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PLANET FRAMEWORK MODEL VERSION 4.3
MODEL DEVELOPMENT REPORT

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1. SUMMARY

1.1.1 MVA Consultancy, Mott MacDonald and RAND Europe were commissioned to undertake a series of model updates to the PLANET long distance model, in order to support the assessment of the HS2 scheme and produce an updated economic case for inclusion in the HS2 hybrid bill.

1.1.2 This document describes the model development work undertaken through the Work Package 2 (WP2) contract for HS2 Ltd. The starting point for this was PLANET Framework Model (PFM) version 3.0 (PFM v3.0) and the ultimate product was PFM v4.3.

1.1.3 The document includes detail on:

- **Minor model improvements made** – which included both addressing issues which had been identified as part of the audit of PFM v3.0 and also improvements to the functionality of the model. Together these improvements produced a more robust model as a starting point for the model development work;
- **An investigation into model parameters –** which was undertaken as the various different component models in PFM v3.0 had different parameters and hence work was undertaken to produce parameter consistency across the modelling framework as far as possible;
- **Revised assignment procedures –**a new version of EMME, which was available for the model update, contained improved assignment functions, in particular the ability to assign demand based on service frequency and journey time, rather than purely service frequency as in PFM v3.0. The revised assignment also allowed for improved analysis of the model outputs;
- **Updated Demand Model –** the demand model in PFM v3.0 was based on stated preference data from 2001: it was completely re-estimated using the long-distance (LD) journey records collected in the 2002-2010 National Travel Survey (NTS), and taking into account methodological advances;
- **Station Choice Model updates –** these were undertaken to retain consistency with the updated model parameters, demand model and assignment procedures. The opportunity was also taken to update some minor issues in the model set up;
- **Improved integration between PLANET Long Distance and PLANET South –** there were issues in the way the model passed data between these two component models. These are described in chapter 8 along with the improvements which have been made to this process. These improvements have been implemented to better represent this key geographical area within the modelling framework;
- **Revised Appraisal Methodology –** chapter 9 describes the updated appraisal methodology and tools which have been implemented in PFM v4.3; and
- **Model performance and validation –** describing the validation of the model against observed data sets, the convergence of the model and benchmarking against other data sets. This is presented to demonstrate the robustness of the model.

1.1.4 It should be noted that this document does not include information from any development undertaken under any of the other work streams.

2. INTRODUCTION

2.1 Background to the Model Development

2.1.1 In January 2012 the Government decided to proceed with HS2 Ltd's proposals for the HS2 high speed rail network. HS2 will be a Y-shaped rail network with stations in London, the Midlands, Leeds, Manchester, and Sheffield, which also allows high speed trains to connect seamlessly with the existing West Coast and East Coast main lines to serve passengers beyond the HS2 network. HS2 would be built in two phases, the first between London and West Midlands by 2026 (Phase One), and the second from West Midlands to Leeds and Manchester (full network) by 2033.

2.1.2 To inform the decision-making process, HS2 Ltd had commissioned extensive forecasting and appraisal both for Phase One and for the full network (also known as Y) network. The primary modelling tool for the forecasting and appraisal is the PLANET Framework Model (PFM). Version 3.0 of the PFM was used for the Update to the Economic Case for HS2 published in 2012.

2.1.3 HS2 Ltd is now preparing for a Hybrid Bill in relation to the London-West Midlands phase of the high speed rail network, to be presented to Parliament in the 2013-14 session. To support the Hybrid Bill, HS2 Ltd commissioned MVA Consultancy, Mott MacDonald and RAND Europe to implement a number of improvements to the PFM, taking it forward through staged development to the most recent version PFM v4.3.

2.1.4 PFM v3.0 had been reviewed by independent experts (external to those who have developed the model) during 2012, including John Bates Services and ALOGIT Software and Analysis. They advised HS2 Ltd on the elements of the model that need to be addressed to ensure that it will be suitable to support the Hybrid Bill. These conclusions were endorsed by HS2 Ltd's Analytical Challenge Panel (ACP).

2.1.5 PFM v3.0 had been reviewed by independent experts (external to those who have developed the model) during 2012, including John Bates Services and ALOGIT Software and Analysis. They advised HS2 Ltd on the elements of the model that need to be addressed to ensure that it will be suitable to support the Hybrid Bill. These conclusions were endorsed by HS2 Ltd's Analytical Challenge Panel (ACP).

2.1.6 Taking account of the reviews undertaken, HS2 Ltd identified a series of tasks to be undertaken to improve the robustness of the model. Atkins were appointed to update the base year matrices of the model, develop new growth forecasts, update the do minimum networks, update the crowding approach and convert the model to operate in a later version of EMME. This work is documented by Atkins in a separate report.

2.2 Model Development Changes

2.2.1 The work documented in this report was mainly undertaken within a contract in which MVA Consultancy, Mott MacDonald and RAND Europe were commissioned to undertake these updates, in order to support the assessment of the HS2 scheme and produce an updated economic case for inclusion in the HS2 hybrid bill. In the course of that contract, some aspects of the work identified in the review were dropped from the development work, while some new requirements were added. More details of the items considered in the review are detailed in Appendix A.

2.2.2 The updates which were included were made in a version of the model called PFM v4.3. The changes which were finally made to the model are listed in Table 1 below.

Table 1. Changes Made to the Model in PFMv4.3

DEVELOPMENT	DESCRIPTION
Minor Improvements to the model	A number of minor improvements were made to the model, most of which stemmed from the previous model audit
Parameter Consistency	A process was undertaken to ensure parameters in all parts of the PLD model were consistent
Improved Assignment Procedure	An improved rail assignment procedure was implemented in the model and a re-validation was undertaken
Re-calibrated Station Choice Model	The station choice model was re-calibrated and updated
Re-calibrated Demand Model	The demand model was re-calibrated and updated
Update appraisal procedure	The appraisal process was updated to make it operate at the station to station level

2.2.3 In order to provide a coherent narrative, this report concentrates on those new aspects which were actually implemented in PFMv4.3, as detailed in the table. However, for the sake of completeness, some of the investigations relating to the original contract are also reported. It should be noted that this document does not include information from any development relating to PFMv4.3 undertaken under any of the other work streams.

2.3 Report Structure

2.3.1 The remainder of this report is laid out in the following structure:

- Chapter 3: Minor Model improvements;
- Chapter 4: Parameter consistency;
- Chapter 5: Revised assignment procedure;
- Chapter 6: Station Choice Model updates;

- Chapter 7: Re-estimating the demand model parameters;
- Chapter 8: Improved integration between PLANET Long Distance (PLD) and PLANET South (PS);
- Chapter 9: Appraisal Methodology changes; and
- Chapter 10: PFM v4.3 model performance

3. MINOR MODEL IMPROVEMENTS

3.1 Introduction

3.1.1 The starting point for the model development was to make a number of minor improvements which were all based on minor issues identified in the PFM v3.0 audit or items which were known to the model developers. All of these items are important for the robustness of the model, but impact little (less than 5%) on the benefits produced by the model.

3.1.2 These improvements fall within the following categories and are discussed in more detail below:

- *Model adjustments* – issues identified in PFM v3.0 (the model used to produce the August 2012 update to the economic case) as part of internal or external audit checks or through using the model; and
- *Model improvements* – changes or improvements to the existing functionality, in particular:
  - Implementing the Underground Crowding in PS;
  - Including the real time growth for the fare premium to access Heathrow airport;
  - Using revised rail matrices for the Heathrow Airport zone; and
  - Reviewing and revising the approach to modelling shadow services.

3.2 Model Adjustments

3.2.1 Since the release version of the PFM v3.0, a number of minor issues had been identified with the model, and these needed to be incorporated into the model as part of this development work stream. Some of these issues related solely to the base year model whereas other issues related to both the base and future year versions of the model. Table 2 provides an overview of the adjustments made to the base and future year models (2026 and cap year).

3.2.2 Further information about each of these adjustments is provided in detail in the subsequent sections. Appendix B details how the files changed during the implementation of these adjustments.

Table 2. Summary of Adjustments Required in Base and Future Year Models

MODEL ADJUSTMENT	BASE YEAR MODEL	FUTURE YEAR MODEL
Inclusion of Salford and Sheffield Meadowhall station in the SCM	✔	
The removal of non "north facing" stations in London in the SCM	✔	
Update to SCM files	✔	
Revised Ensemble for Wormhole Process	✔	
Changes to the control matrix	✔	
Removal of access leg integration	✔	
Price level adjustment factor	✔	
Matrix storage format in EMME/2	✔	✔
Station Choice Model Access Costs	✔	✔

Inclusion of Salford and Sheffield Meadowhall Stations in the SCM

3.2.3 During the development of PFM v3.0, Salford and Sheffield Meadowhall stations were originally not considered as strategically important stations, and were not included in either PLD or within the SCM. However, during the application of the model to assess High Speed station options in the Manchester and South Yorkshire areas, it was evident that both of these stations needed to be represented. Subsequently, in the future year version of PFM v3.0 both stations were added into the SCM. This required updating the SCM related control files and the PLD assignment network so that these stations were connected to the rail network. Therefore in developing PFM v4.3 2010/2011 base year model the SCM control files and PLD assignment networks needed to be updated.

Removal of non 'north-facing' stations in London

3.2.4 During the development of PFM v3.0, the SCM was modified so that during a model run, the SCM was only applied to north facing London stations, ie passengers going north from London zones were not permitted to access the rail network via south facing stations such as Waterloo and Victoria. This was to prevent illogical outputs from the SCM.

Update of SCM Files

3.2.5 Only some of the SCM files (the text files that define all elements of the SCM) had been updated in the base year model to reflect the final SCM specification. The PFM v4.3 base year model contains all updated files.

Revised Ensemble for Wormhole Process

3.2.6 During a run of the rail assignment in PLD, rail demand is passed from PLD to PS using a "wormhole" process. This involves creating a series of select link matrices at the cordon crossing points between PLD and PS. These select link matrices needed to be converted from the PLD station to station zoning system to the PS zoning system. This is achieved using an EMME “ensemble” (a correspondence table defining the relationships between the PLD and PS zoning systems).

3.2.7 In the future year model the ensemble which contains the correspondence listing (ensemble GS) had been adjusted and these adjustments needed to be incorporated in the base year model as well.

Changes to the Control Matrix

3.2.8 The control matrix is a "mask" that defines which origin-destination movements are represented in PLD and which movements are represented in the regional models; it is applied to the demand matrices. During the development of the future year model this mask was modified; however, the base model remained unchanged. These modifications needed to be incorporated in the base year model as well.

Removal of Access Leg Integration

3.2.9 During the development of PFM v3.0 changes to the modelling architecture were made so that PLD rail trips for which the SCM allocated access by public transport and where this access is local rail, had these access trips included as demand in the regional models. This process has been called access leg integration. The final version of PFM v3.0 had access leg integration switched off, as the methodology risked double counting revenue; this functionality was not disabled in the base year model. To address this all of the macros in the base year model which included access leg integration have been amended to disable the functionality.

Price Level Adjustment Factor

3.2.10 During the development of PFM v3.0, the base year observed demand included in the model was updated from 2007/2008 to 2010/2011. The rail fare matrices were updated at the same time to represent 2010/2011 average yield. The updated rail fares were input into the model in 2010/2011 prices. PFM v3.0 operated in a 2002 price base, so a price level adjustment factor is included in the model to adjust the input fares to a 2002 price base. In updating the rail demand and fares, the price level adjustment factor was not updated in the base year model (it was updated in the future year model). The conversion to a 2002 price base uses the All Items Retail Price Index (RPI CHAW)[1]

[1] Table 20, Annual Average Consumer Price Indices, August 2011, Office for National Statistics.

Matrix Storage Format within EMME

3.2.11 Within an EMME databank origin destination matrices can be stored in "column wise" or "row wise" format. In “column wise” format each record is stored in the format “origin zone”, “destination zone”, “value”, whereas in “row wise” format each record is stored in the format “destination zone”, “origin zone”, “value”.

3.2.12 This is an internal storage format and within EMME itself does not make any difference to results as the program recognises the format matrices are stored in and takes account of this during model runs and calculations. However, during a full run of the PFM, matrix data in the form of demand and cost skims is output from PFM for use in the SCM. If these are output in the wrong format the SCM does not recognise this and assumes they are in “row wise” format ie “origin”, “destination”, “value”.

3.2.13 During analysis of model results it was identified that some matrices were stored in "column wise" format. This meant that costs and demand had the demand and costs for the journey in the opposite direction. This is likely to have a small impact on the results for cost matrices, but potentially a much larger one for the demand matrices as the demand is not symmetrical in the two directions for some purposes. This has been corrected by incorporating a process within EMME to ensure all matrices are stored in a "row wise" format prior to a full model run. This process is now included in the model set up procedures prior to each model run.

Station Choice Model Access Costs

3.2.14 Within the SCM the access costs by mode are defined as an input to the model. Within PFM v3.0 some stations were inaccurately defined as not having any public transport access. The impact of this would be that at these locations persons would only use highway to access stations. The list of affected stations is given below:

- Birmingham Snow Hill;
- Hove;
- Seaham;
- Tiverton Parkway;
- Yeovil Junction;
- Holyhead;
- Bicester North; and
- Woking.

3.2.15 To address these issues revised access costs inputs were provided for the station choice model. These stations have the same access costs in the Do Minimum, Phase 1 and in the Y networks.

3.3 Model Improvements

3.3.1 The first stage of model improvements was to improve elements of the model that had been identified as requiring improvement during ongoing model reviews and application of the model. This included:

- Implementing the Underground Crowding in PS;
- Including the real time growth for the fare premium to access Heathrow airport;
- Using revised rail matrices for the Heathrow Airport zone; and
- Reviewing and revising the approach to modelling shadow services.

Underground Crowding in PLANET South

3.3.2 The model audit, which had been undertaken on PFM v3.0, identified that in the PS assignment, the crowding function was not applied to London Underground services. This is because the version of PS included in PFM has more crowding calculations than the standalone version of PS, 16 calculations compared to 12. (The PS in PFM has user classes containing the long distance demand from PLD). However, the assignment macro only referenced 12 of these calculations omitting those relating to the Underground. The assignment macro 'equilibrium_2009.mac' was updated to ensure all sixteen user classes including the Underground were referenced.

Real time growth for Heathrow fare premium included

3.3.3 Within PFM v3.0 a fare premium is included in the fares matrix for trips to and from Heathrow Airport (zone 90). This premium is to represent the fare premium applicable on Heathrow Express services. This premium is £15 for business and £10 for leisure. In the application of PFM v3.0 in future forecasting mode no real growth was applied to this fare premium (all other fares increase in real terms in line with government policy ie RPI+1% pa). In PFM v4.3 this real growth in rail fares has also been applied to the Heathrow fare premium.

Using revised rail matrices for the Heathrow Airport zone

3.3.4 In the rail demand matrices from EDGE, zone 90 represents a geographical area (to the west of London) and includes all demand to/from that area. However within PFM, PLD zone 90 is allocated for Heathrow Airport and contains only air passenger demand. Therefore prior to running the PFM all demand to and/from zone 90 in the EDGE matrices is reallocated to the London West zone (123)

Approach to shadow services

3.3.5 Being a strategic model, PLD only includes strategic rail lines, services and demand. However, in the geographical areas not included in the PFM regional models it includes all rail demand. In certain locations the high level of demand in combination with the lack of network and zoning detail can lead to unrealistic levels of demand on individual services and therefore crowding. These high levels of crowding lead to instability in the model (as levels of demand are at the steep part of the crowding curve).

3.3.6 In reality much of this demand would use local rail services. This is not a problem in the areas covered by the regional models as local demand is represented in the regional models.

3.3.7 To overcome this modelling issue all previous versions of the PFM have included a number of dummy rail services referred to as shadow services. These dummy services enable local demand to access rail without overloading long distance classic rail or HS2 services with unrealistic levels of demand.

3.3.8 Overwhelmingly, the largest problem is in Scotland, due to the large scale of rail commuting to Glasgow and a lesser extent Edinburgh. The second largest area relates to commuting to Cardiff. A good example of this issue is the zone representing south Glasgow. Rail demand from this zone is loaded onto Motherwell near Glasgow, Cross Country and West Coast services calling at Motherwell into Glasgow are loaded with additional trips that in reality they would not carry.

3.3.9 However, the shadow services are associated with specific Do Minimum and Do Something services and specific levels of demand, and hence may not be appropriate if either the services or demand changes significantly. Analysis of sector benefits for a version of the model using the shadow services inherited from the PFM v3.0 indicated that some 2% of overall benefits were from a small number of intra Scotland movements. These movements included Glasgow to South Lanarkshire, Glasgow to North Lanarkshire, Edinburgh to South Lanarkshire, Edinburgh to Glasgow, Glasgow to Dumfries and South Lanarkshire to Glasgow. In particular, Glasgow to South Lanarkshire has the 11th largest origin to destination zone benefits of all zones in the model, and has the greatest non central London related level of benefits. In terms of demand, there was significant HS2 generated demand within Scotland, accounting for 8% of total HS2 generated demand, and there were significant volumes of passengers using HS2 for intra Scotland movements. The level of demand and benefits for these movements was considered unrealistic.

3.3.10 A number of potential solutions were investigated to address this issue, these included:

- Option 1: Keep the current process but include sufficient shadow services to ensure that crowding off does not occur for each model run made;
- Option 2: Ban boarding and alighting of local demand on the long distance services over the movements where problems exist, (with shadows services left in) such that local demand does not impact on strategic services; and
- Option 3: Matrix Masking – ie remove demand from the matrix for the movements involved (e.g. south Glasgow to Glasgow) and remove the shadow services.

3.3.11 Each of these approaches has associated pros and cons as set out below in Table 3.

Table 3. Summary of Pros and Cons of the Approaches to Represent Shadow Services

POTENTIAL SOLUTION	PROS	CONS
Option 1 - Keep shadow services as now but with more capacity ie by increasing number of services, service frequency or train capacity to avoid problems	A known process. Consistent with previous approach. (although specification of shadow services not consistent) Retains the full demand matrix	Needs to be reviewed for each model run, to ensure that enough shadow services are coded in to avoid the crowding problems. (Particularly when looking at released capacity). Scope for mismatch between shadow service specification and demand, resulting in spurious economic benefits.
Option 2 - Ban boarding and alighting on long distance/HS2 services for the locations impacted	Don't have to worry about specifying shadow services. Transit lines only needs to be reviewed if new lines introduced	Scope for miscoding of boarding and alighting - careful coding needed to ensure that boarding and alighting penalties are round the right way
Option 3 - Remove trips from matrix (matrix masking)	Once OD movements are identified the process does not have to be repeated. (Can be automated in a macro, so still works if new demand is input to the model). Totally independent of line coding (can be set up without line coding information).	Demand totals not consistent with previous approach so not directly comparable. The absolute demand will have dropped in the model so a step-through test will be required to determine impacts.

3.3.12 Some testing and analysis was carried out on Option 1 to improve the shadow service specification, and on Option 3 looking at the removal of trips from the matrix. No testing was done on the Option 2 (boarding and alighting bans), as this would require definitive transit line coding which was not available at the time. It would also require assessment of each individual transit line to see if bans were appropriate which is a significant task, and would need to be repeated whenever there was a change to transit lines.

3.3.13 The increase in the overall capacity of shadow services in Scotland (Option 1) was tested by looking at an increase in the frequency of services and by increasing the train capacities. The implementation of both of these changes in Scotland resulted in a reduction in benefits in the order of 2%. The majority of the change in benefits was for intra Scotland movements. Looking at the distribution of the reduction in benefits on a sectored basis, the majority were for the key movements listed in paragraph 3.3.9. There is a reduction in HS2 generated demand in the order of 5%, (4,000 trips) all within Scotland, noting that there is still some remaining intra-Scotland generated demand (3,000 trips).

3.3.14 The implementation of the matrix masking (Option 3) removes all intra-Scotland demand. This resulted in a 3% reduction in benefits. In terms of other changes, there is a 5% reduction in Total HS2 boarders and 8% reduction in HS2 generated demand. All of the reduction in HS2 boarders was for intra Scotland movements and all the reduction in generated demand was for intra Scotland movements. There was very little change in demand for other movements.

3.3.15 Both Option 1 and Option 3 reduce the level of benefits and demand for intra Scotland movements. They have limited impact on demand, benefits and HS2 loadings outside of the Scotland area. The key concern with Option 1 is that it is dependent upon the specification of transit line coding.

3.3.16 In addition attempts to resolve the issue by shadow services does not completely remove the problem of unrealistic intra-Scotland benefits, it only reduces it (by about a half). The reason for this is the combination of large zones with very few stations. For example people from a wide area south of Glasgow drive to Carstairs or Lockerbie to access the train to Glasgow or Edinburgh, as there is no other station (in PLD) they can use, this is not realistic. However, it is not possible in the SCM to define the use of stations for specific destinations, so we cannot restrict the use of Carstairs or Lockerbie to access rail services from these locations.

3.3.17 In contrast removing demand from the matrix is completely independent of the transit line coding, and, therefore, any changes in benefits are not related to the shadow service specification. HS2 phase 2 (Y) does not really benefit intra Scotland services as there are no speed improvements (services are running on classic track); therefore removing all intra-Scotland demand does not have any downside for dealing with Scotland. It is considered that HS2 will not really benefit significantly any intra-Scottish flows with real volumes of demand, nor will crowding be a significant issue on HS2 services caused by intra-Scotland demand. It is therefore concluded that the best approach is to remove the intra-Scotland demand from the matrix. A similar approach has been adopted in south Wales, removing all intra South Wales demand (area from Fishguard to Newport, including the Valleys).

3.3.18 It is not possible to safely remove demand in this way in other areas.

3.3.19 Other areas outside of the regional models were examined to see where problems may be expected. The following areas were looked at - Humberside (both Hull and Grimsby areas); Teesside including Middlesbrough, Redcar, Hartlepool, Sunderland; and the Cumbrian coast area. Analysis of load factors (total passenger volumes/total train capacity) in these areas indicated that the load factors were not high enough to warrant a case for adding in additional shadow services. This analysis is shown in Table 4 below.

Table 4. Analysis of need for Shadow Services in other geographical areas in PLD

CORRIDOR	AREA	TOTAL PASSENGER VOLUMES	TOTAL TRAIN CAPACITY	TOTAL PASSENGER VOLUME/ TOTAL TRAIN CAPACITY
East Coast	Newcastle	17,621	25,647	0.69
West Coast	Lancashire	8,357	12,572	0.66
West Coast	Cumbria	9,046	15,919	0.57
Trans Pennine	Hull	4,746	9,359	0.51
Trans Pennine	Lincolnshire	1,957	4,947	0.40

4. PARAMETER CONSISTENCY

4.1 Introduction

4.1.1 PFM v3.0 consists of a number of different models, namely:

- **Demand Model** - this is the mode choice and generation model. This used a hierarchical logit model structure based on the results of stated preference survey conducted during the late autumn of 2001 for car, air and rail travellers, with supplementary surveys conducted in spring 2002 for car travellers [2]. Separate mode choice parameters were derived from the SP data for business, commuting (car available and non-car available) and other (car available and non-car available). Since only limited information was available for the commuting segment of demand from the SP data, the information was extrapolated forwards.
- **Assignment Model** - the PLD assignment model was based on the PLANET Strategic Model (PSM). The assignment parameters remained the same as PSM. Although the parameter values are well documented, the source of them is not so clear. Available documentation including the PSM model development report does not provide any further explanation;
- **The Station Choice Model** – here parameters were selected so as to be consistent with the assignment model parameters; and
- **The regional models (PLANET North (PN), PLANET South (PS) and PLANET Midlands (PM)**) - The parameters in these models remain unchanged from when they were originally incorporated into the PFM. The individual model development reports for PS, PM and PM do not provide any explanation of the source of these factors; and **The Heathrow Access Model (HAM)** - Documentation on the development of the HAM and its donor model (London Airports Surface Access Model (LASAM)) provide details of the source of the parameters in the HAM.

4.1.2 Each of these models uses estimates of Generalised Journey Time (GJT; GJTC, with crowding; and GJTCAE with crowding and access egress) by weighting different elements of a journey e.g. in-vehicle-time, wait time, boarding penalties, interchange walk time and crowding for public transport. In some cases, the weights are different on the same elements of generalised cost. As far as possible weighting and hence generalised cost calculations should be consistent between different components of the model so that responses from one element of the model accurately reflect the other elements, e.g. the changes from the demand model reflect the cost changes in the assignment (supply) model.

4.1.3 However, there are a number of reasons why weightings are not consistent:

- Constituent models have been developed at different times and in isolation;
- Weightings have been used to calibrate assignments;
- Some weightings are difficult to replicate in different elements of the model;

[2] Atkins 2002

- Non-linear functions may be used in the demand model; and
- Different definitions in different elements of the model, e.g. service interval penalties in PDFH represents both service frequency and wait time.

4.1.4 One of the primary aims of this work package was to review the parameters used in the various components of the previous version of PFM to ensure that, wherever possible, consistent parameters were being used throughout.

4.1.5 As part of the review the parameters within each of the v3.0 model components were reviewed against published sources (the Department for Transport's WebTAG[3] and the Passenger Demand Forecasting Handbook (PDFH) Version 5 (2009)[4] produced by ATOC to ensure that they are in line with best practice.

4.1.6 The following sections review the v3.0 parameters by mode; rail, highway and air. For each mode the existing parameters are presented and reviewed against published data sources, if available. Any inconsistencies are identified and the method used to address these inconsistencies is described.

4.1.7 The v3.0 parameters are described for:

- The Demand model;
- The Station Choice Model;
- The PLD Assignment model;
- The Heathrow Access Model; and
- Regional models – PS, PM and PN.

4.1.8 In addressing the consistency of model parameters the focus has been on those elements of PFM that will have most influence over the forecasts for HS2 and the associated benefits - ie the demand model, PLD assignment models and the SCM. Within these models parameters associated with all modes have been reviewed with a particular focus on the rail elements of the model, as this is the element of the model where generalised costs are expected to change between the Do Minimum and Do Something and hence have the most influence on cost changes and demand and benefits.

[3] http://www.DfT.gov.uk/webtag/

[4] http://www.atoc.org/about-atoc/commercial-activities/passenger-demand-forecasting-council/the-passenger-demand-forecasting-handbook; version 5 was the latest version as at start of this work package, but was updated to version 5.1 in July 2013; in most cases relevant parameter values did not change as a result of this update

4.2 PFM v3.0 Parameter Review: Highway

4.2.1 Table 5 shows the parameters in the demand model for the highway mode.

Table 5. PFM v3.0 Highway Parameters

HIGHWAY	DEMAND MODEL
Time	1
Access / egress time (applies to centroid connector)	1.3

4.2.2 The 1.3 factor on access / egress was derived from the ratio of average actual times (e.g. to include parking) to the zone centroid connectors. As the highway access/egress time generally makes up a very small proportion of highway GJT, is unchanged between the Do Minimum and Do Something, and the demand model is applied incrementally the assignment access/egress factor will have very little effect, if any, on the forecasts.

4.2.3 In the highway assignment model, network routing is determined by the volume delay function (VDF) and distance. The VDF calculates the journey time on a link for a given flow and this is combined with the link length to determine the overall generalised cost on the link. The overall generalised cost is a linear combination of time (in minutes) and distance (in kilometres) as a proxy for monetary cost; hence no further parameter values are required.

4.3 PFM v3.0 Parameter Review: Air

4.3.1 The air parameters in PFM v3.0 are shown in Table 6. It shows that there are differences between the three models (demand model, assignment and the Heathrow model). Whilst the demand model has different parameters for the service interval factor by purpose (Business and Leisure / Other) the assignment model uses a single parameter for all purposes, which is, however, comparable to those in the demand models. There is no reference to the source of parameters for the air assignment in available documentation, including the PLANET Strategic Model (the model that PFM was based on) model development report.

4.3.2 The board penalty for air in the assignment model is high, but reasonable, given check-in and security requirements. UK airports typically recommend allowing between 1-2 hours check-in for domestic flights and the assignment board penalty was derived by calibration based on this. The high value is required to prevent significant interchanging between flights on domestic air services. Similarly the high access time penalty of ten is required to force people into using their local airport where there is a flight, rather than accessing more distant airports or not being assigned to air at all. However, such a high value is not required or appropriate in the demand model when choosing between modes of travel.

4.3.3 No data from industry sources is provided as PDFH is rail only and WebTAG is more applicable to surface modes, rather than domestic air travel.

4.3.4 It should be noted that the HAM addresses a different market from the main PFM model. The HAM considers access trips to international flights from Heathrow, whereas the air mode in the main model relates to domestic travel; hence there is no reason to expect consistency between the parameter values here.

Table 6. PFM v3.0 Parameters for Air in the Different Models

AIR	DEMAND MODEL (BUSINESS) [5]	DEMAND MODEL (OTHER – CA)	HEATHROW MODEL (UK BUSINESS) [6]	HEATHROW MODEL (UK LEISURE)	ASSIGNMENT MODEL
IVT	1	1	1	1	1
Factor applied to service interval	0.23	0.13	0.272	0.275	0.2
Access	1.08	1.00	3.06	4.80	10
Board time penalty Air (minutes)	N/A	N/A	N/A	N/A	163
Board time factor Air	N/A	N/A	N/A	N/A	2

Note: Those items not included in a particular section of the model are indicated with N/A's

4.3.5 It is also to be noted that changes to parameter values for the air mode will only affect the HS2 demand and benefits in situations where the air service level changes between the Do Minimum and the Do Something; currently only rail services are assumed to change between Do Minimum and Do Something, so the air parameters will not affect the forecasts.

4.3.6 As mentioned previously, within PFM, demand is transferred between the component models using "wormholes". The exception where the demand will be affected by the assignment parameters is in the HAM and the transfer of demand from PLD to PS, which is passed between the models as a matrix. There is not an issue with consistency of assignment parameters with the Heathrow model as it does not have its own supply representation and takes cost skim matrices from PLD.

[5] There is assumed to be no commuting trips or other (ie leisure) non car available trips

[6] These are the 2008 parameters – additional parameters are provided for 2031 and for non UK business and non UK leisure trips

4.4 PFM v3.0 Rail Parameter Review

4.4.1 Table 7 provides the parameters for the time elements of the rail mode. These parameters are used to convert the individual components to be In Vehicle Time (IVT) equivalent. They are:

- IVT itself;
- Factor applied to service interval. In some of the models separate factors are provided for converting service interval to average weight time and then weighting the wait time. The factor applied to service interval is the product of these two factors, converting service interval into in-vehicle time;
- Walk time (also includes Access/Egress time in the Regional models); and
- Board time/ interchange penalty (minutes). Assignment models use the concept of boarding penalty which is added to generalised cost every time the traveller boards a train. In mode choice models and in PDFH, the concept of interchange penalty is preferred, which is added every time there is an interchange between public transport modes. In the PLD assignment model and the SCM the penalty is applied to all boards including the first board despite it being called an interchange penalty. The interchange penalty in the demand model was calculated as *(7.16 + (0.066*IVTr))*INT^0.7* where IVTr is the rail in-vehicle time and INT is number of interchanges. As the boarding penalty differs by in-vehicle time in the demand model, for comparison approximate boarding penalties have been calculated for three route lengths: 50 miles, 150 miles and 325+ miles.

4.4.2 Table 7 also provides a comparison against WebTAG (October 2012) and PDFH v5 data. Many of the parameters, particularly within PDFH, are either service interval or distance based; hence different parameters are implied depending on the total distance of the journey. The parameters presented in Table 5 give examples based on typical long distance journeys of 50, 150 and 325 miles (this gives the maximum value for interchange penalty).

Table 7. Parameters for Rail in the Different Models (PFM v3.0) - Relative to In-Vehicle Time

Rail Parameter	IVT	Factor applied to service interval	Walk time weight (also Access/ Egress in Regional models)	Board time/ interchange penalty (mins)		
Journey Miles				50	150	325+
Demand Model (Business)	1	1.09	1.3	25 mins	55 mins	90 mins
Demand Model (Commute CA / NCA)	1	0.94	1.5	16 mins	36 mins	
Demand Model (Other CA)	1	1.5	1.34	25 mins	55 mins	90 mins
Demand Model (Other NCA)	1	1.5	1.34	25 mins	55mins	90 mins
Assignment Model	1	0.8	4	30mins		
SCM	1	0.8	4	30mins		
Planet South	1	1	2	3.5mins		
Planet North & midland	1	1	2	20mins		
WebTAG (unit as described below)	1	0.75 – 1.25	1.5 – 2.0	5-10 mins per interchange		
PDFH v5	1	0.95 for B and C, 0.85 for O[7]	1.5	25 mins (B / O); 16 mins C	55 mins (B / O); 36 mins C	90 mins (B / O)

[7] B – Business, C – Commute, O - Other

4.4.3 The sources and assumptions for the WebTAG and PDFH v5 information:

- The service interval penalty factor is calculated as:
  - WebTAG: wait time factor x wait time;
  - PDFH: service interval penalty from PDFH v5 Table B4.7 divided by service interval. It is assumed that business purpose trips perceive service interval in a similar way to full fare passengers, commute trips similar to season ticket passengers and other trips similar to reduced fare passengers;
- Access/egress and walk time factors for PDFH are based on the valuation of walk time equation provided in PDFH v5 Section B4.8.4. WebTAG access / egress parameters are from Unit 3.10.2; and
- Board time / interchange penalties for PDFH are from Table B4.10. For WebTAG these are in Unit 3.10.2. The 5 to 10 minute interchange from WebTAG penalty per interchange is assumed to be over and above the weighted walk and wait time involved during an interchange. The PDFH interchange values include the interchange penalty as well as the interchange wait and walk time.

4.4.4 Table 7 shows for the following:

- **In vehicle time is consistent at 1;**
- **Service interval factor:**
  - Differs slightly across the various models; however, it is generally in line with other published material, with the possible exception of the rail 'other' journey purpose, which is slightly higher; and
  - In the rail assignment and SCM it is in line with industry sources.
- **Access / egress and walk parameter:**
  - For rail, in the demand model, it is generally in line with industry sources;
  - In the rail assignment and SCM assignment in PFM v3.0 it is significantly higher than industry sources (4 rather than 2);
- **Board time penalty:**
  - For trips greater than 50 miles the demand model rail board time penalty is significantly different to the assignment model and the SCM, as the boarding penalties in the demand model are journey time based compared to the fixed boarding penalties in the SCM and assignment. In addition to this the penalties in the demand model are high for long distance trips; and
  - In the rail assignment model and SCM it is within the anticipated range.

4.4.5 PDFH (Table B4.10 in PDFH v5) indicates that interchange penalty increases with distance travelled. This reflects a number of factors including:

- Longer distance travellers typically have more luggage;

- Longer distance travellers are less likely to know the station at which they are interchanging; and
- Longer distance train services are typically less frequent and so the penalty for missing a connection is greater.

4.4.6 However, the assignment model only considers one link of a journey and does not know the journey length, so within the assignment model a fixed board penalty must be applied. A value of 30 minutes was originally coded into PLANET Strategic and this seems appropriate compared to the average values in PDFH.

4.4.7 The original PFM (v1 and v2) included a different interchange penalty in the demand model from that in the assignment model. This is not ideal in demand forecasting as it can result in inconsistencies. Furthermore, the value used in the demand model depended on journey time rather than distance. This resulted in the interchange penalty reducing when HS2 was introduced giving spurious demand increases and user benefits.

4.5 Summary of Parameter Review

4.5.1 As part of the parameter review no changes were made to the Highway or Air parameters Also, no change to the parameters in the HAM, as this represented a specific market segment and therefore could have different parameters.

4.5.2 There have, also, been no changes made to the parameters used in the regional models as:

- In general they were broadly consistent across the models and in-line with wider industry sources;
- They serve different markets and are much more local in nature than PLD; hence different parameter values would be expected. The only place consistency was sought was where a trip is considered in different models for part of the overall trip, e.g. where a long distance trip is transferred to PS through the 'wormhole'. Note that crowding in PFM v4.3 is treated consistently across PFM and the regional models, using PDFH v5;
- Adjusting the parameter values in the regional models would require the models to be recalibrated, which would have taken a significant amount of time and data collection; and
- It is anticipated that changes in the regional models associated with parameter values should have minimal impact on the overall results for HS2.

4.5.3 The final weightings in PFM v4.3 on the rail time components in PLD are shown in Table 8 below.

Table 8. PFM v4.3 Parameters Relative to In-Vehicle Time

SCM PARAMETER	BUSINESS	LEISURE	COMMUTE
Car access time	2	2	2
PT IVT	1	1	1
PT Wait Time	2	2	2
PT Walk Time	2	2	2
PT Interchange penalty	30	30	30

4.5.4 The weight on walk time was changed from 4 to 2 within PFMv4.3 in order to be consistent with WebTAG.

4.5.5 Also, in PFM v4.3 it was decided that the interchange value of 30 minutes (as in the Assignment Model and Station Choice Model) should be adopted in the Demand Model.

4.5.6 Finally in order to ensure consistency with the model parameters between the demand model, SCM and assignment model, in PFM v4.3, the SCM provides the demand model with the logsum composite cost. This means that the parameters applied within the calculation of the GJTCAE are those within the SCM.

4.6 PFM v3.0 Values of Time

4.6.1 PFM v3.0 worked in in 2002 prices, modelled year values. In all of the assignments the value of time is not an issue as there are no monetary components to the assignment routing ie fares are excluded. The demand model in PFM works on generalised costs in pence and includes monetary components e.g. rail and air fares and vehicle operating costs.

4.6.2 The values of time in PFM v4.3 were therefore updated to reflect 2010 prices as per WebTAG unit 3.5.6 (August 2012).

5. REVISED ASSIGNMENT PROCEDURE

5.1 Introduction

5.1.1 Since v3.0, PFM has been updated to run in EMME version 3.4.1, and this provides improved assignment functions, in particular the ability to assign demand based on service frequency and journey time, rather than purely service frequency as in EMME/2.

5.1.2 Investigations were carried out on the existing rail assignment algorithms and the additional options available in EMME. These concluded that a revised rail assignment procedure which distributes rail demand based on service frequency and journey time should be adopted.

5.2 Assignment Procedure in PFM v3.0

5.2.1 In PFM the overall rail assignment process is complex involving a station choice model (SCM) to predict choice of origin and destination station, a station to station rail assignment procedure in EMME, which includes crowding and utilises a method of successive averages (MSA) to help achieve convergence

5.2.2 The standard transit assignment algorithm implemented in EMME is a multi-path algorithm based on the concept of strategies and optimal strategies. In EMME a strategy is a set of rules that allows a traveller to reach their destination. A traveller may select a more complex choice set than just a simple path toward a destination, so a strategy could constitute a single path using a single transit line or a number of paths each involving one or more transit lines. The optimal strategy between each origin and destination zone is the one that has the least overall travel time (including access, waiting, in vehicle time etc.). Therefore the optimal strategy will only include that combination of paths and related transit lines that results in the least overall travel time. The transit lines included in the optimal strategy are called the attractive lines. Including any other paths within the attractive set as part of the strategy would increase the overall travel time.

5.2.3 The assignment process operates in two stages:

- Calculate the optimal strategy ie the set of attractive routes and lines that minimises the overall journey time; and
- Assign demand according to that strategy

5.2.4 In allocating demand to the attractive transit lines, the proportion of demand is allocated to each transit line based on the frequency of individual transit lines in relation to the overall combined frequency. This is based on the assumption that at a node, the probability of a particular transit line arriving first is based on the service frequency of each transit line in relation to the combined frequency of all attractive transit lines at that node.

5.2.5 There are various concerns with the assignment model processes:

- For attractive routes the allocation of demand to individual services based on service frequency, irrespective of generalised journey time (GJTCAE), can lead to unrealistic choices in the context of long distance travel, particularly if some services are high speed and others not high speed;
- Although additional crowding time is used in determining the set of attractive lines, the allocation of demand based on service frequency to individual lines in the attractive set also fails to take the level of crowding into account; and
- The way a service is represented in the model can impact on its selection as an acceptable service. For example, subtle differences in a regular service coded as individual hourly services or a single service of hourly frequency can lead to different results.

5.3 Additional Options Available in EMME

5.3.1 Traditionally there has only been one assignment algorithm in EMME - the (frequency-based) optimal strategy assignment algorithm. EMME has introduced a variant which distributes flows between attractive alternative services based on frequency and transit time (including crowding): this is known as the Frequency and Journey Time Strategy (FJTS).

5.3.2 The assignment algorithm for this option works in a similar way to the EMME Optimal strategy, with a few key differences. These relate to the calculation of combined frequency, overall travel time and the allocation of demand to each transit line.

5.3.3 In calculating the combined frequency, an adjustment is made to the frequency of the next fastest transit line being considered to reflect the difference in journey time between it and the current attractive lines. As the combined frequency is used to calculate the wait time, and the wait time makes up part of the overall journey time, the overall journey time is different to that calculated in the Optimal strategy. The adjustment factor is also applied to service frequency in the calculation of demand by services, effectively reducing the proportion of demand allocated to slower services.

