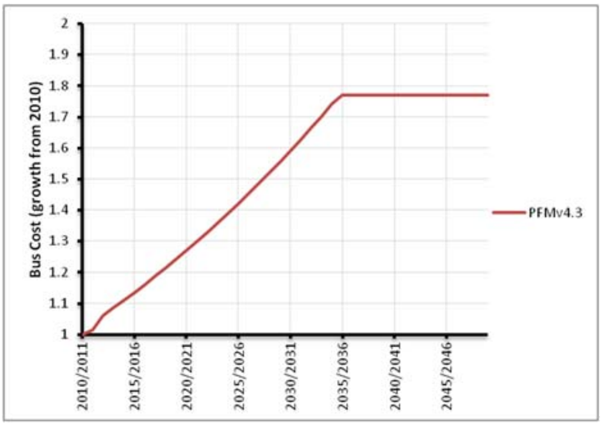


Bus Cost

Although the bus cost forecasts provided are identical to those received for use in PFMv3.0, these had not actually been used in PFMv3.0 as DfT advice at that time was to continue using earlier forecasts. On the advice of the DfT these bus cost forecasts have now been used in the development of the PFMv4.3 forecasts.

Figure 5-22 shows the PFMv4.3 forecasts of bus cost for long distance trips and it can be seen that there is no growth forecast beyond 2036. No growth in bus costs had been applied to long distance trips in the forecasts used in PFMv3.0 and so the assumption of bus cost growth would be expected to have a positive impact on rail demand, as it makes bus travel less attractive.

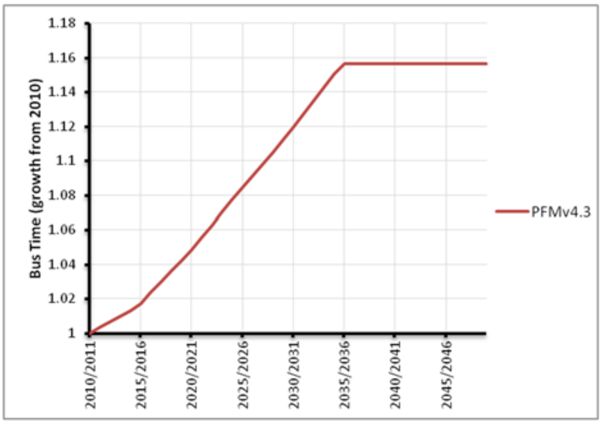
Figure 5-22 Bus Cost Growth (Rest of Country to/from London Travelcard Area)



Bus Time

The bus time forecasts received from the DfT for PFMv4.3 were also identical to those received for the PFMv3.0 update. On DfT advice these had not been used in PFMv3.0 but instead earlier forecasts were used which did not include bus time growth outside of urban areas. For PFMv4.3 the DfT advised that the latest forecasts should be used. Figure 5-23 presents bus time growth for long distance trips in the PFMv4.3 forecasts and it is expected that the introduction of bus time growth should have a positive impact on rail demand.

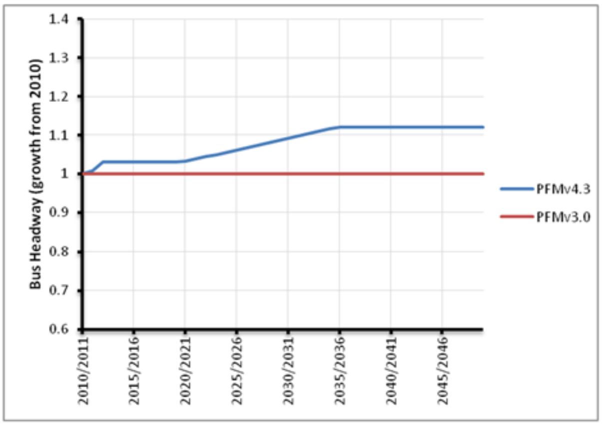
Figure 5-23 Bus Time Growth (Rest of Country to/from London Travelcard Area)



Bus Headway

The bus headway growth forecasts received for PFMv4.3 were labelled as "corrected" and differed significantly from those originally received for PFMv3.0. As with bus cost and bus time, earlier forecasts of bus headway, which show no growth beyond 2010/2011, were used in PFMv3.0. Figure 5-24 below compares the bus headways used in the PFMv3.0 and PFMv4.3 forecasts for long distance trips. By using the PFMv4.3 forecasts, which predict an increase in headway to 2036, rail demand would be expected to increase as bus services become more infrequent.

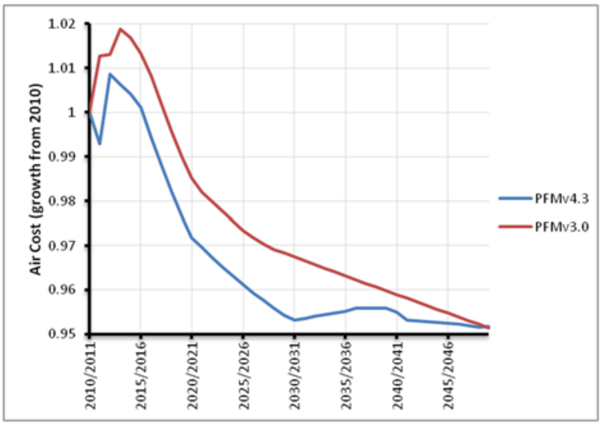
Figure 5-24 Bus Headway Growth (Rest of Country to/from London Travelcard Area)



Air Cost

The PFMv4.3 forecasts of air costs have been updated following a revision of the DfT's Aviation model and are lower than the PFMv3.0 forecasts as shown in Figure 5-25. In PFMv4.3 the decline in costs is greater up to 2031 and beyond that year the air costs are forecast to remain relatively steady. The overall decline in cost to 2050 is similar between the two sets of forecasts.

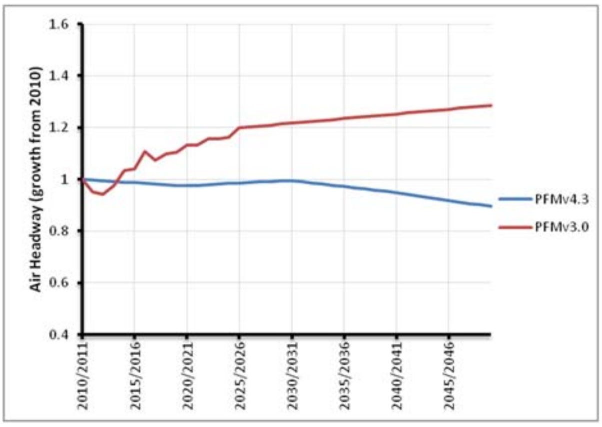
Figure 5-25 UK Air Cost Growth



Air Headway

Forecasts of air headway have also been revised in PFMv4.3. Air headway is forecast to remain fairly steady to 2031 and then decline between 2031 and 2050, as shown in Figure 5-26 for flows between the London Travelcard area and the rest of the country. This represents a significant change from the PFMv3.0 forecasts, which predicted a growth in air headway of just under 30% by 2050.

Figure 5-26 Air Headway Growth (Rest of Country to/from London Travelcard Area)



Air Passengers

Figure 5-27 to Figure 5-30 show the PFMv4.3 forecasts of air passengers at London Heathrow, London Gatwick, Birmingham and Manchester airports, respectively. It can be seen that forecasts of air passenger growth have changed significantly from those received PFMv3.0.

Growth in Heathrow passenger numbers is expected to be higher than previously forecast whilst passenger growth at Gatwick was previously expected to accelerate rapidly from 2025, but is now forecast to grow at a much lower rate.

Birmingham passengers are predicted to grow more quickly between now and 2030 compared with previous forecasts, before levelling off beyond this point. Growth at Manchester is lower to 2030 but then becomes much higher before levelling off at around 2042.

Figure 5-27 Air Passenger Growth (London Heathrow)

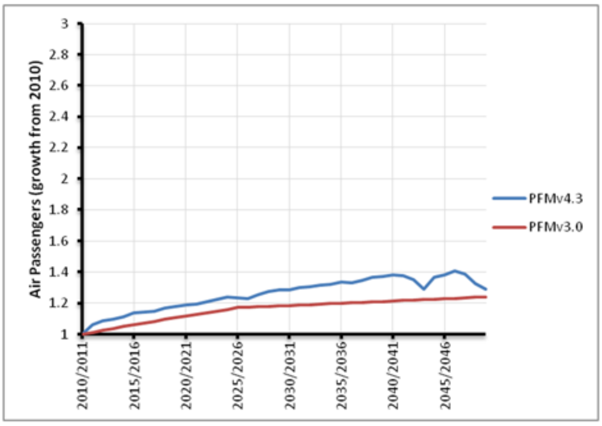


Figure 5-28 Air Passenger Growth (London Gatwick)

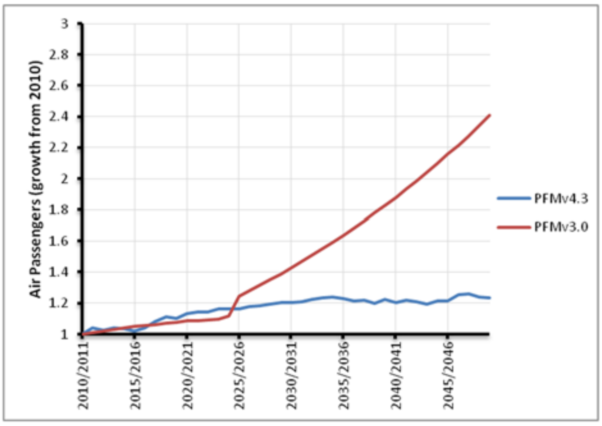


Figure 5-29 Air Passenger Growth (Birmingham)

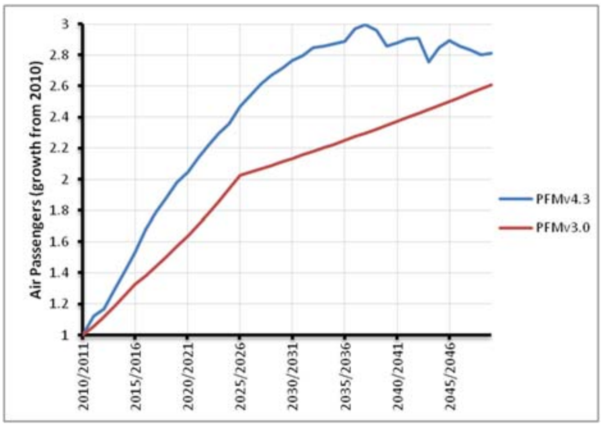
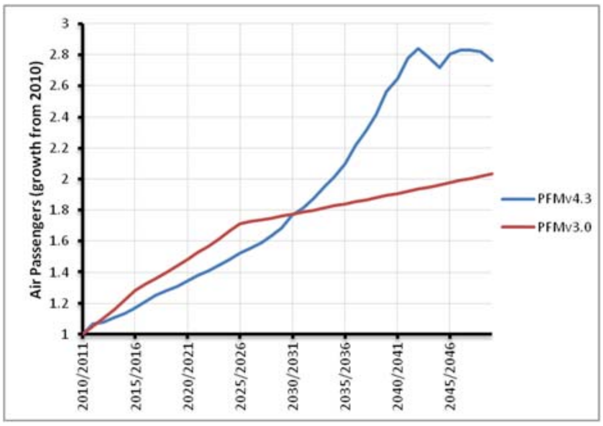


Figure 5-30 Airport Passenger Growth (Manchester)



Summary of Intermodal Drivers

The DfT provided a summary of the most significant changes to forecasts of intermodal competition to 2029/2030 for PFMv4.3 and the equivalent forecasts produced for PFMv3.0. These are summarised in Table 5-7.

Table 5-7 Change in Intermodal Driver Inputs from 2010/2011 to 2029/2030

Driver	London-Rest of Country		Rest of Country-London		Non-London > 20 miles	
	PFMv3.0	PFMv4.3	PFMv3.0	PFMv4.3	PFMv3.0	PFMv4.3
Bus Cost	0%	+55%	0%	+55%	0%	+55%
Bus Time	0%	+11%	0%	+11%	0%	+6%
Air Headway	+28%	-14%	+28%	-1%	+35%	-36%

5.2.6.4. Expected Impact on Demand Forecasts

Table 5-8 presents a summary of the demand drivers received for PFMv4.3 and how these compare with the previous forecasts used. Overall the changes to the drivers are expected to have a positive effect on rail demand, due to the impact of the higher GDP growth, as well as a reduction in rail fares. Lower forecasts of population and improved air services are expected to temper the increase in rail demand to some extent.

Table 5-8 Summary of Demand Drivers & Expected Impacts

Demand Driver	Comparison with PFMv3.0 forecast	Expected impact on HS2 demand
Population	The UK population forecast is lower than before, although there are some local variations.	▼Cities outside of London, such as Birmingham and Manchester, will have lower demand than previously forecast in the long term, though for some cities it will be higher in the short term
Employment	Employment growth is similar to before but on a lower base in 2010/2011	■As growth will be applied to the existing 2010/2011 base, demand is expected to experience relatively little impact
GDP per capita	On average growth is slightly higher by 2030 and is forecast to be approximately 10% higher by 2050	▲The higher GDP per capita growth will amplify the higher growth and is expected to have a positive impact on demand
Rail Fares	Rail fares in 2013 and 2014 are 2% lower than previously forecast due to a change in government policy. RPI growth is also lower than previous forecasts.	▲2% lower fares for 2 years will increase rail demand by approximately 2-3%
London Underground Fares	LU fares forecast to increase in line with National Rail fares	■There is unlikely to be any impact on long distance rail demand. Rail demand will increase in PLANET South.
Car Availability	No change	■None
Car Journey Times	No change	■None
Fuel Prices	Very little change from previous forecast	■Minimal
Bus Cost	A increase in bus cost is now included for long distance services	▲Long distance bus services now effectively less attractive, thus making rail more attractive
Bus Time	Forecast growth now introduced on long distance services	▲Long distance bus services now effectively less attractive, thus making rail more attractive
Bus Headway	Bus headway is now predicted to increase for long distance travel, which equates to a lower frequency of buses	▲Long distance bus services now effectively less attractive, thus making rail more attractive
Air Cost	Generally expected to grow more slowly than previously forecast	▼Air services more attractive, rail demand expected to be lower
Air Headway	Headway now expected to be lower, which equates to a rise in flights	▼Air services more attractive, rail demand expected to be lower
Air Passengers	Air passenger growth varies significantly depending upon the airport	■Overall change expected to be insignificant as positive and negative changes cancel each other out

5.2.7. Rail Demand Forecasts

The final step in the move from PFMv3.0 to v4.3 was to develop revised rail demand matrices using the EDGE software. These matrices were developed incorporating all of the changes to the forecasting process described above plus the use of the revised demand drivers.

For PLD and PLANET South the forecast matrices were produced from the underlying base year rail demand matrices developed for PFMv4.3 and described in Section 2 above. For the remaining regional PLANET models the previous PFMv3.0 base year matrices were used to develop the forecasts as no changes had been made to these base year matrices.

As a number of changes have been made to the forecasting process and the demand drivers the likely changes to the final rail demand matrices are difficult to accurately forecast. However, the overall changes that would be expected can be summarised as follows:

- The move to PDFHv5 would be expected to reduce the leisure and business but increase the commuting demand;
- Increased growth in GDP per capita and lower rail fares growth will lead to higher overall demand; and
- The revised PFMv4.3 rail matrices show reduced commuting demand and an increase in business and leisure demand which will be seen in the forecasts.

5.2.7.1. 2026 Forecasts

Table 5-9 below summarises the matrix totals for the PFMv4.3 demand forecasts compared with the demand matrices used in PFMv3.0.

Table 5-9 Rail Matrix Totals for 2026 by Model & Trip Purpose

Journey Purpose	2026 PFMv3.0	2026 PFMv4.3	Difference	%
PLANET Long Distance (PLD)				
Commuting NCA	99,458	76,781	-22,677	-29.5%
Commuting CA from	241,944	234,325	-7,619	-3.3%
Commuting CA to	241,945	234,326	-7,619	-3.3%
Business NCA	-	-	-	-
Business CA from	92,316	125,884	33,568	26.7%
Business CA to	92,316	93,704	1,388	1.5%
Leisure NCA	82,793	117,162	34,369	29.3%
Leisure CA from	189,126	284,346	95,220	33.5%
Leisure CA to	189,126	208,794	19,668	9.4%
Total	**1,229,023**	**1,375,321**	**146,298**	**10.6%**
PLANET South (PS)				
Commuting PA	1,661,530	1,873,750	212,220	11.3%
Commuting AP	33,714	38,658	4,944	12.8%
Business PA	165,848	182,823	16,975	9.3%
Business AP	10,237	11,830	1,593	13.5%
Leisure PA	180,015	195,779	15,764	8.1%
Leisure AP	19,558	22,446	2,888	12.9%
Total	**2,070,902**	**2,325,286**	**254,384**	**10.9%**
PLANET Midlands (PM)				
Commuting CA	58,870	70,130	11,260	16.1%
Commuting NCA	9,565	11,286	1,721	15.2%
Business CA	12,762	14,208	1,446	10.2%
Business NCA	1,645	1,828	183	10.0%
Leisure CA	11,525	12,844	1,319	10.3%
Leisure NCA	1,621	1,797	176	9.8%
Total	**95,988**	**112,093**	**16,105**	**14.4%**
PLANET North (PN)				
Commuting CA	84,048	98,950	14,902	15.1%
Commuting NCA	17,770	20,618	2,848	13.8%
Business CA	30,321	32,212	1,891	5.9%

Journey Purpose	2026 PFMv3.0	2026 PFMv4.3	Difference	%
Business NCA	5,440	5,793	353	6.1%
Leisure CA	24,817	26,527	1,710	6.4%
Leisure NCA	4,596	4,915	319	6.5%
Total	**166,992**	**189,015**	**22,023**	**11.7%**

Table 5-10 to Table 5-13 show the daily 2026 rail matrices for business, leisure, commuting and total trips.

Table 5-10 2026 Daily Rail Business Person matrix

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	3,227	546	8,179	208	744	125	682	166	79	1,521	1,261	**16,737**
East of England	509	0	0	301	277	72	0	13	125	508	545	**2,349**
London	7,129	0	0	2,050	9,513	1,179	0	640	2,044	10,679	6,498	**39,733**
North East	207	305	2,124	2,123	607	961	155	55	10	159	1,098	**7,804**
North West	640	280	9,571	598	21,980	685	655	438	581	2,019	3,021	**40,468**
Scotland	122	75	1,175	955	692	37,364	60	27	11	122	436	**41,039**
South East	668	0	0	154	668	61	0	79	342	1,728	497	**4,197**
South West	169	14	713	55	453	27	85	358	724	899	320	**3,816**
Wales	84	133	2,305	11	743	14	358	830	6,398	299	74	**11,250**
West Midlands	1,300	512	11,224	153	1,985	120	1,680	838	251	5,777	572	**24,413**
Yorks & Humber	1,165	553	6,638	1,036	3,126	437	495	314	66	579	13,375	**27,783**
Grand Total	**15,221**	**2,418**	**41,928**	**7,645**	**40,787**	**41,045**	**4,171**	**3,757**	**10,631**	**24,289**	**27,696**	**219,588**

Table 5-11 2026 Daily Rail Leisure Person matrix

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	18,301	1,839	6,040	223	3,292	292	1,515	513	214	4,464	3,903	**40,595**
East of England	1,721	0	0	200	670	410	0	24	129	762	909	**4,825**
London	5,264	0	0	1,574	5,993	2,945	0	452	2,093	7,058	4,715	**30,094**
North East	223	216	1,616	10,460	1,029	1,523	262	125	26	302	2,424	**18,207**
North West	2,867	681	6,053	1,015	12,2991	2,481	1,662	684	2,770	4,296	7,376	**152,876**
Scotland	286	418	2,963	1,480	2,509	138,362	401	194	30	447	1,152	**148,242**
South East	1,458	0	0	259	1,668	403	0	198	830	2,757	651	**8,224**
South West	518	25	489	126	702	193	218	1,656	2,470	1,750	474	**8,621**
Wales	229	149	2,375	29	3,302	37	918	2,767	43,590	2,234	234	**55,864**
West Midlands	4,202	775	7,548	292	4,444	448	2,778	1,677	1,995	29,514	1,205	**54,878**
Yorks & Humber	3,664	933	4,843	2,304	7,603	1,156	650	464	217	1,222	64,818	**87,873**
Grand Total	**38,732**	**5,036**	**31,928**	**17,963**	**154,202**	**148,251**	**8,405**	**8,753**	**54,364**	**54,806**	**87,861**	**610,301**

Table 5-12 2026 Daily Rail Commuting Person matrix

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	19,101	909	7,003	54	2,450	38	295	50	12	3,863	2,205	**35,980**
East of England	909	0	0	45	118	50	0	2	23	125	57	**1,330**
London	7,003	0	0	204	1354	127	0	278	366	3,497	682	**13,511**
North East	54	45	204	11,146	124	296	30	19	36	10	1,206	**13,171**
North West	2,450	118	1,354	124	121,733	247	143	38	857	1,604	4,115	**132,783**
Scotland	38	50	127	296	247	169,107	19	7	70	49	150	**170,162**
South East	295	0	0	30	143	19	0	100	71	1,205	110	**1,974**
South West	50	2	278	19	38	7	100	1,809	2,196	723	16	**5,239**
Wales	12	23	366	36	857	70	71	2,196	34,994	204	15	**38,845**
West Midlands	3,863	125	3,497	10	1,604	49	1,205	723	204	33,440	152	**44,874**
Yorks & Humber	2,205	57	682	1,206	4,115	150	110	16	15	152	78,853	**87,561**
Grand Total	**35,980**	**1,330**	**13,511**	**13,171**	**132,783**	**170,162**	**1,974**	**5,239**	**38,845**	**44,874**	**87,561**	**545,432**

Table 5-13 2026 Daily Rail Total Person matrix

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	40,629	3,294	21,222	485	6,485	455	2,492	729	305	9,848	7,368	**93,311**
East of England	3,139	0	0	546	1,065	533	0	39	277	1,396	1,511	**8,505**
London	19,396	0	0	3,827	16,861	4,252	0	1,370	4,504	21,234	11,895	**83,338**
North East	484	566	3,944	23,730	1,761	2,780	448	199	73	472	4,728	**39,183**
North West	5,957	1,079	16,979	1,738	266,704	3,413	2,460	1,160	4,207	7,919	14,512	**326,128**
Scotland	445	544	4,266	2,731	3,448	344,834	480	227	111	618	1,738	**359,443**
South East	2,421	0	0	444	2,478	483	0	377	1,244	5,690	1,258	**14,396**
South West	737	41	1,480	200	1,192	227	403	3,823	5,390	3,373	810	**17,676**
Wales	325	305	5,046	77	4,902	121	1,348	5,793	84,983	2,736	323	**105,959**
West Midlands	9,365	1,413	22,268	455	8,033	617	5,664	3,239	2,450	68,731	1,929	**124,166**
Yorks & Humber	7,035	1,543	12,164	4,546	14,843	1,743	1,256	793	297	1,953	157,045	**203,217**
Grand Total	**89,932**	**8,784**	**87,368**	**38,779**	**327,773**	**359,457**	**14,551**	**17,749**	**103,840**	**123,970**	**203,118**	**137,5321**

5.2.7.2. Derivation of Cap Year Forecasts

The second forecast year is referred to as the cap year and this represents the year at which long distance rail demand is deemed to reach a saturation point, beyond which no further demand growth occurs. The concept of cap year is an artificial construct and there is no standard methodology for its calculation.

To derive the cap year long distance rail trips over 100 miles (within PLD) are matched to the level originally predicted in the February 2011 consultation model: 290,146 trips.

Table 5-14 shows the level of demand for each forecast year using EDGE forecasts at five year intervals from 2026 and linear interpolation for the interim years. The analysis has indicated that the number of trips over 100 miles in 2036 (292,556) lies closest to the target figure of 290,146 trips. Therefore the second model forecast year was determined to be 2036 and no additional matrices were required.

Table 5-14 Derivation of Cap Year for PFMv4.3 Forecasts

PFMv4.3	Total Demand	>100 Miles	% of Total
2026	**1,375,321**	**229,350**	**16.7%**
2027	1,403,158	235,276	16.8%
2028	1,430,994	241,202	16.9%
2029	1,458,831	247,128	16.9%
2030	1,486,667	253,054	17.0%
2031	**1,514,504**	**258,980**	**17.1%**
2032	1,541,132	264,878	17.2%
2033	1,567,760	270,776	17.3%
2034	1,594,388	276,673	17.4%
2035	1,621,017	282,571	17.4%
2036	**1,647,645**	**288,469**	**17.5%**
2037	1,673,661	293,856	17.6%
2038	1,699,677	299,242	17.6%
2039	1,725,693	304,629	17.7%
2040	1,751,709	310,016	17.7%
2041	**1,777,725**	**315,402**	**17.7%**
2042	1,810,341	322,111	17.8%
2043	1,842,956	328,820	17.8%
2044	1,875,572	335,529	17.9%
2045	1,908,188	342,238	17.9%
2046	**1,940,804**	**348,947**	**18.0%**

The rail demand forecast matrix totals for the cap year of 2036 are presented in Table 5-15. These have been compared with the corresponding cap year forecasts for 2037 from PFMv3.0.

Table 5-15 Rail Matrix Totals for the Cap Years (2037 and 2036) by Model and Trip Purpose

Journey Purpose	PFMv3.0 (2037)	PFMv4.3 (2036)	Difference	%
PLANET Long Distance (PLD)				
Commuting NCA	103,149	83,109	-20,040	-24.1%
Commuting CA from	278,426	279,909	1,483	0.5%
Commuting CA to	278,426	279,909	1,483	0.5%
Business NCA	-	-	-	-
Business CA from	112,498	155,621	43,123	27.7%

Journey Purpose	PFMv3.0 (2037)	PFMv4.3 (2036)	Difference	%
Business CA to	112,498	116,323	3,825	3.3%
Leisure NCA	93,910	131,404	37,494	28.5%
Leisure CA from	235,306	345,969	110,663	32.0%
Leisure CA to	235,306	255,401	20,095	7.9%
Total	**1,449,519**	**1,647,645**	**198,126**	**12.0%**
PLANET South (PS)				
Commuting PA	1,858,361	2,197,154	338,793	15.4%
Commuting AP	37,536	45,097	7,561	16.8%
Business PA	200,675	222,915	22,240	10.0%
Business AP	12,425	14,468	2,043	14.1%
Leisure PA	219,747	239,286	19,539	8.2%
Leisure AP	23,775	27,468	3,693	13.4%
Total	**2,352,520**	**2,746,389**	**393,869**	**14.3%**
PLANET Midlands (PM)				
Commuting CA	65,866	83,263	17,397	20.9%
Commuting NCA	10,123	12,660	2,537	20.0%
Business CA	14,652	16,780	2,128	12.7%
Business NCA	1,802	2,064	262	12.7%
Leisure CA	13,331	15,236	1,905	12.5%
Leisure NCA	1,775	2,022	247	12.2%
Total	**107,549**	**132,024**	**24,475**	**18.5%**
PLANET North (PN)				
Commuting CA	93,181	117,931	24,750	21.0%
Commuting NCA	17,999	22,856	4,857	21.3%
Business CA	36,945	39,293	2,348	6.0%
Business NCA	5,991	6,515	524	8.0%
Leisure CA	30,429	32,633	2,204	6.8%
Leisure NCA	5,086	5,576	490	8.8%
Total	**189,631**	**224,804**	**35,173**	**15.6%**

Table 5-16 to Table 5-19 show the daily 2026 rail matrices for business, leisure, commuting and total trips.

Table 5-16 2036 Daily Rail Business Person matrix

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	3,953	674	11,244	253	898	152	836	205	97	1,850	1,549	**21,712**
East of England	629	0	0	367	338	88	0	16	154	619	675	**2,886**
London	9,664	0	0	2,631	12,235	1,500	0	859	2,649	13,853	8,538	**51,928**
North East	252	372	2,763	2,513	725	1,142	188	66	12	189	1,324	**9,547**
North West	773	341	12,441	714	25,739	809	795	532	697	2,416	3,686	**48,943**
Scotland	147	92	1,511	1,135	815	43,260	73	32	13	145	525	**47,747**
South East	819	0	0	187	813	74	0	97	420	2,103	611	**5,124**
South West	208	17	973	67	551	32	105	440	891	1,095	395	**4,774**
Wales	103	164	3,039	14	893	17	439	1,020	7,835	360	90	**13,974**
West Midlands	1,577	623	14,709	183	2,378	142	2,039	1,018	302	6,944	692	**30,608**
Yorks & Humber	1,430	683	8,831	1,253	3,829	528	609	387	80	701	16,367	**34,700**
Grand Total	**19,555**	**2,965**	**55,512**	**9,316**	**49,215**	**47,746**	**5,085**	**4,672**	**13,150**	**30,275**	**34,452**	**27,1945**

Table 5-17 2036 Daily Rail Leisure Person matrix

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	22,472	2,258	8,267	271	3,962	352	1,853	629	262	5,394	4,773	**50,494**
East of England	2,115	0	0	244	814	498	0	29	158	924	1,118	**5,900**
London	7,097	0	0	2,011	7,671	3,740	0	608	2,705	9,140	6,165	**39,138**
North East	268	261	2,089	12,400	1,221	1,800	315	151	31	359	2,904	**21,799**
North West	3,447	825	7,838	1,205	144,140	2,907	2,008	825	3,305	5,122	8,926	**180,548**
Scotland	344	505	3,801	1,748	2,936	159,036	481	232	35	526	1,381	**171,026**
South East	1,786	0	0	313	2,019	484	0	245	1,012	3,335	795	**9,988**
South West	636	30	666	153	849	232	270	2,030	3,024	2,116	581	**10,588**
Wales	279	181	3,114	35	3,946	44	1,118	3,383	53,477	2,678	285	**68,540**
West Midlands	5,070	938	9,878	346	5,305	528	3,357	2,024	2,391	35,431	1,450	**66,719**
Yorks & Humber	4,476	1,147	6,425	2,767	9,227	1,389	794	568	264	1,472	79,505	**108,034**
Grand Total	**47,989**	**6,147**	**42,078**	**21,493**	**182,089**	**171,011**	**10,195**	**10,725**	**66,664**	**66,498**	**107,883**	**732,773**

Table 5-18 2036 Daily Rail Commuting Person matrix

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	23,049	1,186	8,162	70	3,143	49	372	66	16	4,961	2,773	**43,847**
East of England	1,186	0	0	59	153	66	0	3	30	162	75	**1,734**
London	8,162	0	0	230	1,527	145	0	324	425	4,028	783	**15,623**
North East	70	59	230	12,989	159	378	39	25	47	13	1,556	**15,565**
North West	3,143	153	1,527	159	136,036	312	185	49	1,069	2,033	5,354	**150,021**
Scotland	49	66	145	378	312	198,891	24	9	90	63	193	**200,219**
South East	372	0	0	39	185	24	0	130	93	1,551	145	**2,540**
South West	66	3	324	25	49	9	130	2,277	2,858	938	21	**6,699**
Wales	16	30	425	47	1,069	90	93	2,858	42,128	260	20	**47,035**
West Midlands	4,961	162	4,028	13	2,033	63	1,551	938	260	41,128	197	**55,333**
Yorks & Humber	2,773	75	783	1,556	5,354	193	145	21	20	197	93,193	**104,310**
Grand Total	**43,847**	**1,734**	**15,623**	**15,565**	**150,021**	**200,219**	**2,540**	**6,699**	**47,035**	**55,333**	**104,310**	**642,927**

Table 5-19 2036 Daily Rail Total Person matrix

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	49,475	4,118	27,673	594	8,003	554	3,062	900	374	12,206	9,095	**116,053**
East of England	3,929	0	0	670	1,306	651	0	49	342	1,705	1,868	**10,519**
London	24,922	0	0	4,872	21,432	5,385	0	1,791	5,780	27,021	15,487	**106,689**
North East	591	692	5,082	27,902	2,105	3,320	543	242	90	561	5,784	**46,911**
North West	7,362	1,319	21,807	2,078	305,915	4,028	2,988	1,406	5,071	9,571	17,966	**379,512**
Scotland	541	663	5,457	3,261	4,063	401,187	578	273	138	734	2,099	**418,993**
South East	2,977	0	0	539	3,017	582	0	472	1,525	6,989	1,551	**17,652**
South West	909	50	1,963	245	1,449	274	504	4,747	6,773	4,149	997	**22,061**
Wales	398	375	6,577	96	5,909	151	1,650	7,261	103,440	3,298	395	**129,549**
West Midlands	11,608	1,723	28,615	542	9,716	733	6,947	3,980	2,953	83,504	2,339	**152,661**
Yorks & Humber	8,679	1,906	16,039	5,577	18,410	2,110	1,548	976	364	2,371	189,065	**247,044**
Grand Total	**111,392**	**10,846**	**113,213**	**46,375**	**381,325**	**418,976**	**17,820**	**22,096**	**126,849**	**152,107**	**246,645**	**1,647,645**

5.2.8. Growth in Key Rail Movements

Table 5-20 shows the growth in trips in the PLD rail matrices for key rail zone to zone movements. These show total trips, in both directions.

Table 5-20 Growth in Total Weekday Trips in PLD (bi-directional)

Key PLD Zone to Zone Movements	2010 Demand	2026 Demand	% Growth 2010 – 2026	2036 Demand	% Growth 2010 – 2036
Birmingham - Central London	7,000	10,700	53%	13,700	96%
Manchester - Central London	6,600	10,400	58%	13,500	105%
Leeds - Central London	4,200	6,500	55%	8,800	110%
Glasgow - Central London	1,100	1,800	64%	2,200	100%
Liverpool - Central London	2,600	3,800	46%	4,800	85%
Newcastle - Central London	2,300	3,300	43%	4,200	83%
Edinburgh - Central London	2,100	3,400	62%	4,500	114%

5.3. Highway Demand Forecasts

5.3.1. Introduction

This section outlines the methodology used to derive the 2026 and 2036 highway forecasts from the base year highway matrices ensuring consistency with the forecasting methodologies used for the other modes. In addition the highway preloads, which represent short distance trips, were developed for the two forecast years.

5.3.2. PFMv4.3 2010 base year matrices

In order to forecast the future year highway matrices the starting point was the 2010 base year PFMv4.3 highway matrices. These matrices had been developed in Production-Attraction (PA) format where a single non-home based matrix was disaggregated to three separate purposes; these differed from the PFMv3.0 base year highway matrices which were in Origin-Destination format (OD) with business, leisure and commuting trip purposes. The following matrices PA matrices were produced in PFMv4.3:

- Home-based work (HBW) daily person PA matrix;
- Home-based employers’ business (HBEB) daily person PA matrix;
- Home-based other (HBO) daily person PA matrix;
- Non-home-based work (NHBW) daily person PA matrix;
- Non-home -based employers’ business (NHBEB) daily person PA matrix; and
- Non-home -based other (NHBO) daily person PA matrix.

The purposes of these matrices are compatible with the purposes present in the DfT’s TEMPRO (Trip End Model Presentation Program) program which uses data from the DfT’s National Trip End Model (NTEM). Growth factors were derived from TEMPRO for the following trip purposes, where non-home based (NHB) factors were used for all disaggregated non-home based matrices (NHBW, NHBEB and NHBO):

- Home-based work (HBW);
- Home-based employers’ business (HBEB);
- Home-based other (HBO); and
- Non-home-based (NHB).

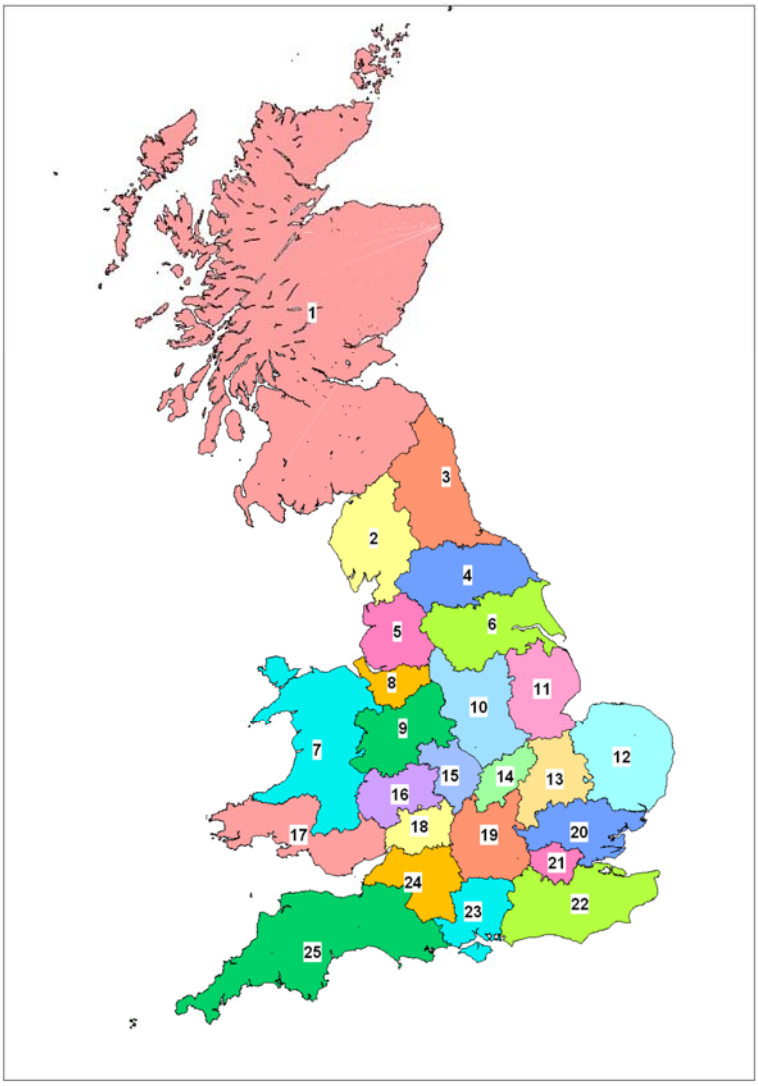
As PFMv4.3 required OD matrices as inputs the PA matrices were converted to OD format using PA to OD factors derived from National Travel Survey data. For non-home-based matrices PA and OD matrices these are identical, so only home-based purposes required conversion.

5.3.3. Derivation of Furness targets from TEMPRO

TEMPRO was used to derive factors which were used to adjust the 2010 daily highway PA base matrices to the two forecast years of 2026 and 2036 using the Furness matrix balancing process. Version 6.2 of the TEMPRO dataset was used as this was the most up to date version at that time.

Trip ends for 2010, 2026 and 2036 were extracted from TEMPRO for all car passenger and driver trip purposes for an average weekday. These data were aggregated from local authority zones to a twenty five zone sector system which can be seen in Figure 5-31. The forecast year aggregated totals were divided by the base year totals to produce a set of eight (four purposes by Production and Attraction) row and column factors to apply to the base year PA matrix to produce targets to be used in the Furnessing process.

Figure 5-31 Twenty Five Sector System for Highway Forecasts



Furness targets were obtained by applying the 2010-2026 and 2010-2036 row and column PA factors to the 2010 daily highway PA base matrices. The Furness calculations were then implemented, scaling to origin totals and this step produced PA matrices for the six purposes (HBW, HBEB, HBO, NHBW, NHBEB and NHBW) for 2026 and 2036 respectively.

5.3.4. Application of GDP elasticity

To ensure consistency between TEMPRO and the rail forecasts which used a more recent OBR GDP growth forecast, a GDP elasticity was applied to the output 2026 and 2036 business, leisure and commuting OD matrices to correct for the difference in the GDP assumptions. The GDP elasticity was applied globally as TEMPRO deals with national GDP, whereas for the rail forecasts using EDGE, regional GDP is applied.

There are two ways in which a change in GDP over time will affect the forecasts of car traffic; one is through a change in car ownership and therefore a change in the number of trips by car, and the other is through a change in the value of time which will change the value of the money cost component of generalised cost. The former impact will be on the number of trips by car and the latter impact will be on the number and length of trips by car.

Table 5-21 illustrates the difference in GDP forecasts assumed in the development of NTEM 6.2 and the June 2012 OBR forecasts used to develop the PFMv4.3 rail forecasts.

Table 5-21 GDP forecasts used in NTEM 6.2 and OBR June 2012 (2010 Rebased to 100)

Year	NTEM 6.2	OBR (June 2012)	OBR/NTEM 6.2
2010	100.00	100.00	1.0000
2026	147.48	139.21	0.9439
2036	185.48	173.57	0.9358

Previous analysis, detailed in the report PLANET Long Distance and Long Distance Model Comparison[9], saw the development of two different sets of highway demand forecasts using a high and low GDP estimate. From these two sets of GDP forecasts, shown in Table 5-22, two sets of demand forecast were produced and these are shown Table 5-23 and these totals were then used to calculate the implied arc elasticities which are shown in Table 5-24.

Table 5-22 Relative changes in GDP for Standard and High forecasts (constant household)

	GDP growth 2008-2021	
	Standard	High
GDP/household	1.115292046	1.22435421

Table 5-23 Daily highway demand totals using standard and high GDP forecasts

	Commuting		Work		Other	
Year	Standard	High	Standard	High	Standard	High
2008	1,335,255	1,335,255	1,344,206	1,344,206	2,108,049	2,108,049
2021	1,436,212	1,447,924	1,461,750	1,482,470	2,335,384	2,367,637

Table 5-24 Implied elasticity of highway demand to GDP derived from Table 5-22 and Table 5-23

Purpose	Commuting	Work	Other
Implied Elasticity	0.087	0.151	0.147

The elasticity calculations are underpinned by two differing GDP forecasts that had been run through the DfT's National Car Ownership Model (NATCOP) and the DfT's Trip End program CTripEnd as part of the PLD and LDM comparison study. As a result the derived factors will include a measure of NTEM's GDP responses.

The analysis undertaken in the PLANET Long Distance and Long Distance Model Comparison report highlights that there is a low elasticity for highway trips to GDP (in the order of 0.125). This is lower than the car vehicle kilometres elasticity of 0.16 specified in WebTAG 3.15.2 that also includes value of time effects. It should be noted that the number of households used in the standard and high GDP forecasts are constant and therefore the implied elasticities are purely for the change in demand with respect to GDP.

An alternative approach to estimating the impact of revised GDP numbers would have been to undertake a full NATCOP/CTripEnd run with the revised GDP values to forecast revised highway trip end totals. However, as only around a 1% reduction in highway trips is expected as a result of a 6.4% reduction in the

[9] PLANET Long Distance and Long Distance Model Comparison, Phase Zero Report, High Speed Two Ltd., March 2012

2036 GDP forecast (between NTEM and OBR 2012), the possible differences were deemed insignificant for the additional complexity required.

The elasticities shown in Table 5-24 were applied to the relative growth in GDP as shown in Table 5-21. Global factors were calculated with these values, which are shown in Table 5-25. These values were applied to the forecast PA matrices to correct for the change in GDP forecast. The correspondence used to map these purposes to the six purposes in the model was as follows:

- HBW = Commute
- HBEB = Work
- HBO = Other
- NHBW = Other
- NHBEB = Work
- NHBO = Other

Table 5-25 Global factors to correct for change in GDP forecasts

Year	Commuting	Work	Other
2026	0.9950	0.9913	0.9916
2036	0.9942	0.9900	0.9903

5.3.5. Creation of OD matrices

The process to create the daily highway OD matrices used PA to OD factors which had been developed during the creation of the PFMv4.3 base year matrices. These factors were input to the process at the twenty-five sector level, and mapped to PLD zones using a correspondence list. The associated PA to OD factor was then created by calculating the reciprocals and the PA to OD factor was then applied to the home based purposes to convert them to OD format.

The final stage of the highway forecast matrix development was the creation of 2026 and 2036 business, leisure and commuting OD matrices by aggregating the six OD purposes using the following correspondences:

- Commuting = HBW
- Business = HBEB+NHBEB
- Leisure = HBO+NHBO+NHBW

5.3.6. Regional total analysis and matrix checks

The matrix development process was followed by checks to ensure that the expected totals were reflected in the output matrices. The first stage was to verify that the output matrix totals for the six 2026/2036 Furnessed matrices equalled the origin totals for the Furness targets. This was accompanied by an overall sense check that the level of growth was representative of the purpose and year.

The second stage of the matrix checking was to ensure that the conversion from the six OD home and non-home based purposes to business, leisure and commuting (used for the assignment) preserved the matrix totals for all years (2010, 2026 and 2036). When this check was completed successfully, the matrix outputs were aggregated to a Government Regional eleven sector level matrix to allow further checks to be undertaken. Table 5-26 illustrates the correspondence between the twenty five sectors (illustrated in Figure 5-31) and the eleven regional sectors.

Table 5-26 Twenty five sector to eleven sector correspondence

25 Sector No.	25 Sector Name	11 Sector No.	11 Sector Name
1	Scotland	1	Scotland
2	Carlisle, Cumbria and Lancaster	2	North West
3	Newcastle, Northumberland and County Durham	3	North East

25 Sector No.	25 Sector Name	11 Sector No.	11 Sector Name
4	North Yorkshire	4	Yorks & Humber
5	Lancashire, Liverpool and Manchester	2	North West
6	Leeds, Sheffield and York	4	Yorks & Humber
7	North Wales	7	Wales
8	Chester, Crewe and Macclesfield	2	North West
9	Shropshire and Staffordshire	6	West Midlands
10	Derbyshire, Leicestershire and Nottinghamshire	5	East Midlands
11	Lincolnshire	5	East Midlands
12	Norfolk and Suffolk	10	East of England
13	Bedfordshire and Cambridgeshire	10	East of England
14	Northamptonshire	5	East Midlands
15	Birmingham, Rugby and Warwickshire	6	West Midlands
16	Herefordshire and Worcestershire	6	West Midlands
17	South Wales	7	Wales
18	Cheltenham, Gloucester and Tewkesbury	8	South West
19	Berkshire, Buckinghamshire and Oxfordshire	9	South East
20	Essex and Hertfordshire	10	East of England
21	London	11	London
22	Kent, Sussex and Surrey	9	South East
23	Hampshire and Isle of Wight	9	South East
24	Bath, Bristol and Wiltshire	8	South West
25	Cornwall, Devon, Dorset and Somerset	8	South West

Table 5-27 to Table 5-32 show the final output matrices by trip purpose.

Table 5-27 2026 Daily Highway Business Person matrix

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	10,126	6,601	2,660	1,136	6747	667	4,010	1,208	2,231	9,043	7,319	**51,748**
East of England	6,019	24,806	3,716	202	1,250	108	13,838	2,428	1,569	5,584	2,034	**61,554**
London	2,870	4,251	0	194	648	101	15,019	6,846	2,354	3,958	1,116	**37,357**
North East	1,047	244	235	514	2,591	2,468	344	135	261	584	5,486	**13,909**
North West	6,284	1,612	773	3,000	22,400	2,207	1,279	873	2,942	9,188	9,634	**60,192**
Scotland	476	111	96	1,782	1,530	30,220	160	99	226	857	890	**36,447**
South East	3,685	14,662	14,960	280	1,098	177	39,446	14,356	1,244	7,992	1,607	**99,507**
South West	1,046	2,397	6,915	95	1,069	171	14,439	30,890	5,096	5,448	479	**68,045**
Wales	2,203	1,510	2,401	236	2,512	345	1,355	4,697	2,439	6,438	1,155	**25,291**
West Midlands	8,988	5,673	3,925	612	9,023	1,058	7,685	5,021	6,472	4,673	3,820	**56,950**
Yorks & Humber	7,283	2,317	1,148	6,160	9,726	1,354	1,745	585	1,222	4,067	17,080	**52,687**
Grand Total	**50,027**	**64,184**	**36,829**	**14,211**	**58,594**	**38,876**	**99,320**	**67,138**	**26,056**	**57,832**	**50,620**	**563,687**

Table 5-28 2036 Daily Highway Business Person matrix

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	10,301	6,918	2,761	1,143	6,874	690	4,143	1,242	2,402	9,317	7,705	**53,496**
East of England	6,225	26,014	3,899	204	1,283	112	14,267	2,508	1,701	5,834	2,156	**64,203**
London	3,008	4,559	0	200	678	108	15,828	7,194	2,627	4,216	1,211	**39,629**
North East	1,058	252	242	516	2,621	2,533	353	138	279	600	5,747	**14,339**
North West	6,417	1,684	804	3,036	2,2791	2,280	1,317	893	3,112	9,506	10,153	**61,993**
Scotland	498	120	103	1,843	1,592	31,875	170	105	245	914	960	**38,425**
South East	3,770	15,269	15,494	282	1,120	183	40,563	14,706	1,339	8,356	1,701	**102,783**
South West	1,073	2,514	7,191	96	1,092	178	14,883	31,655	5,496	5,686	508	**70,372**
Wales	2,372	1,665	2,653	250	2,660	372	1,470	5,079	2,696	7,021	1,277	**27,515**
West Midlands	9,255	6,007	4,134	623	9,315	1,110	8,094	5,251	7,037	4,830	4,087	**59,743**
Yorks & Humber	7,697	2,509	1,242	6,441	10,230	1,444	1,871	624	1,355	4,369	18,579	**56,361**
Grand Total	**51,674**	**67,511**	**38,523**	**14,634**	**60,256**	**40,885**	**102,959**	**69,395**	**28,289**	**60,649**	**54,084**	**588,859**

Table 5-29 2026 Daily Highway Leisure Person matrix

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	30,235	21,569	3,908	2,523	11,113	2,390	13,128	2,186	3,008	13,564	20,184	**123,808**
East of England	20,348	69,799	18,087	1,343	3,862	1,038	36,445	10,356	4,338	5,026	4,329	**174,971**
London	4,708	20,300	0	1,430	2,226	753	51,805	18,366	5,124	8,535	2,767	**116,014**
North East	2,271	1,115	1,170	2,900	9,230	9,544	1,677	705	773	781	11,559	**41,725**
North West	11,962	3,808	2,310	10,167	68,717	7,669	4,676	3,285	18,561	19,585	28,834	**179,574**
Scotland	2,153	905	795	9,062	7,098	108,898	1,155	865	1,198	1,646	3,970	**137,745**
South East	14,991	34,043	48,269	1,553	4,926	1171	102,304	44,775	3,280	15,247	5,749	**276,308**
South West	1,976	10,921	18,111	421	4,222	926	41,766	95,287	16,384	19,802	1,375	**211,191**
Wales	2,974	3,244	4,772	1,008	16,078	1,310	2,930	17,120	33,898	15,856	2,732	**101,922**
West Midlands	14,042	4,845	8,567	1,046	17,220	2,411	15,205	17,075	16,413	16,853	4,493	**118,170**
Yorks & Humber	20,348	4,188	2,598	12,208	27,009	5,102	6,081	2,138	2,854	4,525	78,762	**165,813**
Grand Total	**126,008**	**174,737**	**108,587**	**43,661**	**171,701**	**141,212**	**277,172**	**212,158**	**105,831**	**121,420**	**164,754**	**1,647,241**

Table 5-30 2036 Daily Highway Leisure Person matrix

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	32,577	23,442	4,229	2,669	11,554	2,486	13,929	2,341	3,185	14,369	21,773	**132,554**
East of England	21,947	76,549	19,728	1,438	4,089	1,092	38,736	11,155	4,619	5,383	4,751	**189,487**
London	5,124	22,435	0	1,537	2,360	794	55,321	19,860	5,480	9,136	3,041	**125,088**
North East	2,408	1,207	1,249	3,040	9,554	9,842	1,758	749	806	818	12,339	**43,770**
North West	12,488	4,069	2,436	10,561	70,643	7,851	4,841	3,444	19,029	20,322	30,542	**186,226**
Scotland	2,256	969	840	9,397	7,283	111,678	1,198	911	1,230	1,713	4,218	**141,693**
South East	16,026	36,636	51,387	1,633	5,111	1,211	107,492	47,569	3,423	16,072	6,194	**292,754**
South West	2,129	11,922	19,492	447	4,441	970	44,361	102,721	17,382	20,987	1,492	**226,344**
Wales	3,158	3,485	5,072	1,051	16,462	1,336	3,057	18,112	35,003	16,560	2,923	**106,219**
West Midlands	14,924	5,221	9,122	1,098	17,876	2,500	15,977	18,101	17,118	17,541	4,837	**124,315**
Yorks & Humber	22,034	4,647	2,844	13,040	28,534	5,384	6,539	2,325	3,044	4,870	85,961	**179,222**
Grand Total	**135,071**	**190,582**	**116,399**	**45,911**	**177,907**	**145,144**	**293,209**	**227,288**	**110,319**	**127,771**	**178,071**	**1,747,672**

Table 5-31 2026 Daily Highway Commuting Person matrix

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	6,778	6,496	1,125	130	2,847	86	1,852	252	355	9,060	5,157	**34,138**
East of England	5,973	21,592	4,856	18	136	1	12,716	708	208	2,614	303	**49,125**
London	1,001	4,813	0	17	56	0	23,611	3,250	249	788	132	**33,917**
North East	132	28	24	303	495	477	33	11	9	34	2,031	**3,577**
North West	2,793	170	66	498	13,916	271	128	95	643	3,537	5,937	**28,054**
Scotland	107	2	0	451	261	20,879	5	2	18	171	188	**22,084**
South East	1,784	12,893	23,581	24	128	2	31,001	6,150	180	2,969	263	**78,975**
South West	282	883	3,465	6	123	2	6,005	17,868	2,198	2,127	53	**33,012**
Wales	344	217	309	9	716	23	200	2,404	1,323	2,388	106	**8,039**
West Midlands	8,159	2,565	848	36	3,746	157	3,007	1,994	2,153	4,885	948	**28,498**
Yorks & Humber	5,704	389	144	2,158	6,169	203	261	60	96	981	22,555	**38,720**
Grand Total	**33,057**	**50,048**	**34,418**	**3,650**	**28,593**	**22,101**	**78,819**	**32,794**	**7,432**	**29,554**	**37,673**	**358,139**

Table 5-32 2036 Daily Highway Commuting Person matrix

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	6,779	6,719	1,175	129	2,847	86	1,892	252	373	9,298	5,297	**34,847**
East of England	6,044	22,376	5,083	18	136	1	12,884	714	221	2,734	313	**50,524**
London	1,051	5,174	0	18	58	0	24,709	3,407	277	844	142	**35,680**
North East	132	29	25	304	493	481	34	11	9	35	2,095	**3,648**
North West	2,826	178	70	497	14,034	272	131	96	669	3,629	6,175	**28,577**
Scotland	112	2	0	468	272	21,735	5	2	19	184	202	**23,001**
South East	1,808	13,284	24,289	24	127	2	31,367	6,226	191	3,113	272	**80,703**
South West	282	918	3,616	6	123	2	6,146	18,058	2,357	2,195	54	**33,757**
Wales	364	239	344	10	741	23	217	2,586	1,457	2,570	114	**8,665**
West Midlands	8,400	2,747	908	37	3,816	161	3,182	2,064	2,306	5,031	1,000	**29,652**
Yorks & Humber	5,942	423	158	2,215	6,407	210	278	63	104	1,047	24,058	**40,905**
Grand Total	**33,740**	**52,089**	**35,668**	**3,726**	**29,054**	**22,973**	**80,845**	**33,479**	**7,983**	**30,680**	**39,722**	**369,959**

5.4. Highway assignment and the creation of the short distance preloads

Within PFM short-distance trips and good vehicles are represented as pre-loaded flows on the network as it is assumed that these trips will not transfer on to the strategic rail network. These are calculated by assigning the base year highway matrices onto the highway network and taking the difference between the assigned flows and observed traffic flows. The traffic flow data was primarily derived from the Highways Agency TRADS database. The methodology used to determine the calculation of preloads was consistent with that followed in PFMv3.0.