5.4 Comparison of Results

5.4.1 The best way of assessing the impact of the FJTS assignment algorithm would be to compare the modelled rail assignment results for the standard frequency based assignment algorithm and the FJTS assignment algorithm with observed passenger count data. This would require corridors where there is a combination of fast and slow services that have no fare differentials, and where there is suitable observed data at individual service level for validation purposes.

5.4.2 Unfortunately, it has not been possible to identify suitable corridors that meet these criteria, and hence the suitability of the FJTS assignment algorithm has been examined by looking at the results of the two assignment options, and identifying which of the routines produces more intuitive results.

5.4.3 These have been assessed by looking at an example movement within PLD. Tables 9 to 12 show a comparison of the results for an example movement, between Euston and

Crewe. Results are shown for a Do Minimum (without HS2) and a Do Something (with HS2) scenario. These results are from a standalone assignment model run which excludes the impacts of crowding and the demand model and a full run of PFM in forecasting mode which includes these impacts.

5.4.4 Table 9 and 10 present a comparison of the frequency and FJTS assignment algorithm for a Do Minimum and Do Something scenario using the rail assignment only. In this example the Do Minimum scenario reflects the base year service patterns and the Do Something scenario represent the base year service patterns with the introduction of a single high speed service.

5.4.5 Table 9 illustrates that with the frequency only assignment, demand is allocated to each train service in the set of attractive routes based on the frequency of each individual transit line in relation to the overall combined frequency. With the FJTS assignment algorithm the set of attractive routes remains unchanged in this case but the services with faster journey times get proportionally higher demand. In the Do Something scenario using the frequency only assignment algorithm the introduction of a high speed and high frequency service, the set of attractive routes is significantly reduced, but the demand is still distributed to those attractive routes based on frequency. With the introduction of the FJTS assignment algorithm there is a further change in the set of attractive lines, with more service included than with the frequency only assignment. As the allocation of demand takes into account journey time and frequency, the majority of demand is assigned to the high speed services, (which are also high frequency).

Table 9. Comparison of Assignment Approaches Euston to Crewe - Do Minimum (standalone assignment model)

			FREQUENCY ONLY		FREQUENCY AND TRANSIT TIME		RATIO	
LINE	HEADWAY	NO OF TRAINS	IVT	TRIPS	IVT	TRIPS	IVT	TRIPS
WC132D	80	12	91	33.33	91	38	1	1.14
WC136D	960	1	96	2.78	96	2.91	1	1.05
WC130D	480	2	97	5.56	97	5.72	1	1.03
WC124D	960	1	99	2.78	99	2.77	1	1
WC113D	960	1	99	2.78	99	2.77	1	1
WC108D	960	1	99	2.78	99	2.77	1	1
WC107D	960	1	99	2.78	99	2.76	1	0.99
WC128D	960	1	100	2.78	100	2.69	1	0.97
WC123D	960	1	100	2.78	100	2.69	1	0.97
WC112D	120	8	100	22.22	100	21.5	1	0.97
WC135D	960	1	103	2.78	103	2.41	1	0.87
WC129D	480	2	104	5.56	104	4.59	1	0.83
WC191D	960	1	105	2.78	105	2.08	1	0.75
WC122D	480	2	105	5.56	105	4.25	1	0.76
WC140D	960	1	106	2.78	106	2.06	1	0.74
Total				**100**		**100**		

Table 10. Comparison of Assignment Types: Euston to Crewe - Do Something (Standalone assignment model)

			FREQUENCY ONLY		FREQUENCY AND TRANSIT TIME		RATIO	
LINE	HEADWAY	NO OF TRAINS	IVT	TRIPS	IVT	TRIPS	IVT	TRIPS
HS07-D	60	16	53	55.17	53	85.3		1.55
WC132D	80	12	91	41.38	91	13.2		0.32
WC136D	960	1	96	3.45	96	0.45		0.13
WC130D	480	2	97	-	97	0.63		-
WC124D	960	1	99	-	99	0.11		-
WC113D	960	1	99	-	99	0.11		-
WC108D	960	1	99	-	99	0.11		-
WC107D	960	1	99	-	99	0.11		-
WC128D	960	1	100	-	100	-		-
WC123D	960	1	100	-	100	-		-
WC112D	120	8	100	-	100	-		-
WC135D	960	1	103	-	103	-		-
WC129D	480	2	104	-	104	-		-
WC191D	960	1	105	-	105	-		-
WC122D	480	2	105	-	105	-		-
WC140D	960	1	106	-	106	-		-
Total				**100**		**100**		

5.4.6 Table 11 and 12 present a comparison of results using a full run of PFM. In this instance the Do Minimum reflects the future year Do Minimum network and the Do Something reflect the future year Do Something network. In the Do Something, a number of the competing classic rail services are removed. With the frequency based assignment it can be seen that the demand is assigned to attractive services based on the frequency of each attractive service irrespective of IVT. However, IVT on these services varies by up to 30%, equivalent to 30 minutes. There are a number of impacts of using the FJTS assignment algorithm (all interrelated):

- There is a change in demand assigned to individual services as a result of the revised assignment process and due to IVT (including crowding) being taken into account when assigning demand to attractive services. There are large increases in demand assigned to the faster services (up to 20%) and corresponding reductions in demand on the slower services;
- The changes in demand have an impact on the IVT including crowding on individual services (in some cases quite significantly); and
- The impact of changes to IVT, in particular the reduction in IVT on a number of services is to slightly increase the number of attractive services with 2 additional services equivalent to 5 additional trains per day.

5.4.7 In the scenario including HS2 the attractive set using both assignment methodologies comprises only HS2 services. This is because HS2 provides a much faster service in terms of IVT and the frequency of the service is as least as good as the classic alternative. The impact of the FJTS assignment algorithm is to slightly modify the demand assigned to each service and results in a more consistent IVT between the two attractive services.

5.4.8 Overall, in most examples the move to the FJTS assignment algorithm results in:

- Changes in demand allocated to individual services;
- Change in crowded time on individual services as a result of changes in demand; and
- A change in the transit lines making up the attractive set.

5.4.9 The FJTS assignment algorithm addresses the issues identified with the frequency only assignment algorithm and produces more intuitive results; therefore this has been introduced within PLD. This approach is more consistent with other models in the rail industry: the ORCATS model for allocating Rail revenues between TOCs is based on a combination of frequency and journey time, and MOIRA uses a frequency and journey time based assignment.

5.4.10 Note the standard (frequency-based) algorithm has been retained for the Regional models because they are generally dealing with high frequency local services with fewer advance purchase tickets.

Table 11. Comparison of Assignment Approaches Euston to Crewe - Do Minimum (Full PFM)

			FREQUENCY ONLY		FREQUENCY AND TRANSIT TIME		RATIO	
LINE	HEADWAY	NO OF TRAINS	IVT	TRIPS	IVT	TRIPS	IVT	TRIPS
WC451D	960	1	99	2.7	100	3.18	1.01	1.18
WC440D	960	1	99	2.7	100	3.14	1.01	1.16
WC447D	960	1	99	2.7	100	3.13	1.02	1.16
WC446D	80	12	100	32.43	98	39.2	0.97	1.21
WC469D	960	1	100	2.7	101	3.12	1.01	1.16
WC459D	480	2	105	5.41	106	5.48	1.01	1.01
WC458D	480	2	107	5.41	105	5.57	0.99	1.03
WC432D	960	1	109	2.7	103	2.96	0.94	1.1
WC471D	960	1	111	2.7	108	2.6	0.97	0.96
WC481D	960	1	113	2.7	109	2.49	0.96	0.92
WC425D	120	8	113	21.62	111	18.7	0.98	0.86
WC461D	480	2	116	5.41	112	4.28	0.97	0.79
WC430D	320	3	125	8.11	119	3.93	0.95	0.48
WC483D	960	1	127	2.7	126	0.48	0.99	0.18
WC453D	960	1	139	-	125	0.56	0.9	-
WC444D	240	4	142	-	127	1.2	0.9	-
			Total	**100**	**Total**	**100**		

Table 12. Comparison of Assignment Approaches Euston to Crewe - Do Something (Full PFM)

			FREQUENCY ONLY		FREQUENCY AND TRANSIT TIME		RATIO	
LINE	HEADWAY	NO OF TRAINS	IVT	TRIPS	IVT	TRIPS	IVT	TRIPS
HS07-D	60	16	58.08	50.00	60.60	50.20	1.04	1.00
HS08-D	60	16	63.68	50.00	60.91	49.80	0.96	1.00
			Total	**100**	**Total**	**100**		

Note that in tables 11 and 12 the IVT includes crowding

5.5 Scope of Changes in the Model

5.5.1 To implement the revised assignment procedures all of the macros within PLD that run rail assignments have been amended. No changes have been made to macros in regional models and these are still as they were in PFM v3.0.

5.5.2 Within a full run of the PFM, the PLD rail assignment is carried out a number of times. In addition to the main rail assignment, additional rail assignments are undertaken to skim cost elements (in vehicle time, wait time etc.) from the network by journey purpose, and select link analysis for the "wormhole" process (transfer of demand between PLD and PS) are also undertaken.

5.5.3 Each of these processes is controlled by a series of EMME macros and these vary between the Do Minimum and Do Something. All of the EMME macros controlling these assignments required modifying.

5.5.4 A full list of amended macros is shown in Table 13.

Table 13. Macros Changed in PFM v4.3 to Implement Revised Assignment Procedure

DESCRIPTION	FILES REQUIRED	IMPLEMENTATION
Main Rail assignment – Do Minimum	rail.mac	HS2/01PLD/Macros/Assign
Assignment to skim costs matrices – Do Minimum	skim1rail.mac	HS2/01PLD/Macros/Assign
Assignment to skim costs matrices – Do Minimum	skim2crowd.mac	HS2/01PLD/Macros/Assign
Main Rail assignment – Do Something	HSLrail.mac	HS2/01PLD/Macros/HSLAssign
Assignment to skim costs matrices – Do Something	HSLskim1.mac	HS2/01PLD/Macros/HSLAssign
Assignment to skim costs matrices – Do Something	HSLskim2.mac	HS2/01PLD/Macros/HSLAssign
Assignment to skim costs matrices – Do Something	HSLskim3.mac	HS2/01PLD/Macros/HSLAssign
Assignment to skim costs matrices – Do Something	HSLskim4.mac	HS2/01PLD/Macros/HSLAssign
Select link analysis for Wormhole Process – Do minimum	HS2Select.mac	HS2/01PLD/Macros
Select link analysis for Wormhole Process – Do Something	HS2Select_hs.mac	HS2/01PLD/Macros

6. STATION CHOICE MODEL UPDATES

6.1 Introduction

6.1.1 The station choice model (SCM) is the process that sits between the demand model and the assignment model to translate the PLD to PLD zone level demand data from the Demand Model to station to station demand for use in the assignment model. It also converts station to station costs into PLD to PLD costs for use in the demand model.

6.1.2 During the development of PFM v4.3 a number of changes to other parts of the PFM resulted in a need to re-calibrate the SCM parameters. The key updates that drove the need for re-calibration of the SCM were:

- The parameter consistency changes (Chapter 4);
- Changes to the assignment process (Chapter 5) and
- The demand model re-estimation (Chapter 7).

6.1.3 While this chapter is primarily about the SCM re-calibration, there were also two methodology improvements made to the PFM v3.0 SCM as follows:

- Introducing crowding into the long distance rail generalised journey times; and
- Averaging the directional long distance rail costs to improve model robustness

6.1.4 In addition, during the SCM re-calibration an issue arose that required adjustments to the definition of stations in the SCM to resolve it.

6.1.5 Each of these improvements is discussed in more detail in the following sections, but we start in Section 6.2 with a more detailed description of the SCM to provide the necessary context. Sections 6.3 to 6.6 detail the various improvements and updates to the SCM.

6.1.6 Section 6.7 provides details on how the re-calibrated SCM integrates with the PLD model structure.

6.1.7 The final Section 6.8 details the changes required within the SCM to accommodate the station to station appraisal approach detailed in Chapter 9.

6.1.8 This chapter is therefore structured as follows:

- Section 6.2 – Overview of the SCM
- Section 6.3 – Methodology Improvements over PFM v3.0
- Section 6.4 - Updated Generalised Journey Time Calculation
- Section 6.5 – Definition of Stations within the SCM
- Section 6.6 – Re-Calibration of the SCM Parameters
- Section 6.7 – Integration of the SCM with the PLD
- Section 6.8 – Accommodating the Station to Station Appraisal Approach

6.2 Overview of the SCM

6.2.1 The purpose of this section is to provide an overview of the SCM structure as context for the rest of the chapter.

6.2.2 Each of the 235 model PLD zones are divided into one or more detailed zones (called MZones) to provide enough geographical detail in key areas of the model to allow 'reasonable' decisions to be made about the spread of origin station to destination station pairs which are the right combination for a long distance journey to be made from Origin PLD zone (OPLD) to Destination PLD zone (DPLD).

6.2.3 The SCM is a logit model that has fixed access/egress costs from each MZone to each station.

6.2.4 The SCM therefore has two main purposes:

- To convert the 'origin PLD (OPLD) to destination PLD (DPLD)' demand matrix to 'origin station (Ostn) to destination station (Dstn)' demand matrix (for the assignment model input). The SCM does not change the total demand for any purpose; and
- To average the 'Ostn to Dstn' cost skims to 'OPLD to DPLD' GJTCAE composite cost (for input to the demand model).

Access Mode Choice

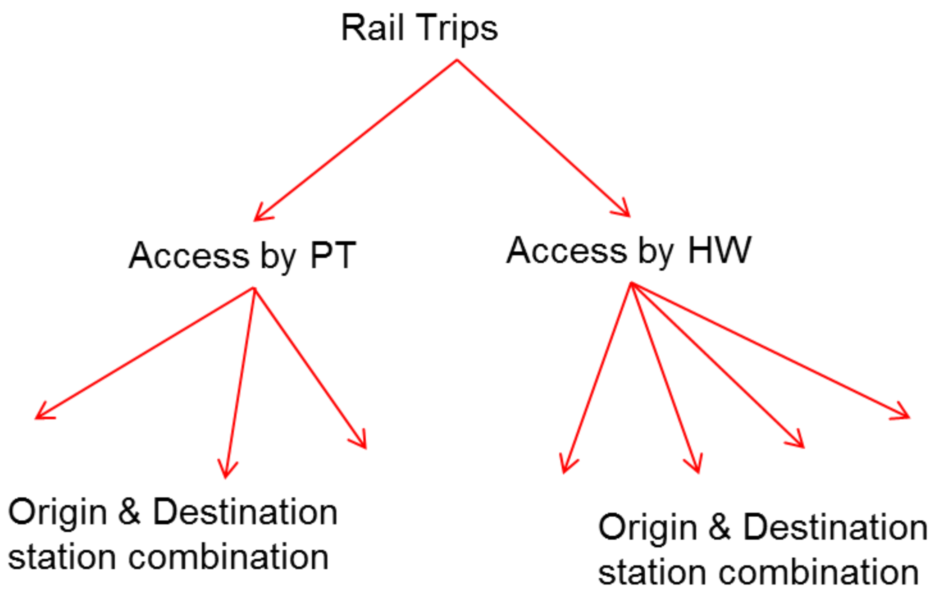
6.2.5 The logit model within the station choice model is illustrated in Figure 1. It consists of two levels. The first is the Access Mode Choice (where there is a choice between highway and public transport) and the second is to choose the route through the rail network defined by the origin and destination stations.

6.2.6 Within the Access Mode Choice process access refers to the home end (P) of the trip and the egress refers to the destination end (A) of the trip. The mode choice therefore only applies to the home end of the trip to/from the station where car is available.

6.2.7 When choosing the route the station choice model considers the whole journey of the access, long distance rail journey and egress time to distribute passengers between all of the available routes within each OPLD-DPLD combination.

6.2.8 One of the main features of a logit model is that probability of all available choices at each point sum to 1. There is a spread parameter calibrated for each level of the model. The station spread parameter for PT and highway is the same in the SCM. The composite cost takes into account the probability of each of the costs of the choices. The SCM is run independently for the Do Minimum and Do Something, so the PLD to PLD costs reflect the best route in the Do Minimum and Do Something.

Figure 1. Access Mode Choice Logit Model



London/Non-London Trip Estimation

6.2.9 As the majority of long distance trips for HS2 are to and from London we have calibrated the SCM on trips that have London as one of the trip ends. Model estimation for the London and non-London ends of the long distance trips was carried out separately:

- The London end was based directly on Railplan data since this was the best available data; and
- The non-London end was calibrated on National Rail Travel Survey (NRTS) data.

6.2.10 Model estimation for the London end was carried out using observed demand data of movement to/from London where station choice exists at the London end. 2008 Railplan data provided by Transport for London was used for model estimations. The 2008 Railplan dataset provides the generalised access times between Railplan model zone and selected station locations.

6.2.11 To supplement the Railplan data a specific London Adjustment Factor (see below) was estimated to adjust the spread of trips across the London stations in the SCM. This parameter was based on 2005 NRTS data for south east flows where there is a choice of London stations e.g. London to/from East Croydon & Brighton where there is a choice of Victoria station and London Bridge.

6.2.12 For non-London trips , it is only the access cost to the origin (non-London) station that is considered. For trips from London, it is only the egress cost from the destination (non-London) station that is considered. Access to/egress from London stations is not taken into account in the calibration since this is provided directly from the Railplan data. Since the majority of long distance trips are to/from London, we then use the parameters for all trips including those which do not have London as one of the trip ends.

6.2.13 The station catchment areas are defined in the SCM model so that each PLD zone has a set of stations defined to /from which passengers can originate/terminate their rail journey. For people accessing by PT, the set of stations is a subset of those accessible by highway. As a consequence, all people originating/terminating their trip in the same PLD zone have the same choice set of access/egress stations.

London Adjustment Factor

6.2.14 The London Adjustment Factor is applied to the London access/egress times that come from the Railplan data. This reflects that the choice of station within London has a different sensitivity to access time than in other parts of the country.

6.2.15 The parameter was estimated from a model looking at the choice of London stations by detailed zone within central London found in NRTS data (which in London and SE dates from 2001 London Area Travel Survey) with Railplan providing the access costs. The estimation used certain flows to/from south London and Kent where a choice of London terminus was realistic (e.g. Victoria vs. London Bridge). These specific routes were chosen because for other intercity routes the choice of London terminus is dominated by the choice between a slower cheaper route and a faster more expensive route rather than a preference for a specific London terminus.

6.2.16 The scale parameter found was -0.157 (see Appendix G) for all purposes. The way that this is applied in the model is as an adjustment to the scale parameter for non-London stations, i.e. it needs to be divided by the relevant lambda - the scale parameter * access coefficient. To maintain a scale parameter of -0.157, the London parameter needs to be recalculated if the access coefficient is changed.

6.3 Methodology Improvements over PFM v3.0

6.3.1 In PFM v3.0 the calibration of the SCM was carried out using only IVT, but in the implementation of the model GJT excluding crowding was used. Crowding has now been included in the SCM to improve consistency with the PLD assignment where crowding was included .

6.3.2 This section therefore discusses three methodology improvements made to improve the SCM from this previous position, namely:

- Undertaking calibration with GJT and crowding,
- Including crowding in GJT for model implementation; and
- Using Average Directional Long Distance Rail GJTs.

6.3.3 When investigating the Long Distance Rail costs it was noticed that the directional costs were inconsistent. It is understandable how this could arise in a complex model such as the PFM, but does not seem logical for an All Day model where it would be expected that the directional costs would be the same. A process to average the Long Distance Rail GJTs was therefore included to make the model more robust.

Introducing Crowding into the Long Distance Rail GJTs

6.3.4 The SCM distributes OPLD to DPLD demand to origin station to destination station demand using the costs without the long distance fare.

6.3.5 The calculation of station to station GJTC from origin station m to destination station n in PFM v4.3 is now:

$$Stn\_GJTC_{m-n} = ivt\_wt \times stn\_ivt_{mn} + walk\_wt \times stn\_walk_{mn} + wait\_wt \times stn\_wait_{mn} + boards\_wt \times stn\_boards_{mn} + crowd\_wt \times stn\_addCrowd_{mn}$$

where

stn_ivt_{mn} is the PLD rail in-vehicle-time from station m to station n

stn_walk_{mn} is the PLD rail walk as interchange from station m to station n

stn_wait_{mn} is the PLD rail wait time from station m to station n

stn_boards_{mn} is the number of PLD rail boards from station m to station n

$stn\_addCrowd_{mn}$ is the PLD crowded time from station m to station n

ivt_wt is the weight given to in-vehicle-time in the GJTC equation. This is defined in the SCM 'input_parameters' file

walk_wt is the weight given to walk as interchange time in the GJTC equation. This is defined in the SCM 'input_parameters' file

wait_wt is the weight given to wait time in the GJTC equation. This is defined in the SCM 'input_parameters' file

boards_wt is the weight given to the number of boards in the GJTC equation. In effect this turns boards into an appropriate number of minutes. This is defined in the SCM 'input_parameters' file

crowd_wt is the weight given to crowded time in the GJTC equation. This is defined in the SCM 'input_parameters' file

6.3.6 Table 14 shows the largest changes in boarders as a result of including crowding time for an interim future year 2036 Do Minimum model run. The Do Minimum model run has no changes in PLD to PLD demand so it only shows the changes in the SCM allocation of demands to stations. The changes are relatively small and it can be seen that there is a change in routing. Fewer people are using Manchester Oxford Road with more going to Manchester Victoria and Manchester Piccadilly. There is also a move away from London Marylebone and London King's Cross to other London stations.

Table 14. DM: Largest Changes in Demand at Origin after Including Crowding

STATION NAME	CHANGE (16 HOUR PEOPLE)
Manchester Oxford Road	-454.4
Manchester Victoria	243.2
Coventry	232.1
Northampton	230.0
London Marylebone	-208.9
London St Pancras International	181.4
Manchester Piccadilly	178.1
Salford Central	167.9
Nottingham	161.5
Milton Keynes Central	-151.0
London Kings Cross	-127.0
Wilmslow	-125.5
Newark North Gate	-116.2
Nuneaton	-111.8
London Paddington	107.3
Machynlleth	-104.5
Macclesfield	104.3
Leamington Spa	-100.5

Using Average Directional Long Distance Rail GJTs

6.3.7 In PFM v3.0 the cost skims in EMME had the potential to vary significantly with direction in part due to the EMME mechanism for choosing a set of services on which demand is spread, but also because for some flows the journey time can be significantly different by direction (up to ten minutes).

6.3.8 For PFM v4.3, the new FJTS algorithm recommended as a result of the work in Chapter 5 does produce more similar routeings in the two directions. However it was still considered beneficial for the SCM to use the average of the two directions' long distance GJTs to make the SCM and Planet models more robust and symmetrical.

6.3.9 In PFM v3.0 the SCM outputs demand weighted PLD to PLD costs for the demand model. In PFM v4.3 this has been changed to output the average directional demand weighted PLD to PLD costs. To do this the station to station GJTC (between origin station m and destination station n) is now calculated using the following equation:

$$Stn\_GJTC_{mn} = 1/2({Stn_{GJTC}}_{m-n} + {Stn_{GJTC}}_{n-m})$$

6.3.10 Table 15 shows the effect on station to station demand when we averaged the costs by direction. Specifically it shows the biggest changes in access and egress demand at stations compared to a previous interim base year run where the only change was the introduction of average costs. It shows that there is a similar and opposite change in demand for the stations with the largest changes as would be expected.

Table 15. Base Year: 10 Largest Changes from the Inclusion of Cost Averaging

STATION NAME	ORIGIN CHANGE	DESTINATION CHANGE
Manchester Piccadilly	-222.2	239.3
Manchester Oxford Road	136.4	-144.7
Milton Keynes Central	-99.9	106.5
Northampton	80.4	-90.0
Leeds	-73.1	77.8
Bridgend	72.2	-72.1
Falkirk High	-72.1	93.7
London Euston	64.9	-96.7

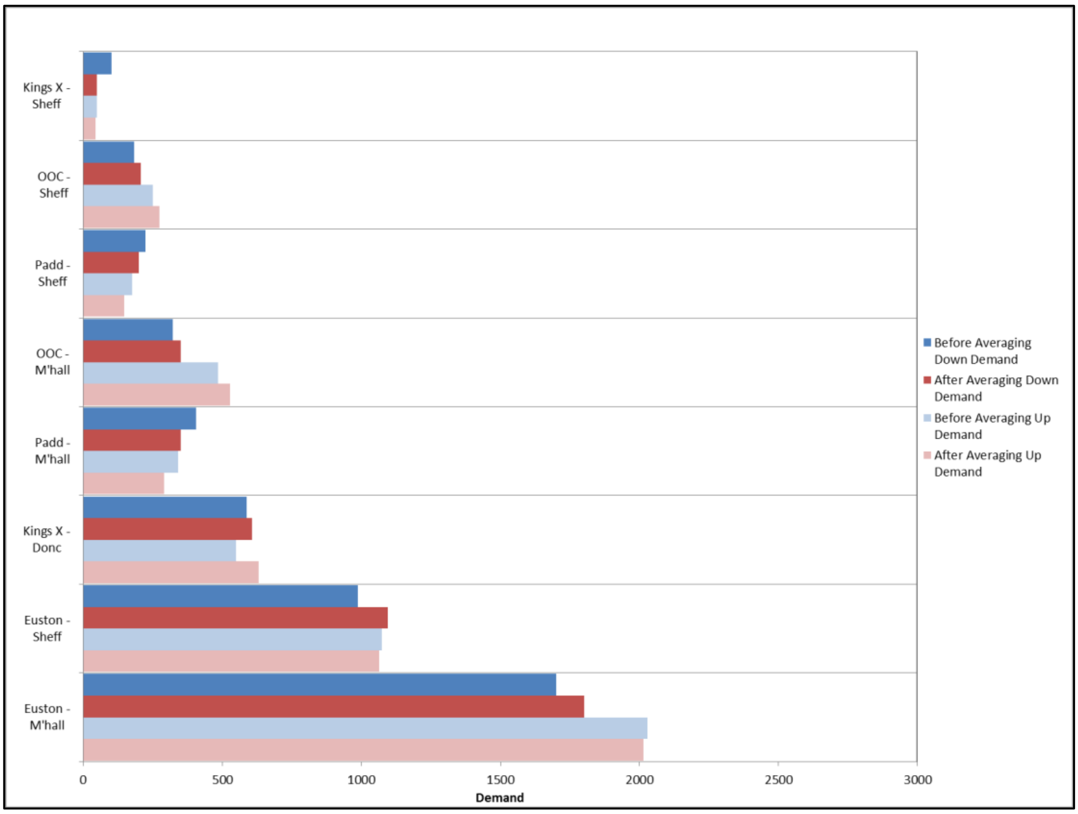
STATION NAME	ORIGIN CHANGE	DESTINATION CHANGE
London Kings Cross	-62.6	70.5
Liverpool Lime Street	-61.3	65.3

6.3.11 Figure 2 shows the changes for one PLD zone pair - Sheffield to Central London with an HS2 service. It shows the changes in demand resulting from the averaging of the directional costs.

6.3.12 There are three possible stations for the Sheffield zone - Sheffield Midland (She), Sheffield Meadowhall (Mha) and Doncaster. There are six possible central London stations. The station pairs shown are those with demand greater than 1% of the PLD to PLD demand. Demand is shown in up and down directions. The before demand is shown in blue, the after demand is shown in red. As would be expected averaging the costs is making a difference in terms of the assigned demand and these differences vary by direction according to the magnitude of the change in costs:

- Kings Cross to Sheffield Midland becomes much more symmetrical in the two directions and is halved in size;
- It is difficult to see whether OOC and Paddington to Sheffield Midland are more symmetrical, but whereas OOC demand has grown overall Paddington has reduced;
- OOC is also stronger against Paddington for Meadowhall, but demand looks more symmetric; and
- Both the Euston to Sheffield Midland and Euston to Meadowhall demand is much more symmetric.

Figure 2. Change in Station Shares for Sheffield to Central London (2036 Y)



6.3.13 Overall from the example we have more people going directly to OOC in the SCM than those going to Paddington which shows that the model is more robust. Also more people are going directly to Meadowhall than to Sheffield in the new version of the model.

6.4 Updated Composite Generalised Journey Time Calculation

6.4.1 The updated definition of composite Generalised Journey Time with crowding and including access egress (GJTCAE) is calculated as:

$$C_{ijp} = \frac{1}{\beta_p} \times ln\left(exp\left(CPT_{ijp} \times \beta_p\right) + exp\left(CHW_{ijp} \times \beta_p\right)\right)$$

$$where\ CPT_{ijp} = \frac{1}{\beta_p \times \alpha_p} \times ln\left(\sum_{mn} exp\left(GPT_{mnijp} \times \beta_p \times \alpha_p\right)\right)$$

$$where\ CHW_{ijp} = \frac{1}{\beta_p \times \alpha_p} \times ln\left(\sum_{mn} exp\left(\left(GHW_{mnijp} \times \alpha_p + \gamma_{mp}\right) \times \beta_p\right)\right)$$

Where C_{ijp} is the cost GJTCAE between MZones i and j for purpose p

CPT_{ijp} is the composite cost for access by public transport (plus egress by PT) between MZones ij for purpose p

CHW_{ijp} is the composite cost for access by highway (and egress by PT) between Mzones ij for purpose p

GPT_{mnijp} is the generalised time for access by public transport (PT) (and egress by PT) between stations m and n for purpose p and where i and j are MZones within PLD zones I and J respectively (see section 6.6.7)

GHW_{mnijp} is the generalised time for access by highway (plus egress by PT) between stations m and n for purpose p and where i and j are MZones within PLD zones I and J respectively (see section 6.6.7)

β_p is the station choice spread parameter for purpose p – the station choice spread parameter is the same for PT and highway

α_p is the scale parameter for access mode choice for purpose p

γ_{mp} is the station highway access constant or alternative specific constant (ASC) for purpose p and station m

6.4.2 Then $C_{IJp} = \sum_{i \in I, j \in J} \pi_{ij}^{pd}[IJ] C_{ijp}$ where $\pi_{ij}[IJ]$ represents the proportions of total demand between PLD zones I and J that is allocated between MZones i and j.

6.4.3 Stations are defined into three different categories with a different ASC associated with each category. The categories are - city centre, parkway and other. The ASC represents the parking and congestion costs which are not included in the model. The choice of category for existing station and the value of the ASC were derived from calibrating the model using MOIRA and NRTS.

6.5 Definition of Stations within the SCM

6.5.1 During the calibration process an issue arose where some commuting trips were lost in the SCM process. This issue was not present in PFM v3.0 but arose as a result of changes made during the calibration process and was associated with the definition of Core and Non-core stations.

6.5.2 In the SCM stations are either defined as core or non-core stations in relation to the level of zonal and network detail:

- Core stations are those in the core area of the model where the modelled rail network is detailed and zone sizes match the network detail i.e. London, Midlands, North East, Yorkshire and North West; and
- Non-core stations are stations which are in the outer geographical areas where there is a sparse rail network and a coarse zone system that may not allow reasonable station to station movement e.g. Scotland, Wales, Cornwall and Devon.

6.5.3 The majority of stations are core stations and for these stations, movements from origin MZone "o" to station "a1" to station "a1" to destination MZone "d" are not allowed. For non-core stations these movements are allowed as the coarse rail network and zone system may not allow a reasonable station to station movement for intra-zonal trips resulting in crowding and unreasonable costs.

6.5.4 During the PFM v4.3 calibration analysis of the SCM input and output matrices indicated that some commuting trips were being lost. Table 16 shows the number of passengers by purpose for PLD to PLD zone and Station to Station after the SCM has been run.

Table 16. Total Numbers of Trips by Purpose in PLD and SCM

	COMMUTING	BUSINESS	LEISURE	TOTAL
PLD to PLD	249,537	93,559	244,281	587,377
Stn to Stn	245,728	93,559	244,281	583,568

6.5.5 Further analysis showed that this was mainly down to a few PLD zones, including:

- 20 – Cardiff;
- 199 - South Wales Central;
- 129 – Monmouthshire;
- 134 – Newport; and
- 200 - South Wales East.

6.5.6 Table 17 shows the differences in demand for a set of PLD zones including those listed above. It shows that the demand only affects the listed MZones.

Table 17. Difference in PLD and MZone origin data for Commuting Car Available From

PLD ZONE	ORIGIN MZONE SUMMED TO PLD ZONE	ORIGIN PLD ZONE	DIFFERENCE
Cardiff (20)	1351	2164	813
Carlisle (21)	206	206	0
South Staffordshire (198)	71	71	0
South Wales Central (199)	2991	2991	0
South Wales East (200)	360	368	8
Middlesbrough (128)	253	253	0
Monmouthshire (129)	625	635	10
Manchester (130)	1961	1961	0
Midlothian (131)	193	193	0
Milton Keynes (132)	236	236	0
Neath Port Talbot (133)	557	557	0
Newport (134)	742	762	20

6.5.7 Further research showed that the differences stemmed from two main sources:

- Overcrowding on some trains in Wales (services to and from Fishguard) because the full timetable is not included; and
- Some remote stations in the SCM in Wales, the South West and North East were [wrongly?]identified as core SCM stations which excludes trips with the same origin and destination station and hence intra-zonal trips were resulting in unreasonable costs.

6.5.8 There were two rail services, one from Holyhead to Cardiff Central and the other from Manchester Piccadilly to Cardiff Central which were causing excessive crowding. The frequency on these services was changed to one service per hour to remove a crowding issue. This is consistent with future year networks where these services already have higher frequencies.

6.5.9 In addition we have changed the following Welsh, South West and North East stations to be non-core SCM stations:

- Newport;
- Cardiff;
- Rhyl;
- Bridgend;
- Port Talbot Parkway;
- Swansea;
- Exeter St David's;
- Truro;
- Sunderland; and
- Middlesbrough.

6.5.10 Giving these stations 'non-core' status, we have much more reasonable costs arising from shorter and less crowded journey times as intra-zonal trips were permitted to use the same origin and destination station.

6.5.11 and therefore we are able to calculate the number of trips going to these stations without reducing the demand.

6.5.12 The result of making these changes is that we lose a total of three trips for the Commuting NCA purpose only. Our consequent analysis showed that the main cause of this discrepancy is a function of rounding in costs inherent in the SCM. The maximum change at any one boarding or alight PLD zone is now 0.835.

6.5.13 The SCM improvements are covered in greater detail in Appendix D.

6.6 Re-Calibration of the SCM Parameters

6.6.1 As a consequence of the various updates and improvements introduced in PFM v4.3, it was necessary to recalibrate the SCM to:

- Achieve consistency between the parameters used in the assignment model and those used in the calibration of the SCM model (see Chapter 4);
- Use an updated version of the base year station-to-station cost skims arising from the new assignment algorithms (FJTS) discussed in Chapter 5; and
- Take account of the change in the price base from 2002 to 2010, in order to be consistent with WebTAG and other components of the modelling suite.

6.6.2 Various improvements were made to the SCM methodology and it was also necessary to reflect these in the re-calibration process as follows:

- As noted it was decided to replace the in-vehicle times (IVT) (see section 6.3.1) used in the expression of generalised station-to-station costs by generalised journey times (GJTC) accounting for crowding, boarding, walk and wait times (in addition to IVT), in order to be consistent with the model application;

- Use averages of origin to destination and destination-to-origin costs instead of directional-specific costs in the SCM; and
- Change the value base to 2005 for consistency with the NRTS demand data used to estimate the SCM.

6.6.3 Please note that the SCM recalibration was undertaken in parallel with updates to other parts of the modelling suite and so comparisons made to identify successful model update were based on relevant interim model versions.

Focus of the Recalibration Exercise

6.6.4 As discussed earlier model estimation for the London end has always been carried out separately to the non-London end for the SCM.

6.6.5 In PFM v3.0 the London end was estimated using 2008 Railplan data supplemented by a specific London end parameter based on 2005 NRTS data that that adjusts the spread of trips across the London stations in the SCM. As part of the re-calibration exercise the Railplan data was updated with 2011 data. An update of the London end parameter was considered but since there is no more recent NRTS data than 2005 there was no justification for updating this parameter

6.6.6 In light of the above the re-calibration exercise has focussed on the non-London end.

6.6.7 As the majority of long distance trips for HS2 are to and from London we have calibrated the SCM on trips that have London as one of the trip ends. We then use the estimated parameters for all trips including those which do not have London as one of the trip ends.

6.6.8 For trips to London, it is only the access cost to the origin (non-London) station that is considered. For trips from London, it is only the egress cost from the destination (non-London) station that is considered. Access to/egress from London stations is not taken into account in the calibration as the Railplan data is considered to be the best source for this aspect.

6.6.9 The SCM parameters obtained from this model re-calibration are used to derive passengers' station and access/egress mode choice outside London. The model therefore focuses on the choice of non-London stations as well as on the choice of the mode of transport to access egress from these stations.

Catchment Review

6.6.10 As the model was re-calibrated against NRTS data, it was important that the station catchments were consistent with the data from this survey.

6.6.11 A review of the station catchment areas resulted in implementing minor changes in the subset of stations for each PLD zone; however it was agreed that the catchment areas used in the calibration would remain unchanged and would not be updated to match those used in the application. There are two main reasons for this:

- The specification of catchment areas required previously unused NRTS demand data to be included in the calibration. This would require substantial time; and
- As a result, our attempts to increase the choice set used for calibrating the SCM (but without new demand data) so that it is consistent with model application were not successful and did not yield any reasonable results.

6.6.12 As a consequence, the catchment areas were kept as they were; however each PLD zone includes all the main stations used and any minor changes are not anticipated to have a significant impact on the SCM parameter recalibration.

6.6.13 Each MZone in the model belongs to one and only one PLD zone (PLDz). From now on, any mention of a PLDz will denote:

- the PLDz of the origin of the trip for trips to London; and
- the PLDz of the destination of the trip for trips from London.

6.6.14 Ideally the SCM should forecast how many people use each station, with no constraint on size of catchment area. There are two reasons we do not permit this:

- First, the PLD requires rail users to access their nearest station within the SCM and therefore the SCM PT catchment areas are restricted to achieve this ; and
- Second is that the model run time is approximately proportional to the square of the number of stations permitted (proportional to both the number of origin and destination stations); with no limit on the number of stations, this would rapidly become unmanageable.

6.6.15 The catchment areas in the SCM application model have therefore been defined as follows: each PLDz has a set of stations defined to/from which passengers can originate/terminate their rail journey. For people accessing/egressing by PT, the set of stations is a subset of those accessible by highway. As a consequence, all people originating/terminating their trip in the same PLDz have the same choice set of access/egress stations.

Model Parameter Calibration

6.6.16 Separate model parameters are estimated for the three journey purposes: Commute, Business and Other. The model specification requires a "utility" to be defined for each option.

6.6.17 For the three journey purposes, the utilities associated with the choice of a first/last station pair were specified as follows in the calibration of the SCM parameters for PFM v4.3[8]:

[8] Compared to PFM v3.0 the only change to the specification is to use GJTC rather than IVT

$$U_{Highway} = \beta\left(HW\ Time_{HW} \times \alpha_{HW} + Petrol\ \frac{Dist}{VoT} + \frac{Parking}{VoT} + GJTC\right) + City \times \delta_{city} + Pway \times \delta_{Pway} + Other \times \delta_{Oth}$$

$$U_{PublicTransport} = \beta\left(PT\ Time_{PT} \times \alpha_{PT} + Walk \times \alpha_{wt} + Fare\ \frac{dist}{VoT} + \frac{Fixed\ Fare}{VoT} + GJTC\right)$$

where:

β = generalised cost coefficient for the access mode choice level

HWTime = highway access/egress time (min);

Dist = distance to the station (km);

Petrol = price of petrol (pence/km);

Parking = parking charge at the station (pence);

GJTC = Generalised Journey Time (incl added crowded time) time between the first and last stations (min) ie $GJTC = IVT + Crowd + 2\,Walk + 2\,Wait + 30\,Board$;

VoT = trip purpose specific value of time (pence/min);

City , *PWy* , *Oth* = alternative specific constants (ASCs) for city, parkway and other stations (utils);

δ_{City}, δ_{PWy}, δ_{Oth} = dummy variables (=1 for station types “City”, “Parkway” and “Other” station types respectively);

PT Time = public transport access/egress time (min);

Walk = average walk time to the station (min) including access / egress;

Wait = average wait time en-route to/from the station (km);

Fare = average public transport fare per km (pence/km);

Fixed Fare = fixed element of the public transport fare (pence);

α_{HW} = highway access/egress time coefficient;

α_{PT} = public transport access/egress time coefficient;

α_{wk} = walk time coefficient;

α_{wt} = public transport wait time coefficient.