5.4.1. Factoring 2010 preloads to 2026 and 2036 using NRTF 2011 Forecasts

The method to calculate the preloads for the forecast years used the NTM traffic forecast component of the Road Transport Forecasts 2011 (RTF11)[10]. The key input assumptions to RTF11 are the following:

- Population and employment data - based on NTEM 5.4;
- GDP Forecasts – 2011-2015 from OBR projections post-Budget 2011, and post 2015 growth from OBR's July 2011 Fiscal Sustainability Report; and
- Fuel Prices – based on DECC's October 2011 fossil fuel price projections.

Note that the above assumptions are not consistent with those used for forecasting other modes, however, these are the latest DfT assumptions and so are the most appropriate source of data.

NTM forecasts traffic levels by region and road type using the DfT's Fitting On of Regional Growth and Elasticities (FORGE) mechanism. FORGE is not a traditional assignment model, as it uses observed data on the level of traffic using each link of the road network from its 2003 base year and then applies elasticities derived from the demand model to forecast future levels of traffic.

The flows for the years required for the study (2010, 2026 and 2036) were derived using interpolation and extrapolation from Table 4.3 from Road Transport Forecasts 2011 which is also shown below in Table 5-33. The link preloads were uplifted using the following assumptions:

- As the projections from the National Transport Model have a broad order of magnitude they possess a significant range of uncertainty. As this uncertainty is likely to be greater for more disaggregate results, a single factor was calculated to be applied globally to all regions.
- The values calculated apply to England only; it is assumed that Wales and Scotland have the same growth factors;
- As the assignment matrices are car only, the car growth factor was used. It should be noted that the preload flow includes both light goods vehicles (LGV) and heavy goods vehicles (HGV), though the proportion of these vehicle types cannot be determined from the observed count data; and
- As the nature of the network modelled is predominantly major roads, the only road types to be considered in the calculation of the growth factors are Motorway, Trunk and Principal.

Table 5-33 Traffic by Vehicle type and Road type, England

Bn Vehicle Miles	Year	Motorway	Trunk	Principal	Other	All Roads
Cars	2010	39.0	24.2	67.8	77.6	208.6
	2035	55.6	33.9	91.6	104.7	285.8
	Growth	42.6%	40.1%	35.1%	34.9%	37.0%
LGV	2010	6.7	4.1	10.9	14.2	35.9
	2035	12.6	7.7	20.4	26.7	67.3
	Growth	88.1%	87.8%	87.2%	88.0%	87.5%
HGV	2010	6.0	2.8	3.5	1.8	14.1
	2035	8.7	4.0	4.9	2.5	20.1

[10] http://assets.dft.gov.uk/publications/road-transport-forecasts-2011/road-transport-forecasts-2011-results.pdf

Bn Vehicle Miles	Year	Motorway	Trunk	Principal	Other	All Roads
	Growth	45.0%	42.9%	40.0%	38.9%	42.6%
Bus & Coach	2010	0.2	0.2	0.9	1.4	2.7
	2035	0.2	0.1	0.8	1.3	2.4
	Growth	0.0%	-50.0%	-11.1%	-7.1%	-11.1%
All Traffic	2010	51.9	31.3	83.1	94.9	261.2
	2035	77.1	45.7	117.7	135.1	375.6
	Growth	48.6%	46.0%	41.6%	42.4%	43.8%

Source: Table 4.3 NTM 2011

5.5. Air Demand Forecasts

5.5.1. Introduction

This section describes the approach used to forecast domestic air passenger demand in the years 2026 and 2036. The approach for both base year and forecast year air demand was to adopt the DfT Aviation Model forecasts of supply and demand which ensured a consistent approach to forecasting domestic air passenger demand and aviation supply between the base and forecast years.

The domestic air passenger demand provided by the DfT came from the “APF02_1209a” (27th Sept 2012) generation of forecasts from the DfT Aviation Model. The data was for future year unconstrained end-to-end, non-transfer demand by trip purpose (employers business and other) and the matrices were in origin destination format.

This section also includes a brief summary of the DfT Aviation Model, more details of which can be found in the DfT publication of *UK Aviation Forecasts, January 2013*, before presenting the forecast data for 2026 and 2036 and a description of the changes between the 2010 base year and the 2026 forecast and between the 2026 and 2036 forecasts.

5.5.2. DfT Aviation Model

The DfT Aviation Model forecasts the number of passengers passing through UK airports ('terminal passengers') each year and includes UK and foreign residents travelling to, from or within the UK.

Within PFM air is only represented in the PLD model and only includes those trips made exclusively within Great Britain and therefore excludes movements to/from Northern Ireland, Isle of Man etc. It also excludes interlining trips (international movements where, for outbound journeys, the first leg of the trip is within Great Britain but the second and any subsequent legs are international). The internal domestic market sector required for PLD accounts for approximately 15% of the passengers in the DfT Aviation Model.

The DfT’s aviation forecasts are primarily prepared to inform long-term strategic aviation policy rather than to provide detailed forecasts at every individual airport. The airport and specific market sector level forecasts, such as those used in PLD, are therefore only generated as an intermediate output of the forecasting approach.

Passenger forecasts are generated for each forecast year in two steps:

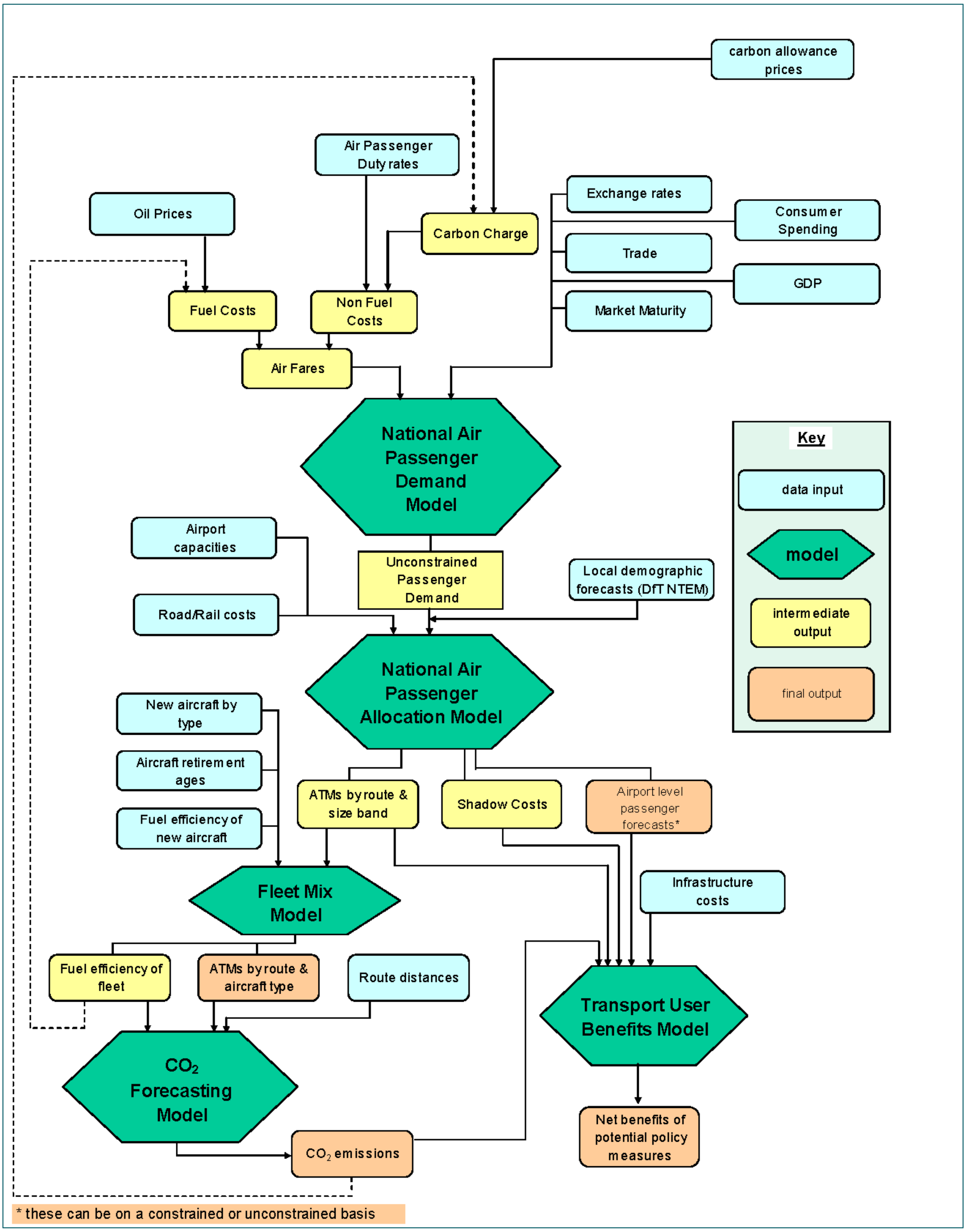
- The first step is the unconstrained national air passenger demand forecasts which are generated using the National Air Passenger Demand Model [NAPDM]. This combines time-series econometric models with projections of key driving variables, to forecast national air travel demand assuming no UK airport capacity constraints; and
- the second step includes the likely impact of future UK airport capacity constraints, allocation of passengers to airports, and translation of passengers into air transport movements is modelled with the National Air Passenger Allocation Model. Within this step the unconstrained growth rates from NAPDM are applied to the base air matrices to provide forecast matrices for assignment.

To ensure consistency with the other modal forecasts in the PLD model unconstrained air matrices were required. This is achieved by switching off the airport capacity constraints used in the National Air

Passenger Allocation Model and are, in contrast, an alternative output to constrained passenger forecasts, showing how UK air passenger numbers would grow if there were no UK airport capacity constraints. It is these unconstrained forecasts that have been used in the PLD model.

Figure 5-32 provides an overview of the framework used by the DfT Aviation Model to produce forecasts of UK air passengers.

Figure 5-32 DfT Aviation Model forecasting framework



Source: UK Aviation Forecasts, DfT, January 2013

5.5.2.1. National Air Passenger Demand Model

The National Air Passenger Demand Model is used to forecast the number of UK air passengers assuming no UK airport capacity constraints. It does this by combining a set of time-series econometric models of past UK air travel demand with projections of key driving variables and assumptions about how the relationship between UK air travel and its key drivers change into the future.

The key drivers vary by market sector. In the leisure sector consumer spending and air fares have been identified as the key drivers, whilst in the business sectors GDP and international trade were shown to be the main drivers, with price having a much more limited impact.

Although the National Air Passenger Demand Model is capable of producing forecasts to 2080; it has been used up to 2050 to produce the forecasts presented in this document. The unconstrained demand forecasts from the National Air Passenger Demand Model provide an input to the National Air Passenger Allocation Model.

5.5.2.2. National Air Passenger Allocation Model

The National Air Passenger Allocation Model comprises several sub-models and routines which are used in combination and iteratively:

- the Passenger Airport Choice Model forecasts how passenger demand will split between UK airports;
- the Air Transport Movement (ATM) Demand Model translates the passenger demand forecasts for each airport into air traffic movements; and
- the Demand Allocation Routine accounts for the likely impact of future UK airport capacity constraints on air transport movements (and thus passengers) at UK airports.

The forecasts provided for PLD were derived from the National Air Passenger Allocation Model but were unconstrained forecasts in that they represent the underlying estimates of demand in the absence of airport capacity constraints.

One of the key features of the National Air Passenger Allocation Model is the ability of the ATM Demand Model to project the availability of routes from each modelled airport. The model assumes that, in line with mainstream economic theory, supply will respond to demand as long as the market is commercially viable.

The ATM Demand Model simulates the introduction of new routes by testing in each forecast year whether sufficient demand exists to make new routes viable from each airport. The test is two-way, so routes can be both opened and withdrawn. Also, airports are tested jointly for new routes, allowing them to compete with each other. To ensure consistency between the supply and demand in the PLD model the air supply was updated at the same time as the demand using the aviation model forecasts. This update is reported in section 6 of this report.

5.5.3. 2026 Forecast Demand

The 2026 DfT Aviation Model matrix represents an average annual demand. As such, the assumption is that over the course of a year demand should have similar levels of origin and destination trip totals. Any asymmetry found between origins and destinations as a result of the production of exportable matrices from the DfT Aviation model was removed by creating a transpose of the matrix and averaging the two matrices. All subsequent analysis is based on the symmetrical matrices using the eleven region sector system.

The outputs from the DfT Aviation Model are at an annual level and these were de-annualised to weekday demand for input to PLD using a factor of 313 which was supplied by the DfT. The tables below show the numbers direct from the model and are therefore at an annual level.

Between 2010 and 2026 there was an overall forecast increase in air demand of 36%, with a 39% increase in business demand and a 32% increase in leisure demand. These values are shown in Table 5-34.

Table 5-34 DfT aviation matrices 2010-2026

Description	Business	Leisure	Combined
2010 DfT Aviation Model matrix	4,753,694	3,809,318	8,563,013
2026 DfT Aviation Model matrix	6,623,156	5,034,911	11,658,067
% change	39%	32%	36%

Changes in regional level trip ends between 2010 and 2026 (origin and destination being the same in the symmetrical matrix) are shown in Table 5-35.

The region with the largest change in absolute demand is Scotland, where demand is forecast to increase by over 1.3 million passenger movements per year between 2010 and 2026. This would be expected as Scotland is the dominant region in UK domestic aviation accounting for around 42% of trips in 2010, with the combined London and the South East region being around 29%. Therefore, the absolute increase in demand is broadly proportionate to the base year distribution of demand.

Table 5-35 Changes in regional trip ends 2010-2026

Region	2010 DfT Aviation Model	2026 DfT Aviation Model	Difference	Difference %
Scotland	3,556,193	4,859,709	1,303,516	37%
North West	329,612	434,683	105,071	32%
North East	408,537	533,998	125,461	31%
Yorks & Humber	126,655	169,415	42,760	34%
East Midlands	163,511	228,641	65,130	40%
West Midlands	253,517	336,249	82,732	33%
Wales	136,855	177,139	40,284	29%
South West	551,037	723,475	172,438	31%
South East	1,019,304	1,409,650	390,346	38%
East of England	593,260	823,148	229,888	39%
London	1,424,531	1,961,964	537,433	38%
Total	8,563,013	11,658,067	3,095,054	36%

Table 5-36 and Table 5-37 show the 2026 matrices for business trips and leisure trips, whilst Table 5-38 shows these combined into an all journey purposes matrix.

Table 5-36 Regional demand for air derived from 2026 DfT Aviation Model (business annual trip matrix)

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	0	127	967	629	0	150,985	302	318	2,290	0	0	**155,617**
East of England	127	0	0	22,517	16,515	399,214	0	518	216	229	1,561	**440,896**
London	967	0	0	47,058	85,688	1,084,095	0	3,579	3,123	69	10,208	**1,234,784**
North East	629	22,517	47,058	0	0	28,159	73,165	61,032	15,577	9,092	0	**257,226**
North West	0	16,515	85,688	0	0	64,769	56,915	27,717	375	0	0	**251,977**
Scotland	150,985	399,214	108,4095	28,159	64,769	1,293	628,389	150,320	42,326	208,168	67,327	**2,825,044**
South East	302	0	0	73,165	56,915	628,389	0	9,585	322	295	19,212	**788,182**
South West	318	518	3,579	61,032	27,717	150,320	9,585	7,715	258	793	12,596	**274,429**
Wales	2,290	216	3,123	15,577	375	42,326	322	258	0	13	473	**64,970**
West Midlands	0	229	69	9,092	0	208,168	295	793	13	0	0	**218,657**
Yorks & Humber	0	1,561	10,208	0	0	67,327	19,212	12,596	473	0	0	**111,376**
Grand Total	**155,617**	**440,896**	**1,234,784**	**257,226**	**251,977**	**2,825,044**	**788,182**	**274,429**	**64,970**	**218,657**	**111,376**	**6,623,156**

Table 5-37 Regional demand for air derived from 2026 DfT Aviation Model (leisure annual trip matrix)

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	1,327	561	146	41	5,890	61,350	236	438	0	2,815	223	**73,025**
East of England	561	0	0	46,874	23,720	290,430	0	10,821	683	2,722	6,443	**382,252**
London	146	0	0	33,525	28,914	647,796	0	9,108	1,542	89	6,060	**727,180**
North East	41	46,874	33,525	0	0	6,316	70,137	109,216	10,218	445	0	**276,772**
North West	5,890	23,720	28,914	0	0	56,397	18,905	48,572	105	205	0	**182,707**
Scotland	61,350	290,430	647,796	6,316	56,397	3,661	513,369	233,516	94,416	111,109	16,308	**2,034,665**
South East	236	0	0	70,137	18,905	513,369	0	6,548	350	161	11,763	**621,468**
South West	438	10,821	9,108	109,216	48,572	233,516	6,548	8,844	4,775	48	17,162	**449,047**
Wales	0	683	1,542	10,218	105	94,416	350	4,775	0	0	81	**112,169**
West Midlands	2,815	2,722	89	445	205	111,109	161	48	0	0	0	**117,592**
Yorks & Humber	223	6,443	6,060	0	0	16,308	11,763	17,162	81	0	0	**58,039**
Grand Total	**73,025**	**382,252**	**727,180**	**276,772**	**182,707**	**2,034,665**	**621,468**	**449,047**	**112,169**	**117,592**	**58,039**	**5,034,911**

Table 5-38 Regional demand for air derived from 2026 DfT Aviation Model (business and leisure annual trip matrices)

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	1,327	688	1,113	669	5,890	212,335	538	756	2,290	2,815	223	**228,641**
East of England	688	0	0	69,391	40,234	689,644	0	11,339	899	2,950	8,004	**823,148**
London	1,113	0	0	80,583	114,602	1,731,891	0	12,687	4,665	158	16,268	**1,961,964**
North East	669	69,391	80,583	0	0	34,475	143,302	170,248	25,795	9,537	0	**533,998**
North West	5,890	40,234	114,602	0	0	121,166	75,820	76,289	479	205	0	**434,683**
Scotland	212,335	689,644	1,731,891	34,475	121,166	4,954	1,141,758	383,835	136,742	319,277	83,635	**4,859,709**
South East	538	0	0	143,302	75,820	1,141,758	0	16,133	671	456	30,975	**1,409,650**
South West	756	11,339	12,687	170,248	76,289	383,835	16,133	16,559	5,033	841	29,758	**723,475**
Wales	2,290	899	4,665	25,795	479	136,742	671	5,033	0	13	554	**177,139**
West Midlands	2,815	2,950	158	9,537	205	319,277	456	841	13	0	0	**336,249**
Yorks & Humber	223	8,004	16,268	0	0	83,635	30,975	29,758	554	0	0	**169,415**
Grand Total	**228,641**	**823,148**	**1,961,964**	**533,998**	**434,683**	**4,859,709**	**1,409,650**	**723,475**	**177,139**	**336,249**	**169,415**	**1,1658,06**

5.5.4. 2036 Forecast Demand

Table 5-39 shows that between 2026 and 2036 there was a forecast overall increase in air demand of 24%, with a 25% increase in business demand and a 24% increase in leisure demand. This continues the trend seen between 2010 and 2026 where the growth in business demand was greater than the growth in leisure demand, however, the differences in the rate of growth between the two purposes is much reduced between 2026 and 2036.

Table 5-39 DfT aviation matrices 2026-2036

Description	Business	Leisure	Combined
2026 DfT Aviation Model matrix	6,623,156	5,034,911	11,658,067
2036 DfT Aviation Model matrix	8,272,533	6,221,565	14,494,098
% change	25%	24%	24%

The changes in regional level trip ends (total origin and destination) are shown in Table 5-40. Changes in forecast regional air passenger demand between 2026 and 2036 are relatively uniform across all regions with there being only a +1%/-2% change around the national average. This is more uniform than seen between 2010 and 2026 where regional growth was between +4%/-7% around the national average.

The region with the largest change in absolute demand is again Scotland, where demand is forecast to increase by over one million passenger movements per year between 2026 and 2036.

Table 5-40 Changes in regional trip ends (business and leisure)

	2026 DfT Aviation Matrix	2036 DfT Aviation Matrix	% Difference between 2026 and 2036
Scotland	4,859,709	6,061,585	25%
North West	434,683	529,743	22%
North East	533,998	654,529	23%
Yorks & Humber	169,415	208,031	23%
East Midlands	228,641	286,140	25%
West Midlands	336,249	416,327	24%
Wales	177,139	220,100	24%
South West	723,475	900,518	24%
South East	1,409,650	1,749,920	24%
East of England	823,148	1,030,227	25%
London	1,961,964	2,436,981	24%
Total	11,658,067	14,494,098	24%

Table 5-41 to Table 5-43 show the 2036 air demand for business trips, leisure trips and all purposes combined.

Table 5-41 Regional demand for air derived from 2036 DfT Aviation Model (business annual trip matrix)

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	0	151	1151	762	0	190,267	357	382	2,915	0	0	**195,983**
East of England	151	0	0	27,989	20,184	502,940	0	764	255	276	1,902	**554,460**
London	1,151	0	0	57,604	104,375	1,355,644	0	4,350	3,808	71	12,546	**1,539,547**
North East	762	27,989	57,604	0	0	34,265	89,788	75,275	19,296	11,145	0	**316,122**
North West	0	20,184	104,375	0	0	80,449	69,416	33,667	451	0	0	**308,541**
Scotland	190,267	502,940	1,355,644	34,265	80,449	1,588	788,159	190,033	52,952	259,634	83,819	**3,539,747**
South East	357	0	0	89,788	69,416	788,159	0	11,885	359	355	23,641	**983,958**
South West	382	764	4,350	75,275	33,667	190,033	11,885	9,800	286	971	15,450	**342,860**
Wales	2,915	255	3,808	19,296	451	52,952	359	286	0	13	582	**80,915**
West Midlands	0	276	71	11,145	0	259,634	355	971	13	0	0	**272,463**
Yorks & Humber	0	1,902	12,546	0	0	83,819	23,641	15,450	582	0	0	**137,939**
Grand Total	**195,983**	**554,460**	**1,539,547**	**316,122**	**308,541**	**3,539,747**	**983,958**	**342,860**	**80,915**	**272,463**	**137,939**	**8,272,533**

Table 5-42 Regional demand for air derived from 2036 DfT Aviation Model (leisure annual trip matrix)

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	1,644	683	159	40	7,291	75,650	265	513	0	3,689	225	**90,157**
East of England	683	0	0	57,557	29,531	362,427	0	13,563	785	3,225	7,998	**475,767**
London	159	0	0	40,495	34,733	801,709	0	10,994	1,860	101	7,385	**897,434**
North East	40	57,557	40,495	0	0	7,567	85,516	134,203	12,492	540	0	**338,407**
North West	7,291	29,531	34,733	0	0	68,041	22,186	59,058	117	246	0	**221,202**
Scotland	75,650	362,427	801,709	7,567	68,041	4,509	635,250	293,754	117,544	135,826	19,561	**2521,838**
South East	265	0	0	85,516	22,186	635,250	0	7,927	394	191	14,235	**765,962**
South West	513	13,563	10,994	134,203	59,058	293,754	7,927	11,101	5,903	48	20,597	**557,658**
Wales	0	785	1,860	12,492	117	117,544	394	5,903	0	0	93	**139,186**
West Midlands	3,689	3,225	101	540	246	135,826	191	48	0	0	0	**143,864**
Yorks & Humber	225	7,998	7,385	0	0	19,561	14,235	20,597	93	0	0	**70,092**
Grand Total	**90,157**	**475,767**	**897,434**	**338,407**	**221,202**	**2,521,838**	**765,962**	**557,658**	**139,186**	**143,864**	**70,092**	**6,221,565**

Table 5-43 Regional demand for air derived from 2036 DfT Aviation Model (business and leisure annual trip matrices)

Area	East Midlands	East of England	London	North East	North West	Scotland	South East	South West	Wales	West Midlands	Yorks & Humber	Grand Total
East Midlands	1,644	834	1,309	802	7,291	265,917	621	894	2,915	3,689	225	**2,86,140**
East of England	834	0	0	85,546	49,715	865,367	0	14,327	1,040	3,501	9,900	**1,030,227**
London	1,309	0	0	98,098	139,108	2,157,352	0	15,344	5,668	172	19,931	**2,436,981**
North East	802	85,546	98,098	0	0	41,832	175,303	209,477	31,788	11,685	0	**654,529**
North West	7,291	49,715	139,108	0	0	148,490	91,602	92,724	568	246	0	**529,743**
Scotland	265,917	865,367	2,157,352	41,832	148,490	6097	1,423,409	483,787	170,496	395,460	103,380	**6,061,585**
South East	621	0	0	175,303	91,602	1,423,409	0	19,812	753	546	37,876	**1,749,920**
South West	894	14,327	15,344	209,477	92,724	483,787	19,812	20,901	6,188	1,019	36,047	**900,518**
Wales	2,915	1,040	5,668	31,788	568	170,496	753	6,188	0	13	674	**220,100**
West Midlands	3,689	3,501	172	11,685	246	395,460	546	1,019	13	0	0	**416,327**
Yorks & Humber	225	9,900	19,931	0	0	103,380	37,876	36,047	674	0	0	**20,8031**
Grand Total	**286,140**	**1,030,227**	**2,436,981**	**654,529**	**529,743**	**6,061,585**	**1,749,920**	**900,518**	**220,100**	**416,327**	**208,031**	**14,494098**

6. Development of Revised Networks

6.1. Introduction

This section describes the work undertaken to update the base year and future year rail, highway and air networks for PFMv4.3.

Section 6.2 details the update of the rail networks. This included the development of a revised future year national rail Do-Minimum using assumptions provided by the Department for Transport. The base year national rail network was not revised. In addition both the base year and future year London Underground networks were updated using assumptions provided by Transport for London.

Rail vehicle capacities were updated in both the base and future years. This was to ensure that the correct level of standing capacity was represented in PFMv4.3 which was essential with the move to PDFHv5 based crowding functions (see section 7).

No changes were made to the additional rail network assumptions in the Do-Something as part of this update.

Section 6.3 describes the update to the base year highway networks. This entailed a complete review of network coverage, network density, link capacity and volume delay functions. Section 6.4 describes the update to the future year highway networks to incorporate revised Do-Minimum schemes.

Section 6.5 describes the revised air networks taken from the DfT's Aviation Model. This includes revised forecast air fares which are applied to the air transit lines within PFMv4.3.

6.2. Rail Network Update

6.2.1. Introduction

The Do-Minimum national rail network updates were undertaken in two stages. The majority of changes were made during Autumn 2012 and are referred to as the October 2012 update. Subsequently the DfT provided further network updates in early 2013 and these are referred to as the March 2013 update.

Base year and forecast year London Underground (LUL) services were also updated using information provided by TfL (Transport for London). The national rail and LUL Do-Minimum networks were assumed to be identical in the modelled years of 2026 and 2036.

This section describes the development of revised Do-Minimum networks for national rail and London underground, plus an update to the base year LUL network which was also undertaken. In addition to the network update, rail seating and standing capacities were also revised.

6.2.2. Stage 1 – October 2012

6.2.2.1. National Rail Data

Timetable data for the future year Do-Minimum was made available as a series of Network Rail CIF[11] files. The CIF files are a comprehensive data source containing rail services scheduled on the national network in the timetable period in question. This can include all days of week, passenger, freight, light engine and empty stock movements. For this update data supplied was limited to passenger train movements on the future year weekday.

Within each rail movement, the route is described in detail in terms of arrival and departures at station stops, and timing point locations together with the activity occurring at each location such as picking up or setting down passengers. For each set of timetables, a matching set of data vehicle formation was provided detailing the stock formation type, number of seats and total capacity (seated and standing). During the

11 CIF = Common Interface Format. The full specification is at http://www.atoc.org/about-atoc/rail-settlement-plan/data-feeds/types-of-data/

update process the vehicle assumptions were revised and replaced with new seated and total capacities. Section 6.2.4 describes the update to these capacities in more detail.

Coding for East West Rail was not included in the files provided by the DfT. Instead a standard hour indicative timetable was made available and this was coded separately into the PLANET Long Distance (PLD) and PLANET South elements of PFMv4.3. Crossrail was supplied (in part) in the DfT data. However the Abbey Wood branch was not included in the coding. The missing transit lines from Abbey Wood were coded separately in PLANET South based upon the late 2012 view of likely Crossrail service patterns.

6.2.2.2. London Underground Transit Line Data

In addition to updating National Rail services the rail network update also included updating both the base year and forecast year LUL network and services. TfL supplied LUL transit line data extracted from TfL's Railplan model which was combined with vehicle type data extracted from Railplan.

6.2.3. Stage 2 – March 2013

After the original CIF files were released in October 2012, further amendments to the national rail assumptions were provided by the DfT, these are shown in Table 6–1.

Table 6–1 List of Coding Amendments, March 2013

TOC	Required Change	Assumption(s) Made
London Overground	25% capacity increase on selected services.	LO services are not attributed a specific vehicle type, so the stored capacity was scaled up by 25%.
Heathrow Express	Services to be changed from five-car rolling stock to nine-car.	HX services are not attributed a particular vehicle type, so new nine-car rolling stock information was input.
East Midland	Rolling stock changes for services between Corby and St Pancras, into a combination of 4/8/12 car services.	Timetable supplied by DfT did include aggregation of services as per existing PLANET coding. Therefore, proxy 6/7 car services were used for a selection of services.
East Coast	New timetable to be coded.	New timetable was manually coded.

6.2.3.1. Transit line checking

The new transit line coding underwent the following checks:

- Interrogation of network plots to ensure that capacity and frequency changes appeared in the expected places;
- Use of checking tools to ensure that journey times and stopping patterns were correctly implemented; and
- Checking of network attributes to ensure that there were no locations where demand is unable to access the network due to no services stopping at certain stations.

All other services that were incorporated during, or prior to, the October 2012 update were retained.

6.2.4. National Rail Update – Rolling Stock

As part of the update to the supply assumptions, a review of the rolling stock assumptions was undertaken in conjunction with HS2 Ltd and the DfT. The aim of this review was to obtain more robust assumptions with regard to the capacities of the rolling stock used in the model.

The implementation of PDFHv5 derived crowding curves meant that crowding levels were obtained using the ratio of total capacity (seated plus standing capacity) to seated capacity. As standing capacity was not used in the calculation of crowding penalties in earlier versions of the model, the previous updates to the rolling stock assumptions had not placed as much importance on the estimation of the standing capacities.

PFMv4.3 holds only a selection of rolling stock types as defined vehicles within the model. These are generally units that are used for strategic services that are not usually combined with other units. To allow for combinations of units to be modelled, for example, a two-car unit joined to a three-car unit, or to allow for changes in type of units during a modelled period, bespoke capacities can be input on the transit line as user defined transit line attributes with defined seated and total capacities.

6.3. Base Year Highway Network Update

6.3.1. Introduction

The PFMv3.0 highway network had been updated as part of the work to rebase from 2007/08 to 2010/11. This included incorporating into the model networks highway schemes that had been opened between 2007 and 2010.

This section describes further work undertaken to update the highway networks for PFMv4.3. This included a review of the existing networks, the re-calculation of the highway pre-loads and a review of the Volume Delay Functions (VDF).

6.3.2. Highway Network Review

The highway network review looked at the following elements:

- network density;
- link types;
- number of lanes; and
- link length

6.3.2.1. Network density

The first stage of the base year highway network review was to consider whether any links in the network were missing and to consequently update the network to include those links. The focus was to ensure that the full Highways Agency trunk road network[12] and other primary roads were included in the highway network. The main reason for this update was to ensure that the density of the highway networks was consistent with the revised highway demand.

The main links that were updated are shown below:

- M60 ring road between J18 and J24 in the east part of Manchester;
- A508 between A14 Kettering and A427;
- A421 between Bedford and M1 J13;
- A45 and A605 between Rushden and Peterborough;
- A5 between Milton Keynes and Rugby;
- A43 between Brackley and Northampton;
- A423 between Banbury and Coventry;
- A 404 between M4 J8/9 and M40 J4;
- A4010 between M40 and A413 in Aylesbury; and
- A34 between M3 J9 and A4 in Newbury.

Figure 6-1 shows the location of all of the changes made in the PFMv4.3 highway network. Each of the additional links was coded into the network and road type (for the VDF), lanes and distances were checked using aerial images from the internet.

6.3.2.2. Link types

In addition to the network density checks, the link types for each link were also checked and amended where necessary. Within PFMv4.3 the highway network link types are defined as:

- motorway;
- dual carriageway;
- single carriageway; and

12 http://www.highways.gov.uk/publications/network-management-map/

- other (reserved for centroid connectors and airport links only).

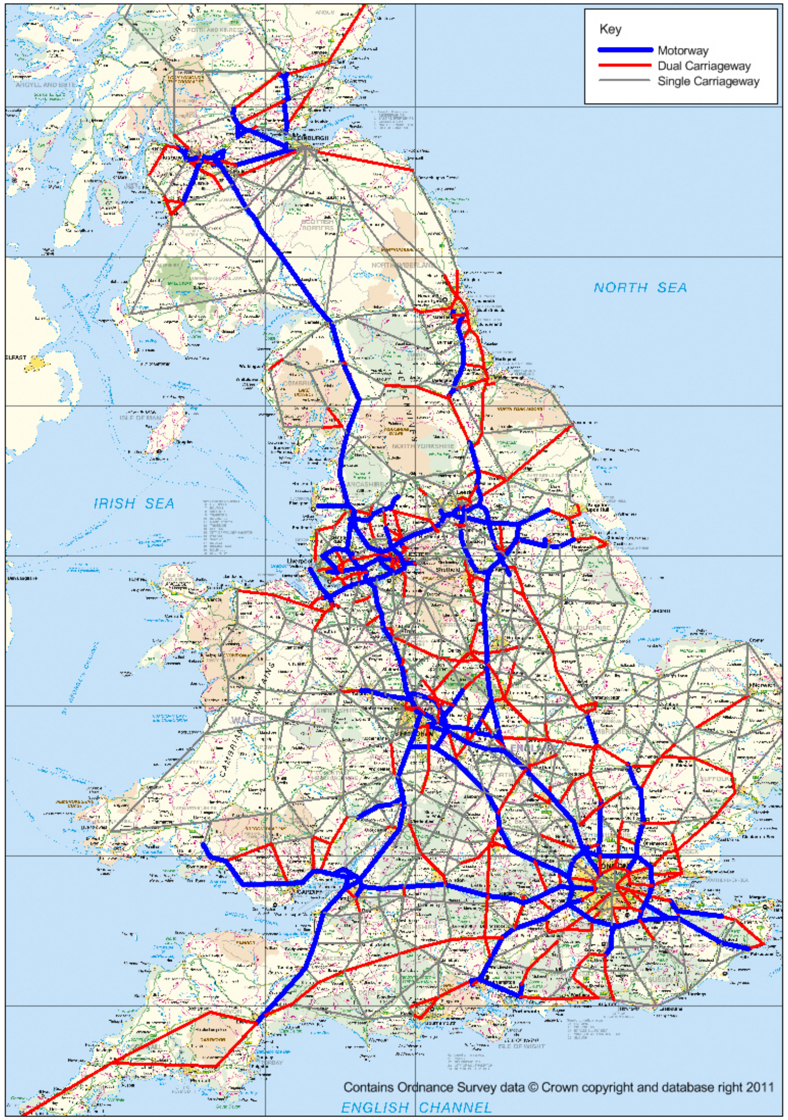
The link types were identified using Ordnance Survey mapping. The link type is used to identify the relevant VDF to be applied to the link. The link types are shown below in Figure 6-2.

6.3.2.3. Number of Lanes

The number of lanes on motorway links was checked using mapping and images from the internet. For other road types Ordnance Survey mapping was used to determine the number of links. The number of lanes (in each direction) on each link is shown below in Figure 6-3.

Figure 6-1 Updated Highway Network

Figure 6-2 Link Types



6.3.2.4. Link Lengths

GIS software was used to calculate the crow-fly distance for each link and these were compared against the distance coded in the model. The following criteria were then used to identify links where the coding needed to be reviewed further:

- crow fly distance was greater than modelled distance; or
- crow fly distance was lower than modelled distance with an absolute difference > 5 Km or a relative difference of > 10%.

Links that failed these criteria were identified and the distances were re-calculated using Ordnance Survey mapping.

6.3.3. Highway Pre-loads

The PFMv4.3 highway assignment demand only contains long distance movements - trips greater than 50 miles. As such, assigned traffic volumes on the highway network should be lower than the observed counts, with the difference between the two sets of traffic volumes assumed to be short distance traffic and goods vehicles. Whereas the longer distance traffic is an output of the demand model, the local traffic is assumed not to be responsive to the introduction of the HS2 scheme and is therefore a fixed flow on the network.

The traffic volume has an impact on modelled journey times, which are governed by the VDFs described below. Where traffic volumes are reduced (due to mode shift to HS2) less delay will occur, providing the HS2 scheme de-congestion benefits. In order to produce a better representation of flow and therefore travel time along the network, the difference between the modelled assigned flow and the total observed traffic flow is pre-loaded on to the network to ensure that the total traffic volume on the links is consistent with observed traffic counts.

Traffic count information was collected from the Highways Agency's TRADS database and supplemented with DfT traffic count data[13] for those links not in the TRADS database. The TRADS data is available as continuously monitored data with values provided for each hour, whereas the DfT traffic count data is only available as Average Annual Daily Traffic (AADTs) flows.

As PFMv4.3 models a weekday the AADT flows were converted to Average Annual Weekday Traffic (AAWT) flows by applying a factor derived from a comparison of AAWT and AADT flows from the 2010 TRADS counts. A summary of the factors by road type are shown in Table 6-2 and these factors were then applied to each count.

Table 6-2 2010 AADT to AADW factors

Road Type	AADT to AAWT factor	Count of Site
Motorway	1.08	250
Dual Carriageway	1.08	152
Single Carriageway	1.07	159
Unclassified	1.07	10
Grand Total	**1.07**	**571**

In total, over 900 TRADS counts and 1950 DfT counts were processed for use in PFMv4.3. Figure 6-4 shows the Average Annual Hourly Traffic (AAHT) flow allocated to each link in the PFMv4.3 highway network. The flows are shown as bandwidths and the highest volumes can been seen on the motorway network as would be expected.

13 Website: http://www.dft.gov.uk/traffic-counts/download.php

Figure 6-3 Number of Lanes in Each Direction

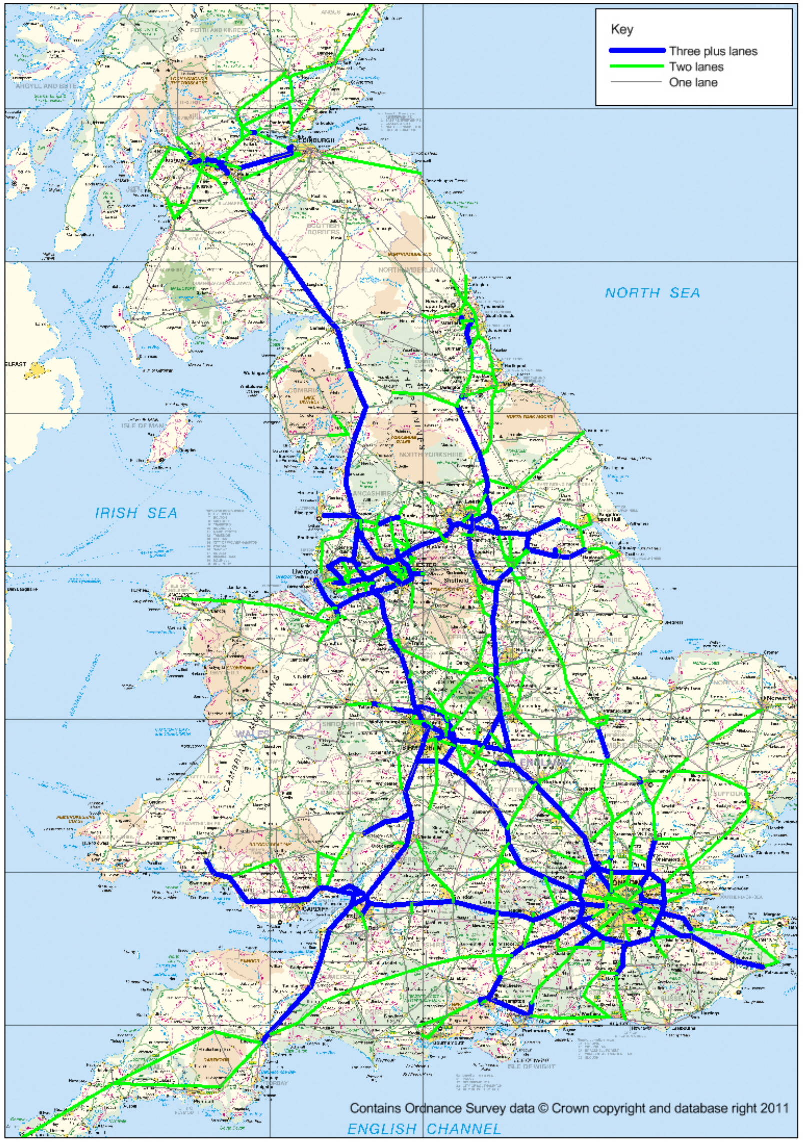
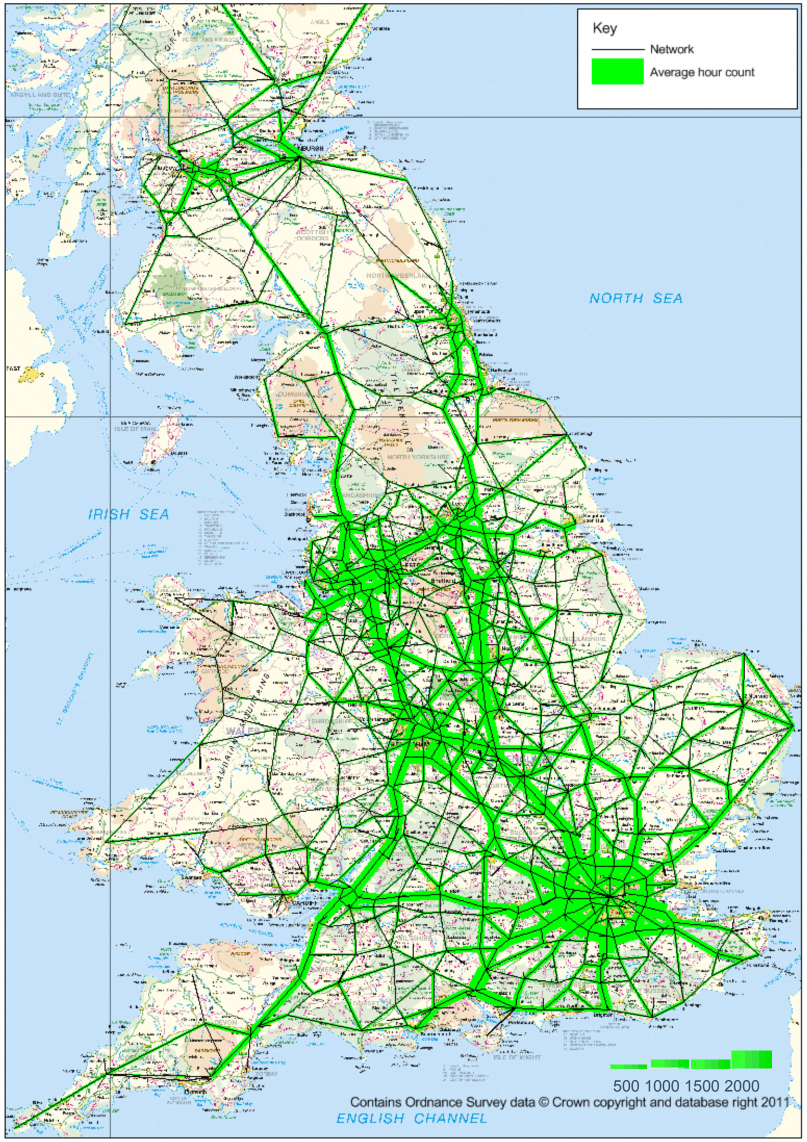


Figure 6-4 HS2 Network with traffic counts [average hourly traffic]



6.3.4. Volume Delay Functions (VDF)

The VDF specifies how journey times increase as flows increase. A VDF is applied to each link with the form of the VDF varying by road type. The majority of PFMv4.3 highway links are assigned with VDF types for motorway, dual carriageway or single carriageway as appropriate; with centroid connectors and airport links assigned fixed speeds. The VDF have been updated to match the form of curves found in the DfT's COBA[14] program.

As part of the VDF review the need for a specific VDF for Managed Motorway Dynamic Hard Shoulder (MM-DHS) running was considered. This had been the case in the previous PFMv3.0 highway networks. At that time the schemes being introduced by the Highways Agency assumed that the hard shoulder would be opened to traffic once the flow on the carriageway reached a threshold, typically 4,500 vehicles for a three lane motorway. Once the hard shoulder was made available to traffic the speed limit would be reduced to 60mph in the first instance.

More recently the Highways Agency has refined the Managed Motorway concept and introduced All Lane Running schemes (MM-ALR) where the hard shoulder is open to traffic at all times and the default speed limit is 70mph (while like all Managed Motorway schemes the speed limit varies with traffic flow, this variation is not modelled in PFMv4.3). In modelling terms this is no different from a conventional motorway with variable speed limits and means that there is no requirement for a specific VDF to represent managed motorways. Therefore, for such schemes the coding has been amended to add an extra lane and the conventional motorway VDF has been applied.

6.3.4.1. Impact of VDF changes

The impact of the network changes varies by link type, making it difficult to determine the overall impact without undertaking assignments in PFMv4.3. The difference between the form of each VDF is discussed briefly below for each link type - motorway, dual carriageway and single carriageway.

Motorway

The impact of adopting the revised VDF is to reduce maximum capacity to 2250 vehicles/lane/hour rather than 2520 vehicles/lane/hour with a revised form of the delay curve. Up to a flow of 1200 vehicles per lane the original and revised VDF's are identical. After that point the revised curves are linear and will lead to higher speeds at any flow. As assigned flows within the PFMv4.3 highway model are average weekday hourly flows they will be lower than peak hour flows so the impact of this change is likely to be small as the assigned flows will be at the lower end of the VDF.

All-Purpose Dual Carriageway

The impact of adopting the revised VDF is a higher free flow speed (116 km/h rather 104.5 km/h) and a revised form of delay curve. As with the motorway VDF the main impact is a difference in journey times at higher flows. However, as the PFMv4.3 highway model assigns an average weekday hourly flow, which is lower than peak hour flows, the impact is likely to be quite small on dual carriageway links.

Single Carriageway

The impact of adopting the revised COBA VDF is a lower free flow speed (72 km/h rather 91 km/h) and a different delay curve at higher flows. The main impact for single carriageway traffic is lower speeds at all levels of flow, though the difference becomes larger where flow is greater.

6.4. Highway Forecast Network

6.4.1. Introduction

This section describes the process of determining the future year highway schemes for PFMv4.3 for the forecast years of 2026 (opening year) and 2036 (cap year). The PFMv3.0 highway network update had included additional schemes added to the networks between 2026 and the cap year to reflect possible improvements to the motorway network. For PFMv4.3 no additional schemes were added, hence the 2026 and 2036 (cap year) networks were identical. It is assumed HS2 will have no impact on the development of

14 https://www.gov.uk/government/publications/coba-11-user-manual

forecast year highway schemes, therefore they are identical in the Do-Minimum and Do-Something scenarios.

Information relating to the proposed enhancements to the highway network between 2010 and 2026 was provided by the DfT and was based on schemes included in the DfT's National Transport Model. This was reviewed against lists on the Highways Agency's Road Projects website together with the Welsh and Scottish equivalents, the National Infrastructure Plan 2011 and subsequent DfT announcements.

6.4.2. Determining the future year highway schemes

The update to the future year PFMv4.3 Do-Minimum highway network follows the advice in DfT's TAG Unit 3.15.5[15] 'Forecasting Using Transport Models - The Treatment of Uncertainty in Model Forecasting'. The guidance states that an uncertainty log should be created that includes an assessment of the uncertainty of each individual input by placing it into one of the four categories shown in Table 6-3 taken from section 1.4.5 of the TAG Unit.

Table 6-3 Classification of Future Inputs

Probability of the Input	Status
Near certain: The outcome will happen or there is a high probability that it will happen.	- Intent announced by proponent to regulatory agencies. - Approved development proposals. - Projects under construction.
More than likely: The outcome is likely to happen but there is some uncertainty.	- Submission of planning or consent application imminent. - Development application within the consent process.
Reasonably foreseeable: The outcome may happen, but there is significant uncertainty.	- - Identified within a development plan. - Not directly associated with the transport strategy/ scheme, but may occur if the strategy/scheme is implemented. - Development conditional upon the transport strategy/scheme proceeding. - Or, a committed policy goal, subject to tests (e.g. of deliverability) whose outcomes are subject to significant uncertainty.
Hypothetical: There is considerable uncertainty whether the outcome will ever happen.	- Conjecture based upon currently available information. - Discussed on a conceptual basis. - One of a number of possible inputs in an initial consultation process. - Or, a policy aspiration.

The uncertainty log was created using the schemes contained in the DfTs National Transport Model and the status of each of the schemes was discussed with the DfT. Further checks were undertaken by reviewing the schemes against other sources such as the Highways Agency's Road Projects website (and Welsh and Scottish equivalents), the National Infrastructure Plan 2011 and other DfT announcements (such as the A14 scheme). The schemes were then assigned an uncertainty category, which was reviewed by DfT.

TAG Unit 3.15.5 guidance states that all the inputs categorised as 'near certain' will be included in the core scenario and it is also expected that those inputs categorised as 'more than likely' will be included. This approach is consistent with that adopted for rail forecasting.