6.6.18 Alternative Specific Constants (ASCs) were used only for the car mode, and they were station-type specific. Three station types were defined: 'City', 'Parkway' and 'Other', for city centre stations, parkway stations, and other stations respectively. These ASCs capture the elements of the car access/egress costs not included in travel time, notably parking cost and congestion in city centres.

6.6.19 The parameters to be estimated were β , City, PWy and Oth, as well as both nest parameters Nest_Car and Nest_PT.

6.6.20 The National Accessibility Model (NAM) is the source of the access /egress cost data i.e. *HW Time*, *PT Time*, *Walk* and *Wait.*The demand data is sourced from the 2005 NRTS.

6.6.21 The modes that passengers have available for station access (trips to London) and egress (trips from London) are accounted for during model estimation. It is noted that all stations appearing in a catchment area are made available by car, whereas the model allows for a few stations not to be accessible by public transport. Where a PLD zone has no public transport access to any of its stations, passengers can only choose stations that are accessible by highway. Similarly, passengers that do not own a car (car availability is accounted for in the model) can only choose between the stations that are accessible by PT.

Changes in the Price and Value Bases

6.6.22 Changes in the price and value bases were made to the following generalised time coefficients:

- The highway cost parameters (petrol cost and parking cost);
- The PT cost parameters (PT fixed and variable components of fare); and
- The values of time for each of the three purposes.

6.6.23 For the SCM model re-calibration, the price and value bases for these coefficients were adjusted to represent 2005 values (consistent with the NRTS demand data) and 2010 prices (consistent with WebTAG and other components of the HS2 modelling suite).

6.6.24 The parameters used in PFM v3.0 (2008/2009 values and 2002 prices) and the updated values for PFM v4.3 (2005 values and 2010 prices) are shown in Table 18.

6.6.25 Petrol cost is derived from calculations using WebTAG statistics and based on fuel price, car efficiency, petrol/diesel car proportions and inflation rates. Updated value of parking charge was obtained accounting only for inflation between years 2009 and 2010. Note that the first intention was to include parking cost as part of the access/egress cost for car, because it was thought that parking costs would be available for each station. As this was eventually not possible, a fixed parking cost was set for all stations, equal to a notional amount of £13 (2009 prices). As a consequence, parking charge does not have any impact on people's choices, because it is equivalent to a generalised cost specification for car where there is no parking cost (in which case it is accounted for in the ASC value).

6.6.26 The public transport cost parameters: pt_fixfare and pt_fare are converted from 2009 prices and values to 2005 values and 2010 prices using the DfT's local bus fares index[9] and Retail Prices Index (RPI) as follows:

$$\begin{aligned}&Updated\ public\ transport\ cost\\&\qquad = 2009\ public\ transport\ cost \times Value\ Factor \times Price\ Factor\end{aligned}$$

[9] DfT (2012) Bus Statistics – Table Bus 0405b Local Bus Fares Index (2010/11 prices), Accessed Oct 2012.

where:

Value Factor = 2005 Bus Fares Index / 2009 Bus Fares Index

Price Factor = 2010 RPI / 2009 RPI (inflation)

RPI values correspond to an annual average of the CHAW index and were taken from ONS (May 2012)[10].

6.6.27 The values of time (VOT) are consistent with PLD. For commute and leisure travel, these were taken from WebTAG Unit 3.10.2, which gives VOTs that vary with both income and distance band. Since WebTAG Unit 3.10.2 does not give distance-varying VOTs for business travel, the cost damping formulation for this purpose was implemented by combining average VOTs taken from WebTAG Unit 3.5.6 with a distance elasticity taken from PDFH.

Table 18. Changes to the Price and Value Bases of Generalised Time Coefficients

PARAMETERS	2009 VALUES / 2002 PRICES	2005 VALUES / 2010 PRICES
Highway cost parameters		
hw_petrol (pence/km)	9.32	6.15
hw_parking (pence)	1300.00	1359.80
PT cost parameters		
pt_fixfare (pence)	100	94.67
pt_fare (pence/km)	12.43	11.77
Value of time (from PLD demand model)		
VOT Business (pence/min)	61.82	70.13
VOT Leisure (pence/min)	16.54	18.42
VOT Commute (pence/min)	15.22	25.14

[10] http://www.ons.gov.uk/ons/datasets-and-tables/data-selector.html?cdid=CHAW&dataset=mm23&table-id=2.1

Changes to the Cost Element Weight Parameters

6.6.28 In addition to these changes in value and price bases, the PT access/egress walking weight, which is one of the four weights used in the generalised cost specifications, was also modified. This change is motivated by issues of consistency with two parameters used in the HS2 assignment models: the station-to-station walking weight GJTC_walk_wt, and the PT access/egress walking weight pt_walk_wt.

6.6.29 The original and updated values of the weights used in the generalised cost specifications are shown in Table 19.

Table 19. Changes to the Weights Used in the Generalised Cost Specification

PT / HIGHWAY ELEMENT WEIGHTS	PFM V3.0	PFM V4.3
pt_walk_wt (weight)	1.0	2.0
pt_wait_wt (weight)	2.0	2.0
pt_ivt_wt (weight)	1.0	1.0
hw_wt (weight)	2.0	2.0

Re-Calibration SCM Parameters

6.6.30 The updated SCM parameters obtained from these updates are described in Figure 3. The result tables present values for Null Log-likelihood, Final Log-likelihood, adjusted rho square, and parameter estimates.

6.6.31 It should be noted that the nest parameters associated with nests 'Car' and 'PT' were forced to be equal in the calibration (and referred to as Nest in Figure 4), because leaving them unconstrained did not lead to significantly different parameter values. For consistency with utility maximisation theory, these parameters have to be non-negative and greater than one. It is noted that the t-statistics for the nest parameters correspond to tests performed against the value 1, as opposed to all other parameters which are tested against 0.

6.6.32 In Figure 3, column (a) is the PFM v3.0 results and column (b) corresponds to the parameter estimates after all changes (have been made to the data i.e. the changes described earlier in this section:

- Price and value base;
- Changes to the cost element weight parameters; and
- Change from using long distance IVT to using long distance GJTC.

Figure 3. SCM Re-Calibration Results [11]

(a) PFM v3.0

Business			
Null Log-Likelihood	-10873.110		
Final Log-Likelihood	-6855.915		
Adj. rho square	0.369		
		t-test	p-value
City (utils)	1.1	13.4	0
Other (utils)	1.49	30.91	0
Parkway (utils)	2.34	16.13	0
α (utils/min) (sp for access mode choice*)	-0.0336	-15.85	0
Nest	1.67	5.97	0
α*Nest (sp for station choice*)	-0.056112		

Leisure			
Null Log-Likelihood	-4151.069		
Final Log-Likelihood	-2760.288		
Adj. rho square	0.334		
		t-test	p-value
City (utils)	1.04	5.48	0
Other (utils)	1.7	11.41	0
Parkway (utils)	2.39	9.13	0
α (utils/min) (sp for access mode choice*)	-0.0209	-8.55	0
Nest	2.39	4.7	0
α*Nest (sp for station choice*)	-0.049951		

Commute			
Null Log-Likelihood	-5131.418		
Final Log-Likelihood	-3064.239		
Adj. rho square	0.402		
		t-test	p-value
City (utils)	3.61	10.33	0
Other (utils)	3.7	18.29	0
Parkway (utils)	4.38	17.4	0
α (utils/min) (sp for access mode choice*)	-0.0441	-14.94	0
Nest	1.44	3.86	0
α*Nest (sp for station choice*)	-0.063504		

(b) PFM v4.3

Business			
Null Log-Likelihood	-10873.085		
Final Log-Likelihood	-5348.795		
Adj. rho square	0.508		
		t-test	p-value
City (utils)	0.772	9.99	0
Other (utils)	1.15	24.9	0
Parkway (utils)	2.01	13.85	0
α (utils/min) (sp for access mode choice*)	-0.0247	-14.7	0
Nest	2.6	8.69	0
α*Nest (sp for station choice*)	-0.064220		

Leisure			
Null Log-Likelihood	-4151.069		
Final Log-Likelihood	-2021.258		
Adj. rho square	0.512		
		t-test	p-value
City (utils)	0.527	3.41	0
Other (utils)	1.16	11.76	0
Parkway (utils)	1.84	7.73	0
α (utils/min) (sp for access mode choice*)	-0.0156	-7.82	0
Nest	3.86	5.62	0
α*Nest (sp for station choice*)	-0.060216		

Commute			
Null Log-Likelihood	-5131.418		
Final Log-Likelihood	-2297.859		
Adj. rho square	0.551		
		t-test	p-value
City (utils)	1.74	6.06	0
Other (utils)	1.73	21.32	0
Parkway (utils)	2.41	13.83	0
α (utils/min) (sp for access mode choice*)	-0.0359	-15.3	0
Nest	1.61	5.33	0
α*Nest (sp for station choice*)	-0.057799		

* sp stands for spread parameter

6.6.33 Relative to the PFM v3.0 results, the data updates lead to a significant improvement in model fit for all purposes, as the rho square values are respectively increased from 0.369 to 0.508, from 0.334 to 0.512 and from 0.402 to 0.551 for business, leisure and commute respectively. The effects on the parameter estimates are diverse, but a general feature is that the updates lead to a decrease in the parameter estimates for the access/egress coefficient, with the station choice spread parameter only changing slightly. It is also important to note that the nesting parameter has increased. The main underlying cause for the improvement in fit is the use of GJTC rather than IVT in the PFM v3.0 version of the model.

SCM Parameters in PFM v4.3

6.6.34 The recalibration of the SCM parameters led to a change in the input parameters file. Table 20 shows the input parameters in PFM v3.0 as compared to the input parameters in PFM v4.3.

[11] Results estimated using Biogeme: Bierlaire, M. (2003). BIOGEME: A free package for the estimation of discrete choice models , Proceedings of the 3rd Swiss Transportation Research Conference, Ascona, Switzerland.

Table 20. SCM Inputs to Calibration

MODEL PARAMETER	PFM V3.0	PFM V4.3
hw_petrol[1]	9.32	6.667
pt_fare[2]	12.43	13.09
pt_fixfare[3]	100	105.3
hw_time_wt	2	2
pt_walk_wt[4]	1	2
pt_wait_wt	2	2
pt_ivt_wt	1	1
VOT_bus[5]	61.82	69.54
VOT_lei[5]	16.54	18.36
VOT_com[5]	15.21	25.05
GJTC_ivt_wt	1	1
GJTC_walk_wt[6]	4	2
GJTC_wait_wt	2	2
GJTC_crowd_wt	1	1
GJTC_boards_wt	30	30

[1] (p/km) 2010 values 2010 prices calculated from the formulae given in WebTAG Unit 3.5.6 (October 2012)

[2] (p/km) 2010 values 2010 prices source SCM input parameters multiplied by 1.046 (for inflation) and 135.7/134.8 as England bus fare increases[12]

[3] see pt_fare

[4] changed to 2 for consistency with PFM model parameters

[5] p/min 2010 values 2010 prices RAND spreadsheet business_VOT_Distance_V4.xls see section 7.2

[6] changed to 2 for consistency with PFM model parameters

[12] DfT Bus Table 0405 published 20 October 2011 taken from National Statistics

6.6.35 The London parameters have changed as a result of the SCM recalibration, these are listed in Table 21 with the PFM v3.0 values as compared to the PFM v4.3 values.

Table 21. Adjustments to the London Scale Parameters

SCALE PARAMETER	PFM V3.0	PFM V4.3
adj_london_bus[1]	2.572084	2.444721
adj_london_lei[2]	2.626033	2.60728
adj_london_com[3]	2.351215	2.71631

[1] Business London scale parameter is calculated as -0.157/(Business_Access_Coefficient * Access_scale_parameter_bus)

[2] Leisure London scale parameter is calculated as-0.157/(Leisure_Access_Coefficient * Access_scale_parameter_lei)

[3] Commuting London scale parameter is calculated as -0.157/(Commuting_Access_Coefficient * Access_scale_parameter_com)

6.7 Integration of the SCM with the Demand and Assignment Models

6.7.1 To reduce the run-times of v3.0 SCM can be run in three modes, these are:

- Full mode in which the full logit model is run and the outputs are:
  - OPLD to DPLD composite cost (GJTCAE);
  - OPLD to DPLD trip weighted averages of (Ostn to Dstn) cost. (The access/egress element of the OPLD to DPLD cost matrix contained walk, access/egress and diversity. The composite GJTCAE can be thought as containing two different elements:
    - Long Distance Rail Skims;
    - The access / egress / walk / diversity cost element;
  - Ostn to Dstn demand matrices; and
  - OPLD to Ostn to Dstn to DPLD proportions so that, when summed each OPLD to DPLD combination sum to 1.
- Demand mode where the OPLD to Ostn to Dstn to DPLD proportions would be used to disaggregate the OPLD to DPLD demand to produce a Ostn to Dstn demand matrix without recalculating the composite costs; and
- Cost mode where the OPLD to Ostn to Dstn to DPLD proportions would be used to average the Ostn to Dstn long distance cost skims. The walk and access / egress costs are assumed not to have changed.

6.7.2 These modes allowed different calls to be made to the SCM depending on where it is called in relation to the Demand and Assignment models. The calls also vary according to the stage in the model run – it is only in the '03 Test' stage that the demand model is called. The earlier stages use a 'fixed' matrix which is only changed by the regional models and HAM and therefore consists of the SCM and the Assignment model:

- **01 Base** – which is an assignment of the Do Minimum demand on the Do Minimum network;
- **02 Base** – which is an assignment of the Do Minimum demand on the Do Something network; and
- **03 Test** – this consists of twelve iterations of the demand model and the station choice model along with assignment of the Do Something Demand on the Do Something networks.

6.7.3 The first two stages are straightforward as they do not involve calls to the demand model and the calls to the station choice model are in full mode.

6.7.4 In PFM v3.0 the cost mode was used in the third stage (03 Test) just before passing costs to the demand model as it runs much faster than full mode.

6.7.5 However, in PFM v4.3, as the station choice model run time has been considerably reduced (by running each purpose in parallel using a multi-core methodology), all calls to the SCM are in full mode or in demand mode.

6.7.6 Figure 4 shows the structure of the Test03 stage, in PFM v3.0, in terms of the rail demand mode, the assignment and the station choice model. It also shows the flow of data passing between the models.

6.7.7 Figure 5 shows the structure in PFM v4.3. The call to run the model in demand mode just after the demand model remains.

Figure 4. Structure of Model Calls (Assignment, SCM and Demand model) in the 03 Test PFM v3.0

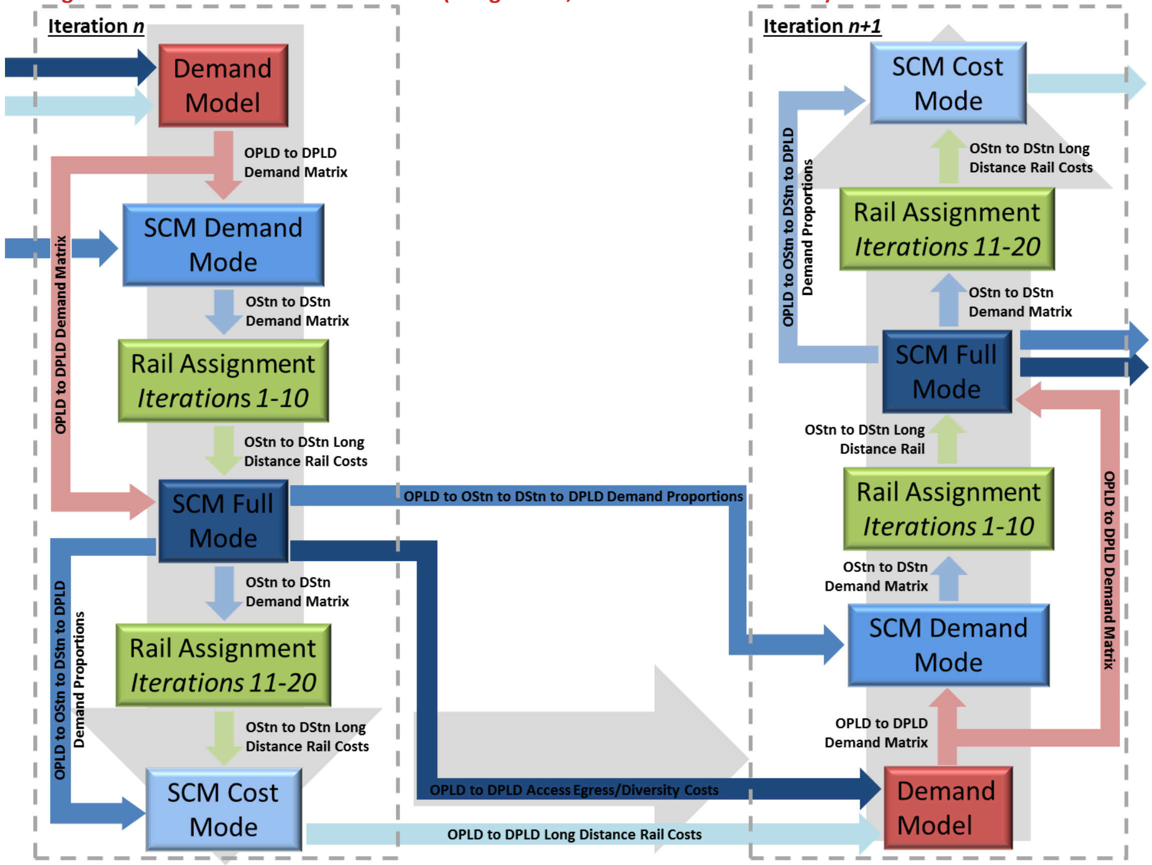
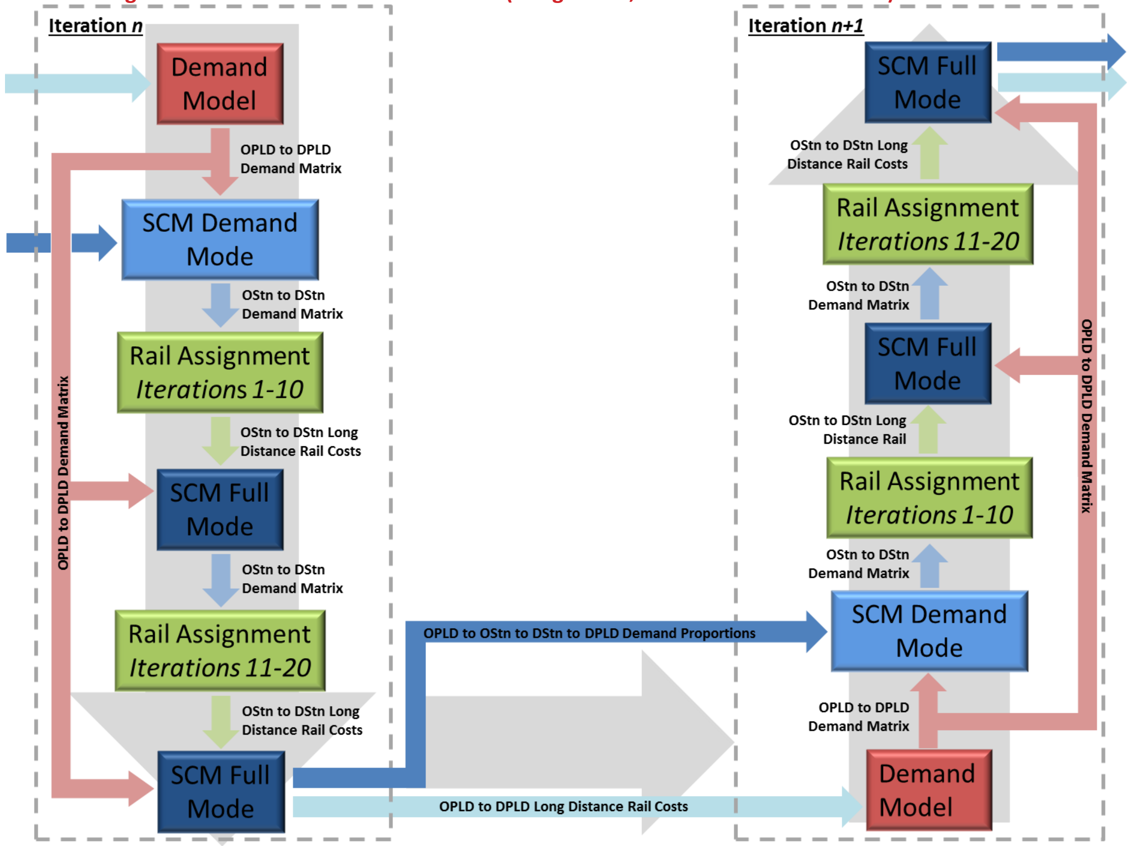


Figure 5. Structure of Model Calls (Assignment, SCM and Demand model) in PFM v4.3



6.7.8 The model structure has changed because we are now feeding GJTCAE straight into the demand model rather than the component parts. Some parts of the model still take in the individual parts these are discussed in Appendix J.

6.7.9 It means though that the initial run of the SCM (demand mode) now uses different proportional Origin station – Destination station splits than the last run of the assignment model. In reality these changes should be small as the choice of route should only change because of difference in crowding costs, but there is potential for models to have slower convergence or to oscillate between different solutions.

6.7.10 The only other alternative would be to produce a version of the SCM that produces change in composite cost without changes to the demand, but this does not seem the right approach as the cost and demand are interrelated.

6.7.11 However as the appraisal is now based on SCM outputs, one final iteration of the SCM outside the main 03Test stage at the end of a model run is undertaken to obtain consistent costs and demand for input to the appraisal.

6.8 Accommodating the Station to Station Appraisal Approach

6.8.1 Chapter 9 explains the new appraisal method that has been adopted for PFM v4.3. The new appraisal methodology is predicated on having the same stations in both the Do-Minimum and Do-Something. For PFM v4.3 this means that there should be the same stations in the Do Minimum, the Phase 1 Do Something and the phase 2 (Y) Do Something.

6.8.2 For earlier model versions we had a different set of stations in each phase of HS2, with the new HS2 stations only introduced in the phase at which services appear so there were different sets of stations in the Do Minimum and the Do Something.

6.8.3 It was not only the access/egress costs that differed by phase but also the catchment areas at certain stations such as Meadowhall where the catchment area is larger with the HS2 station than the current classic station.

6.8.4 However for PFM v4.3 the access/egress costs need to be identical between the phases of the HS2 model. This means that the HS2 stations and corresponding catchments have to be coded into the Do Minimum network with a link to an existing station.

6.8.5 To understand the impact of making this change we ran the 2036 Do Minimum twice, once with the HS2 stations and catchments and once without the HS2 stations and catchments.

6.8.6 It should be noted that if trips are assigned to an HS2 station in the Do-Minimum they will use the walk or transit link in the network to a linked station where they can board a train. For example Passengers going to Birmingham Curzon St will use the walk link to Birmingham New St and passengers going to Toton will take the tram link to Nottingham station where they can board a train. Passengers will do this because the GJTCAE will either be better than going directly to a station or as a result of the spread parameter in the SCM logit model.

6.8.7 Table 22 shows the largest changes between these two model runs. It shows that the biggest changes are the introduction of the HS2 station for Birmingham Curzon St which is within walking distance of the existing New St station. The station choice model has therefore allocated 3,500 passengers to the new station. Salford Central has a large reduction in passengers (3,200) because PFM v4.3 adjusts an issue in PFM v3.0 whereby Salford was given the catchment area of Manchester Interchange station. The next stations are Leeds and the HS2 station at Meadowhall. In the PFM v3.0 Do Minimum and Phase 1 there was a classic station at Meadowhall with a small catchment area. In PFM v4.3 the Classic station has been replaced by the HS2 station with an appropriately larger catchment area.

Table 22. Largest Changes in DM Demand when HS2 stations introduced into DM

STATION NAME	ORIGIN CHANGE	DESTINATION CHANGE
HS Birmingham Curzon St	3515	3739
Birmingham New Street	-3059	-3285
Salford Central	-3264	-2381
HS Leeds	2698	2696
Leeds	-2476	-2500
HS Meadowhall	2224	2087
HS Birmingham Interchange	1935	1847
Birmingham International	-983	-956
Sheffield Meadowhall Classic	-987	-904
HS Toton	710	603

6.8.8 Table 23 shows the largest changes between the two model runs in the Phase 1 Do Something 2036. The largest changes in this scenario are the eastside HS2 stations. The changes are consistent with the changes observed in the Do Minimum.

Table 23. Largest Changes in DS Demand when HS2 stations introduced into DM and Phase 1 DS

STATION NAME	ORIGIN CHANGE	DESTINATION CHANGE
HS Leeds	2692	2691
Leeds	-2419	-2444
HS Meadowhall	2234	2100
Sheffield Meadowhall Classic	-814	-773
Sheffield Midland	-596	-589
HS Toton	477	405
Salford Central	-439	-346
Wakefield Westgate	-347	-288
Manchester Piccadilly	246	230
Birmingham New Street	-177	-193

6.8.9 Table 24 shows the largest changes on station demand for the Y in 2036. It shows that the changes this time are much smaller with the biggest change at Euston. It is mainly the stations which are directly affected by HS2 stations that have changed. It is interesting that there is more demand at Stevenage as this is a station on the ECML, but it may be that passengers are choosing to use HS2 services from Euston and the change in the number of passengers is small.

Table 24. Largest changes in DS Demand when HS2 stations introduced into Y DS

STATION NAME	ORIGIN CHANGE	DESTINATION CHANGE
London Euston	201	203
HS Birmingham Curzon St	193	206
Leeds	162	163
HS Leeds	151	149
Birmingham New Street	141	153
Manchester Piccadilly	-124	-135
HS Birmingham Parkway	130	126
Stevenage	117	120
HS Meadowhall	107	100
Birmingham Moor Street	101	102

6.9 Summary

6.9.1 The station choice model (SCM) is the process that sits between the demand model and the assignment model to translate the PLD to PLD zone level demand data from the Demand Model to station to station demand for use in the assignment model. It also converts station to station costs into PLD to PLD costs for use in the demand model.

6.9.2 During the development of PFM v4.3 a number of changes to other parts of the PFM resulted in a need to re-calibrate the SCM parameters. The key updates that drove the need for re-calibration of the SCM were:

- The parameter consistency changes (Chapter 4);
- Changes to the assignment process (Chapter 5) and
- The demand model re-estimation (Chapter 7).

6.9.3 In addition to the SCM re-calibration, there were also two methodology improvements made to the PFM v3.0 SCM prior to re-calibration as follows:

- Introducing crowding into the long distance rail generalised journey times; and
- Averaging the directional long distance rail costs to improve model robustness

6.9.4 The SCM re-calibration resulted in a significant improvement in model fit.

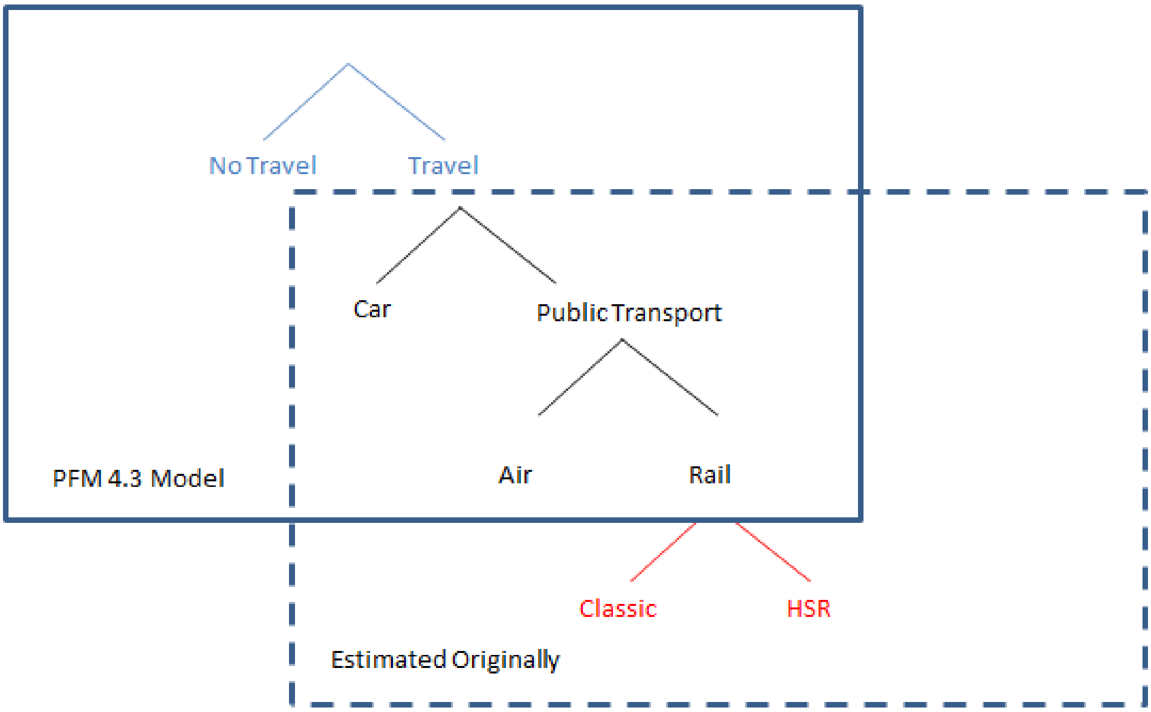
6.9.5 The final step was to integrate the re-calibrated SCM within the PLD and introduce HS2 stations into the Do-minimum to accommodate the station-to-station appraisal approach detailed in Chapter 9.

7. DEMAND MODEL PARAMETERS

7.1 Introduction

7.1.1 The PFM v3.0 PLD demand model (and all preceding versions) was derived from a mode choice model estimated largely from a 2001 stated preference (SP) dataset, but with some revealed preference (RP) adjustment. This estimation was undertaken, by Atkins, as part of the development of the PLANET strategic model in 2002 (approx.), and was not changed when the HS2 PLD model was created from the PLANET strategic model. Values of Time were also derived from the SP dataset. The structure of the PFM v3.0 demand model is shown in Figure 6 in the solid box. However, the model structure within the demand model differs from the structure estimated from the data (the model originally estimated from the SP data is shown in the dotted box).

Figure 6. Model Hierarchical Structure



7.1.2 A number of changes were made to the model structure estimated originally. An additional "frequency" component (no travel, travel) was inserted above the mode choice, with parameters derived, by Atkins, using established transport practice rather than survey based evidence. In addition, for the HS2 application the (classic rail, high speed rail) nest was dropped, and the choice between the two types of rail has been based on assignment (plus use of the station choice model, which is a logit model) rather than using a standard logit model. The model parameters were not adjusted to reflect these changes.

7.1.3 There are three issues with the PFM v3.0 demand model:

- The data used to calibrate the model is dated;
- The frequency parameter is not based on direct survey evidence; and
- The model should have been re-estimated following the removal of the rail sub mode choice nest and the addition of the SCM.

7.1.4 The aim of this section of the work was to re-estimate the demand model parameters based on more recent data and taking into account the changes made to the other aspects of the model; e.g. to the Station Choice Model as well as implementing the revised assignment procedure. This will ensure that as far as possible, consistency is achieved between all aspects of the main individual model components, the SCM, assignment and demand model.

7.1.5 This Chapter provides information on:

- The estimation of the demand model parameters; and
- The implementation of the revised demand model parameters within PFM v4.3.

7.2 Estimation Approach

7.2.1 In PFM v4.3 the demand model parameters have been estimated from the long-distance (LD) journey records collected in the 2002-2010 National Travel Survey (NTS), utilising both the one week diary data, and the recall data collected over a one or three week period (depending on the year of NTS data). The development of the models drew on RAND Europe's experience of estimating a similar demand model in the context of the DfT's Long Distance Model [13]. The demand model parameters were estimated using base year (2010/11) level-of-service (LOS) taken from an intermediate version of PFM, thus ensuring consistency between the LOS used to estimate and apply the models. Note that the LOS data had to be adjusted in order to provide LOS for Business Non-car available (bus_nca) journeys: for this segment PFM v3.0 contains empty demand matrices as it was assumed that business rail travellers would all have a car available.

7.2.2 More detail about the estimation data is provided in Appendix E, which describes the processing of the NTS data, explains how the PFM LOS has been processed into a suitable format for the model estimation procedure, and documents the sources used to account for real changes in modal costs over the 2002-2010 period in the estimations.

7.2.3 As Appendix E explains, the long-distance journey records have been built into long-distance tours, which are a series of linked trips starting and finishing at the traveller’s home. Thus the unit of travel that has been represented in the model estimations is home-based tours, and, since a tour represents both an outward leg from the home to the destination and a return leg from the destination back to the home again, level of service information for both the home-destination and destination-home journeys has been represented. However, the PFM model is currently applied on a trip, not tour, basis. Therefore, for model application the sensitivities to tour level of service are

[13] Rohr, C., J. Fox, A. Daly, B. Patruni, S. Patil, F. Tsang (2010) Modelling Long-Distance Travel in the UK, European Transport Conference, Glasgow.

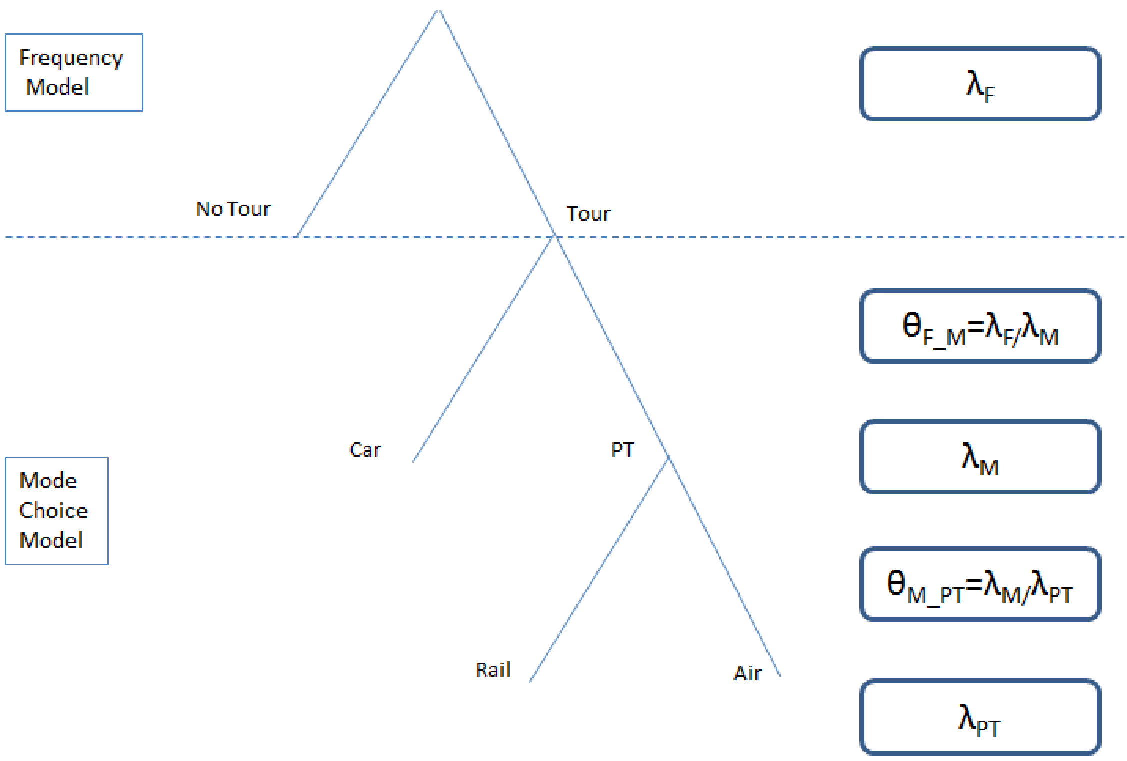
multiplied by two to give sensitivities to level of service for a one-way trip. All of the tables in this Chapter that present model results present the model sensitivities – the 'lambda values' – in terms of sensitivities for a one-way trip.

Model Structure

7.2.4 Mode choice and frequency models were estimated separately for commute, business and leisure purposes. As noted in Appendix E, education travel forms part of the leisure purpose in line with the matrix redevelopment work undertaken.

7.2.5 Figure 7 illustrates the frequency and mode choice model structure, and highlights the relationship between the lambda values, which define the sensitivities to generalised time at each response level, and the theta parameters (which reflect the relative sensitivity of the different responses). It is noted that the mode choice and frequency models are estimated sequentially, not simultaneously.

Figure 7. Frequency and Mode Choice Model Structure



Mode Choice Models

7.2.6 The main objective of the mode choice estimations is to estimate the sensitivities to generalised time at the lowest level in the mode choice structure - the lambda values - and then to estimate structural parameters (thetas) that define the relative sensitivity of higher level choices. In addition to the generalised time parameters, the mode choice models incorporate mode-specific and other constants, and in some models a "day trip effect" which is discussed further below. The specification for the generalised time function used in the mode choice models is as follows:

$GT_k = GJTCAE_k + cost_k[Y] / VOT[Y,D,C]$

where:

GT_k is the generalised time for main mode k (minutes)

$GJTCAE_k$ is the generalised journey time for main mode k (minutes)

$cost_k$ is the monetary cost of the mode (pence in 2010/11 prices) in year Y

VOT[Y,D,C] is the value of time (pence/minute in 2010/11 prices) in year Y, for trip of distance D, for a traveller with household income C

7.2.7 The sensitivity to generalised time is estimated at the lowest level in the structure, i.e. the rail versus air choice. The generalised time parameter defines λ_{PT} and then we can calculate the sensitivities to generalised time for the car versus public transport choice λ_M, and for the no tour versus tour choice λ_F, using the structural parameters θ_{M_PT} and θ_{F_M} that are output from the model estimation procedure (from the ALOGIT program). Note that for commute, the model does not contain air, so there is no rail versus air choice and therefore the generalised time parameter estimated in the model defines λ_M directly.

7.2.8 Analysis of the variation in mode share in the NTS LD data by year demonstrated that rail mode shares were higher in the 2006-10 data compared to the 2002-05 data. Therefore separate mode constants were estimated for the 2002-05 and 2006-10 periods. These separate mode constants make some allowance for significant changes in LOS over the period, in particular that impact of the West Coast Main Line upgrade for rail. The estimation procedure also took account of real cost changes over the 2002-10 period covered by the estimation data.

7.2.9 The mode choice model predicts the choice between car and public transport for all three purposes, and for business and leisure, the choice between rail and air. Only weekday tours were included in the model estimation procedure. If a tour was made where one leg was made on a weekday, and the other leg on a weekend, then it was included with a weight of 0.5.

7.2.10 The PFM v4.3 model operates with separate non car available (NCA) and car available (CA) segments for commute and other travel for rail, but not for business where it was assumed that all travellers had a car available. As in PFM v3.0 it is assumed that all air travellers have a car available, so rail is the only mode available to the NCA segment.

7.2.11 Table 25 summarises the NCA and CA fractions observed in the NTS samples of rail tours included in the mode choice models. The values can be compared to the fraction of rail demand that is NCA in the matrices.

Table 25. Percentages of NTS Rail Tours that are NCA and CA

PURPOSE	RAIL TOURS	
	NCA	CA
Commute	8.7%	91.3%
Business	8.5%	91.5%
Other	27.9%	72.1%

7.2.12 It should be noted that it is assumed in the model that all business travellers have some form of car available (eg Taxi). Hence, the 8.5% observed in the NCA category are ignored. It should also be noted that because rail is the only mode that is available to non-car available (NCA) individuals (because air and car are not available), all NCA records are dropped from the mode choice estimations. This exclusion results in the loss of just 2.5% to 3.5% of all tours (i.e. including car and air tours as well as rail).

Frequency Model

7.2.13 The frequency model predicts the binary choice between not travelling and making a long-distance tour on an average weekday. The frequency models incorporate terms for different socio-economic segments, logsums[14] from the mode choice models, and constants to ensure the overall tour rates observed in the NTS LD data are replicated. Separate constants have been estimated for the 2002-2005 and 2006-2010 periods.

7.2.14 The NTS LD recall data covers a two or four week period, so a period of 10 or 20 weekdays. On each weekday, if an individual does not travel they contribute a 'no tour' observation. If a tour is made where one leg is made on a weekday, and the other leg on a weekend, then it is included in the counts of weekday tours made with a weight of 0.5. Tours where both legs are made on a weekend are excluded from the tour counts.

7.2.15 Ideally, the frequency models would be developed using all the NTS data, including tours made on weekends, as HS2 services will operate at weekends as well as during the week, and for leisure travel a significant proportion of total travel takes place at weekends . However, the PFM network models have been set up as weekday only models and changing these models to represent an average day (over both weekdays and weekends) would be a substantial task. A potential future improvement to the PFM model would change the model to work with an average day.

[14] For more information on this subject see Chapters 6 and 7, "Modelling Transport" Ortuzar and Willumsen

7.2.16 The mean long-distance tour rates in the sample of 2002–2010 NTS data used for model estimation are 0.03 for commute, 0.05 for business and 0.12 for leisure. The tour rates are the mean number of long-distance tours made per weekday.

7.2.17 For the structure illustrated in Figure 8, logsums from the mode choice model are required as an input for the frequency models (and this means that journey frequency will be a function of accessibility, as measured by the mode choice logsums). The following procedure was used to generate mode choice logsums for both CA and NCA individuals:

- For CA and NCA individuals who make a tour, mode choice logsums are calculated for the chosen PA pair. For the NCA segment, these logsums are generated using the rail LOS for the NCA segment, including the business NCA LOS that has been generated from the SCM specifically for these model estimations;
- For individuals who do not make a tour, three different approaches were tested. First, expanding each record so that there is one record for each of the possible 235 attraction zones. The problem with this approach is that it resulted in estimation run times that were unfeasibly high given the timescales available for model development. Second, for each production zone calculating weighted average LOS over the set of destinations visited by those individuals who did make a tour from the production zone. However, this approach did not yield sensible parameter estimates. Third, calculating logsums from the set of individuals who did make a tour from the production zone, and then calculating average logsums. This third approach yielded sensible parameter estimates for reasonable model run times and therefore was adopted for the final estimations; and
- The frequency models are estimated using separate logsums for CA and NCA individuals. For individuals who make a tour, the mode choice logsum for that tour is used. For individuals who do not make a tour, the average mode choice logsum for their production (home) zone is used.

7.2.18 The following formulae set out how the mode choice logsums have been calculated for CA individuals for individuals who make tours. A mode choice logsum represents the average attractiveness for a given OD pair calculated as an average over the available modes:

$$\text{logsum}(\text{PT},\text{CA})_{PA} = \ln\left[\exp(V_{Air,PA}) + \exp(V_{Rail,PA})\right]$$

$$\text{logsum}(\text{M},\text{CA})_{PA} = \ln\left[\theta_{M\_PT}\exp(V_{Car,PA}) + \theta_{M\_PT}\exp\left(\text{logsum}_{PT,PA}\right)\right]$$

where:

$\text{logsum}(\text{PT,CA})_{PA}$ is the logsum for the PT nest for the chosen PA pair (in utility units)

$\text{logsum}(\text{M,CA})_{PA}$ is the overall mode choice logsum for the chosen PA pair (in utility units)

$V_{Air,PA}$ is the utility of air for the chosen PA pair (defined below)

$V_{Rail,PA}$ is the utility of rail for the chosen PA pair (defined below)

$V_{Car,PA}$ is the utility of car for the chosen PA pair (defined below)

θ_{M_PT} is the relative sensitivity of PT mode and main mode choices (see Figure 7 above)

7.2.19 Utility is analogous to negative generalised cost, but as well as including contributions from cost and time it also includes contributions from constant terms and so is defined in simply utility units or 'utils'. To aid interpretation of the parameter values parameter ratios are often calculated, for example if cost (in pence) and time (in minutes) enter the utility function separately then the cost parameter has units of utils/pence and the time parameter has units of utils/minute, and so dividing the time parameter by the cost parameter gives the implied value of time in pence/minute.

7.2.20 The utility functions define the attractiveness of each mode to an individual traveller, and are specified in the following equations. Some of the parameters are only included for some model purposes.

$$\begin{aligned} V_{Car,PA} = {} & \beta_{GenTime} GenTime_{Car,PA} + \beta_{Car2+cars} if\,(2+cars) + \beta_{CarPTworker} if\,(PTworker) \\ & + \beta_{CarMale} if\,(male) + \beta_{CrDsB1} * \min(1, \max(0, (dist-100)/50))) \\ & + \beta_{CrDsB2} * \min(1, \max(0, (dist-150)/50))) \end{aligned}$$

$$\begin{aligned} V_{Rail,PA} = {} & \beta_{GenTime} GenTime_{Rail,PA} + \beta_{Rail2+cars} if\,(2+cars) + \beta_{PTworker} if\,(PTworker) \\ & + \beta_{Rail0205} if\,(2002-2005) + \beta_{Rail0610} * if\,(2006-2010) \end{aligned}$$

$$V_{Air,PA} = \beta_{GenTime} GenTime_{Air,PA} + \beta_{Air0205} if\,(2002-2005) + \beta_{Air0610} * if\,(2006-2010)$$

where:

$GenTime_{ModePA}$ is the generalised time for the mode, including monetary costs converted to generalised time minutes

dist is the one-way trip distance in miles

Mode choice logsums for NCA individuals who make rail tours are calculated as follows, noting that rail is the only mode available:

$$\text{logsum}(\text{k}, \text{NCA})_{PA} = \ln\left(\theta_{M\_PT} \exp(V_{Rail,PA})\right)$$

7.2.21 For individuals who do not make tours, average mode choice logsums for production zone P are then calculated as follows:

$$\text{logsum}(\text{k}, \text{CA})_{P} = \frac{1}{n} \sum\nolimits_{\text{n}} \text{logsum}(\text{k}, \text{CA})_{PA}$$

$$\text{logsum(k, NCA)}_P = \frac{1}{n}\sum_{n} \text{logsum(k, NCA)}_{PA}$$

where:

logsum(k,CA)_{PA} is the average CA logsum for production zone *P* over chosen PA pairs

$\text{logsum(k,NCA)}_{PA}$ is the average NCA logsum for production zone *P* over chosen PA pairs

n is the total number of tours (CA plus NCA) observed from production zone *P*, made to the set of PA pairs observed from production zone *P*

7.2.22 In application, the NCA segment remains rail captive for a given PA pair but additional demand can be generated as a result of reductions in generalised time.

Elasticity Tests

7.2.23 WebTAG Unit 3.10.4 indicates a number of "realism" tests which should be satisfied. In particular (paragraph 1.6.7): " The primary realism tests require that car fuel cost and public transport fare elasticities lie within specified bands (as set out below). Car fuel cost elasticity tests are required in all cases. Public transport fare elasticity tests are required in all cases where changes in public transport generalised costs, including changes in fares, are modelled." However, the values in the guidance are applicable to national or regional models covering all trip lengths, and are not really suitable for models dealing only with LD travel.

7.2.24 To validate the sensitivity of the PLD demand model (frequency and mode choice components), elasticity tests have been run by making fixed changes to four policy variables:

- 10% increase in fuel costs (ie no change to non-fuel car costs);
- 10% increase in car times;
- 10% increase in rail fares; and
- 10% increase in rail in-vehicle times.

7.2.25 For each policy test, the response of the component models in terms of changes in both the numbers of tours and kilometres by mode has been calculated. The changes come about from a combination of mode choice and frequency responses. The calculation procedure used to generate the elasticities is described in the following paragraphs.

7.2.26 The 10% change to the policy variable is applied in the mode choice model for the NCA and CA segments. For commute, for the CA segment the changes in the number of tours by mode are calculated, whereas for the NCA segment no mode shift is possible because the segment is assumed to be rail captive[15]. From the changes in the CA segment the pure mode choice elasticities are calculated (relative to total demand over the NCA and CA segments). In these tests, the pure mode choice response for the mode directly

[15] For business and VFR air as well as rail are modelled for the NCA segment and so the rail captivity argument does not apply.

impacted by the policy test shows greater changes for kilometres than tours (ie reductions in mean tour lengths) because the policy tests typically have a greater impact on longer tours. However, at this stage the total kilometres over all modes (and hence overall mean tour length) is unchanged because the total demand associated with each OD pair is unchanged.

7.2.27 For both the NCA and CA segments modified logsums are output from the mode choice model for input into the frequency model. The frequency model is then applied using these modified logsums, and the changes in total travel are calculated. For the CA segment the additional tours are distributed over the modes using the mode shares from the mode choice run, while for the NCA segment (which is rail captive) the additional travel is added to the rail demand.

7.2.28 Because the mode choice and frequency models were estimated sequentially rather than simultaneously (see Section 7.2.5), and a different implementation was being created for PFM, there was no requirement to link them in an independent simultaneous frequency-mode choice system. The result is that while the frequency model can calculate the additional travel that is generated, it is not associated with particular OD pairs for individuals who do not make tours since, for a given origin zone, average logsums are calculated across the subset of destinations visited by people who Do Make tours from that origin zone. Effectively this gives the additional travel generated from the origin to a representative destination, and there is then no easy way of calculating tour lengths for that representative destination. Therefore the approach followed was:

- to apply the mode choice model, and calculate the changes in mean tour lengths that result from the elasticity test; and
- to assume that all the generated travel has the same mean tours lengths as those calculated in the mode choice model for the sample of individuals who make tours.

7.2.29 As these mean trip lengths for total tours do not vary between the different policy tests, there is no difference between the tour and kilometres elasticities for total demand summed over modes.

7.2.30 The elasticities are calculated from the unweighted samples of OD pairs observed in the 2002-2010 NTS data used for model estimation, and provide an approximation of the actual elasticity response that would be expected in PFM, in particular assuming that generated traffic results in no change in the overall mean tour length.

7.2.31 Note that when running the same policy tests within the overall PFM model system, the policy will be applied across all available OD pairs and the level of generated demand will vary between individual OD pairs. Hence, in the full model implementation, changes in overall mean tour lengths are expected.

7.2.32 The results from the elasticity tests are discussed in Section 7.3 below as part of the discussion of the different model tests, and for the final models detailed elasticity results are presented in Section 7.4 including a decomposition of the total elasticities into frequency and mode choice responses.

7.3 Model Tests

The Impact of Cost Damping on Mode Choice

7.3.1 There is evidence that the sensitivity of demand responses to changes in generalised cost reduces with increasing trip length, and that in order for models to behave sensible in realism testing it may be necessary to include this variation (WebTAG Unit 3.10.2, para. 11.1.1). Mechanisms to incorporate this variation are referred to as 'cost damping'. In the context of long-distance travel, where we are considering a wide range of different trip lengths, investigating the impact of cost damping formulations on the fit of the models to the observed choices was judged to be particularly important. Tests were undertaken to investigate the impact of cost damping on the model results. Cost damping was incorporated by making adjustments to the values of time (VOTs) that are used to convert costs into generalised time units.

7.3.2 The tests to compare models estimated using these distance damped VOTs were undertaken early in the mode choice model development using the initial LOS delivered from PFM v3.0. The impact on the generalised time parameters and the overall fit to the data was assessed when cost damping was introduced. The results from these tests are summarised in Table 26.

Table 26. Cost Damping Tests by Purpose

PURPOSE	OBSERVATIONS	GENERALISED TIME PARAMETER		GAIN IN LOG LIKELIHOOD WITH COST-DAMPED FORMULATION
		NO DAMPING	COST DAMPING	
Commute	2674	-0.000124 (-0.3)	- 0.000643 (-1.4)	0.9
Business	4626	-0.00320 (16.2)	-0.00350 (16.9)	14.2
Other	21737	-0.00130 (16.5)	-0.00160 (16.4)	1.1

7.3.3 For all three purposes, introducing cost damping led to an increase in the magnitude of the generalised time parameter, implying higher mode choice sensitivities, and an improved fit to the data. Therefore cost damping was retained in the final model specifications. It should be noted that in the preliminary commute models on which these tests were run, the generalised time parameters were not statistically significant, i.e. the sensitivity to changes in generalised time was not significantly identified.

7.3.4 Cost damping for commute and leisure has been implemented using the VOT relationship set out in paragraph 1.11.5 of WebTAG Unit 3.10.2 (February 2013) which is given in Appendix A.3.

7.3.5 For business, WebTAG does not provide a distance damped VOT formulation, and therefore a cost damped VOT formulation was estimated from the Stated Preference (SP) data used to develop the Department for Transport's Long Distance Model. To estimate SP VOTs that vary with distance, the distance elasticity of 0.36 from the commute VOT relationship in WebTAG 3.10.2 was used.

The Impact of Income Segmentation

7.3.6 One of the aspects identified in the Scoping Report was to test the feasibility of including the impacts of income within the demand model. Therefore, models were run including income segmentation to test the impact that income segmentation has on the model results. Income segmentation was incorporated in the models in three ways:

- The mode choice models reflect variation in sensitivity to cost with household income band;
- The mode choice models incorporate income band constants, reflecting higher income travellers' preferences for air and rail relative to car. Note that these constants pick up differences in preference over and above those explained by the lower cost sensitivity of higher income travellers to the higher costs associated with rail and air travel (relative to car); and
- The frequency models incorporate constants by income band to reflect higher tour frequency rates for individuals from higher income households.

7.3.7 Three household income segments have been used for these tests: <£50k p.a., £50-75k p.a., £75k p.a. plus. It is possible to identify a higher number of segments to represent variations in frequency but higher numbers of segments were judged to be impractical for implementation.

7.3.8 The main findings from the income segmented runs were as follows:

- for mode choice, segmenting VOT by income band did not give a better fit to the data, but adding income terms to reflect higher income travellers' preference for rail and air did lead to a significant improvement in model fit; and
- for frequency, adding constants by income band gave a large improvement in fit to the data, but the sensitivities to the mode choice logsums showed little change.

7.3.9 Given that the frequency and mode choice models are implemented incrementally in PFM, a key consideration is how income segmentation impacts on the model sensitivities. Tables 27 to 29 compare the lambda values with and without income segmentation for each of the three travel purposes.

Table 27. Impact of Income on Commute Lambda Values

CHOICE	NO INCOME SEGMENTATION	INCOME SEGMENTATION	RATIO (INCOME / NO INCOME)
Frequency	-0.00494	-0.00478	0.968
Car vs. rail	-0.00882	-0.00876	0.994

Table 28. Impact of Income on Business Lambda Values

CHOICE	NO INCOME SEGMENTATION	INCOME SEGMENTATION	RATIO (INCOME / NO INCOME)
Frequency	-0.00487	-0.00523	1.074
Car vs. PT	-0.00978	-0.00977	0.999
Rail vs. air	-0.01243	-0.01137	0.955

Table 29. Impact of Income on Leisure Lambda Values

CHOICE	NO INCOME SEGMENTATION	INCOME SEGMENTATION	RATIO (INCOME / NO INCOME)
Frequency	-0.00505	-0.00488	0.967
Car vs. PT	-0.00636	-0.00620	0.975
Rail vs. air	-0.00698	-0.00691	0.991

7.3.10 The impact of adding income segmentation to the frequency and mode choice model sensitivities is marginal. In most cases a very slight reduction in the model sensitivities for the frequency and mode choices is observed. However, for business there is a slight increase in the sensitivity of the frequency choice in the income segmented model.

7.3.11 The model elasticities have also been run for the income segmented models. Rather than present the full set of detailed elasticities, tables 30 and 31 summarise the impact of income segmentation on the rail fare and rail in-vehicle time kilometres elasticities. These tables give an overview of the key changes and as such focus just on kilometrage.

Table 30. Impact of Income on Rail Fare Kilometre Elasticities

CHOICE	NO INCOME SEGMENTATION	INCOME SEGMENTATION	RATIO (INCOME / NO INCOME)
Commute	-0.745	-0.739	0.993
Business	-0.461	-0.503	1.089
Other	-0.837	-0.839	1.003

Table 31. Impact of Income on Rail In-Vehicle Time Kilometre Elasticities

CHOICE	NO INCOME SEGMENTATION	INCOME SEGMENTATION	RATIO (INCOME / NO INCOME)
Commute	-0.769	-0.726	0.944
Business	-1.365	-1.332	0.976
Other	-1.025	-1.010	0.986

7.3.12 In summary, introducing income segmentation into the models has only a marginal impact on the model sensitivities and the rail fare and in-vehicle time elasticities. Given the time required to implement income segmentation into the model as well the potential impact on model run time it was concluded that income segmentation should not be included in PFM v4.3.

7.3.13 However, it is clear from the income tests that income has a substantial impact on preferences for rail and air, and on travel frequency, and these effects should be represented when generating the future year matrices by mode and when predicting mode switching when incorporating high-speed rail services. The future year matrices by mode are not predicted by PFM v4.3, so these are not arguments for the inclusion of income in the demand models, rather they emphasise the need to take income into account in the processes used to generate the future year matrices.

7.3.14 Moreover, income is likely to play a key role in appraisal and allowing the analysis of which groups would benefit from the introduction of HS2 services would require income segmented forecasts. Income segmented forecasts could be generated either by including an income segmentation in the PFM demand models, or by applying an exogenously derived income distribution to outputs from PFM demand models without income.

Modifications to the Procedure Used to Estimate the Leisure Models

7.3.15 To validate the new demand model parameters, runs were undertaken for a 2043 (cap year in PFM v3.0) run of PFM, assuming the Y-network. The results were compared to an equivalent forecast using the old PFM v3.0 demand model parameters (based on the SP work undertaken in late 2001 and early 2002), but with the same level-of-service and base matrix information. A comparison of these two forecasts showed that the new demand model parameters gave:

- higher generation for commute and leisure; and
- lower abstraction from highway and air for all purposes, but with particularly marked reductions for leisure

7.3.16 While the levels of abstraction for commute and business were lower with the new demand model parameters, the changes are in line with the changes expected as a result of the changes in the model sensitivities. However, the declines for leisure were larger than were anticipated, and following detailed analysis it was found that this was a result of the frequency and mode choice sensitivities being similar in the new leisure mode. Therefore tests were undertaken to investigate whether information on the relative sensitivities of the different choices represented in the models could be imported from elsewhere to give revised model parameters that resulted in generation and abstraction forecasts that were more in line with other evidence. The following sub-sections report the tests that have been run for the leisure mode choice and frequency models.

Additional Mode Choice Model Estimations

7.3.17 In the leisure mode choice models estimated up until this point, the sensitivities of the car versus PT and train versus air choices were similar, with a relative value of 0.91 (the PT nest parameter). The air mode share in the NTS data is just 0.9%, so there is very limited data available to identify differences between the sensitivities for the rail versus air and the PT versus highway choices. Therefore tests were undertaken whereby this relative sensitivity was imported from the (LDM) SP analysis [16], where the PT nest parameter was 0.72 in a comparable model specification without income segmentation. 24% of the leisure SP respondents were existing air users, and therefore there is much more information available from the SP data to identify a value for the PT nest parameter.

7.3.18 The impact on constraining the PT nest parameter for leisure to the value from the LDM SP analysis is summarised in Table 32.

Table 32. Additional Leisure Mode Choice Estimations

	PREVIOUS MODEL (V64)	REVISED MODEL (V67)
Log-likelihood	-2601.1	-2602.6
PT nest	0.9116	0.7179
Generalised time	-0.00349	-0.00411

7.3.19 Constraining the PT nest parameter to the value from the LRM SP analysis results in only a small loss of fit to the data (1.5 log-likelihood points). The generalised time parameter, which gives the sensitivity of the rail versus air choice, increases by 18%. The sensitivity of the car versus PT choice, given by the product of the PT nest and generalised time parameters, reduces by 7%.

[16] Burge, P., Woo Kim, C. And C. Rohr (2011) Modelling Demand for Long-Distance Travel in Great Britain: Stated preference surveys to support the modelling of demand for high-speed rail. http://www.rand.org/pubs/technical_reports/TR899.

7.3.20 As using the SP value for the PT nest parameter resulted in only a slight loss of fit to the RP data, and resulted in an increase in the sensitivity of the rail versus air choice, the revised mode choice model has been used to calculate updated mode choice logsums for the estimation of revised frequency models.

Additional Frequency Model Estimations

7.3.21 As discussed in the preceding section, the sensitivities of the generation and PT versus highway choices were similar in the models that best explain the leisure travel frequency rates observed in the 2002-2010 NTS data, and this results in very low highway and air abstraction in model application. Therefore the impact of reducing the sensitivity of frequency choice (and increasing the cross-elasticity of the mode choice responses) to changes in generalised cost was investigated. To make these tests, the $\theta_{TR\_F\_M}$ structural parameter, which is multiplied by the mode choice logsum, was fixed to different values and the impact on the model fit was assessed. The results from these tests are summarised in Table 33.

Table 33. Additional Leisure Frequency Model estimations

	PREVIOUS FREELY ESTIMATED MODEL (V27)	REVISED FREELY ESTIMATED MIODEL (V36)	REVISED MODEL 1, TR_F_M FIXED TO 0.7 (V37)	REVISED 2, TR_F_M FIXED TO 0.6 (V38)	REVISED MODEL 3, TR_F_M FIXED TO 0.5 (V39)
Corresponding mode choice model	v64	v67	v67	v67	v67
Log-likelihood (LL)	-66,962.1	-66,991.2	-67,009.3	-67,063.2	-67,155.3
Loss in LL	n/a	n/a	-18.1	-72.0	-164.1
TR_F_M	0.7937	0.8024	0.7	0.6	0.5

7.3.22 It can be seen that fixing the TR_F_M parameter to values less than the 0.8024 value estimated from the NTS data leads to substantial loss of fit to the observed data, measured by the log-likelihood measure, particularly for values of TR_F_M less than 0.6. We do not believe values lower than 0.6 can be justified on the basis of the substantial loss of fit to the data which indicates that such models are significantly worse at explaining the travel choices observed in the 2002-2010 NTS data. However, the loss of fit resulting from moving to the value of 0.6 could be justified if the model elasticities and forecasts were judged to be more reasonable. For reference, the freely estimated values for the TR_F_M parameter in the corresponding models for commute and business were lower at 0.56 and 0.47 respectively, although behaviour in these markets could be expected to be somewhat different.

7.3.23 The model elasticities were recalculated using the revised mode choice model (v67) and the revised frequency model (v38). Table 34 summarises the leisure elasticities and Table 35 gives the changes in the elasticities relative to the leisure model parameters (mode choice model v64, frequency model v38). In these we are interested in understanding the impact of the changes on the model response characteristics so looked in more detail at the elasticity changes and hence in this case both kilometrage and tour elasticities are presented.

Table 34. Revised Leisure Model Elasticities

TOUR	FUEL COST	CAR TIME	RAIL FARE	RAIL IVT
Air	0.183	0.944	0.259	0.328
Rail	0.047	0.212	-0.617	-0.721
Car	-0.144	-0.598	0.016	0.019
Total	-0.118	-0.482	-0.057	-0.065
KILOMETRES	**FUEL COST**	**CAR TIME**	**RAIL FARE**	**RAIL IVT**
Air	0.194	1.050	0.231	0.313
Rail	0.077	0.378	-0.751	-0.924
Car	-0.155	-0.655	0.031	0.040
Total	-0.118	-0.482	-0.057	-0.065

Table 35. Changes in Leisure Model Elasticities (revised model/previous model)

TOUR	FUEL COST	CAR TIME	RAIL FARE	RAIL IVT
Air	1.185	1.146	1.764	1.706
Rail	1.475	1.426	0.873	0.876
Car	0.760	0.759	2.255	2.103
Total	0.739	0.736	0.754	0.755
KILOMETRES	**FUEL COST**	**CAR TIME**	**RAIL FARE**	**RAIL IVT**
Air	1.168	1.123	1.682	1.613
Rail	1.200	1.149	0.897	0.902
Car	0.770	0.771	1.305	1.254
Total	0.739	0.736	0.755	0.754

7.3.24 The direct rail IVT elasticities have reduced in magnitude to 88-90% of their previous values because of the reduction in the frequency sensitivity. However, the cross-elasticities for air and car have increased substantially because the ratio of the frequency and mode choice sensitivities has moved further from one. Joyce Dargay obtained cross-elasticities for changes in car kms in response to changes in rail IVT of between 0.08 and 0.26[17]. The higher value in the revised model of 0.04 is still below the range indicated by Dargay, although her work cannot be considered definitive.

7.3.25 Tests of the impact of the changes to the leisure model parameters on the predicted levels of demand for HS2 in a 2043 Y-network test were also undertaken for a selection of example OD pairs. The revised demand model parameters resulted in the expected increases in highway and air abstraction, with highway abstraction increasing by around 65%, and air abstraction doubling.

7.3.26 Overall, the significantly increased cross-elasticities from the revised leisure models were judged to be more plausible, and therefore in all subsequent leisure model estimations the PT nest parameter was fixed to the SP estimate in the mode choice model, and the TR_F_M parameter was fixed to 0.6 in the frequency model.

[17] Dargay, J. (2010) The Prospects for Longer Distance Domestic Coach, Rail, Air and Car Travel in Britain. Report to the Independent Transport Commission, Institute for Transport Studies, University of Leeds.

Day Trip Parameter

7.3.27 The Scoping Study identified the possibility of including a day trip term (for business and other, not commute) within the demand model. The day trip term would allow for effects that occur in long journeys, such as:

- the inability to make the return journey within a normal day, so that the cost and inconvenience of an overnight stay is potentially incurred;
- the fatigue and need to make refreshment stops incurred with long travel times; and
- the inconvenience of scheduling of activities when so much time is taken up by travelling.

7.3.28 Essentially, the variable operates in favour of air travel and to a lesser extent high-speed train, particularly against car alternatives. However, it is a mode-neutral effect which represents the long journey effects described in the bullets above. Importantly in this context, it was found, in the analysis of SP data for the Long-Distance Model, that the day-trip variable was highly significant and that an HSR alternative did not offer any significant benefit over a classic rail alternative (over and above that measured by reduced journeys times or increased reliability) provided this variable was included in the model. If the variable was excluded, the data then indicated that a constant representing the advantage of HSR over classic rail should be included, a formulation that would be difficult to maintain in the face of challenge.

7.3.29 The day trip term has been included in a number of previous studies as listed below and hence, a decision as to whether whether the day trip term should be included in PFM v4.3 was also investigated:

- In Denmark, RAND Europe (RE) constructed a model of mode and route choice for travel between East and West Denmark and found that a variable of the type was needed to explain the impact that the Great Belt Fixed Link, which makes possible many more day trip journeys between Copenhagen and West Denmark, would have. In particular, travelling by air was previously the only way to make many return journeys in a day but now large areas are similarly accessible by car or train;
- For the 'High Speed Line - South' project connecting Amsterdam with Brussels and connections to Paris, London and Germany, RE constructed a model which also had a variable giving an advantage to modes completing the round trip in less than six hours, however in this case for the Leisure International segment only;
- In the Long Distance Mode (LDM), the day trip variable was defined to apply to all trips where the return journey, including access/egress time, waiting time and in-vehicle time could be completed in less than six hours. The specification of the variable, including the use of the 6-hour cut-off, was based on detailed tests using the SP data, but it was also found to work satisfactorily in the RP data used for that study; and
- For Norway, working with Atkins, RE constructed a model of demand for HSR based on an SP survey. This model contained terms giving an advantage to modes

that could complete the round trip in less than six hours, for both work and non-work segments.

7.3.30 Appendix F presents model results from the LDM SP data that demonstrates that the significance of the day trip term is high, and therefore if the terms are dropped from the SP models for Business and Leisure a significant loss of fit to the SP data is observed. Note that these tests omit an HSR constant and the significance of the day trip effect might be reduced if such a constant was introduced.

7.3.31 The day trip terms identified from the SP analysis were imported into the RP mode choice models by expressing the day trip effects as penalties of additional generalised time minutes for longer journeys. For the air and car modes, the day trip term penalties were added directly to the generalised times. For rail, LOS was taken from the Station Choice Model. Therefore the day trip function was coded in the Station Choice model (as per Appendix G), and composite generalise time measures which included the day trip factor were used for the RP mode choice model estimation.

7.3.32 Importing the day trip effect from the SP analysis was preferred to attempting to re-estimate the effect from the RP data for two reasons. First, because the SP data contains a lot of trading between day trip and non-day trip options. Second, because in the RP data choice of car may be observed for long-distance trips because distance and length of stay are correlated. In the SP data, these correlations are avoided because individuals are asked to choose between the modes assuming that they are making the same trip.

7.3.33 The following sub-sections summarise the impact of the day trip term on the business and leisure mode choice models, before summarising the findings regarding the inclusion of the day trip factor in the models.

Business

7.3.34 Table 36 presents the results of business mode choice models with and without the day trip term.

Table 36. Business Mode Choice Results, With and Without Day Trip

File	HS2_BUS_V41.F12		HS2_BUS_V43.F12	
Converged	True		True	
Observations	4653		4653	
Final log (L)	-1824.4		-1824.1	
D.O.F.	10		10	
Rho²(0)	0.504		0.504	
Rho²(c)	0.207		0.207	
Estimated	5 Mar 13		5 Mar 13	
Scaling	1.0000		1.0000	
Rail_0205	0.3631	(1.7)	0.08997	(0.5)
Rail_0610	0.8106	(3.8)	0.5090	(2.7)
Air_0205	-0.6382	(-2.6)	-0.6160	(-2.6)
Air_0610	-0.9267	(-3.6)	-0.9177	(-3.7)
gt2cars	0	(*)	0	(*)
car_male	0.8915	(5.6)	0.8124	(5.5)
car_ptwrk	-0.3785	(-1.7)	-0.3337	(-1.6)
RL_gt2cars	-0.6071	(-4.7)	-0.5609	(-4.6)
GENTime	-0.00616	(-10.7)	-0.00606	(-10.5)
Crdsb1	-2.298	(-7.8)	-2.363	(-7.9)
TR_M_PT	0.7992	(9.3)	0.8731	(9.0)

7.3.35 The terms in the Business mode choice model are defined in Table 37.

Table 37. Business Mode Choice Model Parameter Definitions

DEFINITION	DESCRIPTION
Crdsb1	Distance term on car for one-way distances of 100 miles and above, introduced gradually from 100 to 150 miles, then constant after using function: min(1,max(0,(dist-100)/50))
Rail_0205	Alternative specific constant on rail, 2002-2005 records (2002-2005 car is the base mode)
Rail_0610	Alternative specific constant on rail, 2006-2010 records (2006-2010 car is the base mode)
Air_0205	Alternative specific constant on air, 2002-2005 records (2002-2005 car is the base mode)
Air_0610	Alternative specific constant on air, 2006-2010 records (2006-2010 car is the base mode)
Car_male	Higher probability of men choosing to make LD tours by car
Car_ptwkr	Part-time workers less likely to choose car
RL_ge2cars	Individuals from households with 2 or more cars more likely to choose rail
GenTime	Sensitivity to generalised time for return tour
TR_M_PT	PT nest parameter which defines the relative sensitivity of the car versus PT and rail versus air choices

7.3.36 The impact of dropping the day trip term on model fit is very slight, with the model fit increasing by just 0.3 log-likelihood units[18].

7.3.37 The rail mode constants reduce in magnitude when the day trip is removed; when the day trip term was included larger positive constants were required to explain the rail mode shares. There is a slight reduction in the GenTime parameter which defines the sensitivity of the rail versus air choice; however the PT nest parameter increases

[18] For more information on maximum likelihood see Section 8.4 'Modelling Transport' Ortuzar and Willumsen

noticeably in magnitude from 0.799 to 0.873. This change would be expected to reduce the cross elasticities for air demand in respond to changes in rail generalised time.

7.3.38 To assess the impact of these parameter changes on model elasticity, rail in-vehicle time (IVT) elasticities have been calculated for models v41 and v43. In order to generate these elasticities, frequency models have been estimated using mode choice logsums from models v41 and v43. Table 38 summarises the impact on the rail in-vehicle time elasticities that result from a 10% increase in rail in-vehicle times. It is noted however that when the rail IVT change is applied in model v41, no change is made to the day trip factor because the day trip factor is calculated in the Station Choice model based on in-vehicle times without the 10% IVT increase.

Table 38. Changes to Business Rail IVT elasticities (based on estimated models)

MODE	MODEL V41 WITH DAY TRIP	MODEL V43 NO DAY TRIP
Rail	-1.137	-1.186
Car	0.091	0.096
Air	0.384	0.339
Total	-0.075	-0.080

7.3.39 Dropping the day trip term has resulted in a small increase in the direct elasticity for rail trips, and the cross-elasticity for car trips. However, as expected the cross-elasticity for air trips has reduced. As noted earlier, the elasticities for models v41 are likely to under-estimate the true values because no change to the day trip effect could be made. With the day trip factor applied, the v41 rail elasticities may be higher than those for model v43 with the day trip factor omitted.

7.3.40 When the rail IVT elasticity tests were undertaken in PFM, the elasticities for the model parameters with day trip factor were indeed higher due to the additional response that comes about because of the day trip factor. As a result, the overall elasticities with day trip included were slightly higher than the elasticities with day trip omitted, with trip elasticities for all rail trips greater than 50 miles in length of -1.128 with day trip, and -1.070 without day trip.

Leisure

7.3.41 Table 39 compares results from Leisure mode choice models estimated with and without the day trip term.

Table 39. Impact of Dropping Day Trip Term on Leisure Mode Choice Models

	With day trip		Without day trip	
File	HS2_VFO_V70.F12		HS2_VFO_V73.F12	
Converged	True		True	
Observations	12742		12742	
Final log (L)	-2630.3		-2624.7	
D.O.F.	9		9	
$Rho^2(0)$	0.690		0.691	
$Rho^2(c)$	0.105		0.107	
Estimated	4 Mar 13		5 Mar 13	
Scaling	1.0000		1.0000	
Crdsb1	-1.265	(-6.8)	-1.534	(-8.0)
Crdsb2	-1.068	(-5.5)	-1.119	(-5.8)
Rail_0205	-1.392	(-7.7)	-1.640	(-9.7)
Rail_0610	-1.176	(-6.1)	-1.424	(-7.8)
Air_0205	-2.399	(-10.2)	-2.651	(-11.7)
Air_0610	-2.378	(-9.1)	-2.634	(-10.4)
RL_male	-0.5195	(-4.8)	-0.5191	(-4.7)
ge2cars	0.3967	(3.7)	0.3958	(3.7)
GenTime	-0.00404	(-16.2)	-0.00414	(-16.3)
TR_M_PT	0.7179	(*)	0.7179	(*)

7.3.42 The terms in the Leisure mode choice models are defined in Table 40.

Table 40. Leisure Mode Choice Model Parameter Definitions

DEFINITION	DESCRIPTION
Crdsb1	Distance term on car for one-way distances of 100 miles and above, introduced gradually from 100 to 150 miles, then constant after using function: min(1,max(0,(dist-100)/50))
Crdsb2	Distance term on car for one way distance of 150 miles and above, introduced gradually from 150 to 200 miles, then constant after using function: min(1,max(0,(dist-150)/50))
Rail_0205	Alternative specific constant on rail, 2002-2005 records (2002-2005 car is the base mode)
Rail_0610	Alternative specific constant on rail, 2006-2010 records (2006-2010 car is the base mode)
Air_0205	Alternative specific constant on air, 2002-2005 records (2002-2005 car is the base mode)
Air_0610	Alternative specific constant on air, 2006-2010 records (2006-2010 car is the base mode)
RL_male	Term reflecting lower probability of males choosing rail
ge2cars	Individuals from households with 2 or more cars more likely to choose car
GenTime	Sensitivity to generalised time for return tour
TR_M_PT	PT nest parameter which defines the relative sensitivity of the car versus PT and rail versus air choices (constrained to the value identified from analysis of the SP data)

7.3.43 Comparing models v70 and v73, there is small increase in model fit of 5.6 log-likelihood units when the day trip term is dropped. This is, therefore, an improvement in model fit. When the day trip term is removed, the Crdsbd1 constant on car increases in significance and magnitude. This term was added to reflect the additional disutility of car for journeys with one-way distances of 100 miles and above, and without the day trip term a larger constant is required to explain the variation in mode share with distance.

7.3.44 Dropping the day trip term results in a 2.5% increase in the sensitivity of the GenTime parameter which defines the sensitivity of the rail versus air choice. As the PT nest parameter TR_M_PT is fixed in this model, the sensitivity of the car versus PT choice also increases by 2.5% when the day trip term is dropped.

7.3.45 To assess the impact of these parameter changes on model elasticity, rail in-vehicle time elasticities have been calculated for models v70 and v73. In order to generate these elasticities, frequency models have been estimated using mode choice logsums from models v70 and v73. Table 41 summarises the impact on the rail in-vehicle time elasticities that result from a 10% increase in rail in-vehicle times. It is noted however that when the rail IVT change is applied in model v70, no change is made to the day trip factor because the day trip factor is calculated in the Station Choice model using in-vehicle times without the 10% IVT increase.

Table 41. Changes to Leisure Rail IVT Trip Elasticities (based on estimated models)

MODE	MODEL V70 WITH DAY TRIP	MODEL V73 NO DAY TRIP
Rail	-0.760	-0.777
Car	0.019	0.018
Air	0.326	0.327
Total	-0.069	-0.071

7.3.46 As expected, the direct rail elasticities increase slightly when the day trip term is dropped, consistent with the small increase in model sensitivity. However, very slight decreases in the cross-elasticities to car are observed when the day trip term is dropped. As noted earlier, the elasticities for model v70 are likely to be under-estimates of the true values because they do not incorporate the changes to the day trip term that result from the 10% increase in rail IVT.

7.3.47 When the rail IVT elasticity tests were run in the PFM model for the two sets of model parameters, the impact of the rail IVT change on the day trip factor was taken into account, and the direct elasticities with day trip included were slightly higher than those for the model parameters without day trip, with trip elasticities for all rail trips greater than 50 miles in length of -0.627 with day trip and -0.611 without day trip.

Summary

7.3.48 The day trip factor was identified from analysis of the LDM SP data for business and leisure. The day trip factor represents a perceived disbenefit for journeys where the return trip cannot be undertaken in a day (or a benefit when the journey can be made in a day). The day trip factors were highly significant for business and leisure, and an important finding from the SP analysis was that if the day trip factors were omitted, the data indicated that constants should be included to represent the advantage of HSR over classic rail.

7.3.49 The day trip factor was tested in the mode choice models by expressing the effect as minutes of additional generalised time for longer journeys. There is no improvement in the fit of the mode choice models to the mode choices observed in the 2002-2010 NTS data when the day trip factor is included, and in fact for leisure the model fit is slightly worse when the term is included.

7.3.50 The rail in-vehicle time elasticities are slightly higher when the day trip factor is included, but the differences in the values with and without the day trip term are small.

7.3.51 Analysis of the impact on the day trip term on the Station Choice model also demonstrated a relatively small impact, with only small differences in the origin and destination station shares for selected PLD origin and destination zone pairs (see Appendix F).

7.3.52 Overall, it was judged that there was insufficient evidence to implement the day trip term in PFM v4.3.

7.4 Final Demand Model Parameters and Elasticities

7.4.1 In summary, the final demand models:

- incorporate cost damping on the monetary cost element of generalised time, with damping taken from WebTAG Unit 3.10.2 for commute and leisure, and with VOTs taken from analysis of the SP data with a distance elasticity of 0.36 for business;
- do not include any income segmentation;
- for leisure, incorporate modifications to the relative sensitivities of the different choices to ensure the cross-elasticities in the model are more consistent with the benchmarking evidence (detailed in section 10.5); and
- do not include the day trip term.

7.4.2 The final values for the model parameters are summarised in Table 42, which defines the sensitivities in generalised time minutes for a one-way trip. The associated elasticities resulting from a 10% increase in rail in-vehicle times as based on estimated models are presented in Table 43.

Table 42. Final Demand Model Parameter Values

CHOICE	COMMUTE	BUSINESS	LEISURE
Lambdas (sensitivity to generalised time in minutes, for a one-way trip)			
Frequency	-0.0056	-0.0054	-0.0036
Car vs. PT	-0.0098	-0.0106	-0.0059
Rail vs. air		-0.0121	-0.0083
Thetas (relative sensitivity of lambdas)			
θ_{F_M}	0.57	0.51	0.60
θ_{M_PTM}		0.88	0.71

Table 43. IVT Trip Elasticities (Based on Estimated Model)

MODE	COMMUTE	BUSINESS	LEISURE
Rail	-0.727	-1.186	-0.777
Car	0.021	0.096	0.018
Air		0.339	0.327
Total	-0.076	-0.080	-0.071

7.4.3 Tables 44 to 46 present more detail for other elasticity tests, specifically by distinguishing the relative contributions of frequency and mode choice responses to the overall elasticities The frequency response may be larger than the pure mode choice response. For example, the fuel cost kilometrage elasticity for commute is −0.048 with pure mode choice only, but −0.258 with mode choice and frequency responses combined. The frequency response will partly proxy for destination choice effects. The overall pattern observed is that for the fuel cost and car time tests that impact on car, which has the largest mode share, the frequency response is larger than the pure mode choice response, whereas for the rail fare and rail in-vehicle time tests most of the response is a pure mode choice response.

Table 44. Commute Elasticities, Mode Choice and Frequency Kilometrage Effects

ELASTICITY TEST	MODE	PURE MODE CHOICE ELASTICITY	TOTAL ELASTICITY (MODE CHOICE & FREQUENCY)	CONTRIBUTION FROM FREQUENCY
Fuel cost	Car	-0.048	-0.258	82%
Car time	Car	-0.139	-0.686	80%
Rail fare	Rail	-0.419	-0.532	21%
Rail in-vehicle time	Rail	-0.658	-0.844	22%

7.4.4 For the two elasticity tests applied to car, the frequency response is the dominant effect. However, for the two rail elasticity tests the pure mode choice response dominates.