6.4.3. Future year highway schemes

The list of schemes provided and subsequently reviewed by the DfT included schemes marked as open since 2010 and also on site and these were included in the future year PFMv4.3 highway networks. Following the guidance only schemes considered as near certain and more than likely were included in the future year PFMv4.3 highway networks.

15 http://www.dft.gov.uk/webtag/documents/expert/unit3.15.5.php

A number of schemes in the reviewed DfT list were not included in the final networks. Reasons for excluding schemes were:

- maintenance or structural schemes with no impact on highway capacity;
- junction schemes (not applicable in the PFMv4.3 link only highway network);
- small scale improvements that would affect only a fraction of the modelled link;
- safety schemes; and
- schemes on the fringes of the network.

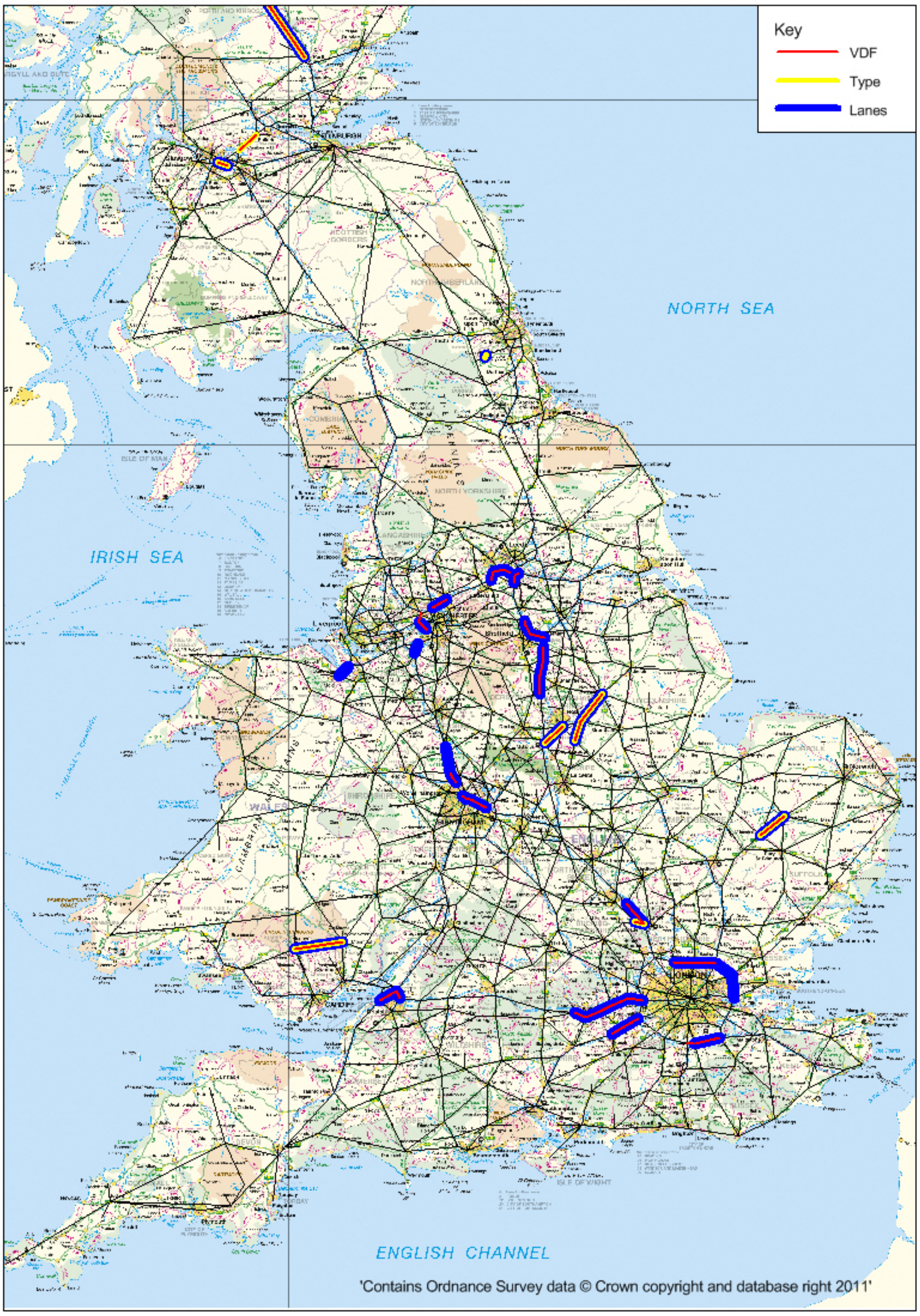
As the future year schemes that were included in the model amounted to improvements to existing links no additional highway links were added into the model. Instead the number of lanes and VDF were amended to reflect the changes made to the links. The schemes that were included in the PFMv4.3 highway model are listed in Table 6-4 and shown in Figure 6-5.

Table 6-4 Schemes in the uncertainty log (open, on site, near certain, more than likely)

Uncertainty	Scheme
Open	A1 Bramham – Wetherby
Open	A3 Hindhead Improvement
Open	A421 Bedford to M1 Junction 13
Open	M1 Junctions 25-28 Widening Scheme
Open	M25 Junctions 16-23 Widening
Open	M25 Junctions 27-30 Widening
Open	M27 J3-4 Widening
Open	M42 J7-9 HSR
Open	M6 J4-5 HSR
Open	M6 Junctions 8-10A Managed Motorways (Birmingham Box Phase 2)
Open	M74 Completion
Open	M80 Stepps to Haggs
On Site	A1 Dishforth to Leeming Improvement Scheme (A1 Dishforth to Barton)
On Site	A23 Handcross to Warninglid
On Site	A46 Newark to Widmerpool Improvement
On Site	M1 Junction 10-13 Improvements
On Site	M4 Junction 19-20 and M5 Junction 15-17 Managed Motorways
On Site	M4 Junction 3-2 Bus Lane Suspension Scheme
On Site	M6 Junctions 5-8 Managed Motorways (Birmingham Box Phase 3)
On Site	M62 Junctions 25 to 30 Managed Motorway
Near Certain	A11 Fiveways to Thetford Improvement
Near Certain	A160 / A180 Improvements, Immingham
Near Certain	A465 Dualling Scheme between Abergavenny and Hirwaun
Near Certain	A556 Knutsford to Bowdon Environmental Improvement
Near Certain	M1 Junctions 28-31 Managed Motorways
Near Certain	M1 Junctions 32-35a Managed Motorway
Near Certain	M1 Junctions 39-42 Managed Motorway
Near Certain	M25 Junctions 23-27 Managed Motorways
Near Certain	M25 Junctions 5-7 Managed Motorways
Near Certain	M60 Junctions 15-12 Lane Gain
Near Certain	M60 Junctions 8-12 Managed Motorways
Near Certain	M62 Junctions 18-20 Managed Motorway

Uncertainty	Scheme
Near Certain	M8 M73 M74 Motorway Improvements
More Than Likely	A453 Widening (M1 Junction 24 to A52 Nottingham)
More Than Likely	A494 Drome Ewloe Improvement
More Than Likely	A5-M1 Link (A505 Dunstable Northern Bypass)
More Than Likely	A9 Dualling
More Than Likely	M3 Junctions 2-4a Managed Motorway
More Than Likely	M4 Junctions 3-12 Managed Motorway
More Than Likely	M54 to M6 / M6 (Toll) Link Road
More Than Likely	M6 Junction 10A - 13 Managed Motorway

Figure 6-5 HS2 PLD 2026 highway network



6.5. Air Passenger Supply

6.5.1. Introduction

This section describes the update to the air passenger supply data in PFMv4.3. The air passenger supply represents domestic air services wholly within mainland Britain, thus excludes services to/from Northern Ireland, the Channel Islands, Isle of Man and Scottish Islands. This update also included revisions to the air fares which are coded as part of the air services within PFMv4.3 and so are within the scope of this work.

The air networks developed during the previous model update (reported in the April 2012 Model Development and Baseline Report) were based on the following data sources:

- Base year (2010) services were derived from the CAA punctuality statistics for the ten largest airports (available on the CAA website) with further infilling to reflect services from the remaining airports. This additional data was obtained from airport and airline websites; and
- Forecast years (2026 and cap year) services were obtained from the DfT Aviation Model, though adjusted to ensure the differences between the PFMv4.3 air networks in the 2010 network were carried through to the forecast years.

For this update the networks for all years were taken direct from the DfT Aviation Model, thus ensuring that there is a consistent approach to forecasting domestic air passenger demand and aviation supply between the base and forecast years in PFMv4.3. The data supplied from the DfT Aviation Model was from the same September 2012 forecasts used for the demand growth update. Two data sets were provided:

- Annual unconstrained air traffic movements; and
- Business and leisure air fares.

This section outlines the supply data from the DfT Aviation Model as used in PFMv4.3 and compares it with the data used in PFMv3.0. Information on air fares is also shown in this section.

6.5.2. 2010 Base Year Air Supply

Table 6-5 shows the percentage changes (based on numbers of fights) between the 2010 networks in PFMv3.0 and PFMv4.3. The main changes in number of flights are:

- an increase of 258% between Wales and the North East;
- an increase of 134% between Yorkshire & Humber and the South West; and
- a reduction of 100% between Wales and the South West, South East internal and London and the South East.

6.5.3. Forecast Year Air Supply

Table 6-6 shows the percentage differences between the PFMv3.0 and PFMv4.3 2026 networks (based on numbers of flights). Overall, the revised networks contain 14% fewer flights with the main changes in number of flights being:

- an increase of 226% between Wales and the North East;
- an increase of 137% between the North East and London (127% in the opposite direction);
- an increase of 126% between Scotland and London (96% in the opposite direction); and
- reductions of 100% between Wales and the South West, south East internal, South West and West Midlands (and vice versa), London and the South West (and vice versa) and East of England and Yorkshire & Humber (and vice versa).

Table 6-5 Changes in 2010 Air Networks between PFMv3.0 and PFMv4.3 (change in number of flights)

Area	Scotland	North West	North East	Yorks & Humber	East Midlands	West Midlands	Wales	South West	South East	East of England	London	Grand Total
Scotland	-	-40%	-3%	-8%	-29%	-29%	-25%	-33%	-14%	-12%	-2%	-15%
North West	-39%	-	-	-	-	-	-	25%	-15%	-41%	33%	-8%
North East	12%	-	-	-	-	8%	27%	-5%	-21%	-31%	-28%	-9%
Yorks & Humber	4%	-	-	-	-	-	-	134%	-9%	-	-	7%
East Midlands	1%	-	-	-	-	-	-	-	-	-	-	1%
West Midlands	-9%	-	31%	-	-	-	-	-	-	-	-	-5%
Wales	-14%	-	258%	-	-	-	-	-100%	-	-	-	6%
South West	-27%	49%	13%	73%	-	-	-	-	-36%	-	-	2%
South East	1%	-15%	-7%	-25%	-	-	-	-36%	-100%	-	-	-14%
East of England	-1%	-6%	0%	-	-	-	-	-	-	-	-	1%
London	10%	33%	-27%	-	-	-	-	-	-100%	-	-	2%
Grand Total	-3%	-5%	5%	-9%	-29%	-25%	-8%	-9%	-28%	-13%	2%	-8%

Table 6-6 Changes in 2026 Air Networks between PFMv3.0 and PFMv4.3 (change in number of flights)

Area	Scotland	North West	North East	Yorks & Humber	East Midlands	West Midlands	Wales	South West	South East	East of England	London	Grand Total
Scotland	-68%	-44%	8%	-44%	-7%	-14%	-50%	-58%	-50%	-82%	126%	-15%
North West	-41%	-	-	-	-	-	-	-17%	-29%	-3%	-	3%
North East	25%	-	-	-	-	-7%	34%	-29%	-10%	-81%	137%	-7%
Yorks & Humber	-48%	-	-	-	-	-	-	-43%	-18%	-100%	-	-47%
East Midlands	-1%	-	-	-	-	-	-	-	-	-	-	-1%
West Midlands	-3%	-	15%	-	-	-	-	-100%	-	-	-	-5%
Wales	-42%	-	226%	-	-	-	-	-100%	-	-	-	-24%
South West	-53%	0%	-12%	-53%	-	-100%	-	-64%	-22%	-82%	-100%	-44%
South East	-41%	-35%	-10%	-32%	-	-	-	-26%	-100%	-	-	-39%
East of England	-63%	9%	-61%	-100%	-	-	-	-76%	-	-	-	-59%
London	96%	-	127%	-	-	-	-	-100%	-	-	-	120%
Grand Total	-14%	4%	2%	-49%	-7%	-17%	-30%	-50%	-43%	-77%	149%	-14%

6.5.4. Modifications to Air Services

The DfT Aviation Model assumes that services will be introduced, or removed, based on forecast demand in each forecast year model run, subject to assumptions on minimum loadings. Hence the networks will be dependent partly on the economic growth assumptions in the demand matrices.

The changes to individual services that have been made between the PFMv3.0 and PFMv4.3 2010 air networks are shown in Table 6-7. This table also shows the services added or removed in PFMv4.3 in 2026 (based on the 2010 networks) and 2036 (based on the 2026 networks).

Table 6-7 Air Routes Added or Removed from PLD Air Networks

2010 Routes Added	**2010 Routes Removed**
Bristol - Manchester	Aberdeen – Exeter
Bristol - Newquay	Birmingham – Dundee
Leeds Bradford – Newquay*	Bournemouth – Manchester
Newcastle - Newquay	Bristol – Inverness
	Cardiff – Glasgow
	Dundee - London City
	Edinburgh – Manston
	Exeter – Leeds Bradford
	Gatwick - Leeds Bradford
	Gatwick – Plymouth
	Glasgow – Plymouth
	Inverness – Southampton
	Manchester – Manston
	Manchester – Newquay
	Manchester – Plymouth
	Newcastle – Plymouth
2026 Routes Added	**2026 Routes Removed**
Aberdeen – London City	Aberdeen – Gatwick
Luton – Manchester	Aberdeen – Luton
Newquay – Leeds Bradford*	Edinburgh – Gatwick*
Newquay – Manchester*	Gatwick – Manchester
	Glasgow – Luton
	Glasgow – Stansted
	London City – Edinburgh*
	Prestwick – Stansted
2036 Routes Added	**2036 Routes Removed**
Edinburgh – Gatwick*	Edinburgh – Stansted*
Edinburgh – Inverness	Gatwick – Glasgow
Exeter – Aberdeen*	Glasgow – Leeds Bradford
Glasgow – Stansted*	Inverness – Luton
Inverness – London City	Newquay – Manchester*
Leeds Bradford – Prestwick	Southampton – Glasgow*
Norwich – Exeter*	
Norwich – Newquay*	

Note: * = route operates one way

6.5.5. Air Fares

For the PFMv3.0 average fare data were developed based on CAA survey data, which were sourced from the DfT. The fare data were ‘average fare paid’ (including appropriate taxes etc.) and were available for the period 2004–2010. Fare data were not available for every year on every route, and so appropriate values were interpolated using data from previous years. The average fares were ultimately factored by the 2010 average business and leisure fares as detailed in the DfT’s Aviation Model fares profile, to derive typical fares for each route by journey purpose.

The revised networks for PFMv4.3 take the base year domestic air fare matrix unadjusted from the DfT Aviation Model which provides air fares between all modelled airports in constant 2008 prices and values. These are adjusted to the 2010 base year and the forecast years using the index of changes in real domestic business and leisure fares supplied by the DfT. The fare matrix is based on a distance function which has been developed for each individual airport with domestic flights. The index of changes in real fares is shown in Table 6-8 and this is consistent with the September 2012 DfT Aviation Model forecasts used to develop the PFMv4.3 forecasts and networks.

Table 6-8 Real Fare Index Factors

Year	Business	Leisure
2010	1.024	1.059
2026	0.999	1.005
2036	1.003	1.004

7. Update to Crowding

7.1. Background

The crowding curves in PFMv3.0 used crowding parameters from PDFHv4. WebTAG guidance updated in August 2012 (TAG Unit 3.15.4) states that the approach to modelling crowding should be consistent with PDFHv5 recommendations. In carrying out the update, advantage was also taken of the opportunity to review the evidence on the variation in loading factors.

This section first describes the methods used in PFMv3.0 to model crowding impacts and then the changes involved in moving to PDFHv5 crowding figures in PFMv4.3. Finally it presents a comparison between PFMv3.0 and PFMv4.3.

7.2. PFMv3.0 Methodology

PFMv3.0 used PDFHv4 crowding penalties. Unlike PDFHv3, where the penalties were expressed in additional minutes (per minute of crowding), PDFHv4 expressed the penalties in pence per minute of crowding. These were therefore converted, using assumptions about the value of time, to in-vehicle time multipliers, which are easier to implement in PLANET.

The model applied these multipliers to the in-vehicle time (IVT) to give a 'crowded time' to represent a penalty applied to passengers travelling in crowded conditions. Separate penalties apply to seated and standing passengers and these penalties are different depending on the load factor or seat utilisation. Table 7-1 shows the penalties. It should be noted that a penalty of 1.0 represents a situation where no crowding disbenefit is perceived.

Table 7-1 PDFHv4 Converted Crowding Penalties

TOC Groups	Load Factor	Passenger Type	Business	Leisure	Commuting
London Inter-Urban	80%	Seated	1.05	1.05	1.00
	100%	Seated	1.25	1.25	1.00
	140%	Seated	1.70	1.70	1.00
	100%	Standing	3.50	3.50	2.50
	140%	Standing	4.90	4.90	2.90
London Suburban	80%	Seated	1.00	1.05	1.00
	100%	Seated	1.05	1.25	1.10
	140%	Seated	1.20	1.70	1.50
	100%	Standing	2.50	3.50	2.50
	140%	Standing	2.90	4.90	2.90
Non-London	80%	Seated	1.07	1.05	1.00
	100%	Seated	1.25	1.25	1.10
	140%	Seated	1.70	1.70	1.50
	100%	Standing	4.00	6.50	2.50
	140%	Standing	5.40	8.50	2.90

7.3. PFMv4.3 Methodology

7.3.1. Change to Crowding Penalty Methodology

PFMv4.3 adopts the PDFHv5 guidance which provides a number of changes to the crowding methodology, these are summarised below.

- Penalties are no longer different by journey purpose. All journey purposes assume the same penalties.

- PDFHv5 factors are given as multipliers applied to IVT, as in PDFHv3, as opposed to the PDFHv4 approach of multipliers applied to VoT, with separate values for seated and standing passengers.
- 'London Inter-Urban', 'London Suburban' and 'Non-London' have been replaced by 'Intercity', 'London and South East' (LSE) and 'Regional' respectively in terms of TOC groups.
- The units used to measure crowding have changed. Seat utilisation is used (as in PDFHv4) up to the point of 100% seat utilisation. Above 100% seat utilisation the crowding measure is based upon the number of passengers standing per square metre (Pax/m^2).

The PDFHv5 crowding penalties are shown in Table 7-2 below.

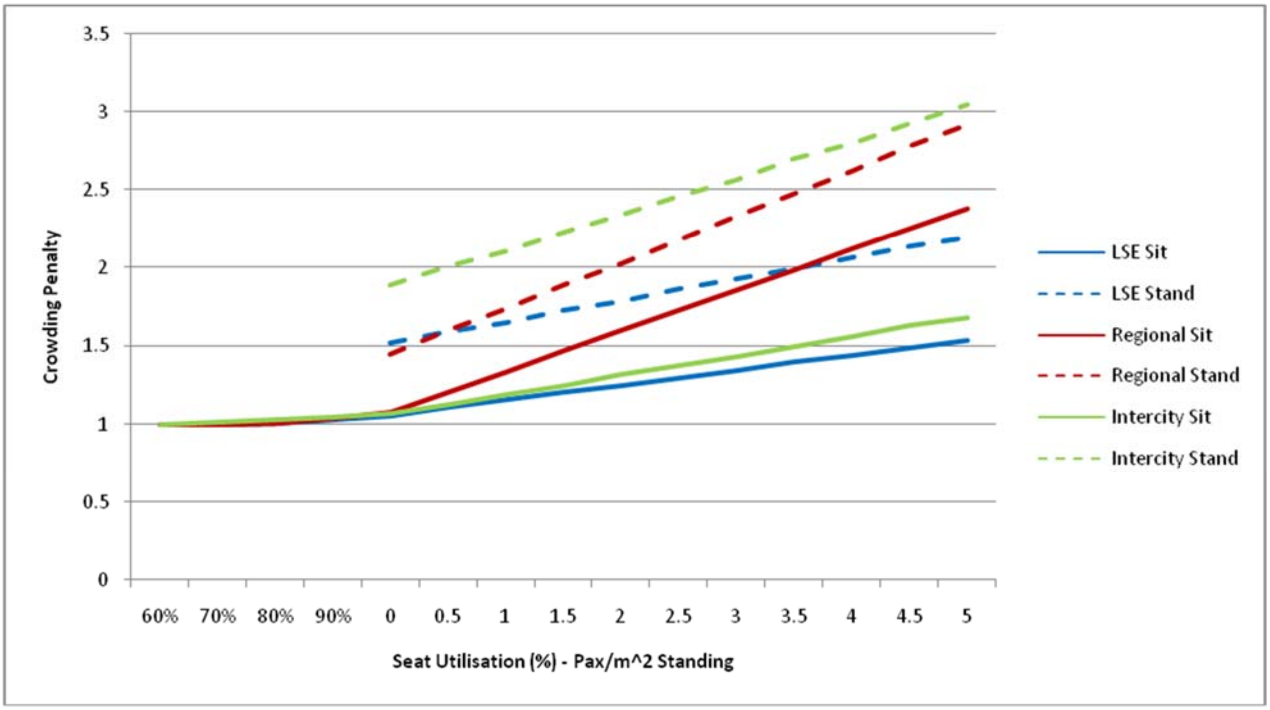
Table 7-2 PDFHv5 Crowding Penalties

	LSE		Regional		Intercity	
	Sit	Stand	Sit	Stand	Sit	Stand
Load Factor						
60%	1.00	n/a	1.00	n/a	1.00	n/a
70%	1.00	n/a	1.00	n/a	1.02	n/a
80%	1.01	n/a	1.01	n/a	1.03	n/a
90%	1.03	n/a	1.04	n/a	1.05	n/a
Pax/m^2						
0.0 [=100%]	1.06	1.52	1.08	1.45	1.07	1.89
0.5	1.11	1.59	1.21	1.60	1.13	2.01
1.0	1.16	1.65	1.34	1.74	1.19	2.11
1.5	1.21	1.73	1.47	1.89	1.25	2.23
2.0	1.25	1.79	1.60	2.03	1.32	2.34
2.5	1.30	1.87	1.73	2.18	1.38	2.46
3.0	1.35	1.93	1.86	2.33	1.43	2.57
3.5	1.40	2.00	1.99	2.48	1.50	2.70
4.0	1.44	2.07	2.12	2.62	1.56	2.80
4.5	1.49	2.14	2.25	2.78	1.63	2.93
5.0	1.54	2.20	2.38	2.92	1.68	3.05
6.0	1.63	2.34	2.64	3.21	1.81	3.31

For the purposes of implementing PDFHv5 crowding penalties it is necessary to recognise standing as well as seated capacity. A notional standing capacity has therefore been defined as 2.5 standing passengers per square metre of standing space, in line with standard MOIRA assumptions. The resulting standing capacity is added to the seated capacity to give the total capacity of the train used in the calculations below.

Figure 7-1 shows the profiles of the new crowding curves, as detailed in Table 7-2. Intercity and LSE seated penalties are low in comparison to the Regional ones, whilst standing penalties on Regional services become steadily more severe (by comparison) as the load factor increases, with Intercity standing penalties being higher than Regional or LSE ones.

Figure 7-1 PDFHv5 Crowding Penalty Profiles per Train



The profiles of the crowding factors in Figure 7-1 show the penalties applied on a particular train for sitting and standing passengers as the load factor increases. These are converted into a weighted average based on the proportion of seated and standing passengers to give a single figure, as shown in the worked example below. This is for an intercity train that has a load factor of 110% and for the purposes of the example it is assumed that this load factor is equivalent to 1.0 passenger standing per square metre. The single value for the crowding penalty is obtained from the following equation:

$$Crowding\ Penalty = \frac{(1\ \times 1.19) +\ (0.1\ \times 2.11)}{1.1} = 1.27$$

Where:

1.19 = the penalty for seated passengers at a load factor of 1.0 pax/m^2; and

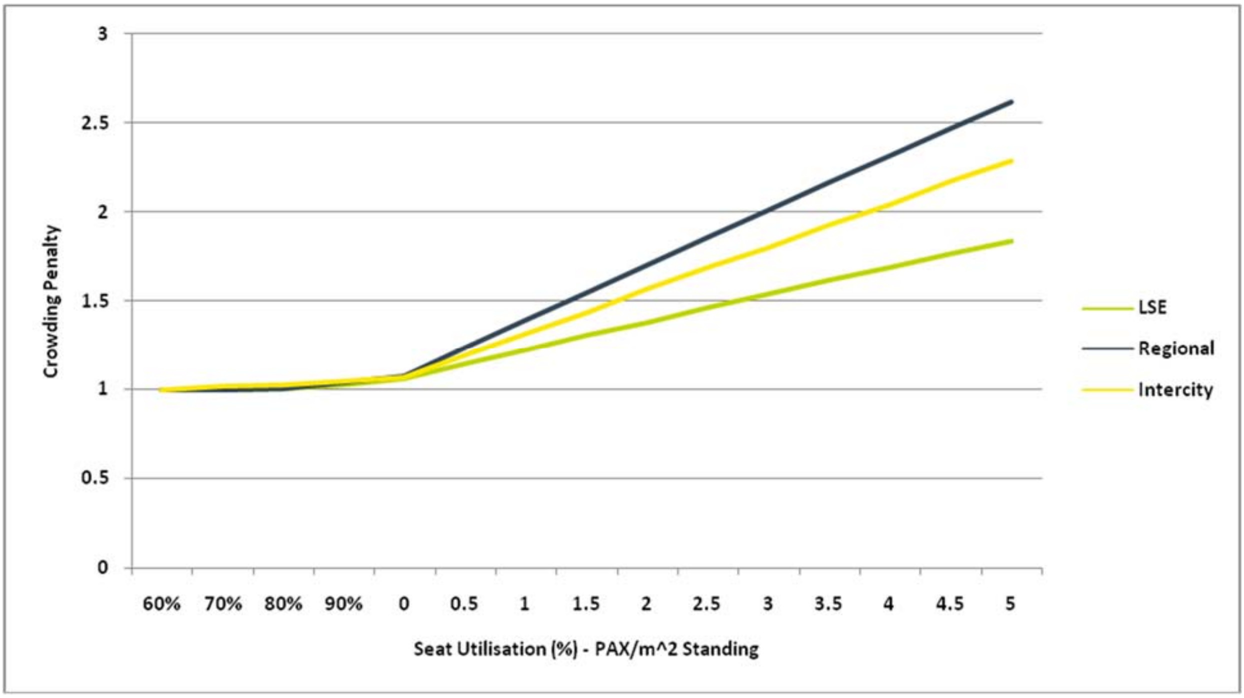
2.11 = the penalty for standing passengers at a load factor of 1.0 pax/m^2

Figure 7-2 shows the crowding penalties across different loadings for each TOC group averaged across seated and standing passengers. It can be seen that the penalties approximate to a piece-wise linear function in three sections:

- An initial flat section with no crowding;
- A shallow graded section at higher seat utilisation up to 100% as seats become more difficult to locate; and
- A more steeply graded section above 100% seat utilisation as an increasing proportion of passengers have to stand.