Table 45. Business Elasticities, Mode Choice and Frequency Kilometrage Effects

ELASTICITY TEST	MODE	PURE MODE CHOICE ELASTICITY	TOTAL ELASTICITY (MODE CHOICE & FREQUENCY)	CONTRIBUTION FROM FREQUENCY
Fuel cost	Car	-0.047	-0.125	62%
Car time	Car	-0.429	-1.033	58%
Rail fare	Rail	-0.382	-0.480	20%
Rail in-vehicle time	Rail	-1.158	-1.387	17%

7.4.5 As per commute, for the two elasticity tests applied to car the frequency response is the larger effect, whereas for the two rail elasticity tests the pure mode choice response dominates.

Table 46. Leisure Elasticities, Mode Choice and Frequency Kilometrage Effects

ELASTICITY TEST	MODE	PURE MODE CHOICE ELASTICITY	TOTAL ELASTICITY (MODE CHOICE & FREQUENCY)	CONTRIBUTION FROM FREQUENCY
Fuel cost	Car	-0.030	-0.156	81%
Car time	Car	-0.143	-0.660	78%
Rail fare	Rail	-0.424	-0.793	47%
Rail in-vehicle time	Rail	-0.529	-0.983	47%

7.4.6 For the two elasticity tests applied to car, the frequency response is the dominant effect. However, for the two rail tests the mode choice and frequency responses are approximately equal.

7.5 Frequency Model Parameters

7.5.1 The frequency model parameters in Table 44 (θ_{F_M}) are a key output from the model estimation process, as they quantify induced travel demand from improved infrastructure (through the logsum term). It is emphasised that induced travel effects for a given OD-pair include additional travel demand because of changes in destinations as a result of the new infrastructure as well as additional travel.

7.5.2 For commute and business travel, the frequency model parameters in the final models have been directly estimated from National Travel Survey data. For leisure travel, realism tests based on the Y-network suggested that the estimated parameter values led to forecasts with unreasonably low abstraction levels from car and air and unreasonably high generation levels. Therefore, additional tests were undertaken constraining the frequency parameter to a series of values from 0.5 through 0.7. It was judged that the values below 0.6 could not be justified because of loss of model fit. Also, the PT nest parameter was fixed to the estimate obtained from the SP modelling because the SP data contained more information on rail-air trading. The car and air cross-elasticities for the revised model in response to changes in rail in-vehicle time were judged to be reasonable and the revised models were judged to return more plausible results in the realism tests. Thus these constrained parameters were used in the final model specification.

7.5.3 Tests have been made for a forecast with the new PFM demand model parameters for 2043, assuming the Y-network. The results have been compared to an equivalent forecast using the old demand model parameters, but the same level-of-service and base matrix information. A comparison of these two forecasts shows that the new model gives:

- Lower abstraction from car and air; and
- Higher generation for all purposes.

7.5.4 Examination of market share between rail and air, for different rail journey time bands indicated that the sensitivity of the rail/air mode share to rail journey time for the new model was appropriate.

7.5.5 Examination of the predicted car abstraction levels in Table 46 indicated that for commute and business travel abstraction levels were much more in line with benchmarks (see section 10.6), although the abstraction values for leisure travel were judged to be somewhat low leading to lower levels of abstraction from car.

Table 47. Car Abstraction Rates for PFM v3.0 and PFM v4.3

PURPOSE	PFM V3.0	PFM V4.3
Commuting	40%	22%
Business	24%	15%
Leisure	18%	7.5%

7.5.6 The proportion of induced travel demand for the new models is higher for all purposes, but this is what is necessary for demand to correspond to known rail time elasticities and when the likely switching from car and air is judged to be small (small for car because of benchmarks from other places and small for air because of the relatively small air market). When comparing induced demand as a proportion of induced demand plus that abstracted from car (Table 48), i.e. excluding air on the basis that the air market in the Y-network is small, the level of demand look similar to benchmarks.

Table 48. Induced demand proportions

PURPOSE	PFM V4.3	BENCHMARK
Commuting	78%	67% - 89%
Business	75%	
Leisure	87%	

7.6 Implementation Within PFM v4.3

7.6.1 Apart from the change in parameter values resulting from the model re-estimation the key changes to the demand model in PFM v4.3 are that it now works in generalised time (minutes), operates in units of pence and in a 2010/2011 price base whereas PFM v3.0

operated in a 2002 prices base. There have been a number of other more minor changes, including a change in the way cost damping is represented in the model.

7.6.2 To incorporate the re-estimated demand model within PFM the following modifications were required:

- Rebase the demand model to operate in a 2010/2011 price base;
- Incorporate revised demand model parameters (lambdas);
- Introduce Value of Time calculations;
- Modify calculation of car vehicle operating costs;
- Modify generalised costs equations for each mode, including importing rail composite generalised costs from the SCM;
- Add in new demand segment (business NCA); and
- Modify cost damping to be based on change in values of time by distance.

7.6.3 Each of the steps is discussed in turn; Appendix H details the macros that are modified to implement these changes.

Price Base Adjustments

7.6.4 Prior to the re-estimation of the demand model PFM v4.3 worked in a 2002 price base. The re-estimated demand model works in a 2010/11 price base and works in units of generalised time (minutes). Note both models work in modelled year values. Incorporating the re-estimated demand model meant that all of the variables provided as inputs to the PFM as monetary values needed to be modified so that they were in 2010/11 prices.

7.6.5 The following data is included in PFM in monetary terms:

- Values of time;
- Rail fares;
- Highway vehicle operating costs; and
- Air fares.

7.6.6 In addition, a number of indices and factors are included in PFM to calculate real changes in parameters over time and to change the cost base of some parameters. Factors include:

- Value of time growth index;
- Rail fare growth index; and
- Price base deflator 2010/2011 to 2002 and 2008.

7.6.7 Values of Time - In the re-estimated base year demand model 2010/2011 values of time are input into the model. In forecasting an index is used to convert from the base year values to forecast year values. The macro that applies this index has been amended so it factored from a 2010/2011 base instead of a 2002 base.

7.6.8 Rail fares - Rail fares are provided as an input to the model, they are input in 2010/2011 values and prices. In PFM v4.3, during a model run they are converted to a 2002 price base. As the revised demand model operates in 2010/2011 prices there is no need to convert to a 2002 price base and this conversion is removed from the macros.

7.6.9 Highway vehicle operating costs - In PFM v3.0 highway vehicle operating costs were calculated in 2002 process and values. There was no further adjustment to these costs to reflect modelled year values. In updating the model to a 2010/2011 price base, the calculation of vehicle operating costs has been modified to rebase costs. In addition the process has been revised so that the real changes in vehicle operating costs are reflected in the model and the calculations reflect the latest version of WebTAG (October 2012).

7.6.10 Air Fares - There are no indices in PFM to represent the real terms increase in air fares. Air fares are provided in modelled year values and 2008 prices. Prior to input into the PFM, they are converted to the appropriate price base.

Inclusion of New Demand Model Parameters

7.6.11 The re-estimation of the demand model resulted in a revised set of Lambda values. The new demand models work in generalised time minutes, rather than in costs in pence, and therefore the lambda sensitivity values have units of 1/min rather than 1/pence. The lambda values are specified in trip units.

Calculation of Values of Time

7.6.12 The previous demand model worked in monetary costs (pence). Values of time are primarily used to convert the time elements of a journey e.g. in vehicle time or wait time into a monetary cost. Values of time are input by mode, journey purpose and journey element.

7.6.13 In the re-estimated demand model, as the demand models works in units of minutes, value of time are used to convert monetary items into time. Values of time are purpose specific but the same values apply to all modes.

7.6.14 In the previous demand model cost damping was included in the demand model calculations using a distance based function. In the re-estimated demand model the demand models for all purposes use values of time (VOTs) that vary as a function of distance. Higher VOTs are calculated for higher distances, and this increase works to dampen the contribution of monetary costs when they are converted into generalised time units in minutes.

Commute and Leisure

7.6.15 The cost damping relationship used for commute and other travel has been taken from WebTAG Unit 3.10.2, Modelling Road Pricing (February 2007, Consultation Status). Appendix A.3 of Unit 3.10.2 gives the following formulation for the calculation of VOTs in p/min:

$$VoT = 1.280 * G^{0.8}\ Z \left[\frac{\beta_t}{\beta_c}\right] \left(\frac{Inc}{Inc_0}\right)^{\eta_{inc}} \left(\frac{D}{D_0}\right)^{\eta_c}$$

where:

1.280 is a factor to account for real terms growth in GDP between 1994 and 2010

G is the real growth in GDP/capita relative to 2010, and 0.8 is the recommended elasticity of VOT to GDP/capita for non-work travel

Z is a correction for inflation between 1994 and the year in which the local data is collected, given by the RPI in the relevant year divided by the same equivalent value for 1994

D is the one-way trip distance in miles.

7.6.16 Table 49 summarises the inflation values used to implement this formula for this work. In this work, all costs have been calculated in 2010/11 UK financial year prices and so the inflation factors were defined on that basis.

Table 49. Inflation Factors[19]

YEAR	RPI (CHAW INDEX)	K
1994	144.1	1.000
2010/11	226.5	1.572

[19] Source: Table 20, Annual Average Consumer Price Indices, May 2012, Office for National Statistics. Downloaded from: http://www.ons.gov.uk/ons/index.html, June 2012.

7.6.17 The remaining parameters in the VoT formula are defined in Table 50.

Table 50. Value of Time Function Parameters[20]

PARAMETER	COMMUTING	OTHER
β_t (time coefficient)	-0.10098	-0.082918
β_c (cost (distance) coefficient)	-0.024729	-0.022275
Inc_0	35 x K	35 x K
D_0	7.58	7.58
η_{inc} (income elasticity)	0.358773	0.156806
η_c (cost (distance) elasticity)	0.421305	0.314727

7.6.18 Distances are expressed in miles, incomes in thousands of pounds. The average incomes in 2010/11 prices are £60.091k for commute and £45.583k for other travel. These are an overall average income across the LD tour records for the model purpose from the NTS dataset.

Business

7.6.19 The calculation of Business values of time is:

$$VOT = G.1.054 \frac{\beta_{IVT}}{\beta_{cost} D^{\alpha}}$$

Where:

G is the real growth in GDP/capita relative to 2010

1.054 is a factor to convert the SP VOTs into 2010/11 prices

β_{IVT} is the in-vehicle time parameter (utils/min)

β_{cost} is the cost parameter (utils/pence)

D is the one-way distance in miles (from the highway network)

α is the distance elasticity, fixed to -0.36

[20] Table A3, WebTAG Unit 3.10.2 (February 2013)

7.6.20 The values for the cost and in-vehicle time parameters are summarised in Table 51

Table 51. Business VOT Parameters

PARAMETER	VALUE
β_{IVT}	-0.00638
β_{cost}	-0.00073

Car Vehicle Operating Cost Calculations

7.6.21 In PFM v3.0 car vehicle operating costs were calculated based on Transport Economics Note (TEN)[21]. This is in 2002 values and prices. It is calculated by applying the vehicle operating cost equations for both fuel and non-fuel costs to each individual origin-destination. In future years these values were not uprated ie there is no real change in vehicle operating costs over time.

7.6.22 In rebasing the model to 2010/2011 prices the calculation of vehicle operating costs has been updated so that they are consistent with WebTAG 3.5.6.

7.6.23 In model estimation, car costs have been calculated following the procedure set out in WebTAG 3.5.6 (October 2012).

7.6.24 Implementing the detailed procedure from WebTAG within the PFM would require significant additional coding in EMME. So for each base and forecast year a single average speed across the network (separately for each journey purpose) has been calculated as a demand weighted average over OD pairs. Using these average speed values, together with the advice given in WebTAG 3.5.6 for forecasting changes in car costs over time, and forecasts of changes in party size over time available from the LDM work[22], an overall average car cost per kilometre values (on a per-person basis) has been calculated. This unit cost (pence per kilometre) representing both fuel and non-fuel costs is applied to the distance skim matrix from the PFM highway assignment. Different unit costs are applied by purpose and year. The vehicle operating cost values for each forecast year are shown in Table 52. The perceived cost of non-fuel VOCs differs for work and non-work time. In work time (business), the perceived costs include non-fuel VOCs whereas in non-work time non-fuel VOCs are excluded. This results in higher VOCs for work compared to non-work purposes.

[21] Transport Economics Note (TEN); Highways Economics and Traffic Appraisal Division of the Department of Environment and Transport for the Regions

[22] The LDM analysis investigated relationships between party size and household size, allowing future party sizes to be forecast as a function of future household sizes. As might be expected, no significant relationship was established for commute and business purposes and therefore party sizes are assumed to remain constant over time for these purposes. However, a relationship was identified for leisure and therefore a small decline in party sizes is assumed over time as a result of decreases in mean household size.

Table 52. Overall Vehicle Operating Costs 2010/11 prices

PURPOSE	OVERALL VEHICLE OPERATING COSTS (PENCE / KILOMETRE)			
	2010	2026	2036	2043
Commute	10.719	9.271	8.863	8.894
Other travel	10.726	9.279	8.870	8.901
Business	12.504	11.130	10.758	10.784

Update of Generalised Cost Calculations

7.6.25 All generalised cost calculations have been updated to reflect the following changes: the change from generalised cost to generalised time, revised values of time, cost dampening and any changes to the definition of generalised cost elements and their weightings.

Rail Generalised Time Calculations

7.6.26 The rail generalised time calculation is: for a one way trip.

$$GT_{Rail} = GTJ_{logsum} + \frac{Fare}{VOT(d)}$$

Where:

$GJTCAE_{logsum}$ is the overall GJTC logsum that is provided by the station choice model (minutes)

Fare is the rail fare in 2010/11 prices (pence)

VOT(d) is the VOT for the OD pair with one-way distance

7.6.27 Rail generalised costs are passed into the demand model as composite costs from the SCM - previously individual generalised cost elements were passed into the demand model.

7.6.28 The GJTC logsum includes a contribution from access and egress costs converted into generalised minutes.

Car Generalised Time Calculations

7.6.29 The car generalised time calculations for a one-way trip are made as follows:

$$GT_{Car} = Car\_IVT + \frac{car\_cost}{VOT(d)}$$

Where:

Car_IVT is the car time (minutes)

Car_Cost is the total car cost (fuel plus non-fuel elements)

VOT(d) is the is the VOT for the OD pair with one-way distance in miles *d*, calculated using the formulae given above (p/min)

Air Generalised Time Calculations

7.6.30 The calculations for air are only made for business and other travel, as air is not modelled for commute. The air generalised time calculation is as follows:

$$GT_{Airl} = Air\_IVT + Air\_Wait + 2 * Air\_aceg + \frac{Fare}{VOT(d)}$$

Where:

Air_IVT is the air in-vehicle time (minutes)

Air_Wait is the air wait time (0.4 * headway) (minutes)

Air_aceg is the access/egress time (minutes)

Fare is the air fare in 2010/11 prices (p)

VOT(d) is the VOT for the OD pair with one-way distance in miles *d*, calculated using the formulae given above (p/min)

7.7 Updates to Heathrow Access Model

7.7.1 As part of the development of PFM v4.3 the calculation of vehicle operating costs has been modified so that it is consistent with WebTAG 3.5.6, and in the process vehicle operating costs are now calculated in pence, as opposed to pounds. Since Vehicle operating costs in pounds are one of the inputs to the HAM, an adjustment has been made so that during a run of the HAM the vehicle operating cost inputs are converted from pence to pounds.

7.7.2 The HAM in the future year version of PFM requires as an input base year costs for all modes. As there have been a number of changes to the base year model including a change to the units for vehicle operating units, new base year costs inputs for all modes have been generated and passed over to the future year model.

8. IMPROVED INTEGRATION BETWEEN PLD AND PS

8.1 Introduction

8.1.1 A representation of long distance demand is required in all the regional PLANETS, and similarly a representation of local demand is required in PLD so that crowding is properly reflected. In most instances this is achieved by passing preloads between the models, however from PLD to PS long distance demand is passed in the form of select link matrices carried out on links where the PLD and PS networks overlap, and in the Do Something scenario this includes the HS2 link. Wormhole factors are used to convert the all-day long distance demand modelled in PLD to equivalent 3-hr AM Peak flow in PS. These factors are applied to all the terms in the select link matrices.

8.1.2 Analysis to date suggests that these factors have a significant impact on AM Peak demand in PS, in particular demand into London stations resulting from the introduction of HS2.

8.1.3 This chapter provides an overview of the process and the change in methodology for PFM v4.3.

8.2 Overview of the Wormhole Process in PFM v3.0

8.2.1 Figure 8 depicts the location of the PS cordon. All rail trips wholly within the cordon (ie south of the blue line) are represented on a matrix basis within PS; these matrices do not include any trips crossing the boundary . Cross boundary trips are modelled in PLD and are passed to PS as a series of matrices representing individual routes so the impact on crowding can be represented. This approach ensures the relative strengths of each separate model are exploited. As 16 hour demand from PLD has to be represented in PS which is an AM peak period model, an appropriate set of conversion factors are required.

Figure 8. PLANET South Cordon

8.2.2 These factors are applied by direction (but not purpose) for each cordon crossing point.

8.2.3 Factors are calculated by comparing long distance demand assigned within PS with long distance demand assigned within PLD. This process is only undertaken for the base year (2010/11), and requires the assignment of a full PS demand matrix (ie before masking to remove flows that cross the PLD-PS cordon). The same factors are applied in all forecast years and scenarios. For the HS2 wormhole in PFM v3.0, a factor of 0.4 was applied into London and a factor of 0.125 out of London, the source of these factors is unknown.

8.2.4 There are a number of potential weaknesses with the v3.0 approach:

- The factors are calculated using link flow data from assignment of a full (ie prior to masking) PS demand matrix. However, this full PS matrix is not included in the HS2 validation process, as the long-distance demand is removed from the PS matrices before application in the HS2 modelling framework. Therefore the calculation of the factors is based on a PS matrix that has not been fully validated and there is a concern that these long distance flows may not have been derived accurately during the PS matrix build;
- The use of a single factor for each cordon link does not take into account the variation in the composition of trips between AM peak and all-day, particularly in relation to journey purpose and trip length distribution;
- Factors are only calculated for the base year, and it may not be reasonable to assume that the factors would remain constant over time. This is of particular importance in the Do Something scenario, where the majority of long-distance trips from the north will transfer to HS2, so by implication the all-day to AM peak factors on the WCML, ECML and to a lesser extent the MML will change as the average journey length of trips crossing the cordon could change significantly;

- Factors applied to HS2 flows have not changed since the initial HS2 modelling framework was developed. There is no clear evidence base and record of assumptions used to derive these factors. Indeed, the factor of 0.4 for in-bound flows is significantly larger than all comparable classic flows; and
- Consideration is needed as to what effects are being captured by the factors adopted and their consistency with other general model assumptions e.g. no land use changes.

8.3 Methodology for PFM v4.3

8.3.1 As there was a general consensus that the wormhole factor process would benefit from further improvement, a number of potential alternative approaches were considered in order to achieve this aim. After careful consideration, it was decided that MOIRA2 demand profiles[23], which were defined by departure time, offered the best option available to derive all-day to AM Peak 3-hour conversion factors within the limits of existing data. Use of MOIRA2 demand profiles offers a number of advantages over the PFM v3.0 methodology:

- It allows a consistent approach to be applied to classic rail and HS2 demand. Previously factors for classic rail were derived from the base year model (as described above) and therefore updated if base year demand changed , whereas factors for HS2 were fixed values which have remained unchanged over time;
- It enables factors to vary by year and scenario in line with the change in the composition of demand by purpose and journey length at each cordon point ;
- It takes independent, calibrated demand profiles as an input, from a standard rail industry data source;
- It moves away from a reliance on the accurate representation of long-distance rail trips within PLANET South - trips that fall outside of the overall HS2 validation process; and
- A fixed set of purpose and journey time band based inputs enables factors to be applied at an OD level within each select link matrix, rather than a single factor being applied to all OD pairs within each select link matrix. It also facilitates the automatic application of factors for each model run, rather than relying on one set of manually input factors calculated externally.

8.3.2 MOIRA2 splits demand into 240 different segments, with each segment allocated a weekday demand profile that apportions weekday daily demand to 15 minute time slices, based upon desired departure times. The 240 segments consist of:

- 3 journey purposes (business, commute, leisure);
- 5 flow categories (To London, From London, To Blue[24], From Blue, Other);
- 2 journey legs (Outward, Return); and

[23] Although there are concerns regarding the modelling process within MOIRA2, the data on demand profiles are considered the most up to date and robust

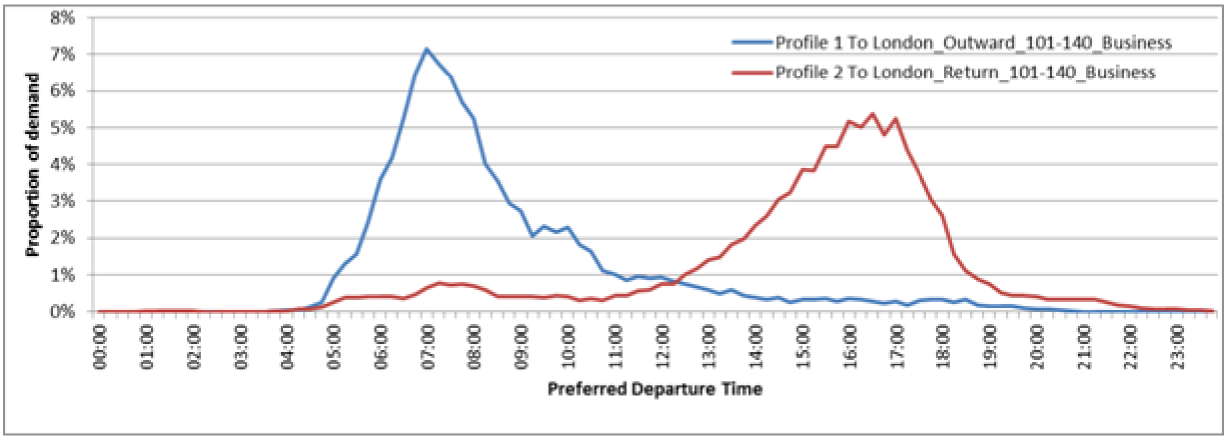
[24] In MOIRA, 'Blue' refers to a major commuting destination station excluding London

- 8 journey time bands (0-20, 21-50, 51-100,101-140, 141-180, 181-270, 271-360 and 361-999 minutes).

8.3.3 It should be noted that journey time in MOIRA2 reflects IVT and interchange time based on timetabled departures and thus connection times, but excludes initial wait time.

8.3.4 Figure 9 shows two MOIRA2 demand profiles. These profiles are for a 'To London', business trip which falls within the 101-140 minute journey time band. There are separate profiles for the outward and return legs of the journey as the desired departure times will obviously differ by leg. For the outward leg, demand is strongest in the AM peak with a peak departure time around 07:00 (meaning a peak arrival time in London 101-140 minutes later, or roughly 09:00). For the return leg, peak departure time is between 15:00 and 17:00.

Figure 9. Example MOIRA2 Demand Profiles



8.3.5 It is possible, with certain assumptions, to segment the PLD station-station select link matrices in a manner which is consistent with the segmentation used in MOIRA2, thereby allowing MOIRA2 profiles to be used to create all-day to AM peak 3-hour factors for use in the Wormhole process. Table 53 details how different MOIRA2 segments are applied in PLD.

8.3.6 A further assumption is required to translate the profile departure times to a PS consistent AM peak 3-hour, to enable the calculation of all-day to 3-hour factors. Using the Manchester-London example, from the MOIRA2 profiles, the proportion of demand arriving at Euston in the AM peak 3-hours is a function of the departure time and the journey time. An offset is required to translate the profile departure time (in this case at Manchester) with the arrival time in the PLANET South area at Euston. The journey time for Manchester to London Euston falls within the 101-140 minute journey time band, so the AM-peak 3-hour demand is calculated using the 101-140 minute demand profile with the departure time offset by 120 minutes to calculate the factor (120 minutes is the centre of the journey time band). This offset is only required for trips to London; for trips from London, the departure time requires no offset.

8.3.7 At this stage, offsets have only been applied for London trips, as the logic is fairly straightforward to implement. The calculation becomes more complicated when considering non-London trips that cross the PLD/PS boundary, such as Manchester-Reading, Leeds-Brighton or Northampton-Milton Keynes. Emphasis has been placed on London trips as they are most critical to the modelling and account for a high proportion of the total demand in the core areas of interest.

8.3.8 All OD pairs in PLD are allocated to a MOIRA2 profile based on their journey time band, journey purpose and flow category. Taking into account the offset, a conversion factor is allocated from the MOIRA2 profiles to each OD pair. These factors can then be applied within the wormhole process for each model run and scenario. By using existing data we are making the assumption that demand profiles will remain constant over time. As this is the only source available and there is no information on how demand profiles may change over time, this seems a reasonable assumption to make. Table 53 shows the final set of 16-hr to 3-hr AM Peak factors associated with MOIRA2 demand profiles.

Table 53. 16-hr to 3-hr AM peak factors based on MOIRA2 Demand Profiles

TRIP FLOW CATEGORY TRIP LEG TYPE TRIP PURPOSE	TIME BANDS (MINUTES)							
	1-20	21-50	51-100	101-140	141-180	181-270	271-360	361-999
Blue_Outward_Business	0.42	0.50	0.55	0.52	0.45	0.42	0.24	0.32
Blue_Outward_Commuting	0.65	0.67	0.64	0.49	0.45	0.42	0.24	0.32
Blue_Outward_Leisure	0.21	0.25	0.33	0.37	0.34	0.34	0.24	0.32
Blue_Return_Business	0.07	0.06	0.05	0.07	0.07	0.06	0.24	0.32

TRIP FLOW CATEGORY TRIP LEG TYPE TRIP PURPOSE	TIME BANDS (MINUTES)							
	1-20	21-50	51-100	101-140	141-180	181-270	271-360	361-999
Blue_Return_Commuting	0.07	0.08	0.06	0.06	0.07	0.06	0.24	0.32
Blue_Return_Leisure	0.05	0.04	0.07	0.06	0.10	0.12	0.24	0.32
From London_Outward_Business	0.42	0.50	0.55	0.52	0.45	0.42	0.24	0.32
From London_Outward_Commuting	0.65	0.67	0.64	0.49	0.45	0.42	0.24	0.32
From London_Outward_Leisure	0.21	0.25	0.33	0.37	0.34	0.34	0.24	0.32
From London_Return_Business	0.03	0.03	0.03	0.02	0.07	0.06	0.24	0.32
From London_Return_Commuting	0.02	0.02	0.01	0.01	0.07	0.06	0.24	0.32
From London_Return_Leisure	0.02	0.04	0.05	0.04	0.10	0.12	0.24	0.32
Other_Outward_Business	0.42	0.50	0.55	0.52	0.45	0.42	0.24	0.32
Other_Outward_Commuting	0.65	0.67	0.64	0.49	0.45	0.42	0.24	0.32
Other_Outward_Leisure	0.21	0.25	0.33	0.37	0.34	0.34	0.24	0.32
Other_Return_Business	0.07	0.06	0.05	0.07	0.07	0.06	0.24	0.32
Other_Return_Commuting	0.07	0.08	0.06	0.06	0.07	0.06	0.24	0.32
Other_Return_Leisure	0.05	0.04	0.07	0.06	0.10	0.12	0.24	0.32
To London_Outward_Business	0.56	0.55	0.55	0.52	0.28	0.08	0.00	0.00
To London_Outward_Commuting	0.81	0.83	0.86	0.75	0.28	0.08	0.00	0.00
To London_Outward_Leisure	0.37	0.28	0.20	0.17	0.08	0.02	0.00	0.00

TRIP FLOW CATEGORY TRIP LEG TYPE TRIP PURPOSE	TIME BANDS (MINUTES)							
	1-20	21-50	51-100	101-140	141-180	181-270	271-360	361-999
To London_Return_Business	0.07	0.06	0.05	0.06	0.03	0.01	0.00	0.00
To London_Return_Commuting	0.07	0.08	0.07	0.07	0.03	0.01	0.00	0.00
To London_Return_Leisure	0.05	0.04	0.05	0.04	0.03	0.00	0.00	0.00

8.4 Implementation of Revised Methodology in PFM v4.3

Application of 16 hr to 3 hr AM Peak Factors

8.4.1 Table 54 details how the appropriate MOIRA2 demand profile is applied to each OD movement.

Table 54. Application of MOIRA2 segments in PLD

MOIRA2 SEGMENT	APPLICATION IN PLD
Journey purpose (Business, Commute, Other)	Direct correspondence, PLD uses the same purpose splits
Flow categories (To London, From London, To Blue, From Blue, Other)	○ flows with Origin end at a London station zone are 'From London' trips: ○ flows with Destination end at a London station zone are 'To London' trips; ○ flows with neither end at a London station zone are 'Blue' trips; and ○ flows with both ends at London station zones are 'London Internal' trips.
Journey leg (outward, return)	○ all 'Car Available-From' flows are making Outward journeys; ○ all 'Car Available-To' flows are making Return journeys; and ○ For 'Non Car Available', it is assumed that flows are mixed with Outward and Return journeys. The proportion of each journey type is calculated from the 'Car Available'

	flows for the same Origin and Destination pair, using the following formulae: • Proportion of Outward Journeys in Non Car Available flows = Car Available-From trips / (Car Available-From trips + Car Available-To trips) • Proportion of Return Journeys in Non Car Available flows = Car Available-To trips / (Car Available-From trips + Car Available-To trips)
Journey time bands	Flows in PLD are allocated to the MOIRA2 journey time bands using PLD IVT and Boarding skims. For trips with an interchange, a 30 minute transfer time penalty is assumed

8.4.2 Based on the journey time for each station to station OD pair together with the flow type, it is possible to define a set of factor matrices by journey purpose and direction (outward or return), using the relevant MOIRA2 demand profile. This process results in a set of six factor matrices, which are:

- Outward_Commuting;
- Outward_Business;
- Outward_Leisure;
- Return_Commuting;
- Return_Business; and
- Return_Leisure.

8.4.3 The model currently uses a fixed set of free flow skim matrices for each year and scenario for to calculate the factor matrices, as it is envisaged that, at the time of writing, there are unlikely to be any major adjustment to the network or services in any subsequent sensitivity tests. Nonetheless, the process can if required be automated within the model run process to yield skims specifically matching the network specification.

Integration of Wormhole Factor Matrices into Model Run

8.4.4 Both of the following processes are applied separately for each wormhole. The process, applied in versions prior to PFM v4.3, involved the following steps:

- Select link analysis to create 9 purpose/car availability matrices;
- Combine individual purpose/car availability matrix into a single matrix;
- Apply a single wormhole factor to above; and
- Export (aggregated to PLD geographic zones) for input to PS.

8.4.5 The integration of wormhole factor matrices in PFM v4.3 has revised the process as below:

- Select link analysis to create 9 purpose/car availability matrices9;
- Factor individual purpose/car availability matrices by 6 purpose/trip type based wormhole factor matrices

- Combine into a single matrix; and
- Export (aggregated to PLD geographic zones) for input to PS.

8.4.6 In addition, the process of generating select link matrices for HS2 was streamlined by removing superfluous select matrix assignment runs -. A further adjustment was made to the code to ensure that all the select link analysis was carried out using a consistent process. Previously some of the resultant assigned volumes from the select link analysis were added to existing assigned volumes whereas other were not. This was a cosmetic change and does not impact on the results.

8.4.7 As the new process uses a series of factor matrices to apply to the select demand, link-based peak factors are no longer used. However, in order to compare against the factors used in PFM v3.0, equivalent factors have been derived by comparing select demand totals at the 16-hour and 3-hour levels for each cordon link. These are shown for PFM v4.3 in Table 55. Factors now change between DM and DS scenarios, and between different forecast years due to differences in demand volumes and hence crowding levels on each route.

Table 55. Comparison of PRMv3 16 hour to 3 hour Peak Factors with Derived 16 hour to 3 hour Peak Factors from PFM v4.3

LINK		PFM V3.0	PFM V4.3 - 2026			PFM V4.3 - 2036		
			DM	DS PHASE 1	Y	DM	DS PHASE 1	Y
1	Newport - Cardiff	0.079	0.221	0.226	0.225	0.221	0.225	0.224
2	Newport – Hereford	0.028	0.139	0.137	0.137	0.139	0.137	0.137
3	Gloucester - Cheltenham	0.012	0.208	0.209	0.208	0.208	0.209	0.209
4	Moreton - Evesham	0.143	0.183	0.250	0.257	0.181	0.249	0.255
5	Banbury - Leamington	0.124	0.219	0.265	0.270	0.222	0.265	0.270
6	Wolverton - Rugby	0.161	0.223	0.243	0.245	0.214	0.235	0.238
7	Wolverton - Northampton	0.048	0.216	0.201	0.203	0.212	0.195	0.197
8	Bedford - Wellingborough	0.088	0.193	0.199	0.207	0.182	0.187	0.198
9	Peterborough - Leicester	0.115	0.262	0.263	0.273	0.265	0.266	0.275
10	Peterborough - Grantham	0.170	0.224	0.224	0.222	0.215	0.214	0.215
11	Cardiff – Newport	0.032	0.218	0.218	0.217	0.217	0.217	0.216
12	Hereford - Newport	0.007	0.151	0.154	0.158	0.149	0.154	0.157
13	Cheltenham - Gloucester	0.022	0.245	0.241	0.238	0.246	0.243	0.240
14	Evesham - Moreton	1.237	0.267	0.228	0.226	0.264	0.223	0.224

LINK		PFM V3.0	PFM V4.3 - 2026			PFM V4.3 - 2036		
			DM	DS PHASE 1	Y	DM	DS PHASE 1	Y
15	Leamington - Banbury	0.106	0.281	0.249	0.246	0.272	0.250	0.246
16	Rugby – Wolverton	0.214	0.264	0.290	0.288	0.264	0.291	0.291
17	Northampton – Wolverton	0.281	0.326	0.351	0.346	0.322	0.350	0.345
18	Wellingborough - Bedford	0.197	0.358	0.358	0.368	0.361	0.361	0.369
19	Leicester - Peterborough	0.007	0.231	0.229	0.228	0.231	0.229	0.227
20	Grantham - Peterborough	0.295	0.219	0.221	0.301	0.211	0.213	0.301
21	HS2 from London	0.125		0.219	0.228		0.211	0.219
22	HS2 to London	0.400		0.289	0.271		0.296	0.274

8.5 Other Improvements to the Wormhole Process

Modification of Select Link Analysis Process

8.5.1 Analysis of wormhole demand matrices in PFM v3.0 indicated that the select demand totals did not match the equivalent link volumes (voltr) on the cordon links. Overall there was a shortfall in the wormhole matrices of around 3-6% depending on model year and scenario, with considerable variation in the shortfall across the cordon links.

8.5.2 Further investigations revealed that the method of select link assignment in EMME/3, did not capture all of the paths being used in a full assignment and this was the reason that there was a shortfall in the select link demand totals compared to the full assignment. A new methodology was implemented to overcome this:

Incorporation of HS2 Heathrow Select Link

8.5.3 Previous versions of the model did not include the facility to transfer long distance demand assigned to the Heathrow spur of HS2 into Planet South. This was included in PFM v4.3, although it should be noted that the HS2 service to Heathrow is not included in this model. .

8.5.4 As there is no HS2 service to Heathrow in PFM v4.3, the process currently generates empty matrices.

Redistribution of External Trip Ends

8.5.5 While the majority of the long distance demand passed from PLD to Planet South will have only one trip end within the Planet South area, there are some instances where this is not the case and both trip ends will be outside the PS area. For example, a trip from South Wales to the north of England will cross the cordon inbound from Cardiff to Newport and then outbound from Gloucester to Cheltenham. Such trips are known to transfer to HS2 in the Do Something, and thus route via London - thereby changing the PS cordon entry and exit points for the same OD pair. Thus it is important that the wormhole matrices accurately reflect the routes by which these external-to-external trips enter and leave the PS area.

8.5.6 The existing wormhole process converts station-to-station select link matrices for use in Planet South as follows:

- For inbound cordon links, origin zones are aggregated to a dummy zone representing the cordon point, while destination zones are aggregated to an equivalent PLD geographic zone using the "gs" ensemble; and
- For outbound cordon links, origin zones are aggregated to PLD geographic zone, while destination zones are aggregated to the dummy cordon zone.

8.5.7 As a result, where trips in the inbound select link matrix have a destination outside Planet South, trip ends are currently aggregated to a PLD geographic zone which lies outside Planet South. When the wormhole matrices are passed to Planet South, these 'external' PLD zones are effectively discarded.

8.5.8 To address this, an additional process was implemented to redistribute the external PLD zone trip end demand across the dummy cordon zones, using the distribution of assigned select link volumes across the cordon links. This additional process involved an automated spreadsheet, called between the production of the wormhole matrices and the import of the wormhole matrices to Planet South.

Revision of PLANET South Trip End Distribution

8.5.9 In PFM v3.0 the process for importing and converting the wormhole demand matrices into Planet South format involved a number of steps:

- Reading in each matrix file in turn;

- Converting the PLD zoning system to Planet South using the relevant ensemble for the dummy cordon point and the "gs" ensemble for the internal trip ends;
- Proportioning the demand for each PLD zone to its constituent PS zones using the trip end proportions held in matrices mo95 (for origins) and md95 (for destinations);
- Combining all individual select link matrices into a single long distance matrix ; and
- Aggregating trip ends within Greater London and redistributing according to trip end proportions from Railplan v4.0 held in matrices mo45 and md45.

8.5.10 This process requires the "gs" ensemble and matrices mo95/md95 to be consistent. During the review of the wormhole process this was found not to be the case; for many PLD zones the factors for the constituent PS zones totalled more or less than 1. In addition, the provenance of the distribution factor in mo95/md95 was not clear.

8.5.11 The process was modified in two ways:

- An automated spreadsheet was developed which updates the distribution in mo95/md95 based on the current "gs" ensemble; and
- Distribution to PS zones is based on the trip end distribution of local demand in the PS matrices.

8.5.12 The advantage of this process is that any change to the "gs" ensemble or the Planet South demand matrices will automatically update the distribution matrices. Also, the disaggregation of trip ends within each PLD zone is based on local trip end information, which provides a reasonably robust proxy for the distribution of key trip attractions and productions within a PLD zone.

8.5.13 This process has been undertaken for PFM v4.3 as an offline process. It is envisaged that it will be incorporated into the standard model run process, as part of the setup procedure for Planet South (for which this process has not been set up).

8.5.14 It should be noted that this revised process does not apply to trips within the Greater London area, which continue to be redistributed using distributions from Railplan 4 in mo45/md45. The distribution factors for this area will be updated in a subsequent stage of model development.

9. APPRAISAL METHODOLOGY

9.1 Introduction

9.1.1 This chapter describes the current method of appraisal as applied in PFM v4.3. It explains how the benefits are calculated for a modelled time period rather than how those benefits are converted into a Present Value of Benefits (PVB).

9.1.2 In PFM v3.0 the appraisal was undertaken using a composite cost approach, but it was shown that this was not mathematically robust and hence the methodology now included was developed, which allowed for appraisal at the most disaggregate level, namely MZones.

9.1.3 The requirements for the calculation of benefits is that it is WebTAG compliant;

- uses WebTAG weights for the aggregation of costs; and
- calculates benefits to be consistent with the level of aggregation in the assignment model.

9.1.4 The appraisal in the PLANET long distance (PLD) model is carried out at on an origin station to destination station level. The demand is distributed at the origin station to destination station level from an origin PLD zone to destination PLD zone level using the station choice model. The station choice model works at a MZone level which is equivalent to the census Middle layer Super Output Areas (MSOA) for places within the catchment area of HS2 track. Outside of the core geographical area of the model the MZones are the same as PLD zones.

9.1.5 We do not store information at the most detailed MZone to station to station to MZone level from the SCM (as the file size would be impractical). Although this is the level at which the appraisal needs to be carried out, we can use the "PLD zone to Station to Station to PLD zone" demand output from the station choice model to calculate the 'rule of a half', because the access and egress costs do not change between the Do Something and the Do Minimum. This process uses the elements of station to station cost skims, undertakes the RoH calculation and then aggregates the benefits to Origin PLD zone (OPLD) to Destination PLD zone level (DPLD). This is mathematically equivalent to undertaking the appraisal at MZone to station to station to MZone.

9.1.6 This chapter describes how the 'rule of a half' is undertaken using this method with an example of London to York PLD zones.

9.1.7 Benefit calculations within the regional models are not covered in this document as the methodology for calculating these remains unchanged from previous versions of the model: these are undertaken in EMME.

9.2 Methodology

9.2.1 This section describes the methodology used in calculating the benefits from the PFM v4.3 model.

9.2.2 The existence of the logit model at the station choice level means that the RoH must be carried out at this level. There is a constant allocation between MZones and PLD zones which allows the calculations to be aggregated to the PLD level.