A similar type of linear function was also demonstrated by the PDFHv4 crowding parameters.

Figure 7-2 Weighted Average of Seated and Standing Penalties against Seat Utilisation



7.3.2. Development of New Crowding Curves to represent daily averages

7.3.2.1. Background

The PFM models (v3.0 and v4.3) represent either an all day (16-hour) period (PLD), or a 3-hour AM peak period (PS, PM, PN), and the load factor on each service in the model represents the average load factor across the day/period of that train, or trains, where services with the same itinerary are grouped together.

In reality, the profile of crowding across the day, or the AM peak, is not flat. In an all day scenario there is usually higher crowding in the AM and PM peaks than in the inter-peak, and during the AM peak models, there is usually a higher level of crowding from 08:00-09:00, generally speaking, though the peak period is variable. This is due to more people wishing to travel in the peak, but it is important to note that there is also more capacity/frequency to cater for this. It is also worth noting that this is not always true of long distance travel.

As noted in the previous section, the overall crowding curves (averaged across seated and standing passengers) can be approximated by three sections (as per the PDFHv4 methodology) as follows.

- The penalty is equal to 1 (equivalent to no crowding uplift) for a load factor between 0 and the lower crowding limit, defined separately for each trip group (LSE, Regional, Intercity).
- The penalty for a load factor between the lower crowding limit and 1 (100% seat utilisation) can be defined by a straight line with gradient A and intercept B.
- The penalty for a load factor higher than 1 (100% seat utilisation and standing passengers) can be defined by a straight line with gradient C and intercept D.

Parameters A, B, C and D are calculated using the following equations.

$$A = \frac{CP_{100\%\,Seated} - 1}{1 - LCT}$$

$$B = CP_{100\%\,Seated} - A$$

$$C = \frac{\left[CP_{2.5pax\,Standing} \times \frac{Cap_t - Cap_s}{Cap_t} + CP_{2.5\,pax\,Seated} \times \frac{Cap_s}{Cap_t} - CP_{100\%\,Seated}\right]}{\frac{Cap_t - Cap_s}{Cap_s}}$$

$D = CP_{100\%\,Seated} - C$

Where:

CP = Crowding Penalty

Cap_s= Seated Capacity

Cap_t= Total Capacity

LCT = Lower Crowding Threshold

To allow for variation over the day, the following equation (from Atkins' 2010 Model Development Report) is applied to the weighted average of standing and seated penalties as shown in Figure 7-2. This gives the period average value of the crowding penalty for the service, given an average load factor (x-bar), assuming a normal distribution with a defined standard deviation. It should be noted that journey purpose *p* is no longer relevant as penalties are now assumed constant across journey purposes.

$$C_{r,p}(\bar{x}) = \frac{1}{\sqrt{2\pi\delta_r^{\,2}}}\int_{-\infty}^{\alpha_{r,p}} e^{\frac{-(x-\bar{x})^2}{2\delta^2 r}}\,dx$$

$$+\frac{1}{\sqrt{2\pi\delta_r^{\,2}}}\int_{\alpha_{r,p}}^{1} (A_{r,p} + B_{r,p}x)e^{\frac{-(x-\bar{x})^2}{2\delta^2 r}}\,dx$$

$$+\frac{1}{\sqrt{2\pi\delta_r^{\,2}}}\int_{1}^{\infty} (C_{r,p} + D_{r,p}x)e^{\frac{-(x-\bar{x})^2}{2\delta^2 r}}\,dx$$

Where:

$\bar{x}$ is the average level of vehicle occupancy

δ_r is the observed standard deviation of vehicle occupancy by TOC group r

$\alpha_{r,p}$ is the lower threshold of crowding for TOC group r and journey purpose p

$A_{r,p}$ and $B_{r,p}$ are the lower crowding function parameters for TOC group r and journey purpose p

$C_{r,p}$ and $D_{r,p}$ are the higher crowding function parameters for TOC group r and journey purpose p

7.3.2.2. Data analysis

To calculate this period average crowding penalty, information is required describing the variability of load factors across the day. Whilst this was already used in PFMv3.0, it was considered important to obtain up to date data on observed variability. The relative standard deviation (actual standard deviation divided by the mean) of load factors across the modelled period was used to give a factor which when multiplied by the observed value of $\bar{x}$ provides a value of σ for the equation above.

Guard counts were received for the following TOCs at the stations listed below.

- Virgin West Coast (VWC) – London Euston, Birmingham New Street, Manchester Piccadilly
- East Coast (EC) – London Kings Cross, Leeds
- Midland Main Line (MML) – London St. Pancras, Sheffield
- Virgin Cross Country (VXC) – Manchester Piccadilly, Leeds

- Trans Pennine Express (TPE) – Manchester Piccadilly, Manchester Oxford Road, Liverpool Lime Street, Leeds
- Southern Trains (STN) – London Bridge, London Victoria
- Thameslink (TLK) – London Bridge, London Blackfriars, London St. Pancras

Load factors were derived from the guards counts based upon the seated capacity for each service. The seated capacities were also provided with the guards counts. The standard deviations from this data are shown in Table 7-3 (for all day data) and Table 7-4 (for AM peak data).

Table 7-3 Standard Deviations of Observed Load Factors – All Day (16 hr)

TOC	Station	Arrive/Depart	St. Deviation	Mean	Rel St. Dev.
VWC	BHM	Arrive	0.183	36%	0.514
VWC	BHM	Depart	0.177	35%	0.505
VWC	EUS	Arrive	0.162	45%	0.360
VWC	EUS	Depart	0.152	44%	0.345
VWC	MAN	Arrive	0.115	39%	0.292
VWC	MAN	Depart	0.136	38%	0.358
EC	KGX	Arrive	0.173	44%	0.391
EC	KGX	Depart	0.196	46%	0.427
EC	LDS	Arrive	0.140	33%	0.430
EC	LDS	Depart	0.192	34%	0.563
MML	STP	Arrive	0.264	57%	0.466
MML	STP	Depart	0.240	58%	0.414
MML	SHF	Arrive	0.123	34%	0.364
MML	SHF	Depart	0.177	35%	0.513
VXC	LDS	Arrive	0.231	49%	0.475
VXC	LDS	Depart	0.291	55%	0.528
VXC	MAN	Arrive	0.201	45%	0.445
VXC	MAN	Depart	0.268	47%	0.572
TPE	LDS	Arrive	0.240	44%	0.544
TPE	LDS	Depart	0.224	42%	0.536
TPE	LIV	Arrive	0.111	28%	0.399
TPE	LIV	Depart	0.187	36%	0.523
TPE	MAN	Arrive	0.214	33%	0.647
TPE	MAN	Depart	0.212	32%	0.653
TPE	MCO	Arrive	0.238	51%	0.467
TPE	MCO	Depart	0.219	50%	0.441
STN	LBG	Arrive	0.502	56%	0.896
STN	LBG	Depart	0.423	48%	0.875
STN	VIC	Arrive	0.306	36%	0.839
STN	VIC	Depart	0.295	37%	0.799
TLK	LBG/BFR	Arrive	0.428	48%	0.896
TLK	LBG/BFR	Depart	0.344	43%	0.798
TLK	STP	Arrive	0.402	46%	0.881
TLK	STP	Depart	0.368	53%	0.701

Table 7-4 Standard Deviations of Observed Load Factors– AM Peak (3 hr)

TOC	Station	Arrive/Depart	St. Deviation	Mean	Rel St. Dev.
VWC	BHM	Arrive	0.167	0.474	0.352
VWC	BHM	Depart	0.163	0.423	0.386
VWC	EUS	Arrive	0.192	0.605	0.317
VWC	EUS	Depart	0.143	0.413	0.346
VWC	MAN	Arrive	0.136	0.438	0.311
VWC	MAN	Depart	0.118	0.364	0.325
EC	KGX	Arrive	0.159	0.643	0.248
EC	KGX	Depart	0.106	0.363	0.293
EC	LDS	Arrive	0.160	0.581	0.276
EC	LDS	Depart	0.062	0.422	0.147
MML	STP	Arrive	0.086	0.381	0.226
MML	STP	Depart	0.118	0.410	0.287
MML	SHF	Arrive	0.274	0.851	0.322
MML	SHF	Depart	0.079	0.363	0.218
VXC	LDS	Arrive	0.240	0.724	0.332
VXC	LDS	Depart	0.451	0.535	0.842
VXC	MAN	Arrive	0.187	0.734	0.255
VXC	MAN	Depart	0.182	0.470	0.386
TPE	LDS	Arrive	0.352	0.581	0.605
TPE	LDS	Depart	0.265	0.407	0.650
TPE	LIV	Arrive	0.114	0.432	0.265
TPE	LIV	Depart	0.177	0.348	0.508
TPE	MAN	Arrive	0.291	0.458	0.636
TPE	MAN	Depart	0.208	0.326	0.638
TPE	MCO	Arrive	0.305	0.678	0.451
TPE	MCO	Depart	0.175	0.492	0.357
STN	LBG	Arrive	0.494	1.233	0.401
STN	LBG	Depart	0.086	0.189	0.458
STN	VIC	Arrive	0.429	1.115	0.385
STN	VIC	Depart	0.161	0.289	0.557
TLK	LBG/BFR	Arrive	0.443	1.128	0.392
TLK	STP	Depart	0.333	0.608	0.547
TLK	STP	Arrive	0.311	1.106	0.281
TLK	LBG/BFR	Depart	0.249	0.352	0.707

Relative standard deviations for use in PFMv4.3 have been developed from the observed data in Table 7-3 and Table 7-4 based on average values for the relevant train operators and time period and rounded down to one decimal place. The resulting values are shown in Table 7-5, together with the relative standard deviations used previously in PFMv3.0.

Table 7-5 Recommended Relative Standard Deviations

Model	Groups	PFMv3.0	PFMv4.3
PLD	Intercity	0.300	0.400
	Regional	0.300	0.500
	LSE	0.300	0.800
PS/PM/PN	Intercity	0.491	0.300
	Regional	0.491	0.500
	LSE	0.191	0.400

Applying the average crowding equation for particular rolling stock type examples using the recommended relative standard deviations from Table 7-5 gives the average crowding penalties as a function of the average load factor. Figure 7-3 shows theses curves as dashed lines, together with the corresponding curves for a single train shown as a solid line.

The curves for the average crowding penalties sit above those for the single train. For a single train that has 60% seat utilisation, the crowding penalty will be a value of 1, i.e. there is no crowding penalty. For a set of trains with that has an average seat utilisation of 60%, variability will result in some individual trains with seat utilisations of more than 60% thus a crowding penalty greater than 1 would be applied.

To investigate the importance of the choice of the standard deviations used to measure variability, sensitivity tests have been undertaken to show how the resulting crowding curves vary as the chosen value of standard deviation changes.

Figure 7-3 shows how changing the standard deviation for Intercity trips would change the resulting crowding curves. The most notable change is that at seated capacity, the crowding penalty is approximately 0.05 higher, or a proportional change of around 4% in the crowding penalty.

This shows that changes to the standard deviations used results in relatively small changes to the crowding penalties used which in turn would have relatively minor impacts on the business case.

Figure 7-3 Single Train and Average PDFHv5 Crowding Curves

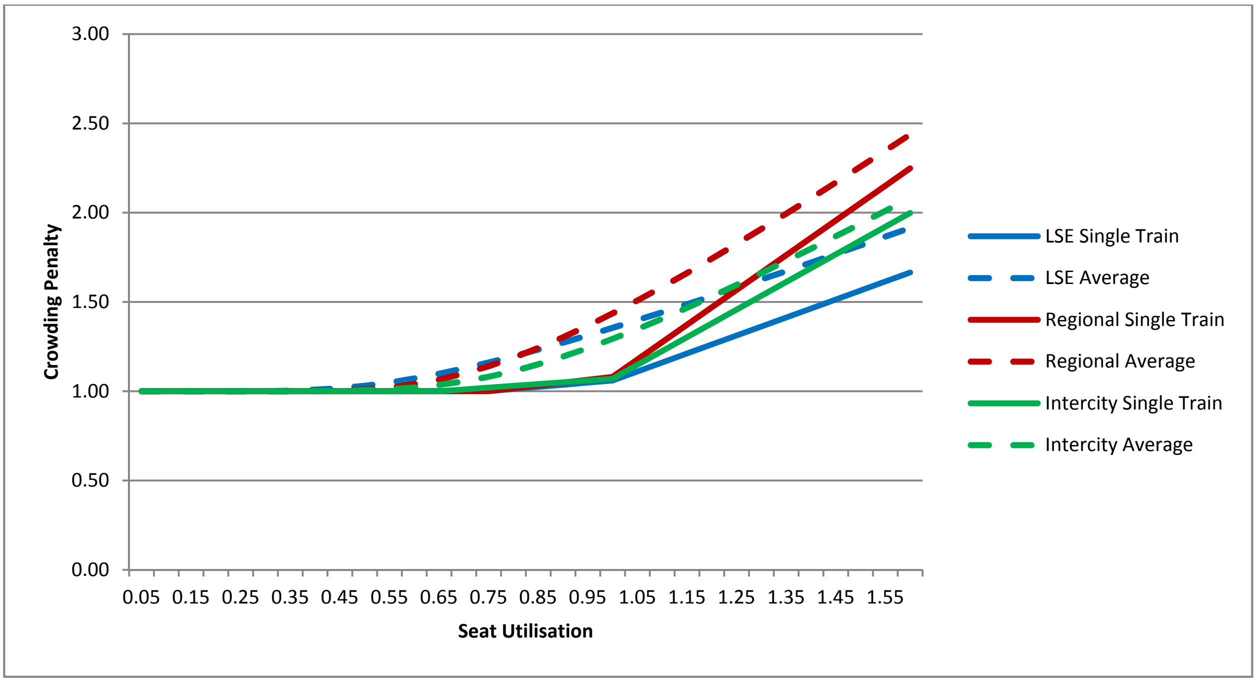
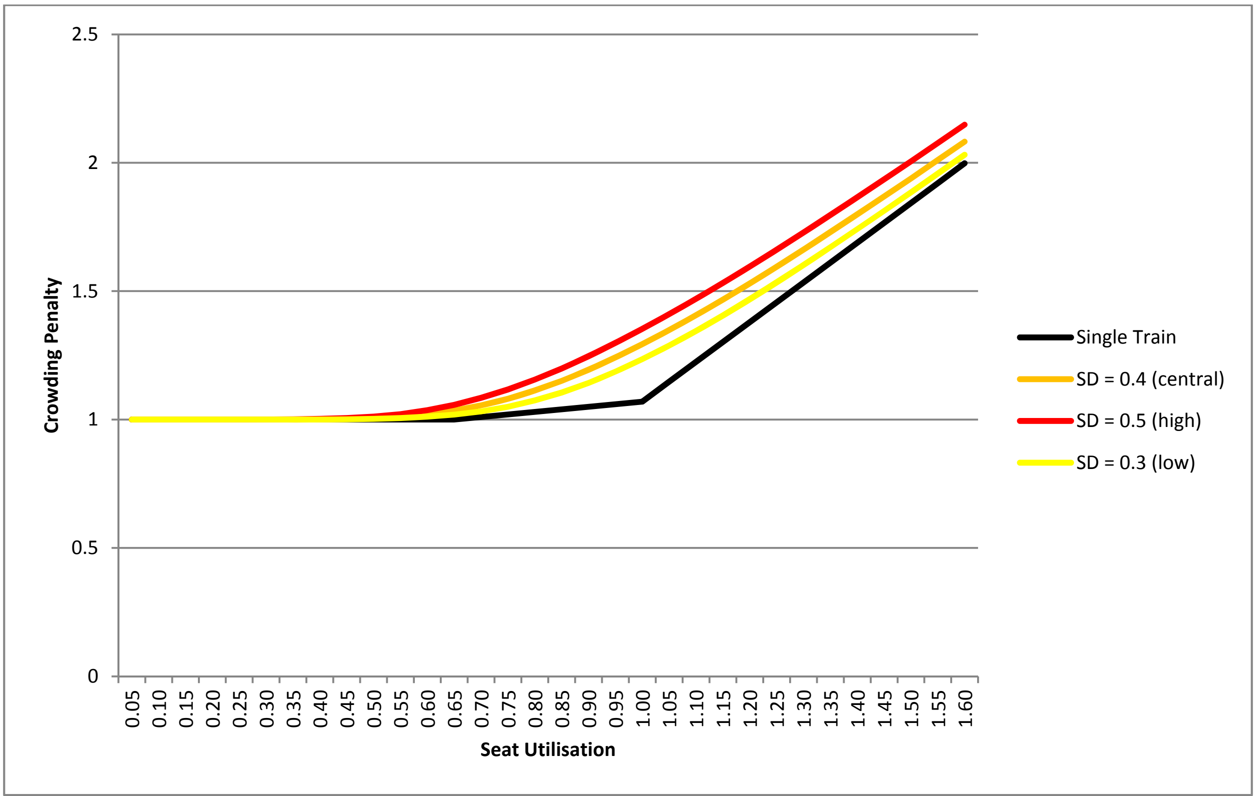


Figure 7-4 Sensitivity of Intercity Crowding Curves to Changes in Standard Deviation

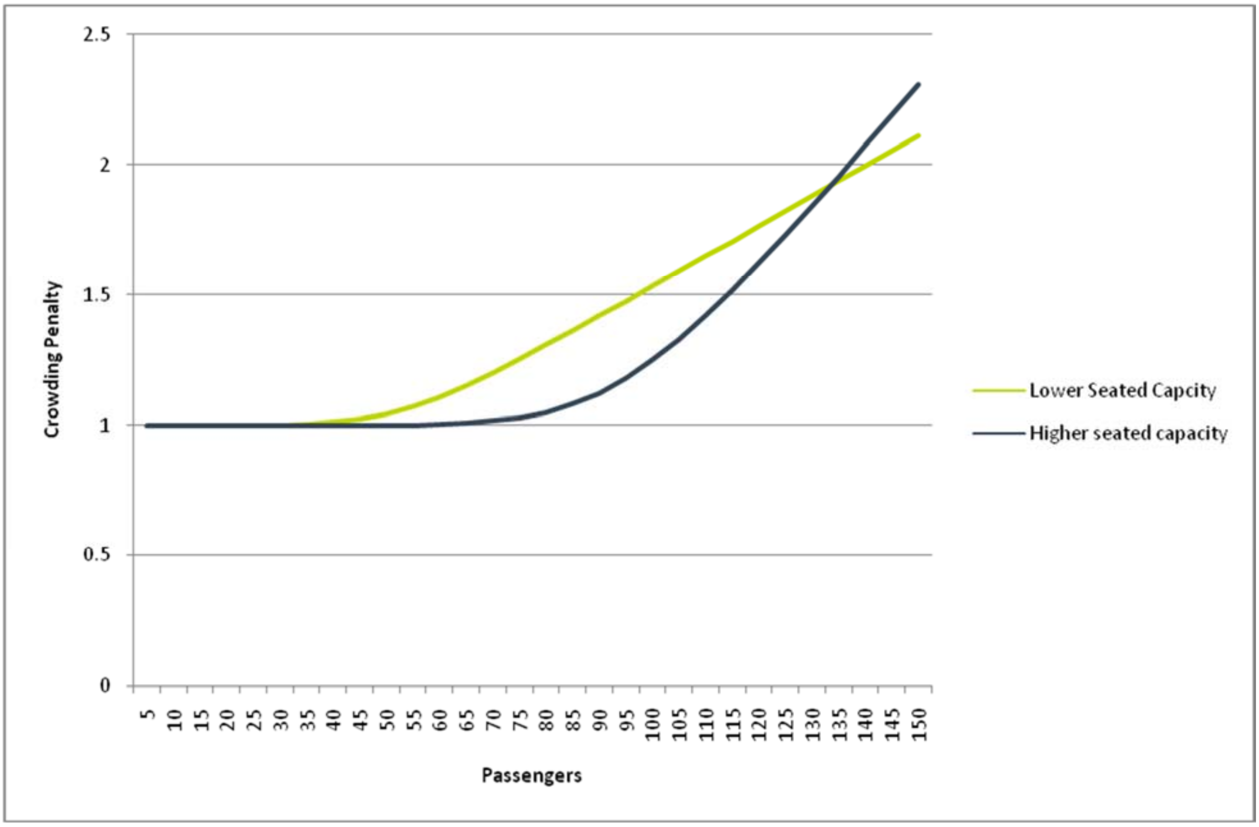


7.3.3. Example of Period Average Crowding Curves for Various Rolling Stock Types

The PFMv4.3 period average crowding curves will look different for each train, depending on the proportion of seating and standing spaces. To highlight this, Figure 7-5 shows the period average crowding curves for the following hypothetical (Intercity) rolling stock types.

- A train with a high proportion of seats to standing spaces – 100 seats and 20 standing spaces.
- A train with a low proportion of seats to standing spaces – 60 seats and 80 standing spaces.

Figure 7-5 PFMv4.3 Period average Crowding Curves for Example Rolling Stock Types - Intercity



The graph demonstrates that the process is working as expected. The train with a higher seated capacity experiences a lower crowding penalty for lower numbers of passengers, owing to the high availability of seats. As the seated capacity is approached the curve increases steeply due to the relatively low number of standing spaces available.

7.3.4. Comparison of PFMv3.0 and PFMv4.3 Crowding Penalties

Table 7-6 shows a comparison between the crowding penalties in PFMv3.0 and PFMv4.3 for three levels of loading, 80% of seated capacity, 100% of seated capacity and total capacity. The PFMv3.0 values assume that total capacity is equivalent to a load factor of 1.4 (i.e. seated capacity x 1.4) whereas the PFMv4.3 values are based on standing capacity of 2.5 Pax/m2 as described earlier. As also described previously, the PFMv4.3 uses a single set of penalties for all journey purposes whereas PFMv3.0 used separate penalties by journey purpose.

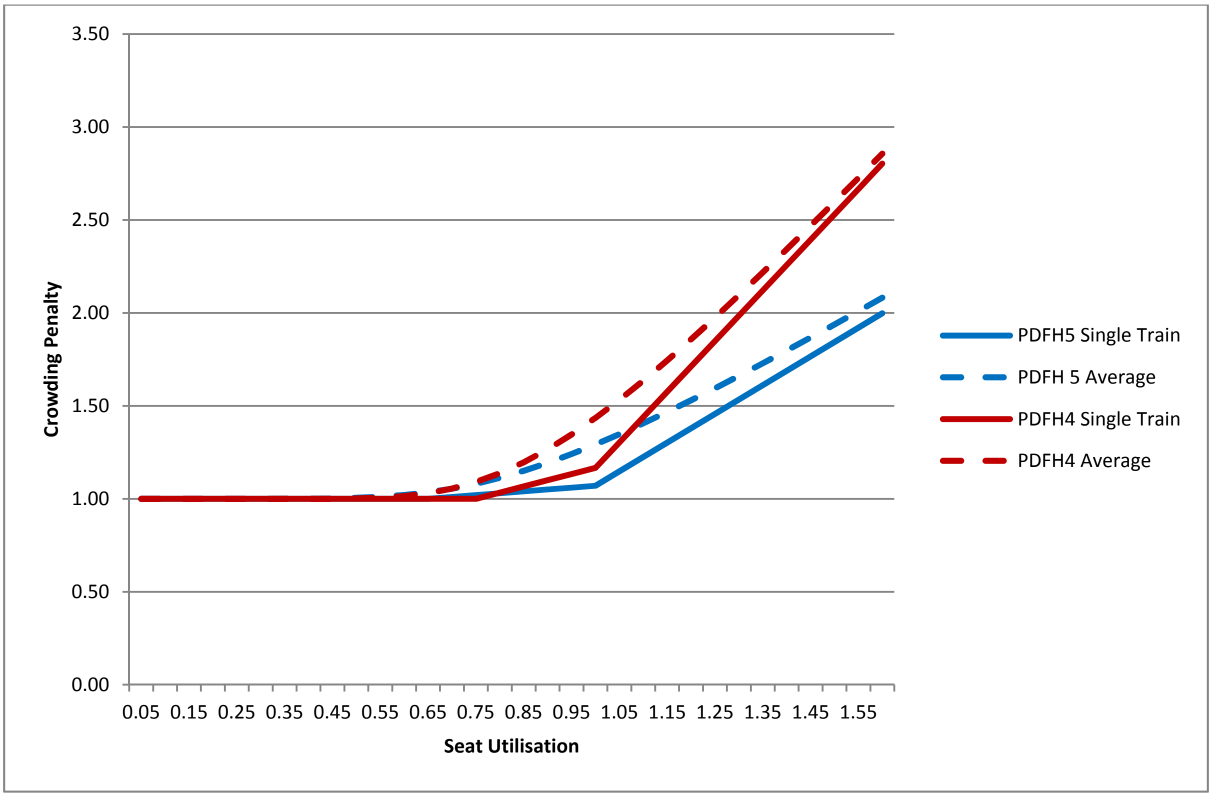
Table 7-6 Comparison of PDFHv4 and PDFHv5 Crowding Penalties

TOC Groups	Load Factor	Passenger Type	PFMv4.3 all purposes	PFMv3.0 Business	PFMv3.0 Leisure	PFMv3.0 Commute
London Inter-Urban (Intercity)	80% of seats	Seated	1.03	1.05	1.05	1.00
	Seated Capacity	Seated	1.07	1.25	1.25	1.00
	Total Capacity	Seated	1.38	1.70	1.70	1.00
	Seated Capacity	Standing	1.89	3.50	3.50	2.50
	Total Capacity	Standing	2.46	4.90	4.90	2.90
London Suburban (LSE)	80% of seats	Seated	1.01	1.00	1.05	1.00
	Seated Capacity	Seated	1.06	1.05	1.25	1.10
	Total Capacity	Seated	1.30	1.20	1.70	1.50
	Seated Capacity	Standing	1.52	2.50	3.50	2.50
	Total Capacity	Standing	1.87	2.90	4.90	2.90

TOC Groups	Load Factor	Passenger Type	PFMv4.3 all purposes	PFMv3.0 Business	PFMv3.0 Leisure	PFMv3.0 Commute
Non-London (Regional)	80% of seats	Seated	1.01	1.07	1.05	1.00
	Seated Capacity	Seated	1.08	1.25	1.25	1.10
	Total Capacity	Seated	1.73	1.70	1.70	1.50
	Seated Capacity	Standing	1.45	4.00	6.50	2.50
	Total Capacity	Standing	2.18	5.40	8.50	2.90

Figure 7-6 compares the PDFHv4 (used in PFMv3.0) and PDFHv5 (used in PFMv4.3) crowding curves for the 'Intercity' TOC group. A true like-for-like comparison is not possible due to PDFHv4 separating the curves by journey purpose so for the purpose of this exercise, an average across the three journey purposes is shown. It can be seen that the new PDFHv5 curves used in PFMv4.3 give lower crowding penalties than the PDFHv4 curves used in PFMv3.0. It should be noted that the period average curves reflect not only the change from PDFHv4 to PDFHv5 but also the revised load factor variability results.

Figure 7-6 Comparison of PDFH 4 and PDFH 5 Crowding Curves – Intercity



8. Other Model Developments

8.1. Introduction

This section describes two areas of work where PFMv4.3 was enhanced from PFMv3.0 and shows that the changes had minimal impact on the model results.

Section 8.2 describes the introduction of a method of successive averages approach into the mode choice algorithm in PFM4.3, whilst section 8.3 describes the conversion from running PFMv3 using the EMME/2 software to using the later EMME3 software.

8.2. Method of Successive Averages (MSA)

8.2.1. Background

This work investigated the effects of introducing an approach using the method of successive averages (MSA) to the mode choice algorithm in PLANET Long Distance. This was implemented for two main reasons:

- It was expected to improve model stability and convergence; and
- It would allow the Relative Gap between demand and supply to be measured in line with WebTAG guidance on model convergence.

The PFM (all versions) mode choice model is an incremental model; it recalculates mode shares based upon the changes in cost between the Do-Minimum scenario and the Do-Something scenario. Therefore, in each mode choice iteration the generalised cost elements produce the next iteration's mode share.

The model has previously demonstrated that there was a tendency for oscillation, with demand alternating between air and rail modes in the assignment scenarios, particularly in later forecast years if there were constraints due to higher demand and/or lower capacity. As a result, it sometimes made comparison between scenarios difficult, due to potential model instability.

This section of the report deals with the theoretical issues, practical implementation and model results.

8.2.2. Theoretical MSA Approaches

In general, a weighting process is required to achieve equilibrium between supply and demand in a transport model. The following section investigates using the method of successive averages (MSA) which in general terms is where each latest unweighted iteration is combined with the weighted 'rolling average', such that oscillation will be reduced.

This weighting can be applied to either the input cost skims to the mode choice model, or the output demand from the mode choice model. Either of the two options ensures that forecast outputs by mode will stop oscillating after multiple iterations, since the 'rolling average' costs or demand are successively combined with a diminishing proportion of the latest iteration.

Input cost averaging was taken forward as the preferred approach because it could be implemented easily into the PFMv4.3 model whilst maintaining the structure and functionality of the model in its existing state.

8.2.2.1. Measurement of Demand and Supply Convergence

WebTAG section 3.10.4, paragraph 1.5.2 sets out the following recommendation for measuring convergence:

Gap Type 1: Demand Averaging

The relative gap when using demand averaging is given as follows:

$$RelGAP\ (Demand\ averaging) = \frac{\sum_{ijctm} C(X_{ijctm}).\left|D\left(C(X_{ijctm})\right) - X_{ijctm}\right|}{\sum_{ijctm} C(X_{ijctm}).X_{ijctm}}$$

This represents a cost-weighted demand change as a proportion of the total cost-weighted demand, with demand averaging as the input. Although not specifically stated in WebTAG, this measure is suitable only for situations where demand is being averaged.

Gap Type 2: Cost Weighting
If cost averaging is used instead, then the measure should be written as below:

$$RelGAP\ (Cost\ Weighting) = \frac{\sum_{ijctm} D(C_{ijctm}).\left|Y\left(D(C_{ijctm})\right) - C_{ijctm}\right|}{\sum_{ijctm} D(C_{ijctm}).C_{ijctm}}$$

In either case, WebTAG suggests 0.1% (0.001 or 10-3) is an achievable target. The adjustments made to the model as part of this process allows us to measure this easily, therefore making the PFMv4.3 model convergence more readily measured and transparent.

8.2.3. Sensitivity Testing

The following tests were undertaken to test the sensitivity of the MSA approach.

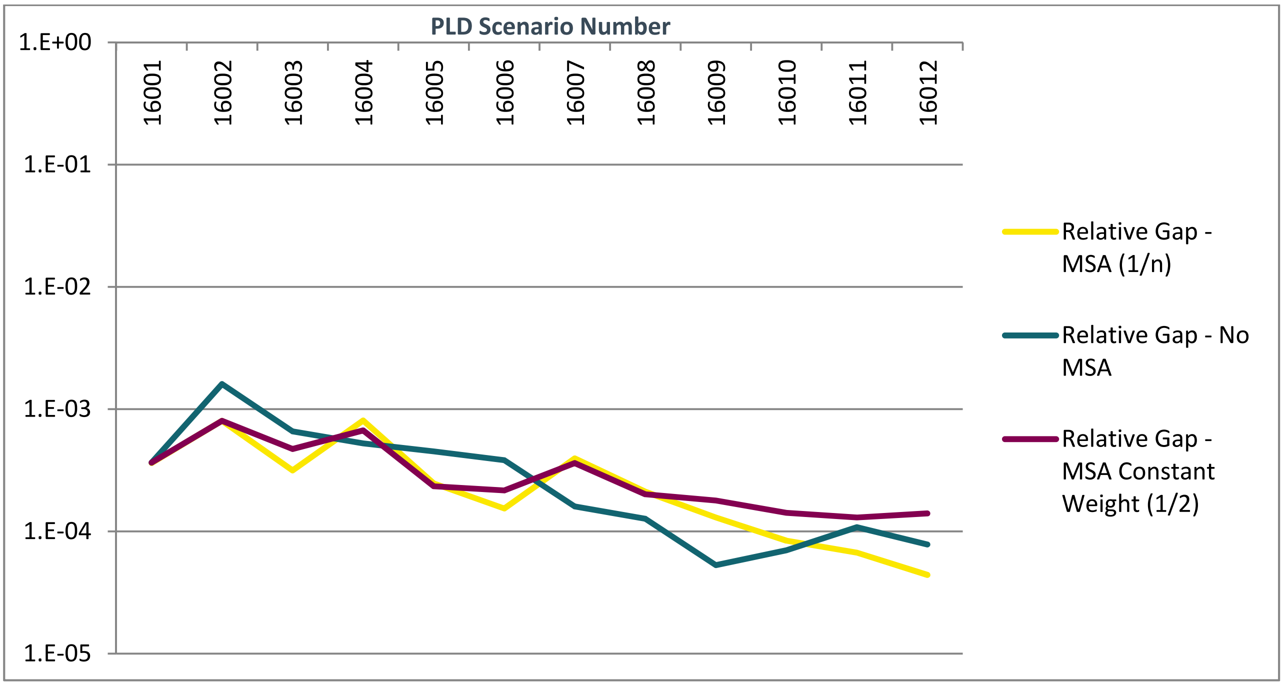
- Normal demand and costs, ‘with MSA’, variable weight by iteration number (1/n);
- Normal demand and costs, ‘with MSA’ , constant weight of 2 (1/2);
- Normal demand and costs, ‘no MSA’;
- Normal demand, 25% higher base costs, ‘with MSA’, variable weight by iteration number (1/n);
- Normal demand, 25% higher base costs, ‘with MSA’, constant weight of 2 (1/2); and
- Normal demand, 25% higher base costs, ‘no MSA’.

As shown above, a test was devised whereby base costs were uplifted by 25%. This was to force exaggerated oscillation in costs (and therefore demand) in the test scenario, by increasing the incremental difference in costs between test and base.

8.2.3.1. Gap measurement

Figure 8-1 shows the impact the MSA approach has on the gap measurement in PFMv4.3 over consecutive mode choice iterations (scenarios 16001-16012).

Figure 8-1 Gap Measurement – Normal Demand & Costs



The figure above shows the following points:

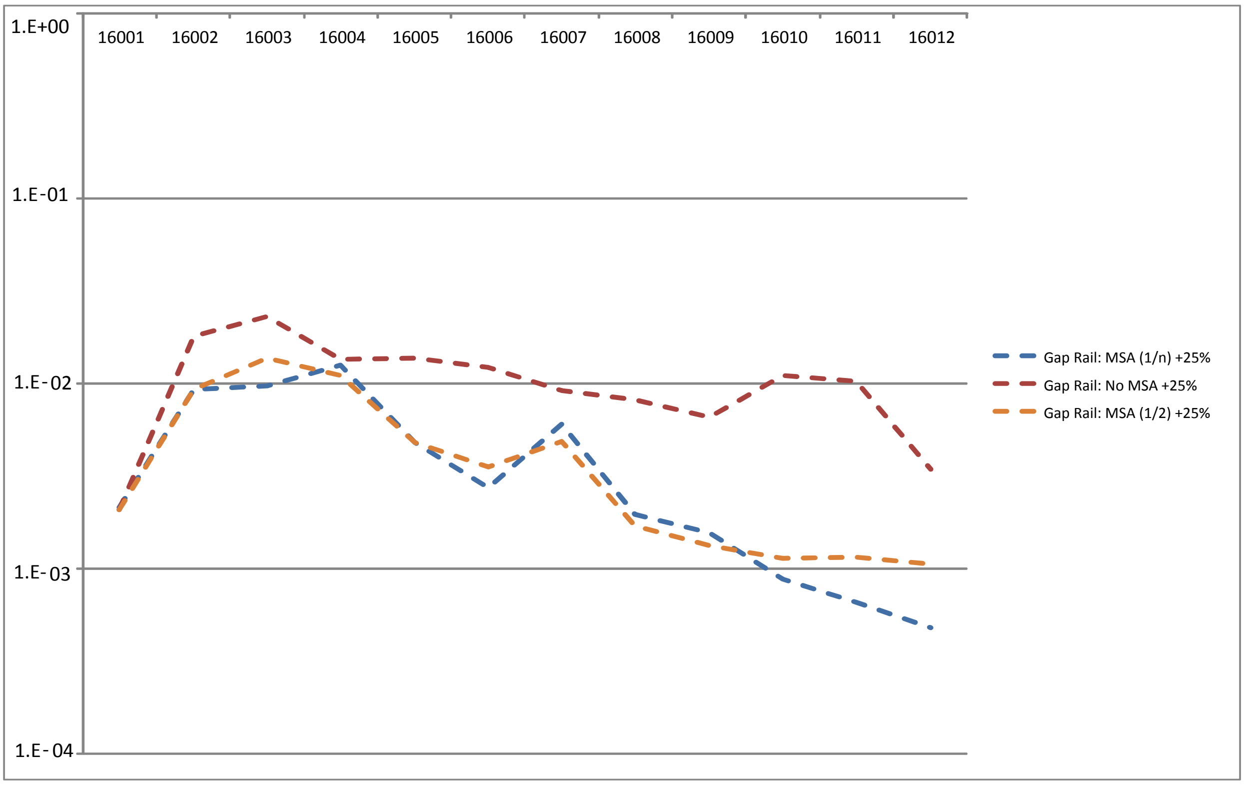
- 'No-MSA' version is relatively erratic, but achieves 0.0001 (10^{-4}) relative gap;
- 'With-MSA $\frac{1}{n}$' catches up more slowly but progressively to converge at a relative gap of better than 0.0001 (10^{-4});
- 'With-MSA $\frac{1}{2}$' is for the most part consistent 'with MSA' $\frac{1}{n}$, but fails to converge to quite the same degree as the others;
- All MSA iterations have a 'bump' at scenarios 16004 and 16007 – this where the regional models are re-run and all costs are recalculated without reference to prior iterations. This is not evident with the 'No MSA' approach, as this happens for every iteration; and
- All iterations have an artificially low Relative Gap in the first mode choice iteration. This is due to all modes being assigned as part of a single rail assignment iteration, causing highway and air costs to be unchanged at the point of comparison. This can safely be ignored.

Figure 8-2 shows the impact the MSA approach has on the gap measurement in PLD over consecutive mode choice iterations (scenarios 16001-16012) with a 25% uplift in base costs:

- the 'no-MSA' run converges to better than 0.01;
- the 'with-MSA' run achieves better than 0.001; and
- the fixed weight method doesn't converge quite as tightly as the ($\frac{1}{n}$) method.

This shows that in both cases, the model converges better with the MSA approach, and in the case of the sensitivity test with inflated base costs, ensures that the WebTAG standard is met.

Figure 8-2 Gap Measurement – Normal Demand & Inflated Base Costs



8.2.3.2. Network Impacts

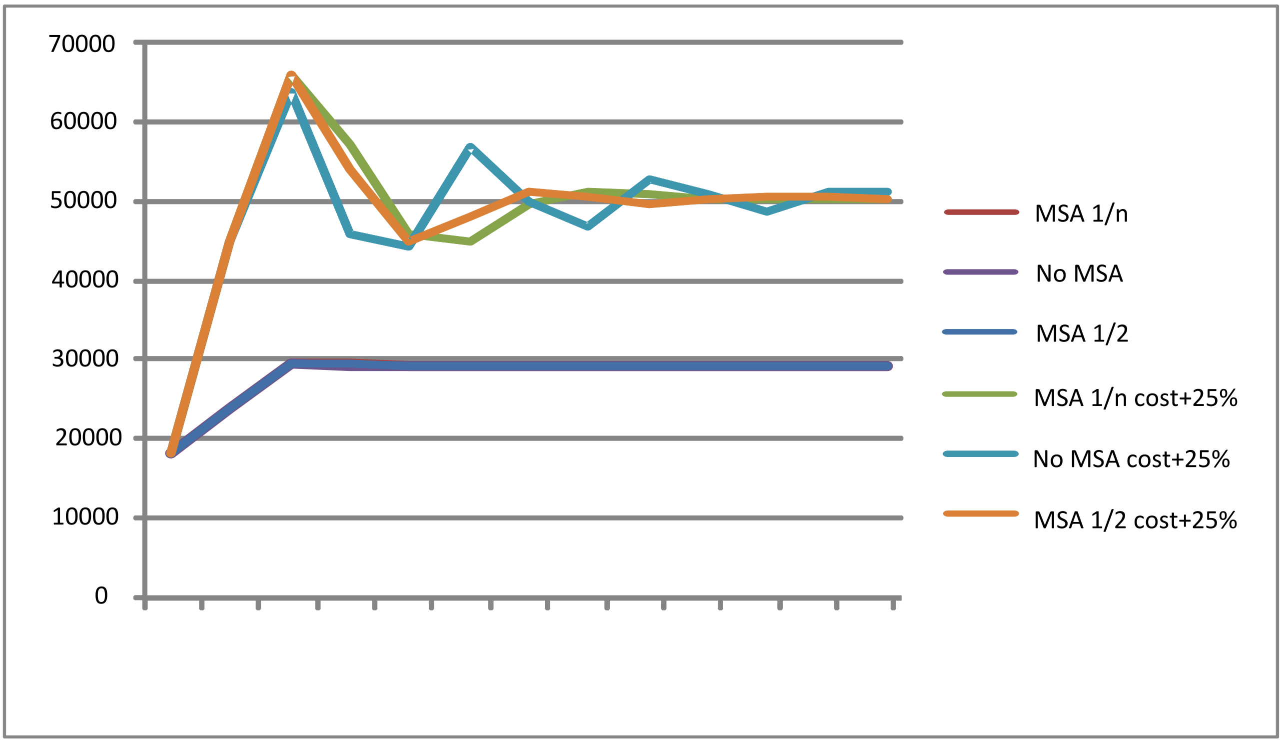
A network-based measure could show reduction in oscillation but would not provide the conclusive indication of convergence given by the 'gap' measurement. In this case, points on the network can be monitored to show the differences in demand due to the 'with-MSA' approaches.

Figure 8-3 shows the loading by scenario on the Preston-Lancaster section of the West Coast Main Line. This location was chosen as it represents a section where route choice is limited, so demand oscillations can be observed more easily.

The runs without uplifted base costs are virtually identical and appear on the figure superimposed together as the lower straight line. The group of upper lines are the three tests with the uplifted base costs. The test with uplifted cost and without MSA shows some oscillation occurring, this oscillation is greatly reduced by the tests using MSA.

The two types of MSA ($\frac{1}{2}$) and ($\frac{1}{n}$) are very close to each other and do not display significant oscillation, while the 'No MSA' scenario does oscillate; it is this oscillation which must be avoided.

Figure 8-3 Load on Lancaster – Preston Segment of the Network



8.2.3.3. Conclusion

This section has shown that the implementation of MSA has a neutral effect in situations of ordinary crowding in the future, while smoothing the oscillations resulting from higher levels of crowding in the future. Interestingly, the use of $\frac{1}{n}$ converged to tighter tolerances than the fixed weight of $\frac{1}{2}$. It may be that a different fixed weight converges better than $\frac{1}{n}$, but this has not been put to the test due to run-time constraints. Overall, the use of either MSA method makes the results more robust and reliable.

8.3. Conversion of Model to EMME3

8.3.1. Background

The PFMv3.0 modelling framework had been based on the EMME/2 modelling software since the time when it was originally developed. The software is no longer maintained by its developers and so there is a requirement to upgrade the software to the currently supported version which is EMME3.

8.3.2. Software Requirements

8.3.2.1. Base Software

The original software for the PFMv3.0 model was EMME/2 9.6 which was last modified in 2005. The model was migrated to the most current version (at the time of writing) of the EMME software which was EMME3.4.

8.3.2.2. Additional Software

In addition to the EMME3 software there are a number of additional pieces of software that need to be installed as part of moving the model to EMME3.

INRO Key Server (IKS) version 2.0 is required for use with EMME3, and is not compatible with IKS version 1.2 for use with EMME/2. It is recommended that a key server is set upon a centralised server, allowing multiple PCs to access the licences without the need for physical moving of the dongles.

EMME3 allows access to ArcGIS data, and is supplied with a run-time version of ArcGIS licensed for this purpose. It is necessary to install at least the run-time version should a full version of ArcGIS not be installed on the same PC. This will allow mapping data to be easily added to the map backgrounds.

As with EMME/2, the PFM model requires an installation of Excel 2007 (or above) to be available.

8.3.3. Macro Cleanup

As part of the EMME/2 to EMME3 conversion process the opportunity was taken to clean up the model macros. Three main actions were undertaken:

- Macros no longer used by the model were transferred to a ‘superseded’ folder;
- All macros were given a descriptive header; and
- Where necessary comments were added to the macros.

8.3.4. Model Tests

The Day1 and Y Network runs, on model version PFMv3.0, were run in both EMME/2 and EMME3.4 in order to understand the scale of the differences in the assignment and the economics results.

There are likely to be differences in assignment results, despite the inputs remaining the same. There has been quite a large change in the functionality of the software between EMME/2 and EMME3. As well as the very obvious changes to the graphical interface that EMME3 provides, there have also been changes to the software itself, and highway (auto) assignments in particular. INRO, the software developers, have advised that there are two changes in particular which may affect results - a compiler change which occurred in EMME3.1 and an improvement in numerical precision used in module 5.21 (auto assignment) which occurred at the same time.

Different compilers will round numbers to different levels of accuracy, and with a large model such as PFMv3.0 this will have small, but noticeable effects on results. PFMv3.0 incorporates a demand model that uses mode split calculations to estimate new rail, highway and air demand based on differences in travel costs per mode. Changes to the highway assignment will feed through to highway costs which in turn will feed through into new demand for each mode. Once results of this daily model are projected over sixty years for the economic appraisal, these very small changes can add up to reasonably significant values.

8.3.4.1. Base Year Assignment

For the Base Year (2011) runs, there is barely any difference between the EMME/2 runs and the EMME3 runs. As the base year features no mode choice, highway assignment has no effect on rail demand, and so differences would be expected to be minimal and this is confirmed with these results.

8.3.4.2. Forecast Year Model Runs

There are some differences in the results from running the forecast year models though these differences are generally small. Table 8-1 shows the output matrix totals for a 2043 Day1C run for the runs in EMME/2 and EMME3.

As can be seen, the results for the Do-Minimum (Base) runs are almost identical, whilst there are small differences in the Do-Something (Test) runs. As there is no mode choice in the Do-Minimum, no significant changes would be expected. Differences in the highway assignment are likely to lead to differences in highway costs, and therefore mode choice calculations that result in changes to rail, highway and air demand. Whilst there are some differences the final column of Table 8-1 shows that these are very small when compared to the overall levels of demand. EMME3 produces slightly fewer trips in the Do-Something test but the difference from EMME/2 is less than 100 trips in all cases.

Table 8-1 Summary of Matrix Totals – PFMv3.0 2043 Day1 Runs

Matrix Totals	EMME/2		EMME3		Difference
PLD	Base	Test	Base	Test	Test
Rail					
Commute NCA	56,706	56,805	56,706	56,805	-0.5
Commute CA to	166,672	166,998	166,672	167,000	2.0
Commute CA from	166,672	168,197	166,672	168,194	-3.1
Business NCA	-	-	-	-	-
Business CA to	78,709	87,065	78,709	87,056	-8.5
Business CA from	78,709	86,898	78,709	86,880	-18.5
Leisure NCA	64,668	67,383	64,668	67,378	-5.2
Leisure CA to	170,189	180,763	170,189	180,748	-14.9
Leisure CA from	170,189	180,429	170,189	180,397	-31.9
TOTAL	952,514	994,539	952,514	994,458	-80.6
Highway					
Commute	1,089,769	1,089,032	1,089,769	1,089,057	25.0
Business	1,213,074	1,208,898	1,213,074	1,208,848	-50.0
Leisure	2,039,591	2,035,199	2,039,591	2,035,208	9.0
TOTAL	4,342,434	4,333,129	4,342,434	4,333,113	-16.0
Air					
Business	37,830	35,831	37,830	35,834	2.9
Leisure	36,795	34,759	36,795	34,765	6.5
TOTAL	74,625	70,590	74,625	70,599	9.4
Extracted from Highway		9,305		9,321	16
Extracted from Air		4,035		4,026	-9
Generated		28,685		28,597	-88
PS	**Base**	**Test**	**Base**	**Test**	**Difference**
Business	229,991	230,072	229,991	230,073	1.1
Leisure	257,612	257,552	257,612	257,552	-0.1
Commute	1,968,934	1,969,009	1,968,934	1,969,005	-4.0
TOTAL	2,456,537	2,456,633	2,456,537	2,456,630	-3.0
PM	**Base**	**Test**	**Base**	**Test**	**Difference**
Business	8,772	8,979	8,772	8,979	0.0
Leisure	10,016	10,255	10,016	10,255	0.0
Commute	69,621	71,127	69,621	71,128	0.2
TOTAL	88,409	90,362	88,409	90,362	0.3
PN	**Base**	**Test**	**Base**	**Test**	**Difference**
Business	25,897	25,931	25,897	25,931	-0.3
Leisure	20,570	20,604	20,570	20,604	-0.2
Commute	88,649	88,783	88,649	88,783	-0.4
TOTAL	135,116	135,318	135,116	135,318	-0.9

Table 8-2 and Table 8-3 below shows the percentage differences in the vehicle passenger kilometres between the Day1 runs in EMME/2 and EMME3. The Do-Minimum and Do-Something scenarios are shown, across all three models (rail, highway and air). Again, the differences are extremely small, particularly in the Do-Minimum runs, and fall well within what would be expected if rounding to a different number of decimal places. Thus the change from EMME/2 to EMME3 does not have a material effect on the model results and thus EMME3 has been adopted for PFMv4.3.

Table 8-2 PFMv3.0 2043 Day1 – Comparison of Do-Minimum Run Statistics

	Mode	EMME/2	EMME3	Difference
Network Length	Highway	48,504	48,504	0.00%
Vehicle-hours	Highway	309,469	309,454	0.01%
Vehicle-kms	Highway	22,001,425	22,001,370	0.00%
Total Passengers	Air	76,864	76,865	0.00%
Passenger-km	Air	36,951,179	36,951,226	0.00%
Passenger- hours	Air	453,613	453,613	0.00%
Total Passengers	Rail	1,024,412	1,024,436	0.00%
Passenger-km	Rail	150,368,636	150,369,773	0.00%
Passenger- hours	Rail	1,651,294	1,651,330	0.00%

Table 8-3 PFMv3.0 2043 Day1 – Comparison of Do-Something Run Statistics

	Mode	EMME/2	EMME3	Difference
Network Length	Highway	48,504	48,504	0.00%
Vehicle-hours	Highway	308,039	308,036	0.00%
Vehicle-kms	Highway	21,895,166	21,893,732	0.01%
Total Passengers	Air	72,467	72,480	-0.02%
Passenger-km	Air	35,203,969	35,213,199	-0.03%
Passenger- hours	Air	428,917	428,981	-0.02%
Total Passengers	Rail	1,102,265	1,102,092	0.02%
Passenger-km	Rail	164,897,073	164,868,040	0.02%
Passenger- hours	Rail	1,694,305	1,694,119	0.01%

9. Changes to Appraisal Values

9.1. Introduction

This section describes a number of changes made to values used in the HS2 appraisal which takes values from PFM4.3.

Section 9.2 details economic appraisal updates where changes to WebTAG parameters for the average indirect tax rate and the marginal external cost of car use were implemented. In addition the average rail fares/km in the regional PLANET models was revised. Note that a description of the revised PFMv4.3 rail fares can be seen in section 2.

Section 9.3 describes the update to annualisation factors for highway and air. Note that the update to the rail annualisation factors can be found in section 2.

Section 9.4 describes the updates made to the Value of Time real growth figures used in the appraisal template. The revisions were required to reflect changes to the input forecast variables (GDP and population) and to improve the transparency of the calculation of the figures used in the appraisal.