9.2.3 The method relies on having the same choice set in both the Do Minimum and Do Something. Since for both highway and public transport access, this implies the same definition of access/egress costs and catchment areas between the MZones and stations, the change in access/egress costs is 0 between the Do Something and the Do Minimum. This means access/egress costs can be ignored when calculating the benefits.

9.2.4 Generalised Journey Time (GJTC) consists of the following cost elements:

- In vehicle time (IVT);
- Walk (for interchanging between stations);
- Wait time;
- Boards/interchanges; and
- Crowded time.

9.2.5 The total benefits need to be calculated separately for each element and purpose so that WebTAG weights can be applied, as these are different (in some cases) from the weights in the demand model. The benefits are calculated in minutes (with the exception of boards which are the change in number) for a single day. These benefits elements are then annualised and put into appropriate cost units within the Appraisal Spreadsheet. The WebTAG weights are also applied within the Appraisal Spreadsheet.

9.2.6 The station choice model produces a file containing demand at Origin PLD Zone (OPLD) to Origin Station (OStn) to Destination Station (DStn) to Destination PLD zone (DPLD) level. The assignment model produces IVT, walk time, wait time, boards and crowded time on a Ostn to Dstn level. These files are produced both in the Do Minimum and Do Something and therefore we can calculate the change in benefits associated with each of these elements of GJTC at OPLD to DPLD (IJ), for example:

$$\mathrm{IVTBEN_{IJ}} = \sum_{\mathrm{mn}}^{225} 0.5 * \left(\mathrm{DEM_{IJmn}} + \mathrm{DEM'_{IJmn}}\right) * (\mathrm{IVT_{mn}} - \mathrm{IVT'_{mn}})$$

Where

mn is origin station m to destination station n available to people moving from PLD zone I to PLD zone J.

$\mathrm{DEM_{IJmn}}$ is the proportion of trips using station mn out of the total combination of stations in the Do Min

DEM'$_{IJmn}$ is the proportion of trips using station mn out of the total combination of stations in the Do Something

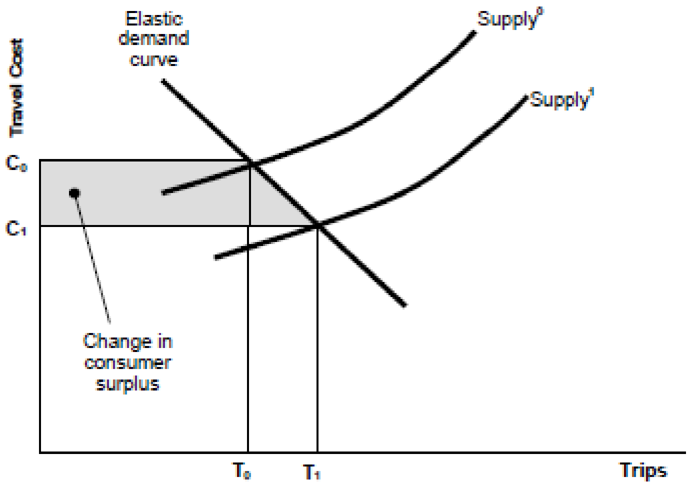
IVT_{mn} is the IVT in minutes in the Do Min

IVT'_{mn} is the IVT in minutes in the Do Something

The other elements of GJTC can be calculated in a similar manner.

9.2.7 The formulation above shows the RoH being undertaken for each PLD to station to station to PLD movement. This is then summed over the individual PLD zones. Figure 10 shows the calculation which is undertaken

Figure 10. Change in Consumer Surplus



9.2.8 The individual rule of a half calculations for each of the elements are then summed to calculate the total benefits. These are fed into the appraisal spreadsheet for each modelled year (currently 2026 and 2036) to calculate the total PVB.

9.2.9 The appraisal spreadsheet also takes in revenue which is simply calculated (in EMME) as follows:

$$Revenue = (DS\ Demand - DM\ Demand) \times Fares\ Matrices$$

9.2.10 This process is undertaken separately for each purpose as the average station to station fares by purpose are different due to differences in trip making behaviour.

9.3 Example - Central London to York

Introduction

9.3.1 The example we have taken to explain the rule of a half calculations is London to York. In the Station Choice Model we have seven north facing London stations. These are:

- Euston;
- Kings Cross;
- St Pancras;
- Marylebone;
- Paddington;
- Old Oak Common; and
- Heathrow.

9.3.2 York has just one station so there are seven station pairs in total between the Central London PLD zone and the York PLD zone.

9.3.3 In the Do Minimum there is a fast East Coast Main Line (ECML) service to York from Kings Cross station. In the Do Something there is also a direct HS2 service from Euston, which goes onto classic track just south of York.

9.3.4 The data we are showing is for one purpose only 'Business Car Available From'.

9.4 Input Data

9.4.1 The input data needed for the 'rule of a half' is the Do Minimum and Do Something station to station IVT, walk as interchange, wait, boards and crowded time. We also need the OPLD-Ostn-Dstn-DPLD demand for both the Do Minimum and Do Something.

9.4.2 The Do Minimum cost skims and demand data for the Central London to York example is given in Table 56. The Do Something cost skims and demand data for Central London to York is given in Table 57.

9.4.3 The station to station cost skims are outputs from the assignment and inputs to the station choice model. The demand file is output from the station choice model.

9.4.4 In the Do Minimum, except for King's Cross, demand using all other stations makes an access journey (on LUL or similar) to King's Cross and then travels to York; this can be seen in the number of boards. In the Do Something, passengers from King's Cross, Euston and Old Oak Common travel direct to York (using East Coast trains for the first of these, HS2 for the second and third); passengers from other stations interchange at one of the stations with a direct service.

Table 56. DM Costs and Demand for Central London to York PLD zone - 2036

LONDON STATION	DO MIN DEMAND	DO MIN IVT (mins)	DO MIN WALK (mins)	DO MIN AVERAGE WAIT (mins)	DO MIN CROWD (mins)	DO MIN BOARDS (number)
Euston to York	5	149	0	14	9	2
Kings Cross to York	409	111	0	13	9	1
Marylebone to York	20	164	0	14	9	2
Paddington to York	0	154	0	14	9	2
St Pancras to York	5	131	0	14	9	2
Heathrow to York	14	174	0	18	9	3
Old Oak Common to York	0	169	0	16	9	3

Table 57. DS Costs and Demand for Central London to York PLD zone - Phase 2 2036

LONDON STATION	DO SOME DEMAND	DO SOME IVT (mins)	DO SOME WALK (mins)	DO SOME AVERAGE WAIT (mins)	DO SOME CROWD (mins)	DO SOME BOARDS (number)
Euston to York	402	79	0	10	3	1
Kings Cross to York	29	121	0	14	0	1
Marylebone to York	3	130	0	11	3	2
Paddington to York	77	77	0	11	3	2
St Pancras to York	12	112	0	11	3	2
Heathrow to York	0	91	0	14	3	2
Old Oak Common to York	77	73	0	10	3	1

9.5 Calculating the Rule of a Half

9.5.1 The calculation of a 'rule of a half' is undertaken for each element of GJTC separately. The following are the calculations for the Euston to York. The daily single year benefits are then aggregated to form the total benefits in minutes.

9.5.2 This follows the equation: $0.5 * \left(\mathrm{DEM}_{\mathrm{IJmn}} + \mathrm{DEM}'_{\mathrm{IJmn}}\right) * (\mathrm{IVT}_{\mathrm{mn}} - \mathrm{IVT}'_{\mathrm{mn}})$, as Section 9.2.5

IVT: 0.5*(5+402)*(149-79) = 0.5*407*70 = 14,245

Walk as Interchange: 0.5*(5+402)*(0-0) = 0.5*407*0 = 0

Wait: 0.5*(5+402)*(14-10) = 0.5*407*4 = 814

Crowd: 0.5*(5+402)*(9-3) = 0.5*407*6 = 1,221

Boards: 0.5*(5+402)*(2-1) = 0.5*407*1 = 204

Each formulation is set out as in the formula above with the different elements replacing the IVT.

9.5.3 The GJTC benefits for Euston to York station is calculated in the appraisal spreadsheet (which then applies VOT), but it is illustrated here.

9.5.4 The WebTAG weights for business are given in Table 58 below.

Table 58. WebTAG Weights for Business

GJTC Element	Business Weights
IVT	1
Walk	1
Wait	1
Crowd	1
Boards	30

9.5.5 The single year benefits for 2036 for Euston to York in minutes are:

Benefits = 1*14,245 + 1 * 0 + 1* 814 + 1 * 1,221 + 30*204

= 14,245 + 0 + 814 +1,221 +6,105 = **23,385**

9.5.6 The output from the rule of a half calculations for all stations are given in Table 59 for London to York.

9.5.7 The reason that there are dis-benefits in the table for Kings Cross to York trips is because the service patterns on the East Coast Mainline have changed with a slightly lower frequency and more intensive stopping pattern. There is however a crowding benefit for these trips as a number of the northbound trips have been removed from these services onto the HS2 services.

Table 59. Daily Benefits for Central London GJTC for Phase 2 in 2036

LONDON STATION	Un-weighted IVT Benefits (mins)	Un-weighted WALK Benefits (mins)	Un-weighted WAIT Benefits (mins)	Un-weighted CROWD Benefits (mins)	Un-weighted BOARDS Benefits (number)	GJTC Benefits (mins)
Euston to York	14,245	0	814	1,221	204	22,385
Kings Cross to York	-2,222	0	-251	1,968	0	-505
Marylebone to York	139	0	11	24	0	174
Paddington to York	3,783	0	148	284	0	4,215
St Pancras to York	245	0	35	76	0	357
Heathrow to York	0	0	0	0	0	0
Old Oak Common to York	3,685	0	242	224	77	6,449
TOTAL London to York	**19,875**	**0**	**999**	**3,797**	**281**	**33,075**

9.6 Implementation within PLD

EMME

9.6.1 EMME outputs the cost skims from the assignment model at a station to station level and the revenues for rail calculated by multiplying the fares skim by the demand matrix for the Do Minimum and the Do Something. This chapter does not describe in detail the processes undertaken in EMME.

Appraisal Pre-Processing Step

9.6.2 There is a pre-processing step which has been written in VB to undertake the Rule of a Half Calculations. The executable for this is called CreateEconomicOutput_OD.exe.

9.6.3 The files used in this process are described in the next few paragraphs.

9.6.4 The station choice model produces demand and cost matrix outputs once it has been run. These SCM outputs then become the inputs for the "create economic outputs" process. The matrices produced cover the nine model segments, which are:

- 1 - Commute Non Car Available;
- 2 - Commute Car Available From;
- 3 - Commute Car Available To;
- 4 - Business Non Car Available;
- 5 - Business Car Available From;
- 6 - Business Car Available To;
- 7 - Leisure Non Car Available;
- 8 - Leisure Car Available From; and
- 9 - Leisure Car Available To.

9.6.5 For each of the cost element outputs produced by the SCM there is a matrix for each of the purposes. The cost element matrices are as follows:

- 1-9 - Station to Station Demand;
- 51-59 - In Vehicle Time (IVT);
- 61-69 - Walk Time;
- 71-79 - Wait Time;
- 101-109 - Total Boardings; and
- 121-129 - Crowded Time.

9.6.6 These files are produced for both the DM and the DS. The files are located in the following folders:

- 1 – Do Minimum - ….\HS2\01PLD\01Base\01base_assign\output; and
- 2 – Do Something - ….\HS2\01PLD\03Test\03test_assign\output.

Note: The demand files are located in the input folders rather than the output folders.

9.6.7 The inputs are processed in Create_Economic_Outputs_OD.exe using a rule of a half calculation on each of the individual cost elements.

9.6.8 This calculation is carried out for all the PLD-PLD pairs within the model. The individual PLD-PLD elements for each element and the totals are both output by the process.

9.6.9 Once the rule of a half calculation has been completed the programme produces a list of benefits totals and a set of EconMatSCM#.dat files which are then imported into the Appraisal spreadsheets.

9.6.10 These output files (EconMatSCM#.dat) are then grouped together into elements as shown in Table 60 below.

Table 60. WebTAG Weights for Business

EconMatSCM	Purpose
1 to 9	Base Demand
10 to 18	Test Demand
19 to 27	IVT
28 to 36	Walk
36 to 45	Wait
46 to 54	Board
55 to 63	Crowd
64 to 72	Revenue

Appraisal Spreadsheet

9.6.11 The outputs from the appraisal pre-processing step are read into the appraisal spreadsheet template which calculates the benefits and revenues over the sixty year appraisal period from the two forecast model years (2026 and the cap year).

9.6.12 The workings of the appraisal spreadsheet are not covered here in detail as they are discussed in a separate report.

9.6.13 Benefits and revenues are displayed in the spreadsheet in real terms as defined by the GDP deflator. Revenue is extracted from the PLD demand model in 2010/11 prices and based on a Retail Price Index (RPI) measure of inflation. These are made consistent with stated fares assumptions by applying a compound difference between RPI and GDP deflator (which is based on the Consumer Price Index – CPI) which is around 0.9%pa.

9.6.14 The outputs from the appraisal spreadsheet is a basic TEE table of benefits and revenues for a particular test.

10. MODEL PERFORMANCE

10.1 Introduction

10.1.1 Although most of the model development tasks are related to improving the model in forecasting mode, a key part of model development is ensuring that PFM v4.3 performs as well as if not better than PFM v3.0.

10.1.2 This section covers:

- Validation of base model;
- Convergence of assignment; and
- Benchmarking of model against other data sources

10.2 Base Model Rail Assignment Validation

10.2.1 It is normal practice to validate transport models by checking whether they accurately represent the current situation - for PFM base year rail models (PLD and the regional models) this would be to check that the assignment gives the current demand by train service. Where possible this should be done using independent data. However, to provide the best possible calibration, the data we used in matrix building included the majority of available data, and certainly the most reliable data. As a result, undertaking a detailed validation is challenging, as alternative sources of data are likely to be less robust.

10.2.2 Of the data sources available, MOIRA represents one of the best, although it is not strictly independent as the rail models and MOIRA draw their data from LENNON, the rail industry ticket sales data. It does, however represent a valuable model validation check.

10.2.3 Guards count data represents a further data source, and unlike MOIRA, it is an independent data source; however, these data are likely to be less accurate than the LENNON data used to create PLD. As with MOIRA, these data provide a useful validation cross check.

10.2.4 For all of the models a series of screenlines have been defined that capture the key rail movements, specifically in the context of the proposals for HS2.

10.2.5 EMME has been used to output assigned transit segment volumes for the PFM base year model. WebTAG unit 3.11.2 provides guidance on the validation of public transport models, each link on a screenline has been designated as a 'Pass' or 'Fail' to indicate whether it meets the WebTAG validation guidance of being within 25% of observed on each modelled link flow. Note in some locations validation has been undertaken by TOC and does not represent total link flow. Screenlines are also labelled as a 'Pass' or 'Fail' to show if they meet WebTAG validation guidance of being within 15% of the screenline observations as a whole.

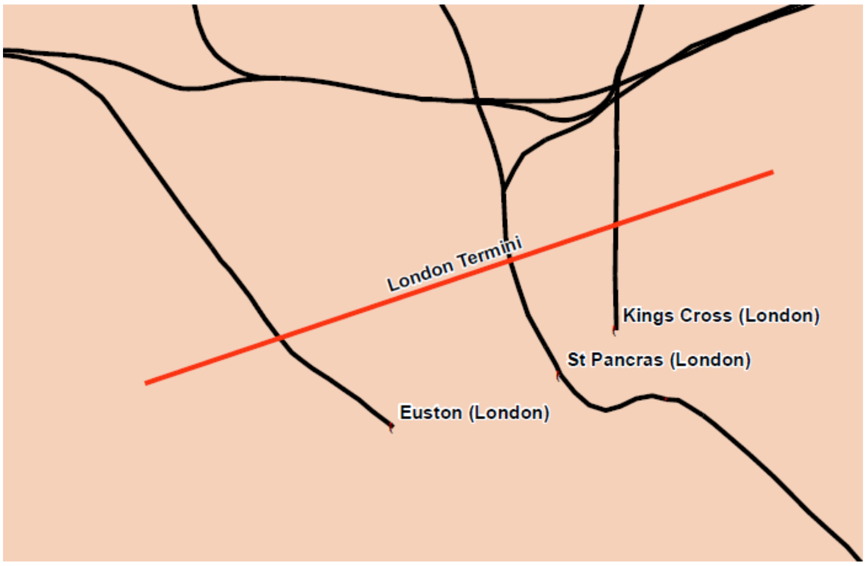
10.2.6 Results of the validation across screenlines are presented in the following section, along with a comparison of the results with PFM v3.0.

10.3 PLD Rail Assignment Validation

London Termini Validation

10.3.1 Figure 11 shows the screenline for three London termini – Euston, St. Pancras and Kings Cross. The validation data are calculated for long-distance TOCs only. There are two sources of observed data at these locations – MOIRA and Guards counts. The available data are a useful check against the assigned flows on each TOC, but are incomplete in terms of other TOCs operating from the same stations. This implies that if the modelled and observed data for a particular TOC do not match, it will not be clear whether the overall modelled loading on the link is incorrect, or whether the balance between TOCs in that corridor is incorrect.

Figure 11. Location of London Termini Screenlines



10.3.2 Table 61 shows the validation of the modelled flows against the Guards counts. As can be seen, the modelled flows on long distance WCML services at Euston are higher than observed Guards counts, whilst flows at St. Pancras are lower. The validation results of the PFM v4.3 are similar to PFM v3.0, with general small improvements on all routes.

10.3.3 Table 62 shows London termini screenline validation against MOIRA data. Unlike the guard's counts which show an all-day balanced flow, MOIRA suggests directionally imbalanced demand allocations to MML and ECML. It should be noted that the PLD demand matrices are balanced by direction, ie demand from zone A to B is equal to demand in the opposite direction. MOIRA 'counts' do not take account of crowding - important for Central London trains. PFM v4.3 shows similar results to PFM v3.0, with a few key differences:

- ECML shows balanced flow in both directions;
- the MML inbound now meets the validation criteria;
- small improvements in validation on all routes compared to PFM v3.0;
- there is a significant reduction in flows on the ECML inbound, although it still meets validation criteria; and
- The total inbound shows much better validation with only 1% difference to the observed data.

Table 61. London Termini Screenline Validation Results – Guard Counts

OBSERVED DATA: GUARDS COUNTS				PFM V3 BASE (PFM V3_1025B)				PFM V42_BASE_V2			
ROUTE / STRATEGIC TOC	STATION	DIRECTION	TOTAL COUNT (2010)	MODELLED	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	MODELLED	DIFFERENCE	% DIFFERENCE	PASS/FAIL
West Coast Main Line	Euston	Outbound	27,097	33,504	6,407	24%	Pass	32,937	5,839	22%	Pass
		Inbound	27,123	34,942	7,819	29%	Fail	34,568	7,445	27%	Fail
Midland Main Line	St Pancras	Outbound	14,558	11,502	-3,056	-21%	Pass	11,499	-3,059	-21%	Pass
		Inbound	13,896	11,221	-2,675	-19%	Pass	11,754	-2,142	-15%	Pass
East Coast Main Line	King's Cross	Outbound	17,129	18,817	1,687	10%	Pass	18,536	1,407	8%	Pass
		Inbound	16,882	18,168	1,287	8%	Pass	15,575	-1,306	-8%	Pass
Total		Outbound	58,784	63,823	5,039	9%	Pass	62,972	4,187	7%	Pass
		Inbound	57,900	64,331	6,431	11%	Pass	61,897	3,996	7%	Pass

Table 62. London Termini Screenline Validation Results – MOIRA Flows

ROUTE / STRATEGIC TOC	STATION	DIRECTION	MOIRA 2010/11	PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE)			
				PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
West Coast Main Line	Euston	Outbound	28,739	33,504	4,765	17%	Pass	32,937	4,198	15%	Pass
		Inbound	28,537	34,942	6,405	22%	Pass	34,568	6,031	21%	Pass
Midland Main Line	St Pancras	Outbound	17,542	11,502	-6,040	-34%	Fail	11,499	-6,043	-34%	Fail
		Inbound	15,344	11,221	-4,123	-27%	Fail	11,754	-3,590	-23%	Pass
East Coast Main Line	King's Cross	Outbound	21,180	18,817	-2,363	-11%	Pass	18,536	-2,644	-12%	Pass
		Inbound	17,654	18,168	514	3%	Pass	15,575	-2,079	-12%	Pass
Total		Outbound	67,461	63,823	-3,638	-5%	Pass	62,972	-4,489	-7%	Pass
		Inbound	61,535	64,331	2,796	5%	Pass	61,897	362	1%	Pass

Midlands Screenline Validation

10.3.4 A number of screenlines have been defined in the Midlands to capture inter regional demand on key corridors.

10.3.5 Figure 12 and Figure 13 show the location of the Peterborough and Bedford screenlines.

Figure 12. Location of Peterborough screenlines

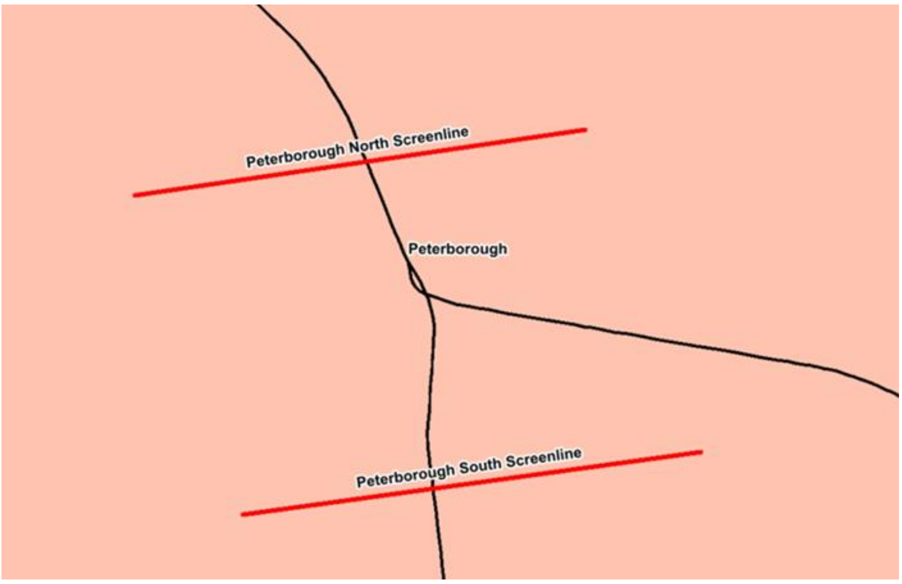
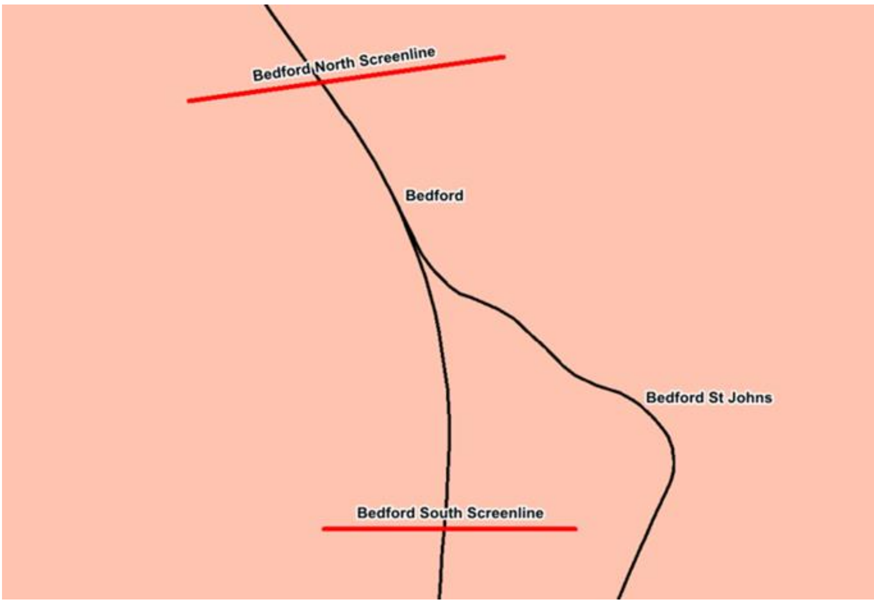


Figure 13. Location of Bedford screenlines



10.3.6 Tables 63 to 66 present the validation of these screenlines. Overall, the model appears to validate well for long distance trains, with all routes meeting the validation criteria across all of the Peterborough and Bedford screenlines. Differences between observed and modelled flows are slightly reduced compared to PFM v3.0.

Table 63. Peterborough North Screenline Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE / STRATEGIC TOC	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
East Coast and Open Access	Peterborough	Northbound	16,820	18,922	2,102	12%	Pass	18,104	1,284	8%	Pass
		Southbound	16,637	18,247	1,610	10%	Pass	18,170	1,533	9%	Pass
Total		Northbound	16,820	18,922	2,102	12%	Pass	18,104	1,284	8%	Pass
		Southbound	16,637	18,247	1,610	10%	Pass	18,170	1,533	9%	Pass

Table 64. Peterborough South Screenline Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE / STRATEGIC TOC	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
East Coast and Open Access	Peterborough	Northbound	19,052	20,041	989	5%	Pass	19,194	142	1%	Pass
		Southbound	19,040	19,313	273	1%	Pass	19,337	297	2%	Pass
Total		Northbound	19,052	20,041	989	5%	Pass	19,194	142	1%	Pass
		Southbound	19,040	19,313	273	1%	Pass	19,337	297	2%	Pass

Table 65. Bedford North Screenline Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE / STRATEGIC TOC	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
Midland Main Line	Bedford	Northbound	10,244	8,744	-1,500	-15%	Pass	8,859	-1,385	-14%	Pass
		Southbound	10,301	8,799	-1,502	-15%	Pass	9,333	-968	-9%	Pass
Total		Northbound	10,244	8,744	-1,500	-15%	Pass	8,859	-1,385	-14%	Pass
		Southbound	10,301	8,799	-1,502	-15%	Pass	9,333	-968	-9%	Pass

Table 66. Bedford South Screenline Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE / STRATEGIC TOC	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
Midland Main Line	Bedford	Northbound	12,732	10,868	-1,864	-15%	Pass	11,073	-1,659	-13%	Pass
		Southbound	11,991	10,852	-1,139	-9%	Pass	11,453	-538	-4%	Pass
Total		Northbound	12,732	10,868	-1,864	-15%	Pass	11,073	-1,659	-13%	Pass
		Southbound	11,991	10,852	-1,139	-9%	Pass	11,453	-538	-4%	Pass

10.3.7 Figure 14 shows the location of the South of Midlands screenlines, and Figure 15 shows the location of the North of Midlands screenlines. Table 66 and Table 67 show the validation for the South of Midlands screenlines. Table 68 and Table 69 show the validation for the North of Midlands screenlines.

Figure 14. Location of South of Midlands Screenlines

Figure 15. location of North of Midlands Screenlines

Table 67. South of Midlands Upper Screenline Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
West Coast	Milton Keynes	Northbound	27,067	32,494	5,427	20%	Pass	30,950	3,883	14%	Pass
		Southbound	27,462	33,942	6,480	24%	Pass	32,001	4,539	17%	Pass
Chiltern	Bicester North	Northbound	4,020	2,672	-1,348	-34%	Fail	2,917	-1,103	-27%	Fail
		Southbound	4,095	2,768	-1,327	-32%	Fail	3,089	-1,006	-25%	Pass
Cross Country	Oxford	Northbound	4,343	4,390	47	1%	Pass	4,068	-275	-6%	Pass
		Southbound	4,265	4,189	-76	-2%	Pass	4,010	-255	-6%	Pass
Total		Northbound	35,430	39,557	4,127	12%	Pass	37,934	2,504	7%	Pass
		Southbound	35,822	40,899	5,077	14%	Pass	39,100	3,278	9%	Pass

Table 68. South of Midlands Lower Screenline Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
West Coast	Milton Keynes	Northbound	28,397	33,895	5,498	19%	Pass	33,247	4,850	17%	Pass
		Southbound	28,537	35,331	6,794	24%	Pass	34,905	6,368	22%	Pass
Chiltern	Bicester North	Northbound	5,209	3,893	-1,316	-25%	Fail	4,478	-731	-14%	Pass
		Southbound	5,275	3,902	-1,373	-26%	Fail	4,460	-815	-15%	Pass
Cross Country	Oxford	Northbound	4,165	3,441	-724	-17%	Pass	3,503	-662	-16%	Pass
		Southbound	3,538	3,320	-218	-6%	Pass	3,453	-85	-2%	Pass
Total		Northbound	37,771	41,229	3,458	9%	Pass	41,228	3,457	9%	Pass
		Southbound	37,350	42,553	5,203	14%	Pass	42,818	5,468	15%	Pass

Table 69. North of Midlands Upper Validation Screenline

			PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
Crewe	Northbound	13,402	14,290	888	7%	Pass	14,259	857	6%	Pass
	Southbound	13,835	14,213	378	3%	Pass	14,299	464	3%	Pass
Stoke	Northbound	8,292	8,599	307	4%	Pass	8,375	83	1%	Pass
	Southbound	8,003	8,515	512	6%	Pass	8,075	72	1%	Pass
Total	Northbound	21,694	22,889	1,195	6%	Pass	22,633	939	4%	Pass
	Southbound	21,838	22,728	890	4%	Pass	14,259	857	6%	Pass

Table 70. North of Midlands Lower Screenline Validation Results

			PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
Crewe	Northbound	13,156	14,530	1,374	10%	Pass	14,564	1,408	11%	Pass
	Southbound	13,455	14,103	648	5%	Pass	14,133	678	5%	Pass
Stoke	Northbound	8,825	9,084	259	3%	Pass	8,725	-100	-1%	Pass
	Southbound	8,564	9,019	455	5%	Pass	8,546	-18	0%	Pass
Total	Northbound	21,981	23,614	1,633	7%	Pass	23,289	1,308	6%	Pass
	Southbound	22,019	23,122	1,103	5%	Pass	22,679	660	3%	Pass

10.3.8 At the South of Midlands screenlines there is a general improvement in the flow validation compared to PFM v3.0. There is an improvement in the validation on the Chiltern Line which now meets the validation criteria in 3 of the 4 cases whereas it failed validation in all 4 cases in PFM v3.0. It is worth noting that neither version of PFM takes into account the lower fares on Chiltern services between London and Birmingham.

10.3.9 For the north of Midlands screenlines the PFM v4.3 model achieves the WebTAG levels of acceptable validation and results are marginally improved compared to PFM v3.0.

North of England Screenline Validation

10.3.10 A number of screenlines have been defined in the north of England covering both the west coast and east coast routes. The North of Midlands and Preston screenlines give an indication of the quality of validation at various points between London/Birmingham and Manchester/Liverpool/Glasgow – ie the West Coast route. The Preston screenlines are shown in Figure 16.

Figure 16. Location of Preston Screenlines

10.3.11 Although the Preston North screenlines (Table 71) meets overall validation criteria, it does suggests unbalanced choice between TOCs in PFM, where West Coast is over assigned and Trans Pennine is under-assigned. This pattern is also evident in PFM v3.0.

10.3.12 The Preston South screenline (Table 72) shows a similar pattern, although it should be noted that the individual TOCs all meet the validation criteria. The results are very similar to PFM v3.0.

Table 71. Preston North Screenline Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE/ STRATEGIC TOC	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
West Coast Main Line	Preston	Northbound	4,867	6,072	1,205	25%	Pass	5,983	1,116	23%	Pass
		Southbound	4,762	6,510	1,748	37%	Fail	6,309	1,547	32%	Fail
TransPennine	Preston	Northbound	4,395	2,404	-1,991	-45%	Fail	2,370	-2,025	-46%	Fail
		Southbound	4,538	1,928	-2,610	-58%	Fail	2,204	-2,334	-51%	Fail
Total		Northbound	9,262	8,477	-785	-8%	Pass	8,353	-909	-10%	Pass
		Southbound	9,300	8,438	-862	-9%	Pass	8,513	-787	-8%	Pass

Table 72. Preston South Screenline Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE/ STRATEGIC TOC	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
West Coast Main Line	Preston	Northbound	5,946	7,037	1,091	18%	Pass	6,869	923	16%	Pass
		Southbound	5,579	6,994	1,415	25%	Fail	6,898	1,319	24%	Pass
TransPennine	Preston	Northbound	4,008	3,315	-693	-17%	Pass	3,283	-725	-18%	Pass
		Southbound	4,298	3,552	-746	-17%	Pass	3,638	-660	-15%	Pass
Total		Northbound	9,954	10,351	397	4%	Pass	10,152	198	2%	Pass
		Southbound	9,877	10,545	668	7%	Pass	10,536	659	7%	Pass

10.3.13 To show validation for routes to Leeds/York/Newcastle/Edinburgh, screenlines were also examined for the North of England on the East Coast route.

10.3.14 There are two screenlines in the Doncaster area, lower and upper, as shown in Figure 17. Results are presented in Tables 73 and 74.

Figure 17. Doncaster Screenlines

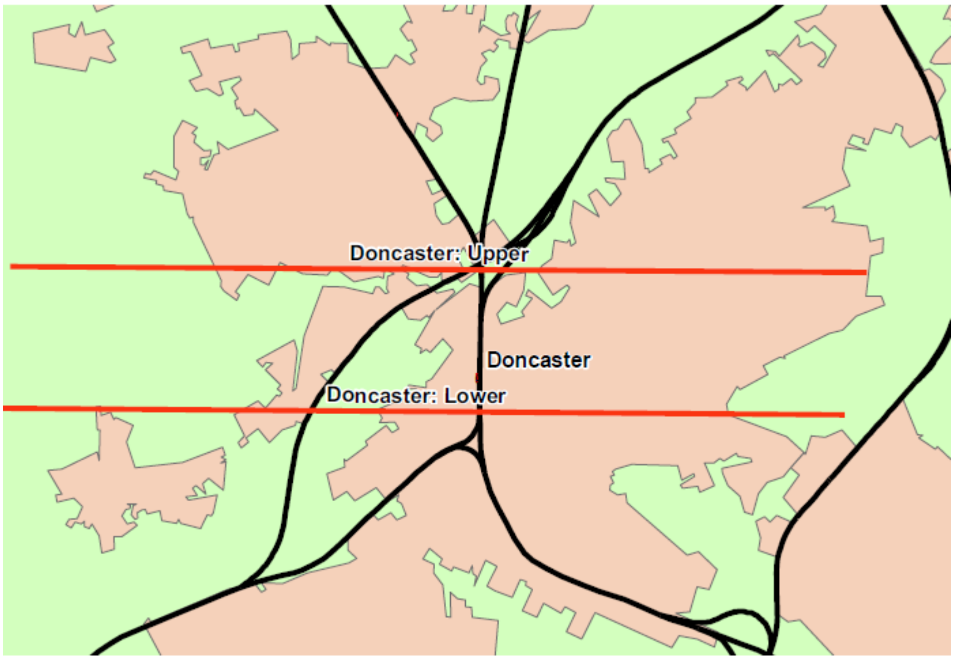


Table 73. Doncaster Upper Screenline Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
Cross Country	Doncaster	Northbound	1,534	2,022	488	32%	Fail	2,028	494	32%	Fail
		Southbound	1,769	2,132	363	21%	Pass	2,181	412	23%	Pass
East Coast and Open Access	Doncaster	Northbound	15,101	15,315	214	1%	Pass	15,178	77	1%	Pass
		Southbound	15,418	15,370	-48	0%	Pass	15,494	76	0%	Pass
Total		Northbound	16,635	17,337	702	4%	Pass	17,206	571	3%	Pass
		Southbound	17,187	17,502	315	2%	Pass	17,675	488	3%	Pass

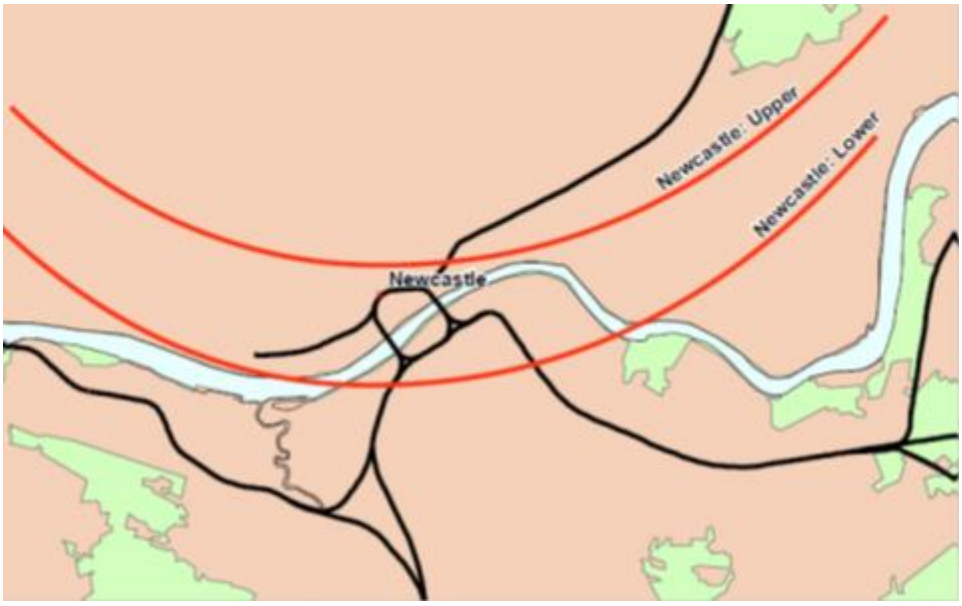
Table 74. Doncaster Lower Screenline Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
Cross Country	Doncaster	Northbound	1,731	1,789	58	3%	Pass	1,859	128	7%	Pass
		Southbound	2,393	2,099	-294	-12%	Pass	2,187	-206	-9%	Pass
East Coast and Open Access	Doncaster	Northbound	15,611	16,601	990	6%	Pass	16,144	533	3%	Pass
		Southbound	15,526	16,398	872	6%	Pass	16,319	793	5%	Pass
Total		Northbound	17,342	18,391	1,049	6%	Pass	18,003	661	4%	Pass
		Southbound	17,919	18,496	577	3%	Pass	18,506	587	3%	Pass

10.3.15 At both of the Doncaster screenlines there are some differences in the level of validation at individual locations. Both PFM v3 and PFM v4.3 achieve the same levels of validation compared to WebTAG validation criteria. The Doncaster Upper screenline, whilst struggling to differentiate between TOCs at this location, nevertheless meets WebTAG criteria for the screenline.

10.3.16 Newcastle screenlines are shown in Figure 18, with results in Table 75 and Table 76.

Figure 18. Location of Newcastle Screenlines



10.3.17 The screenlines at Newcastle also show consistency in validation between the different versions. As can be seen, all TOC flows meet the WebTAG validation guidance of being within 25% of observed data on the modelled link flows, and within 15% of the screenline data as a whole.

Table 75. Newcastle Upper Screenline Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
Cross Country	Newcastle	Northbound	1,685	2,044	359	21%	Pass	1,991	306	18%	Pass
		Southbound	1,593	1,892	299	19%	Pass	1,879	286	18%	Pass
East Coast	Newcastle	Northbound	4,611	4,477	-135	-3%	Pass	4,562	-49	-1%	Pass
		Southbound	4,726	4,574	-152	-3%	Pass	4,634	-92	-2%	Pass
Total		Northbound	6,296	6,521	225	4%	Pass	6,553	257	4%	Pass
		Southbound	6,319	6,466	147	2%	Pass	6,513	194	3%	Pass

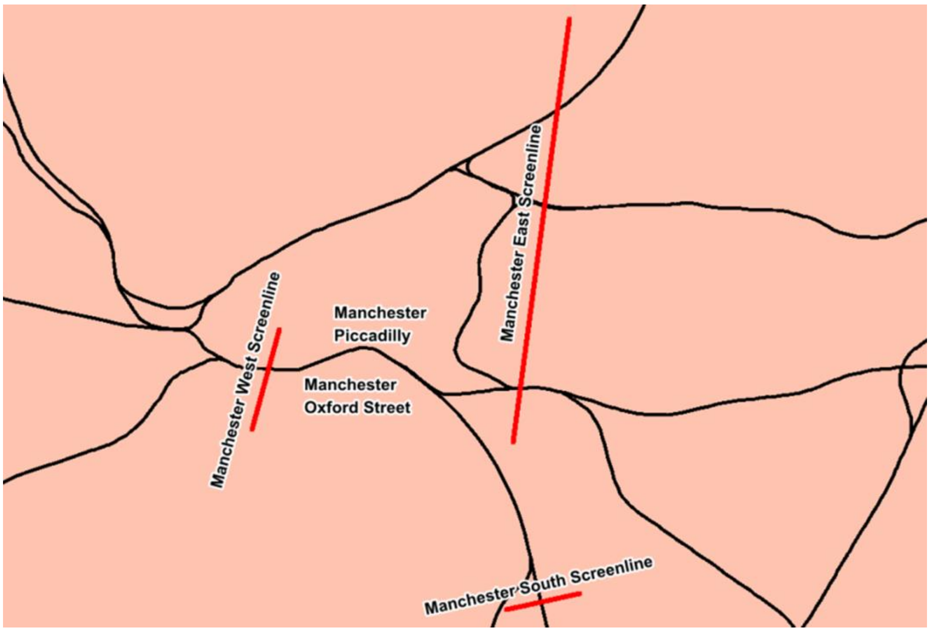
Table 76. Newcastle Lower Screenline Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
Cross Country	Newcastle	Northbound	3,645	3,929	284	8%	Pass	3,939	294	8%	Pass
		Southbound	3,619	3,771	152	4%	Pass	3,819	200	6%	Pass
East Coast	Newcastle	Northbound	6,505	7,287	782	12%	Pass	7,500	995	15%	Pass
		Southbound	6,818	7,552	734	11%	Pass	7,535	717	11%	Pass
Total		Northbound	10,150	11,216	1,066	11%	Pass	11,439	1,289	13%	Pass
		Southbound	10,437	11,323	886	8%	Pass	11,354	917	9%	Pass

Manchester and Leeds Screenlines Validation

10.3.18 Validation has also been carried out for routes into Manchester and Leeds. The location of the Manchester screenlines are shown in Figure 19.

Figure 19. Location of Manchester Screenlines



10.3.19 Table 77 to Table 79 show the validation results for screenlines around Manchester area , which indicate a general weakness in route choice (where certain routes are over assigned and others are under-assigned) to and from Manchester. Nevertheless, with the exception of one individual link (Ashton-under-Lyne to Manchester Victoria Eastbound) which just falls outside the 25% link validation criteria, all the rest of the individual links that make up the screenline are within the acceptable levels set out in WebTAG criteria. Although at an individual link level the validation is mixed compared to PFM v3.0 with validation improving on some links and deteriorating on others, PFM v4.3 , as a whole, shows a similar level of validation as PFM v3.0.

Table 77. Manchester South Screenline Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE/ STRATEGIC TOC	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
West Coast Main Line	Manchester Piccadilly	Northbound	7,268	6,796	-472	-6%	Pass	7,086	-182	-3%	Pass
		Southbound	7,757	7,184	-573	-7%	Pass	7,171	-586	-8%	Pass
Cross Country	Manchester Piccadilly	Northbound	2,657	3,315	658	25%	Pass	3,175	518	20%	Pass
		Southbound	2,872	3,166	294	10%	Pass	3,005	133	5%	Pass
East Midlands Trains	Manchester Piccadilly	Northbound	1,916	2,031	115	6%	Pass	2,279	363	19%	Pass
		Southbound	2,067	2,194	127	6%	Pass	2,332	265	13%	Pass
TransPennine	Manchester Piccadilly	Northbound	1,623	1,366	-257	-16%	Pass	1,337	-286	-18%	Pass
		Southbound	1,669	1,418	-251	-15%	Pass	1,292	-377	-23%	Pass
Arriva Trains Wales	Manchester Piccadilly	Northbound	964	985	21	2%	Pass	1,153	189	20%	Pass
		Southbound	1,169	1,084	-85	-7%	Pass	1,173	4	0%	Pass
Total		Northbound	14,428	14,493	65	0%	Pass	15,030	602	4%	Pass
		Southbound	15,534	15,045	-489	-3%	Pass	14,972	-562	-4%	Pass

Table 78. Manchester West Screenline Validation Results

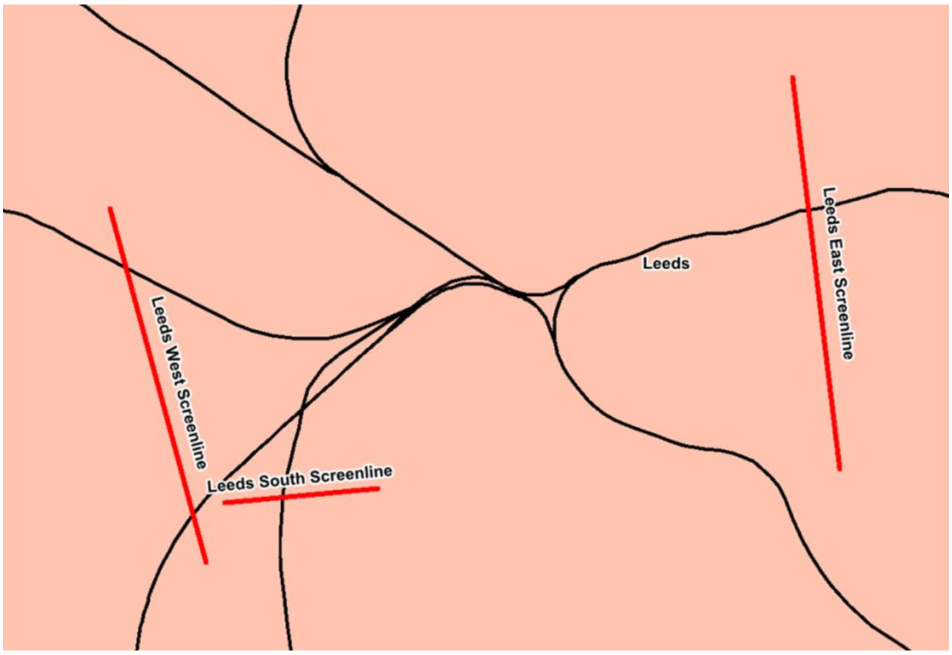
				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE/ STRATEGIC TOC	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
East Midlands Trains	Manchester Piccadilly	Eastbound	1,748	2,122	374	21%	Pass	2,125	377	22%	Pass
		Westbound	1,720	1,834	114	7%	Pass	1,886	166	10%	Pass
Arriva Trains Wales	Manchester Piccadilly	Eastbound	1,756	1,532	-224	-13%	Pass	1,755	-1	0%	Pass
		Westbound	1,812	1,855	43	2%	Pass	1,722	-90	-5%	Pass
TransPennine	Manchester Piccadilly	Eastbound	8,187	6,909	-1,278	-16%	Pass	6,904	-1,283	-16%	Pass
		Westbound	7,069	6,970	-99	-1%	Pass	6,877	-192	-3%	Pass
Total		Eastbound	11,691	10,563	-1,128	-10%	Pass	10,784	-907	-8%	Pass
		Westbound	10,601	10,659	58	1%	Pass	10,485	-116	-1%	Pass

Table 79. Manchester East Screenline Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE/ STRATEGIC TOC	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
TransPennine	Manchester Piccadilly	Eastbound	6,614	7,495	881	13%	Pass	7,011	397	6%	Pass
		Westbound	6,690	8,076	1,386	21%	Pass	7,535	845	13%	Pass
Ashton-under-Lyne	Manchester Victoria	Eastbound	2,212	1,592	-620	-28%	Fail	1,638	-574	-26%	Fail
		Westbound	2,161	1,666	-495	-23%	Pass	1,703	-458	-21%	Pass
Calder Valley	Manchester Victoria	Eastbound	3,678	2,844	-834	-23%	Pass	2,993	-685	-19%	Pass
		Westbound	3,697	2,894	-803	-22%	Pass	2,961	-736	-20%	Pass
Total		Eastbound	12,504	11,930	-574	-5%	Pass	11,727	-777	-6%	Pass
		Westbound	12,548	12,635	87	1%	Pass	12,208	-340	-3%	Pass

10.3.20 The location of the Leeds screenlines are shown in Figure 20.

Figure 20. Location of Leeds Screenlines



10.3.21 Table 80 to Table 82 present the validation results for screenlines around the Leeds area. The Leeds East screenline in PFM v4.3 has failed the WebTAG criteria in both directions, whilst in PFM v3.0 all individual links and the screenline as a whole have comfortably passed the validation criteria. A detailed investigation suggests that in PFM v4.3 the model demand to/from zones in the east of Yorkshire & the Humber region is around 30% higher than PFM v3.0, which pushes up the flows on the services serving these areas, resulting in deteriorated validations on TransPennine services and the screenline.

10.3.22 The validation of the Leeds South screenline is very similar to PFM v3.0. Overall the screenline achieves WebTAG criteria; however Cross Country in the northbound direction is under assigned. The Leeds West screenline validates to WebTAG criteria. The validation of this screenline is very similar to PFM v3.0.

Table 80. Leeds East Screenline Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE/ STRATEGIC TOC	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
East Coast	Leeds	Eastbound	0	45	-	-	-	62	-	-	-
		Westbound	0	0	-	-	-	0	-	-	-
Cross Country	Leeds	Eastbound	2,354	2,085	-269	-11%	Pass	2,233	-121	-5%	Pass
		Westbound	2,049	2,136	87	4%	Pass	2,305	256	13%	Pass
TransPennine	Leeds	Eastbound	5,880	5,852	-28	0%	Pass	7,233	1,353	23%	Pass
		Westbound	5,912	6,098	186	3%	Pass	7,505	1,593	27%	Fail
Northern	Leeds	Eastbound	1,605	1,912	307	19%	Pass	1,860	255	16%	Pass
		Westbound	1,453	1,778	325	22%	Pass	1,725	272	19%	Pass
Total		Eastbound	9,839	9,894	55	1%	Pass	11,387	1,548	16%	Fail
		Westbound	9,414	10,012	598	6%	Pass	11,536	2,122	23%	Fail

Table 81. Leeds South Screenline Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE/ STRATEGIC TOC	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
East Coast	Leeds	Northbound	5,537	5,203	-334	-6%	Pass	5,024	-513	-9%	Pass
		Southbound	5,565	5,297	-268	-5%	Pass	5,018	-547	-10%	Pass
Cross Country	Leeds	Northbound	3,856	2,641	-1,215	-32%	Fail	2,673	-1,183	-31%	Fail
		Southbound	3,537	2,824	-713	-20%	Pass	2,735	-802	-23%	Pass
Total		Northbound	9,393	7,844	-1,549	-16%	Fail	7,697	-1,696	-18%	Fail
		Southbound	9,102	8,120	-982	-11%	Pass	7,753	-1,349	-15%	Pass

Table 82. Leeds West Screenline

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE/ STRATEGIC TOC	STATION	DIRECTION	MOIRA 2010/11	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
TransPennine	Leeds	Eastbound	9,102	9,925	823	9%	Pass	9,412	310	3%	Pass
		Westbound	9,228	10,540	1,312	14%	Pass	9,604	376	4%	Pass
Calder Valley (Northern)	Leeds	Eastbound	6,536	7,002	466	7%	Pass	6,759	223	3%	Pass
		Westbound	6,195	6,613	418	7%	Pass	6,582	387	6%	Pass
Total		Eastbound	15,638	16,928	1,290	8%	Pass	16,171	533	3%	Pass
		Westbound	15,423	17,153	1,730	11%	Pass	16,187	764	5%	Pass

Guard Counts on Long Distance TOCs

10.3.23 Validation has also been undertaken on modelled flows on a selection of long distance TOCs at various station locations. These flows are compared against Guard Counts; the results are shown in Table 83. Generally the validation is consistent, with all TOCs meeting WebTAG validation criteria with the exception of East Midlands in the northbound direction.

Table 83. Long Distance TOCs Guard Counts Validation Results

				PFM V3 BASE (PFM V3_1025B)				PFM V4.3 BASE			
ROUTE/ STRATEGIC TOC	STATION	DIRECTION	GUARD COUNTS (OBSERVED)	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	PLD MODEL (MODELLED)	DIFFERENCE	% DIFFERENCE	PASS/FAIL
East Coast	Leeds	Southbound Departure	5,467	5,297	-170	-3%	Pass	5,018	-449	-8%	Pass
	Newcastle	Southbound Departure	6,533	7,552	1,019	16%	Pass	7,535	1,002	15%	Pass
Virgin Trains	Birmingham New St	Southbound Departure	8,601	9,811	1,210	14%	Pass	10,129	1,528	18%	Pass
		Northbound Arrival	9,515	9,556	42	0%	Pass	9,922	407	4%	Pass
	Manchester Piccadilly	Southbound Departure	6,980	7,184	204	3%	Pass	7,171	191	3%	Pass
		Northbound Arrival	7,481	6,954	-526	-7%	Pass	7,222	-258	-3%	Pass
	Liverpool Lime St	Southbound Departure	2,441	2,418	-23	-1%	Pass	2,072	-369	-15%	Pass
		Northbound Arrival	2,592	2,232	-360	-14%	Pass	2,261	-331	-13%	Pass
East Midlands Trains (MM services)	Sheffield	Southbound Departure	3,131	2,555	-576	-18%	Pass	2,472	-659	-21%	Pass
		Northbound Arrival	3,565	2,373	-1,192	-33%	Fail	2,385	-1,180	-33%	Fail
	Nottingham	Southbound Departure	3,399	3,226	-173	-5%	Pass	3,237	-162	-5%	Pass

ROUTE/ STRATEGIC TOC	STATION	DIRECTION	GUARD COUNTS (OBSERVED)	PFM V3 BASE (PFM V3_1025B) PLD MODEL (MODELLED)	PFM V3 BASE (PFM V3_1025B) DIFFERENCE	PFM V3 BASE (PFM V3_1025B) % DIFFERENCE	PFM V3 BASE (PFM V3_1025B) PASS/ FAIL	PFM V4.3 BASE PLD MODEL (MODELLED)	PFM V4.3 BASE DIFFERENCE	PFM V4.3 BASE % DIFFERENCE	PFM V4.3 BASE PASS/FAIL
		Northbound Arrival	3,879	3,204	-675	-17%	Pass	3,484	-395	-10%	Pass
	Leicester	Southbound Departure	9,260	8,569	-691	-7%	Pass	8,966	-294	-3%	Pass
		Northbound Arrival	10,540	8,430	-2,110	-20%	Pass	8,641	-1,899	-18%	Pass
Total by TOC	East Coast	Southbound Departure	12,000	12,849	849	7%	Pass	12,553	553	5%	Pass
	Virgin Trains	Southbound Departure	18,021	19,413	1,391	8%	Pass	19,372	1,350	7%	Pass
		Northbound Arrival	19,587	18,742	-845	-4%	Pass	19,405	-183	-1%	Pass
	East Midlands Trains	Southbound Departure	15,790	14,349	-1,441	-9%	Pass	14,675	-1,115	-7%	Pass
		Northbound Arrival	17,984	14,007	-3,977	-22%	Fail	14,509	-3,475	-19%	Fail

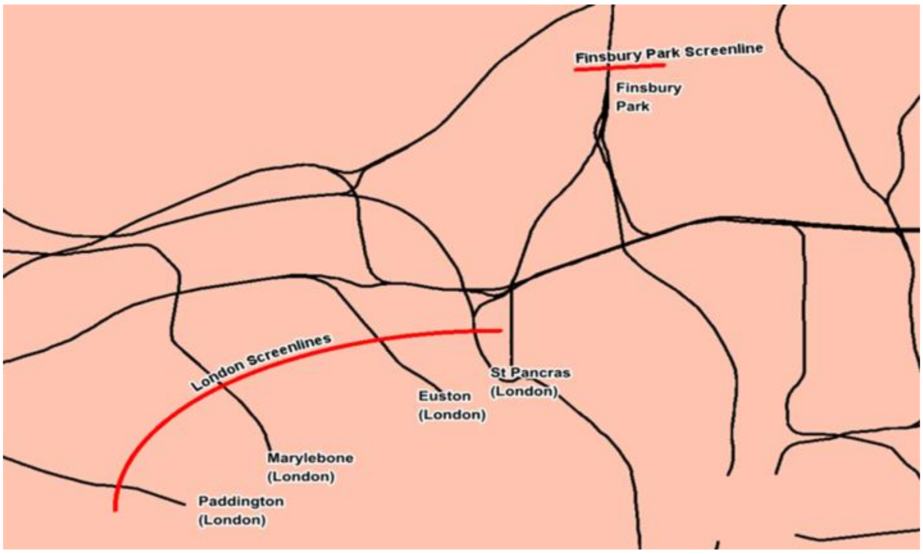
10.4 Regional Models Assignment Validation

10.4.1 A separate validation exercise has been carried out for the Regional Planet models. In all cases the validation has focussed on areas that would be impacted by HS2.

PLANET South

10.4.2 The location of the Central London screenline is shown in Figure 21.

Figure 21. Location of Planet South Validation Screenlines



10.4.3 For Planet South, results of validation at Central London stations are presented in Table 84. The overall screenline validation shows an improvement compared to PFM v3.0. The Chiltern Line shows an improvement in validation but still does not meet validation criteria, and the MML at St Pancras now fails validation.

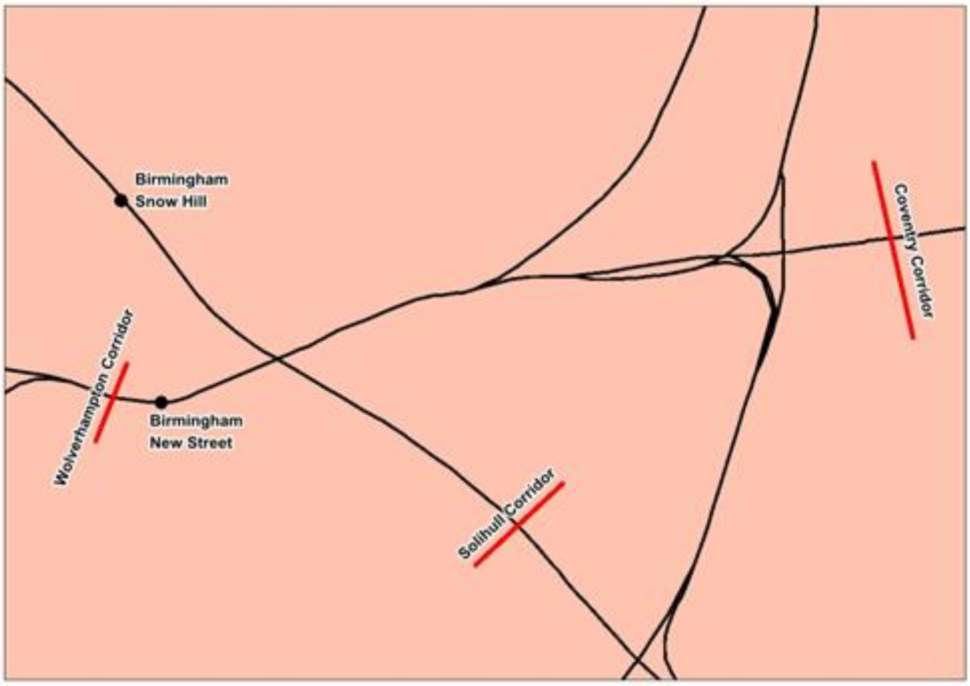
Table 84. PLANET South Validation Flows compared to PFM v3.0 (0700 -1000 arrivals in Central London)

		PFM V3.0 BASE				PFM V4.3 BASE			
ROUTE/COUNT POINT	COUNTS 2010/11	PS FRAME WORK	DIFFER ENCE	% DIFFER ENCE	PASS/ FAIL	PS FRAME WORK	DIFFER ENCE	% DIFFER ENCE	PASS / FAIL
Great Western Main Line (Paddington)	28,275	22,776	-5,499	-19%	Pass	22,291	-5,984	-21%	Pass
Chiltern Main Line (Marylebone)	11,546	7,260	-4,286	-37%	Fail	8,283	-3,263	-28%	Fail
West Coast Main Line (Euston)	22,603	19,667	-2,936	-13%	Pass	25,236	2,632	12%	Pass
Midland Main Line (St Pancras)	23,144	27,144	3,999	17%	Pass	29,935	6,791	29%	Fail
East Coast Main Line (Finsbury Pk)	35,939	33,010	-2,929	-8%	Pass	38,237	2,298	6%	Pass
Total	121,508	109,857	-11,651	-10%	Pass	123,982	2,475	2%	Pass

PLANET Midlands

10.4.4 The location of the Birmingham New Street screenlines are shown in Figure 22.

Figure 22. Location of Birmingham New Street Screenlines



10.4.5 Planet Midlands validation results are shown in Table 85 below. Generally levels of validation are very similar to PFM v3.0, with the only exception being the Solihull corridor, where validation has deteriorated although it still meets WebTAG criteria. There is a small improvement in the overall screenline validation.

Table 85. Planet Midlands Validation Results (0700-1000 to Birmingham New Street)

	OBSERVERED DATA	PFM V3.0 BASE				PFM V4.3 BASE			
CORRIDOR FROM	FLOWS 2010/11	PM FRAME WORK	DIFFER ENCE	% DIFFER ENCE	PASS/ FAIL	PM FRAME WORK	DIFFER ENCE	% DIFFER ENCE	PASS / FAIL
West Coast Main Line (Coventry Corridor)	4,851	4,612	-239	-5%	Pass	4,495	-356	-7%	Pass
Solihull Corridor to New St (Long-distance TOCs)	421	387	-34	-8%	Pass	332	-89	-21%	Pass
West Coast Main Line (Wolverhampton Corridor)	5,959	6,649	690	12%	Pass	6,520	562	9%	Pass
All Corridors	11,230	11,648	418	4%	Pass	11,347	117	1%	Pass

PLANET North

10.4.6 In PN, validation screenlines have been created around Manchester, Leeds and South Yorkshire. The location of the Manchester screenlines are shown in Figure 23 and Figure 24.

Figure 23. Location of Manchester Validation Screenlines (1)

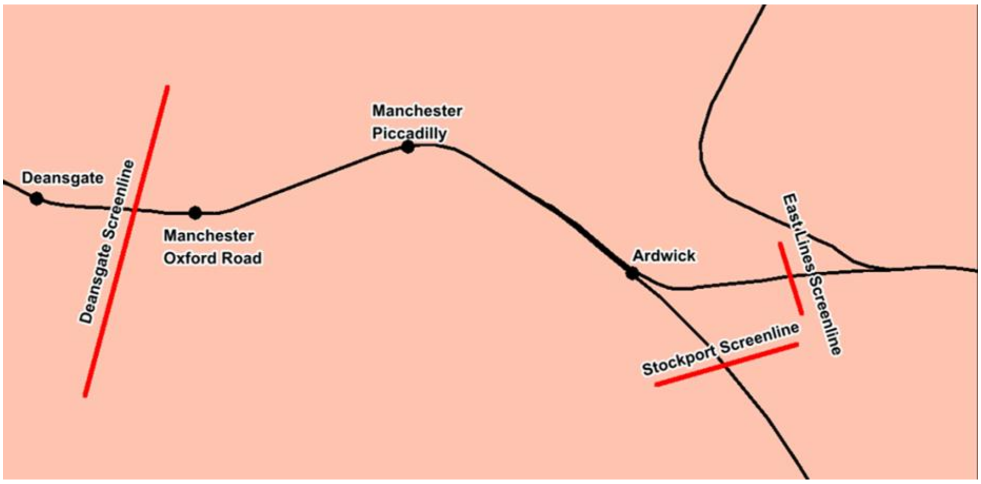
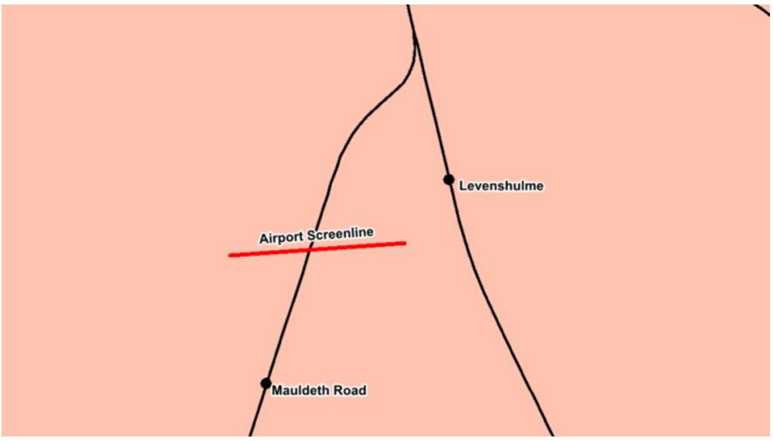


Figure 24. Location of Manchester Validation Screenlines (2)



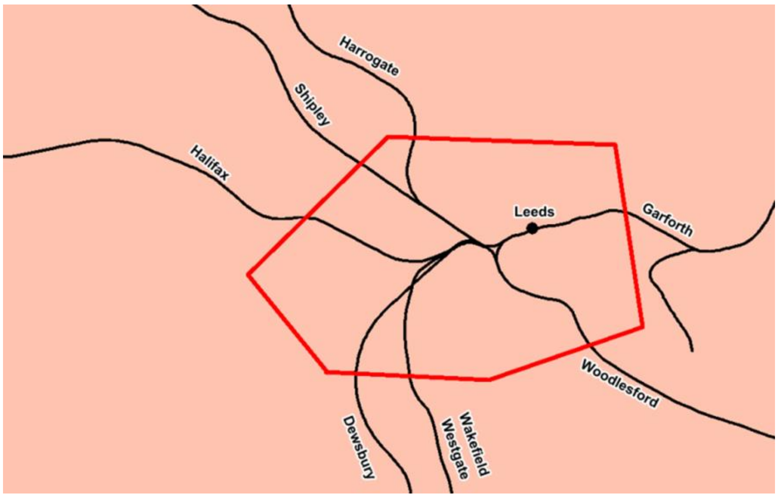
10.4.7 Validation results for the Manchester screenline are presented in Table 86. Validation at Manchester is generally good, with only two links falling outside of the WebTAG criteria. This very localised inaccuracy is offset by under-assignment at other Manchester termini, with the overall result being a very good level of validation at the screenline level.

Table 86. Planet North Validation Results (Manchester)

		PFM V3.0 BASE				PFM V4.3 BASE			
CORRIDOR	FLOWS 2010/11	MODEL FLOW	DIFFER ENCE	% DIFFER ENCE	PASS/ FAIL	MODEL FLOW	DIFFER ENCE	% DIFFER ENCE	PASS / FAIL
Stockport	6,379	6,301	-79	-1%	Pass	6,101	-279	-4%	Pass
East Lines	3,876	4,819	943	24%	Pass	4,662	786	20%	Pass
Airport	1,886	1,533	-353	-19%	Pass	1,401	-485	-26%	Fail
Piccadilly sub-total	12,141	12,662	521	4%	Pass	12,170	29	0%	Pass
Deansgate	6,431	5,576	-856	-13%	Pass	5,459	-972	-15%	Pass
Oxford Rd sub-total	6,431	5,576	-856	-13%	Pass	5,459	-972	-15%	Pass
Salford Central	1,918	3,200	1,282	67%	Fail	2,877	959	50%	Fail
Rochdale	1,744	1,637	-107	-6%	Pass	1,597	-147	-8%	Pass
Ashton	1,225	1,064	-161	-13%	Pass	1,077	-148	-12%	Pass
Victoria sub-total	4,887	5,901	1,014	21%	Pass	5,550	663	14%	Pass
All Corridors	23,459	24,139	680	3%	Pass	23,179	-280	-1%	Pass

10.4.8 The location of the Leeds screenline are shown in Figure 25.

Figure 25. Leeds Screenlines



10.4.9 Validation results for the Leeds screenline are presented in Table 87. The Leeds validation shows three links that fail to meet WebTAG criteria, this is slightly worse than PFM v3.0. Overall validation of the screenline does pass the WebTAG criteria.

Table 87. Planet North Validation Results (Leeds)

		PFM V3.0 BASE				PFM V4.3 BASE			
CORRIDOR	FLOWS 2010/11	MODEL FLOW	DIFFERENCE	% DIFFERENCE	PASS/ FAIL	MODEL FLOW	DIFFERENCE	% DIFFERENCE	PASS / FAIL
Wakefield Westgate	2,951	3,440	489	17%	Pass	2,910	-41	-1%	Pass
Woodlesford	1,766	726	-1,040	-59%	Fail	701	-1,065	-60%	Fail
Dewsbury	3,835	4,357	522	14%	Pass	4,099	264	7%	Pass
Halifax	2,545	2,709	164	6%	Pass	2,596	51	2%	Pass
Shipley	3,449	3,212	-237	-7%	Pass	2,917	-532	-15%	Pass
Ilkley	2,197	1,646	-551	-25%	Fail	1,540	-657	-30%	Fail
Harrogate	2,251	1,760	-491	-22%	Pass	1,535	-716	-32%	Fail
Garforth	4,337	3,904	-434	-10%	Pass	4,162	-176	-4%	Pass
All Corridors	23,331	21,753	-1,578	-7%	Pass	20,458	-2,873	-12%	Pass

10.4.10 The location of the Sheffield screenlines is shown in Figure 26 and the Chesterfield screenlines in Figure 27.

Figure 26. Location of Sheffield Screenline

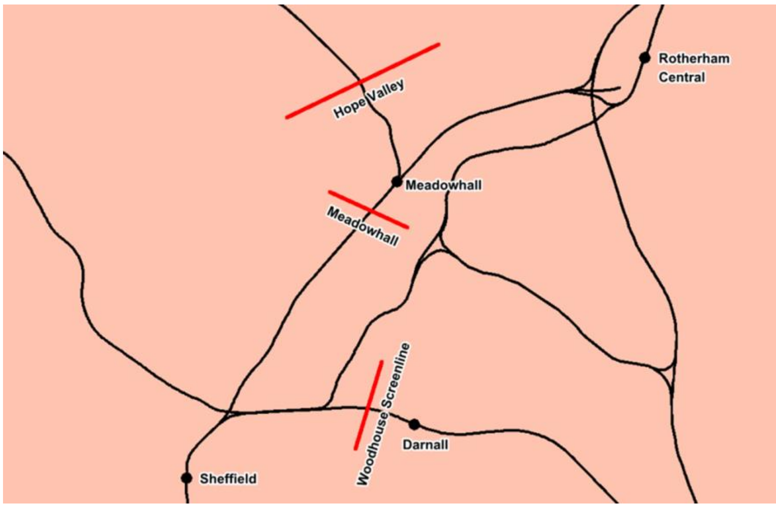
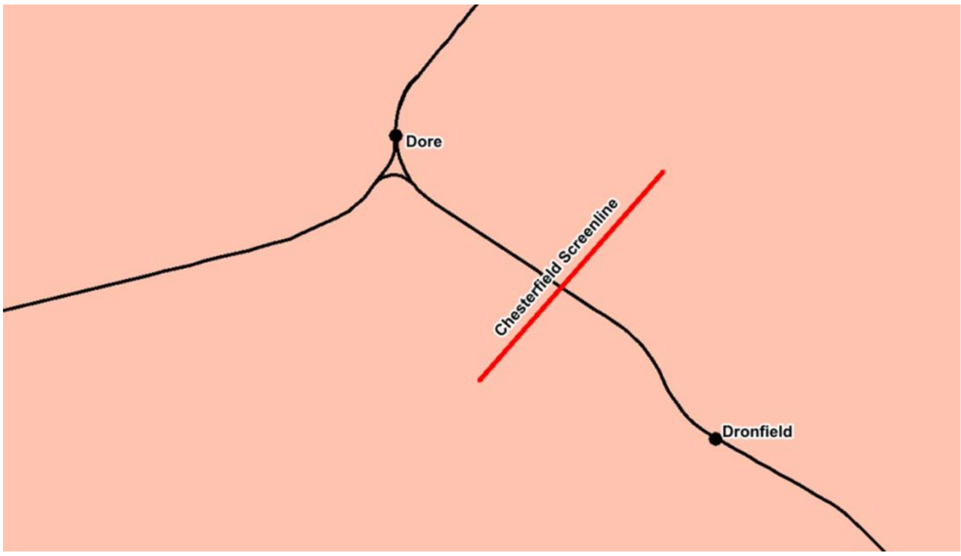


Figure 27. Location of Chesterfield Screenline



10.4.11 Validation results for Sheffield and Chesterfield are presented in Table 88. The Sheffield screenline validates within the WebTAG limits. Within the screenline we can see that there is sensitivity between route choice, affecting the link level validation of Hope Valley and Woodhouse corridors. Although the percentage difference from observed appears high, the absolute values using this corridor are small.

Table 88. Planet North Validation Results (Sheffield)

CORRIDOR	NEW FLOWS 2010/11	PFM V3.0 BASE MODEL FLOW	PFM V3.0 BASE DIFFERENCE	PFM V3.0 BASE % DIFFERENCE	PFM V3.0 BASE PASS/ FAIL	PFM V4.3 BASE MODEL FLOW	PFM V4.3 BASE DIFFERENCE	PFM V4.3 BASE % DIFFERENCE	PFM V4.3 BASE PASS / FAIL
Meadowhall	3,637	3,006	-631	-17%	Pass	2,889	-748	-21%	Pass
Hope Valley	726	1,014	288	40%	Fail	893	167	23%	Pass
Woodhouse	552	333	-219	-40%	Fail	298	-254	-46%	Fail
Chesterfield	1,774	1,822	48	3%	Pass	1,816	42	2%	Pass
All Corridors	6,689	6,175	-514	-8%	Pass	5,895	-794	-12%	Pass

Validation Summary

10.4.12 A summary of the rail validation for PLD and the regional models is included in Tables 89 to 91. Table 89 presents a summary of the PLD validation against MOIRA data, Table 90 presents a summary of the PLD validation against Guards counts and Table 91 presents a summary of the validation of the regional models.

10.4.13 Overall the PFM model exhibits an acceptable level of validation across the vast majority of links. The functionality development that has occurred since PFM v3.0 has had a positive impact on the validation. Overall, the PFM v4.3 performs equally, and in some cases better than PFM v3.0. There are a small number of screenline flows where the validation has deteriorated, though the scale and overall impact of these is negligible.

10.4.14 In conclusion, we believe that the model represents a reasonable representation of observed travel patterns in the base year and is suitable as a basis for developing forecasts.

10.4.15 In most cases the model accurately assigns demand to the appropriate train services. However, in some cases there are differences from the estimates in MOIRA and/or the Guards' counts data. This is to be expected, as models will always be better at modelling some areas than others. In general the PLD model differs to other data sources in the following areas:

- Outside of the core areas of interest, ie the proposed HS2 scheme alignment;
- Where significant amounts of local demand are modelled outside PLD (by PLANET South / Midlands). In these locations, an improved level of validation is observed when the models (PLD and the relevant regional model) are considered together;
- Where fare differential may be affecting choice of route - though the total level of demand across these routes is more robust; and
- Where MOIRA predicts flow patterns that are unlikely to be observed in reality

(e.g. where flows differ substantially by direction).

10.4.16 No model of the size and complexity of the PLD model is going to produce a perfect validation. On the WebTAG criteria being examined, the validation is good. The key corridors and areas of interest validate to within the levels outlined in the criteria. The functionality changes made to the model have proved successful in improving validation, and of equal importance, have not caused significant negative impacts.

Table 89. Planet Long Distance Validation Summary vs Moira

SCREENLINE LOCATIONS	DIRECTON	OBSERVED	PFM V3_1025B					PFM V4.3 BASE				
			MODELLED	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NO. OF PASS LINKS AT 25%	MODELLED	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NUMBER OF PASS LINKS AT 25%
London Termini Screenline	Outbound	67,461	63,823	-3,638	-5%	Pass	2 / 3	62,972	-4,489	-7%	Pass	2 / 3
	Inbound	61,535	64,331	2,796	5%	Pass	2 / 3	61,897	362	1%	Pass	3 / 3
Peterborough North Screenline	Northbound	16,820	18,922	2,102	12%	Pass	1 / 1	18,104	1,284	8%	Pass	1 / 1
	Southbound	16,637	18,247	1,610	10%	Pass	1 / 1	18,170	1,533	9%	Pass	1 / 1
Peterborough South Screenline	Northbound	19,052	20,041	989	5%	Pass	1 / 1	19,194	142	1%	Pass	1 / 1
	Southbound	19,040	19,313	273	1%	Pass	1 / 1	19,337	297	2%	Pass	1 / 1
Bedford North Screenline	Northbound	10,244	8,744	-1,500	-15%	Pass	1 / 1	8,859	-1,385	-14%	Pass	1 / 1
	Southbound	10,301	8,799	-1,502	-15%	Pass	1 / 1	9,333	-968	-9%	Pass	1 / 1
Bedford South Screenline	Northbound	12,732	10,868	-1,864	-15%	Pass	1 / 1	11,073	-1,659	-13%	Pass	1 / 1
	Southbound	11,991	10,852	-1,139	-9%	Pass	1 / 1	11,453	-538	-4%	Pass	1 / 1
South of Midlands Upper Screenline	Northbound	35,430	39,557	4,127	12%	Pass	2 / 3	37,934	2,504	7%	Pass	2 / 3
	Southbound	35,822	40,899	5,077	14%	Pass	2 / 3	39,100	3,278	9%	Pass	3 / 3

SCREENLINE LOCATIONS	DIRECTON	OBSERVED	PFM V3_1025B					PFM V4.3 BASE				
			MODELLED	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NO. OF PASS LINKS AT 25%	MODELLED	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NUMBER OF PASS LINKS AT 25%
South of Midlands Lower Screenline	Northbound	37,771	41,229	3,458	9%	Pass	2 / 3	41,228	3,457	9%	Pass	3 / 3
	Southbound	37,350	42,553	5,203	14%	Pass	2 / 3	42,818	5,468	15%	Pass	3 / 3
North of Midlands Upper Screenline	Northbound	21,694	22,889	1,195	6%	Pass	2 / 2	22,633	939	4%	Pass	2 / 2
	Southbound	21,838	22,728	890	4%	Pass	2 / 2	14,259	536	2%	Pass	2 / 2
North of Midlands Lower Screenline	Northbound	21,981	23,614	1,633	7%	Pass	2 / 2	23,289	1,308	6%	Pass	2 / 2
	Southbound	22,019	23,122	1,103	5%	Pass	2 / 2	22,679	660	3%	Pass	2 / 2
Preston North Screenline	Northbound	9,262	8,477	-785	-8%	Pass	1 / 2	8,353	-909	-10%	Pass	1 / 2
	Southbound	9,300	8,438	-862	-9%	Pass	0 / 2	8,513	-787	-8%	Pass	0 / 2
Preston South Screenline	Northbound	9,954	10,351	397	4%	Pass	2 / 2	10,152	198	2%	Pass	2 / 2
	Southbound	9,877	10,545	668	7%	Pass	1 / 2	10,536	659	7%	Pass	2 / 2
Doncaster Upper Screenline	Northbound	16,635	17,337	702	4%	Pass	1 / 2	17,206	571	3%	Pass	1 / 2
	Southbound	17,187	17,502	315	2%	Pass	2 / 2	17,675	488	3%	Pass	2 / 2

SCREENLINE LOCATIONS	DIRECTON	OBSERVED	PFM V3_1025B					PFM V4.3 BASE				
			MODELLED	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NO. OF PASS LINKS AT 25%	MODELLED	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NUMBER OF PASS LINKS AT 25%
Doncaster Lower Screenline	Northbound	17,342	18,391	1,049	6%	Pass	2 / 2	18,003	661	4%	Pass	2 / 2
	Southbound	17,919	18,496	577	3%	Pass	2 / 2	18,506	587	3%	Pass	2 / 2
Newcastle Upper Screenline	Northbound	6,296	6,521	225	4%	Pass	2 / 2	6,553	257	4%	Pass	2 / 2
	Southbound	6,319	6,466	147	2%	Pass	2 / 2	6,513	194	3%	Pass	2 / 2
Newcastle Lower Screenline	Northbound	10,150	11,216	1,066	11%	Pass	2 / 2	11,439	1,289	13%	Pass	2 / 2
	Southbound	10,437	11,323	886	8%	Pass	2 / 2	11,354	914	9%	Pass	2 / 2
Manchester South Screenline	Northbound	14,428	14,493	65	0%	Pass	5 / 5	15,030	602	4%	Pass	5 / 5
	Southbound	15,534	15,045	-489	-3%	Pass	5 / 5	14,972	-562	-4%	Pass	5 / 5
Manchester East Screenline	Eastbound	12,504	11,930	-574	-5%	Pass	2 / 3	11,727	-777	-6%	Pass	2 / 3
	Westbound	12,548	12,635	87	1%	Pass	3 / 3	12,208	-340	-3%	Pass	3 / 3
Manchester West Screenline	Eastbound	11,691	10,563	-1,128	-10%	Pass	3 / 3	10,784	-907	-8%	Pass	3 / 3
	Westbound	10,601	10,659	58	1%	Pass	3 / 3	10,485	-116	-1%	Pass	3 / 3

SCREENLINE LOCATIONS	DIRECTON	OBSERVED	PFM V3_1025B					PFM V4.3 BASE				
			MODELLED	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NO. OF PASS LINKS AT 25%	MODELLED	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NUMBER OF PASS LINKS AT 25%
Leeds East Screenline	Eastbound	9,839	9,894	55	1%	Pass	3 / 3	11,387	1,548	16%	Fail	3 / 3
	Westbound	9,414	10,012	598	6%	Pass	3 / 3	11,536	2,122	23%	Fail	2 / 3
Leeds South Screenline	Northbound	9,393	7,844	-1,549	-16%	Fail	1 / 2	7,697	-1,696	-18%	Fail	1 / 2
	Southbound	9,102	8,120	-982	-11%	Pass	2 / 2	7,753	-1,349	-15%	Pass	2 / 2
Leeds West Screenline	Eastbound	15,638	16,928	1,290	8%	Pass	2 / 2	16,171	533	3%	Pass	2 / 2
	Westbound	15,423	17,153	1,730	11%	Pass	2 / 2	16,187	764	5%	Pass	2 / 2

Table 90. Planet Long Distance Validation Summary vs Guards Counts

SCREENLINE LOCATIONS	DIRECTON	OBSERVED	PFM V3_1025B					PFM V4.3 BASE				
			MODELLED	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NO. OF PASS LINKS AT 25%	MODELLED	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NUMBER OF PASS LINKS AT 25%
London Termini Screenline	Outbound	58,784	63,823	5,039	9%	Pass	3 / 3	62,972	4,187	7%	Pass	3 / 3
	Inbound	57,900	64,331	6,431	11%	Pass	2 / 3	61,897	3,996	7%	Pass	2 / 3
East Coast TOC	Southbound	12,000	12,849	849	7%	Pass	2 / 2	12,553	553	5%	Pass	2 / 2
Virgin Trains TOC	Southbound	18,021	19,413	1,391	8%	Pass	3 / 3	19,372	1,350	7%	Pass	3 / 3
	Northbound	19,587	18,742	-845	-4%	Pass	3 / 3	19,405	-183	-1%	Pass	3 / 3
East Midlands Trains TOC	Southbound	15,790	14,349	-1,441	-9%	Pass	3 / 3	14,675	-1,115	-7%	Pass	3 / 3
	Northbound	17,984	14,007	-3,977	-22%	Fail	2 / 3	14,509	-3,475	-19%	Fail	2 / 3

Table 91. Regional models Validation Summary

SCREENLINE LOCATIONS	DIRECTON	OBSERVED	PFM V3_1025B					PFM V4.3 BASE				
			MODELLED	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NO. OF PASS LINKS AT 25%	MODELLED	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NUMBER OF PASS LINKS AT 25%
Planet South												
To Central London	Total	121,508	109,857	-11,651	-10%	Pass	4 / 5	123,982	2,475	2%	Pass	3 / 5
Planet Midlands												
To Birmingham New Street	All Corridors	11,230	11,648	418	4%	Pass	3 / 3	11,347	117	1%	Pass	3 / 3
Planet North												
Manchester	All Corridors	23,459	24,139	680	3%	Pass	9 / 10	23,179	-280	-1%	Pass	8 / 10
Leeds	All Corridors	23,331	21,753	-1,578	-7%	Pass	6 / 8	20,458	-2,873	-12%	Pass	5 / 8
Sheffield	All Corridors	6,689	6,175	-514	-8%	Pass	2 / 4	5,895	-794	-12%	Pass	3 / 4

10.5 Assignment Convergence

Introduction

10.5.1 It is important that the PFM provides stable, consistent and robust outputs. To ensure this happens model convergence is monitored for all of the assignment models within PFM. Within PLD there are separate rail, highway and air assignments models and each of the regional models has separate rail assignments. The assignment of demand to networks in all of the assignment models (with the exception of the air assignment) includes some form of relationship between level of demand and level of service. In the rail assignment models this is in the form of crowding functions, in the highway assignment models this is in the form of speed/flow curves. All of the assignment models have assignment algorithms which attempt to minimise the overall network costs, this is an iterative process. Overall network performance indicators are calculated at each iteration of the assignment model which are compared to previous iterations to determine how close consecutive iterations are.