9.2. Economic Appraisal Updates

This section provides a summary of the changes in appraisal parameters between those applied to PFMv3.0 and those applied to PFMv4.3. The changes fall in two categories:

- Changes in WebTAG parameters used in the appraisal, in line with revisions released in draft in May 2012 and formalised in August 2012 i.e.:
  - Update to the average indirect tax rate; and
  - Revision of the Marginal External Costs of Car use (MECCs).
- Changes in scheme specific assumptions and parameters used in the appraisal i.e.:
  - Average rail fares/km for PLANET South, North and Midlands; and
  - PLANET Long Distance annualisation factors for highways and air.

9.2.1. Changes in WebTAG parameters

The following two changes were made to the appraisal calculations to reflect changes in WebTAG guidance released in draft in May 2012 and subsequently formalised in August 2012:

- The assumed average rate of indirect tax in the economy was adjusted from 20.9% to 19%, in line with the revised guidance in WebTAG unit 3.5.6. The average rate of indirect tax is used to convert between resource and market prices in the appraisal and therefore influences the scheme costs and the value of revenue in the appraisal, as well as the value of changes in indirect tax received by the government due to changes in the amount of expenditure on fuel and rail fares; and
- The Marginal External Costs of Car use (MECCS) were updated, in line with the revised guidance in WebTAG unit 3.13.1. MECCs are the estimated average monetary value of the benefits caused by each vehicle kilometre of car traffic removed from the road network at the margin due to the associated reduction in externalities such as congestion, accidents, noise and local air pollution. The WebTAG MECC values are used in the HS2 appraisal to estimate noise, local air quality and accident impacts across all four models and highway decongestion effects for the PLANET South, Midlands and North models.

9.2.2. Changes in Scheme Specific Parameters

Two updates were made to the HS2 scheme specific parameters (i.e. those not defined in WebTAG) used in the appraisal process:

- Fare per kilometre figures used for PLANET South, PLANET Midlands and PLANET North; and
- Annualisation factors for the PLD component of PFMv4.3.

The following sections provide more detail on each update.

9.2.2.1. Update to PLANET South, Midlands and North Fares Rates

This section outlines the analysis undertaken to update the assumptions applied in the appraisal for average yields by journey purpose for rail travel within the Midlands, North and wider South-East, as represented in the PLANET Midlands, PLANET North and PLANET South models respectively.

MOIRA-Based Yield Matrices

The approach applied was based on the use of three regional versions of the rail industry's MOIRA model. The primary purpose of MOIRA is to estimate the impact of improved timetables on rail demand and revenue. However, for the fares update, the most important facet of MOIRA was its use of processed LENNON rail sales data, with aggregation of station-to-station demand (i.e. journeys and revenue) by three ticket types:

- Full (i.e. Anytime);
- Reduced (i.e. Off-peak / Advance); and
- Season tickets.

DeltaRail process LENNON data for input to MOIRA, including the process of infilling 'missing demand' associated with rail travel on zonal (and often multimodal) 'travelcard' products, mainly augmenting the Season ticket matrices. This pre-processing is particularly important because, in recent years, sales of PTE/ITA travelcards have tended to shift away from stations, in favour of direct debit and shops.

The change in sales channels means that LENNON station sales are becoming an increasingly unreliable barometer of rail journeys originating at particular stations within PTE/ITA areas. This change, combined with the issue of distributing trips on zonal tickets between destinations (for which purpose survey data was used for creating the original HS2 matrices in 2009) complicates the process of identifying travel patterns. As a result, the option of re-processing the 2010/11 LENNON data supplied to update the HS2 demand matrices specifically for this analysis was rejected in favour of using the MOIRA data. This provided the advantage of being able to draw on the pre-processing undertaken by DeltaRail on the demand data for these ticket types.

2010/11 demand matrices were made available by DeltaRail for the following versions of MOIRA:

- OR23 DfT North
- OR25 DfT Midlands
- OR36 DfT Wider Thameslink (for the South)

These models provide granular coverage of the areas modelled by PLANET North (PN), PLANET Midlands (PM) and PLANET South (PS), respectively.

For a given station to station flow, the average yield for each of the three broad ticket types is simply revenue divided by journeys. Conversion to the 2010/11 pence per kilometre yield was initially straightforwardly achieved by dividing again by station-to-station distance; the latter estimated by applying Pythagoras' theorem to station grid references, as the MOIRA demand matrices do not include passenger miles/kilometres.

To allow for the non-linearity of rail infrastructure, MOIRA's 'Data Inspector' functionality was used to estimate a journey-weighted ratio of actual rail distance to straight-line distance between stations. Based on (non-London) flows carried by London Midland, this factor was 1.150, and assumed to be applicable to PLANET North as well as PLANET Midlands, as both models represent similar regional (non-London) areas. For PLANET South, the Wider Thameslink MOIRA model produced a corresponding figure for Southern and FCC flows of 1.150, after allowing 1.5 km for travel on the underground from London termini to ultimate destinations (as underground travel is omitted from MOIRA rail distances.)

PLANET South Data Filtering

The structure of PN and PM is conducive to the conversion of station-to-station yields to zone-to-zone yields. This is because the base matrices include station-to-station route information for all zone-zone pairings, although often only one route is active, thus with 100% of demand. Where the National Rail Travel Survey suggested that there are multiple rail routes between two zones, the weighting for each route is given directly by the 'mini-matrices' calculated within the logit functionality of PM and PN which identify the proportion of trips using each available route. Then, a weighted average yield between zones across all the flows is calculated using the identified proportions and appropriate PLANET demand matrix.

PLANET South (PS) has a different model structure and therefore the processing involved identifying the nodes (stations) attached to each zone. PS zones connected only to LUL or DLR stations were excluded from the analysis. For each origin-destination zonal flow, all MOIRA demand was summed across all the relevant station-station pairs. Allowing a maximum of 5 nodes (stations) per zone, this necessitated calculations for 25 potential origin-destination station routeings for each zone-zone flow. For each ticket type (Full, Reduced, Season) the revenue was summed across the routes, the journeys were summed similarly, and the yield for the zone to zone flow was the revenue total divided by the journey total.

As MOIRA divides demand to Travelcard Zone 1 between 12 sub-zones (e.g. Oxford Circus), the revenue and journeys data were re-aggregated to a Central London total before the yield was estimated. All PS zones within Travelcard Zone 1 and Canary Wharf were associated with Central London for the purposes of calculating their yields.

To rationalise the processing, attention was confined to principal stations and flows, assumed to be representative of yields on the London South East network as a whole. (Fares anomalies were not expected to undermine this assumption.) Filtering was based on (a) deleting rows from the MOIRA station-to-station yield matrix and (b) removing pairings of PS zones where demand fell below a threshold level for each journey purpose. The latter involved removing zone-to-zone pairings with less than 5 (commuting) or 0.5 (business and leisure) trips per day.

To test the sensitivity of results to the severity of filtering of the MOIRA yield matrix (a), two sets of runs were undertaken.

In the first runs, the station-to-station fares matrix was filtered to exclude flows to/from stations where, across all the connected PS zones, there are less than 750 outward commuting trips (produced/attracted) per day in the HS2 version of the model (commuting was chosen as PS excludes longer distance journeys as these are provided by PLD). This process retained 498 stations (PSAM National Rail nodes), and filtered out another 448. After all filtering, the commuting yield was based on 11,000 zone to zone pairings drawing from 123,000 rows of station-station yield data; i.e. 56,000 rows for Full and Reduced and 12 thousand for Season, this lower figure reflecting the concentration of daily rail commuting into relatively few stations/zones.

In the second set of runs, the commuting filter was cut from 750 to 100 daily trips. This extended the fares matrix to 228,000 rows of station-station yield data, with only 149 stations excluded. The analysis showed very little sensitivity to the degree of filtering.

Mapping to Journey Purpose

PDFHv5 guidance was used to convert from ticket type to journey purpose: Business, Leisure and Commuting. For PLANET Midlands and North, PDFH Table B0.10 was used to provide the requisite weightings of the yields by ticket type. For PLANET South, PDFH Table B0.2 was used (Rest of South East to/From London Travelcard area).

Results

Table 9-1 to Table 9-3 show the yields per kilometre for each of the PLANET models estimated through the calculations described above.

For PLANET Midlands and North, separate results are shown for car available (CA) and non-car available (NCA). These show that the NCA figures tend to be higher. This is because non-car owning households tend to be in inner-cities, and – with the presence of the ‘taper effect’ on rail fares – shorter flows (into city centres) tend to have higher yields per kilometre. An exception is the PLANET North commuting values for which the non-car available figure is lower, possibly due to the local PTE/ITAs favouring deprived areas in their pricing of Travelcard seasons. It is possible that interaction with incidence of child seasons tickets may also be relevant.

An average fare per km for CA plus NCA, weighted by the matrix journey totals is also shown for PLANET Midlands and North. These weighted average values were the ones adopted for use in the HS2 appraisal.

For PLANET South separate car available and non car available figures are not available because PLANET South does not model these demand segments separately (unlike PLANET North and Midlands).

Table 9-1 PLANET Midland Yields per Kilometre 2010/11 Prices

PLANET Midlands	Commute	Business	Leisure
Car available	£0.135	£0.147	£0.136
Non car available	£0.164	£0.206	£0.177
Total (weighted by journeys)	£0.139	£0.155	£0.142

Table 9-2 PLANET North Yields per Kilometre 2010/11 Prices

PLANET North	Commute	Business	Leisure
Car available	£0.160	£0.145	£0.134
Non car available	£0.145	£0.165	£0.156
Total (weighted by journeys)	£0.157	£0.148	£0.138

Table 9-3 PLANET South Yields per Kilometre 2010/11 Prices

PLANET South	Commute	Business	Leisure
Total	£0.129	£0.138	£0.125

It is noted that for PS, the weightings applied to yields on individual flows are based on (total) LENNON journeys rather than the PLANET demand matrices themselves. This is because the pattern of rail travel around the wider south-east in the AM peak (as represented in PS) may not be particularly representative of travel at other times. In particular, incidence of longer distance travel is likely to be greater outside the AM peak. As the 'taper effect' causes the marginal cost of rail travel to decline as flow length increases, this can have a significant bearing on the yield results. By contrast, the PLANET Midlands and PLANET North networks are more tightly focussed on short distance travel into regional hubs, so differences between the AM peak and all week patterns of travel will be less pronounced.

A comparison of the tables shows that the yields estimated for Midlands and North are slightly higher than their counterparts for South. Although at first sight this may appear somewhat counterintuitive, the area modelled by PS has a significantly higher average distance of rail journeys so that the 'taper' effect pulls down the average for each journey purpose.

9.3. Update to Highway and Air PLD Annualisation Factors

The PLANET Long Distance (PLD) model demand element of PFMv4.3 represents the impacts of HS2 over an average 24 hour weekday and therefore annualisation factors are required to expand the benefits forecast for the modelled day (in each modelled year) to represent a full year for inclusion in the economic appraisal.

The annualisation factors are calculated on the basis of relative levels of demand in different time periods i.e. on the assumption that the average benefit per trip calculated for the time period represented in PFMv4.3 also applies to each trip made at the weekend and on bank holidays and therefore that total annual benefits are directly related to total demand levels across the year.

This section describes updates to the PFMv4.3 rail, highway and air annualisation factors undertaken to reflect the most recent available data and, where relevant, to ensure consistency with the assumptions underlying the derivation of the demand and fares matrices used in PFMv4.3.

For each factor a description is provided of the source of data used to derive the factor along with a description of the analysis undertaken and a summary of the revised annualisation factors derived.

Highway Annualisation Factors

Highway annualisation factors are also needed to expand from the average benefits per average 24 hour weekday to estimated annual benefits in each PFMv4.3 modelled year.

The DfT's National Travel Survey provides a good basis for calculating the factors as it provides data on patterns of car driver trips by purpose across the day and week and forms the basis of assumptions on purpose splits used in WebTAG guidance (unit 3.5.6).

The calculation of the factors relied on the identification of the relative numbers of trips for each purpose (business, commuting and leisure) falling on average weekdays and weekends (and bank holidays). This relationship was calculated for car trips on the basis two main sources:

- NTS Table 0501 - which provides the average number of car trips on an average weekday, Saturday and Sunday; and
- WebTAG Unit 3.5.6 Table 7 - which provides an estimate of the proportion of car trips in each time period that are assumed to be for each purpose (business, commuting and leisure) on an average weekday and across an average weekend.

The information from the two sources was combined to form an estimate of the relative numbers of car trips on weekdays, weekends and bank holidays (trip numbers on bank holidays were assumed to be half of the total across an average weekend), as shown in Table 9-4 below.

Table 9-4 Relative Daily Trip Numbers by Type of Day and Purpose[16]

Purpose	Weekday	Weekend (2 days)	Bank Holiday
Commuting	27	14	7
Business	7	3	1
Other/Leisure	74	142	71
Total	108	159	79

-The bottom daily total row in is taken from NTS 2011, Table 0501. The previous rows (by purpose) are the result of multiplying the total row by assumptions on proportions of trips by purpose from Table 7 in WebTAG unit 3.5.6.
-Numbers are indices, where 100 is the number of trips on an average day across a week.

These daily trip numbers by purpose and day were then converted into estimated annual trip totals on the basis of the assumption of eight bank holidays, 52 weekends and 253 weekdays per annum, giving the annual totals shown in Table 9-5 below.

Table 9-5 Relative Annual Trip Numbers by Type of Day and Purpose

Purpose	Weekday	Weekend (2 days)	Bank Holiday	Annual Total
Commuting	6955	752	58	7764
Business	1780	140	11	1931
Other/Leisure	18646	7,378	568	26592

-Weekday totals are derived by multiplying the index of daily trip numbers by purpose in the previous table by 253, the equivalent factors applied to produce weekend and bank holiday totals from the daily indices are 52 and 8.

Annualisation factors for each purpose were derived by dividing the annual trip totals (from the last column of Table 9-5) by the average weekday trip numbers (from the first column of figures in Table 9-4), producing factors which are summarised in Table 9-6 below, alongside the set of factors used previously.

[16] It is recognised that the proportions in this table apply to trips of all length, rather than just the long distance trips of relevance for the PLD element of PFMv4.3. The characteristics of long distance trips are likely to vary from the average characteristics of trips of all length. However, the variation is most likely to be in the proportion of trips being made for each purpose. These purpose proportions are not used in the calculation which draws instead on the relative number of trips for each purpose on each day type (weekday, weekend, bank holiday). It was judged less likely that these characteristics would vary with trip length and therefore that average 'all trip' proportions would be appropriate for the long distance PFMv4.3 trips (by purpose).

Table 9-6 Comparison of Revised and Previous Highway Annualisation Factors

Purpose	Revised Factors	Previous Factors	Change
Commuting	282	365	-23%
Business	275	365	-25%
Other/Leisure	361	365	-1%

The table shows that the revised factors are up to 25% lower than those used previously which had been based on the simple approach of applying a factor of 365 to daily trip totals.

A cross check of the results was undertaken using an NTS table (0504) which shows the relative number of trips at different times of the week for trips of different purposes. This was not used as the main source of the annualisation factors as it contains trips by all modes (not just car) and therefore is influenced to an extent by the different patterns of travel behaviour on different modes.

The results are summarised in Table 9-7 below, showing that they are similar (within 5%) to those described above and shown in Table 9-6.

Table 9-7 Summary of Highway Annualisation Factor: Cross Check Calculation

Purpose	Average Weekday **p.a.** (a)	Weekend (Total) **p.a.**(b)	Total Annual Trips **p.c.** (c)*	Annualisation Factors (d) = (c/(a/52))
Commuting	28	8	155	288
Business	6	1	31	286
Other/Leisure	115	113	800	362

*Source NTS:0504, July 2011. Trips per person, per annum, all modes. (c = a*5+b), d= (c/(a/52))*

Air Annualisation Factors

As for the other modes, air annualisation factors are needed to expand from the average benefits per average 24 hour weekday to estimated annual benefits in each PFMv4.3 modelled year.

A deannualisation factor of 313 was used in the process of deriving the PFMv4.3 daily trip matrices from annual Civil Aviation Authority data, based on analysis undertaken to support the development of the DfT's Long Distance Model. In discussion with the DfT Air division, it was agreed that this factor was still appropriate and should be used as to annualise air benefits for all purposes, ensuring consistency between the process of deannualising and annualising demand and benefits.

As show in Table 9-8 below this revised factor fell between the annualisation factors previously used for business and leisure trips, representing an 8% increase on the previous business factor and a 21% decrease on the previous leisure factor.

Table 9-8 Comparison of Revised and Previous Air Annualisation Factors

Purpose	Revised Factors	Previous Factors	Change
Business	313	291	8%
Other/Leisure	313	395	-21%

9.4. Value of Time Adjustments

9.4.1. Introduction

This section describes the updates made to the Value of Time real growth figures used in the appraisal template and PFMv4.3 in March 2013. The revisions were required to:

- reflect changes to the input forecast variables (GDP and population); and

- improve the transparency of the calculation of the figures used.

The following sections provide further detail on each of these two components of the changes made.

9.4.2. Revised Growth Rates

9.4.2.1. Input Variables

The appraisal template follows the WebTAG guidance that real growth in Value of Time should be assumed to grow in line with GDP per capita (Unit 3.5.6[17]), with an elasticity of 1 for business travel time and an elasticity of 0.8 for non-business travel time.

Value of Time growth forecasts therefore need to reflect the latest GDP growth and population growth forecasts. The sources of these variables used in the March 2013 updates are summarised in Table 9-9 below.

Table 9-9 Data Sources – GDP and Population Forecasts

Item	Short Term	Long Term
GDP	Forecasts published in "March-2012-EFO-charts-and-tables.xls" (table 4.3), *Source*: OBR website[18]:	OBR document "Fiscal sustainability report – Supplementary data series July 2012" (table 1.1), available on the OBR website *Source*: OBR website[19]:
Population	Population forecasts: from the ONS low migration variant, consistent with the population forecasts that fed into the forecast GDP growth rates published by the OBR *Source*: ONS website[20]:	

The inputs used in the appraisal template are expressed in terms of financial years. This is consistent with the format of the outputs from the PFMv4.3 used in the template. It is however inconsistent with the calendar year format used in WebTAG. It is therefore important to note that it will not be possible to make future updates to Value of Time growth rates in the appraisal template directly from WebTAG. Instead it will be necessary to access the underlying population and GDP data to calculate consistent inputs on a financial year basis.

9.4.2.2. Inputs to the Appraisal Template

The following table summarises the input variables and resultant forecast real Value of Time growth as entered to the appraisal template.

Table 9-10 March 2013: Value of Time Real Growth Forecasts – Appraisal Template

Financial Year	GDP annual growth rate - CPI Based (Central)	Population annual forecast growth rate	GDP per capita annual growth rate	Value of time (work) annual growth rate	Value of time (non-work) annual growth rate
2011/2012	0.5%	0.711%	-0.2%	-0.2%	-0.2%
2012/2013	1.0%	0.712%	0.3%	0.3%	0.2%
2013/2014	2.3%	0.710%	1.6%	1.6%	1.3%
2014/2015	2.8%	0.697%	2.1%	2.1%	1.7%
2015/2016	3.1%	0.676%	2.4%	2.4%	1.9%
2016/2017	3.0%	0.653%	2.3%	2.3%	1.9%
2017/2018	2.6%	0.630%	2.0%	2.0%	1.6%

[17] WebTAG Unit 3.5.6: Values of Time and Operating Costs - http://www.dft.gov.uk/webtag/documents/expert/pdf/u3_5_6-vot-op-cost-120723.pdf
[18] http://budgetresponsibility.independent.gov.uk/economic-and-fiscal-outlook-march-2012/
[19] http://budgetresponsibility.independent.gov.uk/category/topics/long-term-sustainability/
[20] http://www.ons.gov.uk/ons/publications/re-reference-tables.html?newquery=*&newoffset=150&pageSize=25&edition=tcm%3A77-229866

Financial Year	GDP annual growth rate - CPI Based (Central)	Population annual forecast growth rate	GDP per capita annual growth rate	Value of time (work) annual growth rate	Value of time (non-work) annual growth rate
2018/2019	2.4%	0.615%	1.8%	1.8%	1.4%
2019/2020	2.4%	0.601%	1.8%	1.8%	1.4%
2020/2021	2.4%	0.588%	1.8%	1.8%	1.4%
2021/2022	2.4%	0.573%	1.8%	1.8%	1.5%
2022/2023	2.4%	0.557%	1.8%	1.8%	1.5%
2023/2024	2.4%	0.539%	1.9%	1.9%	1.5%
2024/2025	2.4%	0.520%	1.9%	1.9%	1.5%
2025/2026	2.5%	0.501%	2.0%	2.0%	1.6%
2026/2027	2.5%	0.482%	2.0%	2.0%	1.6%
2027/2028	2.5%	0.464%	2.0%	2.0%	1.6%
2028/2029	2.5%	0.448%	2.0%	2.0%	1.6%
2029/2030	2.5%	0.434%	2.1%	2.1%	1.6%
2030/2031	2.5%	0.420%	2.1%	2.1%	1.7%
2031/2032	2.4%	0.408%	2.0%	2.0%	1.6%
2032/2033	2.4%	0.397%	2.0%	2.0%	1.6%
2033/2034	2.4%	0.388%	2.0%	2.0%	1.6%
2034/2035	2.3%	0.381%	1.9%	1.9%	1.5%
2035/2036	2.4%	0.375%	2.0%	2.0%	1.6%
2036/2037	2.4%	0.369%	2.0%	2.0%	1.6%
2037/2038	2.4%	0.365%	2.0%	2.0%	1.6%
2038/2039	2.4%	0.364%	2.0%	2.0%	1.6%
2039/2040	2.4%	0.362%	2.0%	2.0%	1.6%
2040/2041	2.5%	0.361%	2.1%	2.1%	1.7%
2041/2042	2.5%	0.358%	2.1%	2.1%	1.7%
2042/2043	2.5%	0.352%	2.1%	2.1%	1.7%
2043/2044	2.6%	0.350%	2.2%	2.2%	1.8%
2044/2045	2.5%	0.349%	2.1%	2.1%	1.7%
2045/2046	2.5%	0.348%	2.1%	2.1%	1.7%
2046/2047	2.5%	0.341%	2.2%	2.2%	1.7%
2047/2048	2.4%	0.321%	2.1%	2.1%	1.7%
2048/2049	2.4%	0.320%	2.1%	2.1%	1.7%
2049/2050	2.4%	0.319%	2.1%	2.1%	1.7%
2050/2051	2.4%	0.318%	2.1%	2.1%	1.7%
2051/2052	2.4%	0.308%	2.1%	2.1%	1.7%
2052/2053	2.3%	0.280%	2.0%	2.0%	1.6%
2053/2054	2.3%	0.279%	2.0%	2.0%	1.6%
2054/2055	2.3%	0.278%	2.0%	2.0%	1.6%
2055/2056	2.3%	0.278%	2.0%	2.0%	1.6%
2056/2057	2.3%	0.271%	2.0%	2.0%	1.6%
2057/2058	2.3%	0.253%	2.0%	2.0%	1.6%
2058/2059	2.3%	0.252%	2.0%	2.0%	1.6%
2059/2060	2.3%	0.251%	2.0%	2.0%	1.6%

Financial Year	GDP annual growth rate - CPI Based (Central)	Population annual forecast growth rate	GDP per capita annual growth rate	Value of time (work) annual growth rate	Value of time (non-work) annual growth rate
2060/2061	2.4%	0.249%	2.1%	2.1%	1.7%
2061/2062+	2.2%	0.246%	1.9%	1.9%	1.6%

9.4.2.3. Inputs to PFMv4.3

Value of Time growth forecasts used in the PFMv4.3 were updated at the same time for consistency. However, whilst the inputs were consistent, they were not identical to those used in the appraisal template. This is because, in line with DfT guidance, they were based on a different version of the real GDP growth forecasts, calculated using the Retail Price Index (RPI) as an index of consumer prices whereas the appraisal values use real GDP growth forecasts calculated using the Consumer Price Index (CPI) as an index of consumer prices.

Nominal GDP forecasts are converted to forecasts of real GDP growth (i.e. removing the effects of price inflation) by deflating the nominal values of the various elements of economic output contributing to total nominal GDP by appropriate deflators (such as producer price indices and the agricultural price index)   In the past, the Office for National Statistics used the RPI to deflate the value of consumer goods. However, in 2012 they revised their approach to use the CPI, for consistency with international guidance. Whilst this had no impact on nominal GDP values and forecasts, it did affect estimates and forecasts of real GDP through time, increasing growth by approximately 0.2 percentage points per annum on average.

The CPI based approach to calculating real GDP growth is now the government standard and is applied in appraisal. However, government advice is that where modelling and forecasting tools have been calibrated on the basis of the real GDP growth series derived using the previous RPI based approach, they should continue to use RPI based values for forecasting until they can be updated to use the new CPI based series.

PFM falls in this category and therefore uses Value of Time growth inputs that are based on real GDP growth calculated using the RPI, resulting in growth rates that are 0.2 percentage points lower than those presented in the table and used in the appraisal template.

9.4.3. Revised Input Format and Application

During the update to PFMv4.3, the format in which the value of time growth forecasts are entered into the template was also updated, to improve transparency by showing the underlying variables and calculation stages. The revised format shows the real GDP growth and population growth forecasts by year and the resultant Value of Time growth forecasts and provides full detail of the source of each dataset.

Two changes to the calculations of future year growth values in the template were also made. The first involved removing the adjustment to reduce Value of Time growth by 0.86[21], 30 years after the current year of appraisal, to coincide with the reduction in discount rate. This adjustment was applied in previous versions of the template in line with WebTAG advice (Unit 3.5.6). However, HS2 Ltd was advised during March 2013 that the original advice in WebTAG had been based on a misunderstanding of the HM Treasury Green Book[22]. The adjustment is therefore no longer required and WebTAG will shortly be updated to reflect this change.

The sensitivity test previously included in the template to allow GDP and Value of Time growth to be forecast on the basis of forecast RPI as a consumer price index rather than CPI was removed after clarification from HS2 Ltd that it was no longer required as the CPI approach is now the central approach applied in WebTAG.

[21] Calculated as 3%/3.5% i.e. modelled year discount rate/current appraisal year discount rate
[22] The Green Book Appraisal and Evaluation in Central Government: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/179349/green_book_complete.pdf.pdf

Atkins Limited
Euston Tower
286 Euston Road
London
NW1 3AT