Rail Assignments

10.5.2 As part of the rail assignments in PLD and all of the regional models, a number of model convergence statistics are calculated. The following assignment statistics are output to monitor convergence:

- the overall network wide passenger kilometres is calculated for each iteration, the percentage and absolute changes between iterations are compared;
- the segment with the minimum and maximum flow difference between each iteration is identified. (A segment is a specific transit line on a specific link); and
- The total network generalised cost is calculated for each iteration (on a matrix basis) the percentage and absolute changes between iterations are compared.

10.5.3 There is no automatic convergence stopping criteria built into the rail assignment. All of the models run for a set number of iterations. In PLD the rail assignment is run for 20 iterations, in PS 12 iterations, and in PM and PN 10 iterations. Network convergence statistics are monitored and the end of a model run to ensure a suitable level of convergence is achieved.

10.5.4 Outputs for PLD and each of the regional models is presented in Tables 92 to 95.

Table 92. PLD Rail Assignment Convergence Statistics

Convergence Outputs: (Scenario 15002 - mf mf mf) 20130614

	NETWORK									MATRIX		
Iter	Pass km	Passkm Change	%Change	Min Diff Value	Line	i-j	Max Diff Value	Line	i-j	Change between Iterations		
0	59879112	59879112	100.00%	-4102.99	2876	914- 739	.00	5	92136- 92141	3502469376	3502469376	100.00%
1	59849620	2682858	4.48%	-284.69	647	629- 2394	527.60	648	610- 629	5834529	3508304640	.17%
2	59848736	454146	.76%	-51.56	647	482340- 6885	61.37	648	481615- 610	1169804	3507178496	.03%
3	59846724	140821	.24%	-22.71	647	482340- 6885	26.65	648	481615- 610	130788	3507216384	.00%
4	59845272	72035	.12%	-18.47	647	93899-482340	21.23	40	93899-482340	28615	3507207936	.00%
5	59844548	44379	.07%	-8.79	647	482340- 6885	9.88	648	481615- 610	16292	3507196160	.00%
6	59844116	29945	.05%	-6.10	647	482340- 6885	6.86	648	481615- 610	9341	3507191552	.00%
7	59843632	21500	.04%	-4.48	647	482340- 6885	5.01	648	481615- 610	6779	3507187712	.00%
8	59843052	16243	.03%	-3.33	647	482340- 6885	3.79	648	481615- 610	4815	3507185152	.00%
9	59842396	12641	.02%	-6.29	647	93899-482340	10.46	40	93899-482340	3499	3507182848	.00%
10	59842160	10265	.02%	-3.45	40	93899-482340	2.49	648	481615- 610	4577	3507179008	.00%
11	59842036	9578	.02%	-2.83	40	93899-482340	2.03	648	481615- 610	2894	3507177728	.00%
12	59841740	7906	.01%	-2.38	40	93899-482340	1.67	648	481615- 610	2968	3507176448	.00%
13	59841620	6701	.01%	-1.31	647	481615- 610	1.43	648	481615- 610	2360	3507174912	.00%
14	59841580	5683	.01%	-3.41	647	93899-482340	6.15	40	93899-482340	1967	3507174400	.00%
15	59841640	5003	.01%	-2.11	40	93899-482340	1.09	648	481615- 610	2546	3507172608	.00%
16	59841544	4371	.01%	-1.86	40	93899-482340	.97	648	481615- 610	1977	3507172352	.00%
17	59841352	3879	.01%	-.92	40	93899-482340	.86	648	481615- 610	1413	3507171840	.00%
18	59841340	3429	.01%	-.79	40	93899-482340	.76	648	481615- 610	1302	3507171072	.00%
19	59841232	3074	.01%	-2.39	647	93899-482340	4.59	40	93899-482340	1341	3507170560	.00%
20	59841160	2735	.00%	-1.55	40	93899-482340	.65	651	93899-482340	1864	3507169024	.00%

End (Macro terminated normally, after 5 CPU minutes)

Source \01PLD\01Base\01Base_Assign\convergence-15002.prn

Table 93. PS Rail Assignment Convergence Statistics

Convergence Outputs: (Scenario 1001 - mf253 mf254 mf255) 20130614

Iter	NETWORK: Pass km	Passkm Change	%Change	Min Diff Value	Line	i-j	Max Diff Value	Line	i-j	MATRIX: Change between Iterations		
0	41933952	41933952	100.00%	-35164.43	1680	268- 411	.00	3	26139- 28017	**********	**********	100.01%
1	42002492	7312641	17.41%	-5425.70	1682	274- 298	12473.53	1680	268- 411	5675977	**********	.00%
2	41946356	2191669	5.22%	-2346.93	1680	274- 298	2292.15	1682	298- 1013	1425827	**********	.00%
3	41964092	896954	2.14%	-1035.07	1680	274- 298	1226.98	1682	298- 1013	741354	**********	.00%
4	41952340	501851	1.20%	-573.93	1680	274- 298	724.39	1682	298- 1013	438990	**********	.00%
5	41955104	316655	.75%	-370.52	1680	274- 298	470.35	1682	298- 1013	290845	**********	.00%
6	41945628	302665	.72%	-268.83	1680	274- 298	331.90	1682	298- 1013	206430	**********	.00%
7	41949420	208281	.50%	-206.08	1680	274- 298	244.67	1682	298- 1013	153356	**********	.00%
8	41950924	154325	.37%	-137.09	1680	274- 298	187.75	1682	298- 1013	118864	**********	.00%
9	41944820	147505	.35%	-117.88	1680	274- 298	150.69	1682	298- 1013	94439	**********	.00%
10	41946312	130683	.31%	-112.81	1680	274- 298	121.76	1682	298- 1013	76904	**********	.00%
11	41942892	100813	.24%	-80.15	1680	274- 298	101.03	1682	298- 1013	63882	**********	.00%
12	41941936	123029	.29%	-94.28	1688	655- 844	90.60	1698	914- 739	53895	**********	.00%

End (Macro terminated normally, after 49 CPU minutes)

Source: \02PS\01Baseconvergence-1001.prn

Convergence Outputs: (Scenario 2001 - mf117 mf118 mf119) 20130614

Iter	NETWORK: Pass km	Passkm Change	%Change	Min Diff Value	Line	i-j	Max Diff Value	Line	i-j	MATRIX: Change between Iterations		
0	1305415	1305415	100.00%	-2318.37	174	91132- 91004	.00	5	94387- 91351	4214309	4214309	100.00%
1	1319699	133342	10.10%	-531.73	167	91004- 91040	686.54	174	91004- 91040	322485	4536793	7.11%
2	1319220	40288	3.05%	-228.53	174	91004- 91040	200.25	175	91004- 91040	77999	4612932	1.69%
3	1319943	17591	1.33%	-72.02	174	91004- 91040	100.06	167	91004- 91040	41856	4654787	.90%
4	1320442	9377	.71%	-19.05	176	91132- 91004	42.40	167	91004- 91040	26601	4681386	.57%
5	1320811	7465	.57%	-25.24	325	91215- 91034	28.14	167	91040- 91127	17806	4699187	.38%
6	1320978	7631	.58%	-12.25	174	91004- 91040	23.58	332	91218- 91143	12824	4712009	.27%
7	1321160	4052	.31%	-8.00	174	91004- 91040	11.65	167	91040- 91127	9578	4721583	.20%
8	1321336	3334	.25%	-9.30	179	91132- 91004	21.63	174	91044- 91138	7470	4729050	.16%
9	1321402	2860	.22%	-11.19	174	91004- 91040	15.06	179	91044- 91138	5916	4734960	.12%
10	1321443	2240	.17%	-3.94	137	91030- 91129	7.93	167	91040- 91127	4854	4739808	.10%

End (Macro terminated normally, after 11 CPU seconds)

Table 94. PM Rail Assignment Convergence Statistics

Source: 03PM\PMAM\MidTest\02AssignDBconvergence-2001.prn

Table 95. PN Rail Assignment Convergence Statistics

Convergence Outputs: (Scenario 2001 - mf117 mf118 mf119) 20130614

Iter	NETWORK: Pass km	Passkm Change	%Change	Min Diff Value	Line	i-j	Max Diff Value	Line	i-j	MATRIX: Change between Iterations		
0	1883123	1883123	100.00%	-2552.27	88	92245- 92249	.00	1	92412- 92546	**********	**********	100.00%
1	1888618	153592	8.13%	-395.47	294	98556- 98346	222.86	246	98505- 98487	355597	**********	.00%
2	1887156	51043	2.70%	-105.84	246	98326- 98484	105.32	254	92599- 92606	90943	**********	.00%
3	1886475	21090	1.12%	-36.83	250	98504- 98484	33.57	279	98309- 98487	49432	**********	.00%
4	1886053	15505	.82%	-22.42	279	98591- 98309	75.09	250	98519- 98518	30111	**********	.00%
5	1885788	9376	.50%	-30.70	250	98504- 98484	10.82	122	92599- 92606	19847	**********	.00%
6	1885609	7288	.39%	-21.85	250	98504- 98484	19.19	279	98309- 98487	14374	**********	.00%
7	1885492	5825	.31%	-16.38	250	98504- 98484	10.01	274	98506- 98345	10848	**********	.00%
8	1885365	5744	.30%	-12.74	250	98504- 98484	27.73	254	92599- 92606	8540	**********	.00%
9	1885271	5728	.30%	-8.36	254	92599- 92606	37.90	250	98326- 98519	6855	**********	.00%
10	1885214	3439	.18%	-12.67	250	98504- 98484	5.09	122	92599- 92606	5417	**********	.00%

End (Macro terminated normally, after 29 CPU seconds)

Source: \04PN\PNAM\NorthTest\02AssignDBconvergence-2001.prn

MODEL	SCREENLINE LOCATIONS	DIRECTON	PFM V3_1025B				PFM V4.3 BASE			
			DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NO. OF PASS LINKS AT 25%	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NUMBER OF PASS LINKS AT 25%
PLD	**Existing Screenlines**									
	London Termini Screenline - Counts	Outbound	5,039	9%	Pass	3 / 3	4,187	7%	Pass	3 / 3
		Inbound	6,431	11%	Pass	2 / 3	3,996	7%	Pass	2 / 3
	London Termini Screenline - MOIRA Flows	Outbound	-3,638	-5%	Pass	2 / 3	-4,489	-7%	Pass	2 / 3
		Inbound	2,796	5%	Pass	2 / 3	362	1%	Pass	3 / 3
	South of Midlands Upper Screenline	Northbound	4,127	12%	Pass	2 / 3	2,504	7%	Pass	2 / 3
		Southbound	5,077	14%	Pass	2 / 3	3,278	9%	Pass	3 / 3
	South of Midlands Lower Screenline	Northbound	3,458	9%	Pass	2 / 3	3,457	9%	Pass	3 / 3
		Southbound	5,203	14%	Pass	2 / 3	5,468	15%	Pass	3 / 3
	North of Midlands Upper Screenline	Northbound	1,195	6%	Pass	2 / 2	939	4%	Pass	2 / 2
		Southbound	890	4%	Pass	2 / 2	536	2%	Pass	2 / 2
	North of Midlands Lower Screenline	Northbound	1,633	7%	Pass	2 / 2	1,308	6%	Pass	2 / 2
		Southbound	1,103	5%	Pass	2 / 2	660	3%	Pass	2 / 2
	Doncaster Upper Screenline	Northbound	702	4%	Pass	1 / 2	571	3%	Pass	1 / 2

MODEL	SCREENLINE LOCATIONS	DIRECTON	PFM V3_1025B				PFM V4.3 BASE			
			DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NO. OF PASS LINKS AT 25%	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NUMBER OF PASS LINKS AT 25%
		Southbound	315	2%	Pass	2 / 2	488	3%	Pass	2 / 2
	Doncaster Lower Screenline	Northbound	1,049	6%	Pass	2 / 2	661	4%	Pass	2 / 2
		Southbound	577	3%	Pass	2 / 2	587	3%	Pass	2 / 2
	Newcastle Upper Screenline	Northbound	225	4%	Pass	2 / 2	257	4%	Pass	2 / 2
		Southbound	147	2%	Pass	2 / 2	194	3%	Pass	2 / 2
	Newcastle Lower Screenline	Northbound	1,066	11%	Pass	2 / 2	1,289	13%	Pass	2 / 2
		Southbound	886	8%	Pass	2 / 2	914	9%	Pass	2 / 2
	New Screenlines:									
	Manchester South Screenline	Northbound	65	0%	Pass	5 / 5	602	4%	Pass	5 / 5
		Southbound	-489	-3%	Pass	5 / 5	-562	-4%	Pass	5 / 5
	Manchester East Screenline	Eastbound	-574	-5%	Pass	2 / 3	-777	-6%	Pass	2 / 3
		Westbound	87	1%	Pass	3 / 3	-340	-3%	Pass	3 / 3
	Manchester West Screenline	Eastbound	-1,128	-10%	Pass	3 / 3	-907	-8%	Pass	3 / 3
		Westbound	58	1%	Pass	3 / 3	-116	-1%	Pass	3 / 3

MODEL	SCREENLINE LOCATIONS	DIRECTON	PFM V3_1025B				PFM V4.3 BASE			
			DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NO. OF PASS LINKS AT 25%	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NUMBER OF PASS LINKS AT 25%
	Leeds East Screenline	Eastbound	55	1%	Pass	3 / 3	1,548	16%	Fail	3 / 3
		Westbound	598	6%	Pass	3 / 3	2,122	23%	Fail	2 / 3
	Leeds South Screenline	Northbound	-1,549	-16%	Fail	1 / 2	-1,696	-18%	Fail	1 / 2
		Southbound	-982	-11%	Pass	2 / 2	-1,349	-15%	Pass	2 / 2
	Leeds West Screenline	Eastbound	1,290	8%	Pass	2 / 2	533	3%	Pass	2 / 2
		Westbound	1,730	11%	Pass	2 / 2	764	5%	Pass	2 / 2
	Preston North Screenline	Northbound	-785	-8%	Pass	1 / 2	-909	-10%	Pass	1 / 2
		Southbound	-862	-9%	Pass	0 / 2	-787	-8%	Pass	0 / 2
	Preston South Screenline	Northbound	397	4%	Pass	2 / 2	198	2%	Pass	2 / 2
		Southbound	668	7%	Pass	1 / 2	659	7%	Pass	2 / 2
	Peterborough North Screenline	Northbound	2,102	12%	Pass	1 / 1	1,284	8%	Pass	1 / 1
		Southbound	1,610	10%	Pass	1 / 1	1,533	9%	Pass	1 / 1
	Peterborough South Screenline	Northbound	989	5%	Pass	1 / 1	142	1%	Pass	1 / 1
		Southbound	273	1%	Pass	1 / 1	297	2%	Pass	1 / 1

MODEL	SCREENLINE LOCATIONS	DIRECTON	PFM V3_1025B				PFM V4.3 BASE			
			DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NO. OF PASS LINKS AT 25%	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NUMBER OF PASS LINKS AT 25%
	Bedford North Screenline	Northbound	-1,500	-15%	Pass	1 / 1	-1,385	-14%	Pass	1 / 1
		Southbound	-1,502	-15%	Pass	1 / 1	-968	-9%	Pass	1 / 1
	Bedford South Screenline	Northbound	-1,864	-15%	Pass	1 / 1	-1,659	-13%	Pass	1 / 1
		Southbound	-1,139	-9%	Pass	1 / 1	-538	-4%	Pass	1 / 1
	Guard Counts, Autumn 2010:									
	East Coast	Southbound	849	7%	Pass	2 / 2	553	5%	Pass	2 / 2
	Virgin Trains	Southbound	1,391	8%	Pass	3 / 3	1,350	7%	Pass	3 / 3
		Northbound	-845	-4%	Pass	3 / 3	-183	-1%	Pass	3 / 3
	East Midlands Trains	Southbound	-1,441	-9%	Pass	3 / 3	-1,115	-7%	Pass	3 / 3
		Northbound	-3,977	-22%	Fail	2 / 3	-3,475	-19%	Fail	2 / 3
PM	**Existing Screenlines:**									
	PM Validation Flows (To Birmingham New Street)	All Corridors	418	4%	Pass	3 / 3	117	1%	Pass	3 / 3
	Additional Validation data (PM):									
	Leicester	All Corridors	44	1%	Pass	2 / 3	79	1%	Pass	2 / 3

MODEL	SCREENLINE LOCATIONS	DIRECTON	PFM V3_1025B				PFM V4.3 BASE			
			DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NO. OF PASS LINKS AT 25%	DIFF	% DIFF	SCREENLINE PASS/FAIL AT 15%	NUMBER OF PASS LINKS AT 25%
	Nottingham	All Corridors	-18	-1%	Pass	1 / 5	-70	-2%	Pass	1 / 5
PN	Manchester	All Corridors	680	3%	Pass	9 / 10	-280	-1%	Pass	8 / 10
	Leeds	All Corridors	-1,578	-7%	Pass	6 / 8	-2,873	-12%	Pass	5 / 8
	Sheffield	All Corridors	-514	-8%	Pass	2 / 4	-794	-12%	Pass	3 / 4
PS	**Existing Screenlines:**									
	PLANET South Validation Flows (0700-1000 arrivals in Central London, 2007)	Total	-11,651	-10%	Pass	4 / 5	2,475	2%	Pass	3 / 5
Air	Comparison of CAA Annual Passenger Data and Modelled Flows at Heathrow Airport	Total	-2,166,537	-100%	Fail	0 / 6	-2,166,537	-100%	Fail	0 / 6

PLD Air Assignment

10.5.5 The air assignment in PLD uses the standard public transport assignment algorithm in EMME. These is no crowding function in the air assignment, this means that only a single iteration of the assignment is carried out and no convergence statistics are required (any additional iterations would yield exactly the same results).

PLD Highway Assignment

10.5.6 The PLD highway model utilises the standard EMME highway assignment algorithm. EMME has a number of stopping criteria built into the assignment routine, these automatically stop the assignment process once one of the stopping values are achieved. The stopping criteria are based on the following four values:

- Maximum number of iterations;
- The best relative gap - is an estimate of the difference between the current assignment and a perfect equilibrium assignment, in which all paths used for a given OD pair would have exactly the same time. This estimate is based on the values of the objective function . The best relative gap is specified together with the relative gap;
- The relative gap is the difference between the total travel time on the network and the total travel time on the shortest paths for the current iteration, divided by the total travel time on the network; and
- The normalized gap, or trip time difference, is the difference between the mean trip time of the current assignment and the mean minimal trip time. The mean trip time is the average trip time on the paths used in the previous iteration; the mean minimal trip time is the average time computed using the shortest paths of the current iteration. The relative gap decreases strictly from one iteration to the next, whereas the trip time difference does not necessarily have this property. In a perfect equilibrium assignment, both the relative gap and the normalized gap are zero.

10.5.7 The assignment will stop when: the number of iterations reaches the maximum, or, one of the gaps is less than or equal to the specified value for it, whichever occurs first.

10.5.8 In the PLD highway assignment the following criteria are adopted.

Table 96. Highway Assignment Stopping Criteria

CRITERIA	STOPPING VALUE
Number of iterations	50
Best Relative Gap (Bgap)	0.01%
Normalised Gap (Ngap)	0.01%
Relative Gap (Rgap)	0.00

10.5.9 The assignment statistics from a run of the model are presented in Table 97. In the base year the highway assignment converges after 4 iterations when the Best Relative Gap convergence value is achieved.

Table 97. Highway Assignment Convergence Statistics

```
STANDARD TRAFFIC ASSIGNMENT
***************************

Scenario:                    15002: PLD base year demand databank       ...: PL
Network size:                  235  centroids       917 reg. nodes
                              3467  road links        0 turn entries

Class  1:                    Mode: c (car        )        3467 active links
Fixed cost on links:         1.00000*length
Demand:                      mf25: PComAV       Vehicle Trips Commuting Av Hour
Additional demand:           ms999:Zero         Zero for Additional Volumes
Travel cost:                 mf31: AutimC       Auto Times - Commuting
Link volumes:                @cvolc  Car PCU Volume - Commuting

Additional volumes:                additional demand assigned to active paths
Additional link attribute:         length
Binary operator for paths:         +
Lower threshold for paths:   -999999.000
Upper threshold for paths:    999999.000
Additional O-D attribute:    mf34: AuDist       Auto Distances
........ containing:               additional path attributes

Class  2:                    Mode: c (car        )        3467 active links
Fixed cost on links:         1.00000*length
Demand:                      mf26: PBusAV       Vehicle Trips Business   Av Hour
Travel cost:                 mf32: AutimB       Auto Times - Business
Link volumes:                @cvolb  Car PCU Volume - Business

Class  3:                    Mode: c (car        )        3467 active links
Fixed cost on links:         1.00000*length
Demand:                      mf27: POthAV       Vehicle Trips Other      Av Hour
Travel cost:                 mf33: AutimO       Auto Times - Other
Link volumes:                @cvolo  Car PCU Volume - Other

Stopping criteria:      iter=    50      bgap=     0.0100 %
                        rgap=    0.0000  ngap=     0.0100

------------------------------- Iteration   0 -------------------------------

Number of trips:  Total persons:        9413.13
                  Class  1 veh.:        9413.13    Additional veh.:          0.00
                  Class  2 veh.:       17390.16    Class  3 veh.:        29081.49
                  Total vehicles:      55884.78    Not assigned:             0.00

Additional trips: Tot. add. demand:        0.00
                  Selected trips:          0.00    Total assigned:           0.00

Obj. function:    Initial value:    0.171646E+08

CPU time:         Subproblem:     0.2 (     0.2)   Steplength:     0.0 (     0.0)
                  Update:         0.0 (     0.0)   Total:          0.2 (     0.2)


------------------------------- Iteration   1 -------------------------------

Number of trips:  Total persons:        9413.13
                  Class  1 veh.:        9413.13    Additional veh.:          0.00
                  Class  2 veh.:       17390.16    Class  3 veh.:        29081.49
                  Total vehicles:      55884.78    Not assigned:             0.00

Search for lambda:L= 0.000000  0.062500  0.125000  0.250000  0.500000  1.000000
                  G=-.151E+05-0.117E+05-0.871E+04-0.380E+04 0.291E+04 0.165E+05
                  Appr. optimal lambda:0.391833    Estimated error:     -0.001242

Avg trip costs:   Currently on network:  309.61    On shortest paths:      309.34

Additional trips: Tot. add. demand:        0.00
                  Selected trips:          0.00    Total assigned:           0.00

Vol. difference:  Average per link:       -0.16    Avg absolute diff:        8.92
                  Minimum difference:   -528.12    (on link          1471    1470)
                  Maximum difference:    322.39    (on link          1465    1466)

Obj. function:    Absolute gap:      15050.9590    Normalized gap:       0.269321
                  Relative gap:      0.00086987
                  New lower bound: 0.171495E+08    Best lower bound:0.171495E+08
                  Current value:   0.171621E+08    Best relative gap:    .0733 %

CPU time:         Subproblem:     0.1 (     0.3)   Steplength:     0.0 (     0.0)
                  Update:         0.0 (     0.1)   Total:          0.2 (     0.4)
------------------------------- Iteration   2 -------------------------------

Number of trips:  Total persons:        9413.13
                  Class  1 veh.:        9413.13    Additional veh.:          0.00
                  Class  2 veh.:       17390.16    Class  3 veh.:        29081.49
                  Total vehicles:      55884.78    Not assigned:             0.00

Search for lambda:L= 0.000000  0.057993  0.115986  0.231972  0.463944  0.927889
                  G=-.522E+04-0.500E+04-0.477E+04-0.432E+04-0.340E+04-0.157E+04
                  Appr. optimal lambda:1.000000    Estimated error:      0.325538

Avg trip costs:   Currently on network:  309.36    On shortest paths:      309.27

Additional trips: Tot. add. demand:        0.00
                  Selected trips:          0.00    Total assigned:           0.00

Vol. difference:  Average per link:        0.27    Avg absolute diff:       10.30
                  Minimum difference:   -318.27    (on link          1466    1467)
                  Maximum difference:    316.04    (on link          1475    1474)

Obj. function:    Absolute gap:       5224.4891    Normalized gap:       0.093487
                  Relative gap:      0.00030219
                  New lower bound: 0.171569E+08    Best lower bound:0.171569E+08
                  Current value:   0.171588E+08    Best relative gap:    .0114 %

CPU time:         Subproblem:     0.2 (     0.4)   Steplength:     0.0 (     0.0)
                  Update:         0.0 (     0.1)   Total:          0.2 (     0.5)
```

```
------------------------------- Iteration   3 -------------------------------

Number of trips:  Total persons:          9413.13
                  Class  1 veh.:          9413.13   Additional veh.:          0.00
                  Class  2 veh.:         17390.16   Class  3 veh.:        29081.49
                  Total vehicles:        55884.78   Not assigned:             0.00

Search for lambda:L= 0.000000  0.062500  0.125000  0.250000  0.500000  1.000000
                  G=-.260E+04-0.176E+04-0.917E+03 0.755E+03 0.408E+04 0.110E+05
                  Appr. optimal lambda:0.193523   Estimated error:     -0.000019

Avg trip costs:   Currently on network:  309.22   On shortest paths:      309.17

Additional trips: Tot. add. demand:         0.00
                  Selected trips:           0.00   Total assigned:           0.00

Vol. difference:  Average per link:        -0.08   Avg absolute diff:        1.51
                  Minimum difference:    -156.83   (on link         1469   1467)
                  Maximum difference:     159.80   (on link         1465   1466)

Obj. function:    Absolute gap:        2596.9622   Normalized gap:       0.046470
                  Relative gap:       0.00015028
                  New lower bound: 0.171562E+08    Best lower bound:0.171569E+08
                  Current value:   0.171586E+08    Best relative gap:     .0099 %

CPU time:         Subproblem:     0.2 (     0.6)   Steplength:     0.0 (     0.0)
                  Update:         0.0 (     0.1)   Total:          0.2 (     0.7)

------------------------------- Iteration   4 -------------------------------

Number of trips:  Total persons:          9413.13
                  Class  1 veh.:          9413.13   Additional veh.:          0.00
                  Class  2 veh.:         17390.16   Class  3 veh.:        29081.49
                  Total vehicles:        55884.78   Not assigned:             0.00

Search for lambda:L= 0.000000  0.049730  0.099460  0.198921  0.397841  0.795682
                  G=-.123E+04-0.102E+04-0.810E+03-0.389E+03 0.446E+03 0.210E+04
                  Appr. optimal lambda:0.291341   Estimated error:      0.000018

Avg trip costs:   Currently on network:  309.21   On shortest paths:      309.18

Additional trips: Tot. add. demand:         0.00
                  Selected trips:           0.00   Total assigned:           0.00

Vol. difference:  Average per link:        -0.07   Avg absolute diff:        1.06
                  Minimum difference:    -132.88   (on link         1538   1539)
                  Maximum difference:     132.62   (on link         1540   1541)

Obj. function:    Absolute gap:        1232.7891   Normalized gap:       0.022059
                  Relative gap:       0.00007134
                  New lower bound: 0.171573E+08    Best lower bound:0.171573E+08
                  Current value:   0.171584E+08    Best relative gap:     .0062 %

CPU time:         Subproblem:     0.2 (     0.8)   Steplength:     0.0 (     0.0)
                  Update:         0.0 (     0.1)   Total:          0.2 (     0.9)

------------------------- Stopping criterion: Best Relative Gap -------------
```

10.6 Model Benchmarking

10.6.1 A benchmarking study collated information from a variety of European high speed rail experiences. The study set down typical levels of impacts on air, car and also generated (induced) travel. This section compares the forecasts in HS2 model PFM v4.3 with those in the benchmark study to assess whether the model is behaving as expected.

10.6.2 It should be noted that this study will be reported more thoroughly in a report to be published by HS2 Ltd and what is contained in this section is a summary of that information.

10.6.3 The benchmark study covered:

- Abstraction from air and rail/air mode share;
- Abstraction from car;
- Induced travel; and
- Overall sensitivity to journey time.

Abstraction from air

10.6.4 Because air competition is focused on specific flows, we cannot use global statistics to examine abstraction from air, but need to consider the specific flows. However, airports serve wide catchment areas and the benchmark evidence is for mode shares between regions which may be cities or rather larger. The best comparison we can readily achieve from PFM is to consider the mode shares on flows between Government Office Regions (GORs). The GORs are probably rather larger than the catchment areas of airports but not that much, and we include air travel between all airports (and rail between all stations). Only a few GOR pairs are relevant (ie have significant air demand), and we show in Table 97 the following flows:

- between London and Scotland, North West, North East;
- between South East and Scotland, North West, North East;
- between London and South East, and Scotland, North West, North East; (ie the combination of the previous two pairs); and
- between West Midlands and Scotland.

10.6.5 Table 98 shows for each of the flows the rail proportion of the air/rail market in the Do Minimum and Do Something (with HS2 Y network); it also gives the rail journey time that would have generated that mode share and hence the change in journey time. The expected market shares are shown below in Figure 28.

Figure 28. Rail/Air mode shares

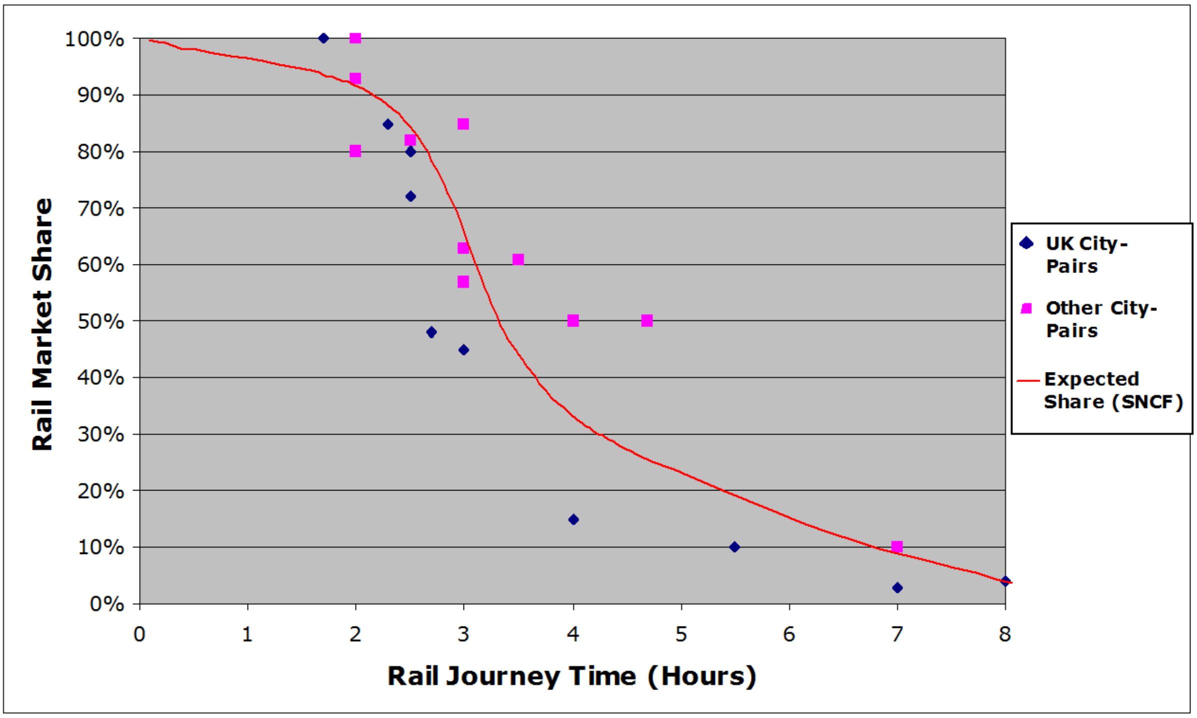


Table 98. Rail/air mode choice

FLOW	BASE RAIL MODE SHARE	DS RAIL MODE SHARE	IMPLIED BASE RAIL JOURNEY TIME	IMPLIED DS RAIL JOURNEY TIME	IMPLIED CHANGE IN RAIL TIME
Scotland - London	43%	56%	3hrs 30m	3hrs 10 m	20min
Scotland – South East	12%	21%	6hrs 25m	5hrs 10m	75min
Scotland	**33%**	**46%**	**4hrs 0m**	**3hrs 30m**	**30min**
North West - London	96%	98%	low	low	N/A
North West – South East	90%	93%	2hrs 10m	1hr 50m	20min
North West	**95%**	**97%**	**1hr 25m**	**1hr 5m**	**20min**
North East – London	92%	94%	1hr 55m	1hr 35m	20min
North East – South East	49%	61%	3hr 25m	3hrs 0m	25min
North East	**84%**	**88%**	**2hr 30m**	**2hr15m**	**15min**
Scotland – West Midlands	37%	49%	3hrs 50m	3hrs 20m	30min

10.6.6 Unsurprisingly, the London flows have a significant higher rail mode share than the South East, due to easier access to central London rail stations and in some cases worse access to airports. The more realistic comparison with the benchmarks is for the whole of the London and South East area.

10.6.7 The implied rail journey times in Table 98 are generally lower than actual, but most relevant is the implied change in rail time. Here we see that it ranges from 15 to 30 mins for the bold numbers. These are in general less than we would have expected from HS2. We can therefore say that the sensitivity of the rail/air mode share to rail journey time is a bit lower than would have been expected from the benchmarks.

10.6.8 One reason for this is likely to be that in reality (and hence in the benchmarks) flows with fast rail services tend to have less frequent air services; however, in modelling the impact of HS2 we have deliberately chosen not to change the air service and hence will have underestimated the impact of HS2. However, it remains that PFM appears relatively insensitive in the rail/air mode choice.

Abstraction FROM Car

10.6.9 To consider abstraction from car, it is best to look at the global figures rather than specific city pairs; this is particularly the case, as any flow to/from central London has virtually zero base car demand (and hence zero abstraction).

10.6.10 We have focused our examination on model runs undertaken with base demand levels, as these should be comparable to the benchmarks. As car demand grows much slower in future than rail demand (in the base), the proportion of future demand that comes from car will reduce.

10.6.11 The benchmark evidence is very varied, possibly because collecting this data is difficult. Nevertheless, we can see that in most cases, of the new rail demand that results from the introduction of high speed rail, between 10% and 15% comes from car. The overall figure for HS2 taken from model runs for the Y network is 16%.

10.6.12 By purpose the proportions abstracted from car in PFM v4.3 are:

Commuting	14%
Business	15%
Leisure	17%

10.6.13 These figures look appropriate for all purposes.

10.6.14 In the PFM v3.0 model, the proportions from car (in a base year model) were as follows:

Commuting	40%
Business	24%
Leisure	18%

10.6.15 Overall, the revised figures look more in line with the benchmarks.

Induced travel

10.6.16 The proportion of induced travel depends fundamentally on the availability of demand by other modes to be abstracted – it is in effect a residual. Furthermore, induced travel compared to that transferred from classic rail depends on the scale of improvement. Nevertheless we present below a comparison of induced demand in the PFM v4.3 model with some estimates from other sources.

10.6.17 The proportions of the generated demand that is induced (ie not abstracted from another mode) are:

Commuting	86%
Business	80%
Leisure	79%

10.6.18 The benchmark figures are not very consistent. International services tend to be low (20% - 25% for Eurostar and Thalys); most domestic international experience gives figures of 48% - 62%, except for Madrid – Barcelona where due to the large amount abstracted from air, only 22% is assessed as induced.

10.6.19 It can be seen that the figures for PFM are high compared to the benchmarks. However, if we are to achieve typical demand growth compared to the journey time reduction (see 10.4.21 and following) and have low abstraction from other modes, then inevitably, induced demand must be high; the proportion of induced demand is high mainly due to low proportions of abstracted demand, rather than due to high levels of generation per se.

10.6.20 It is also worth comparing the induced demand (shown in Table 99) as a proportion of induced plus abstracted from car, as this adjusts for the significantly higher base air market in most of the benchmark scenarios.

Table 99. Induced Demand

	INDUCED DEMAND AS PROPORTION OF INDUCED PLUS ABSTRACTED FROM CAR	
PURPOSE	PFM v4.3	BENCHMARKS
Commute	86%	} }
Business	84%	} 67% - 89% }
Leisure	83%	} }

10.6.21 On this comparison, which excludes abstraction from air, the levels of induced demand look similar to the benchmarks, albeit at the higher end of the range.

Overall increase in rail demand

10.6.22 The overall elasticity of rail demand to rail journey time is relatively well documented, both in Britain (the PDFH) and overseas. It is almost inevitable in a model structured as PFM that elasticities will increase with distance. This is because a 1 minute increase in a 1 hour journey is 1.7%, whereas a 1 minute increase in a 2 hour journey is 121 minutes and hence 0.8%; Logit models are driven by the absolute difference in journey time rather than proportional; hence a 1.7% change in time at short distance will have a similar impact to 0.8% at long distance, resulting in the long distance elasticity being approximately twice that at short distance. Furthermore, at long distances there is air demand to be abstracted.

10.6.23 Table 100 shows the model elasticity for rail IVT by distance band and purpose. It also shows the elasticities to IVT from PDFH v5 and the recently published PDFH v5.1. These have been calculated as 85% of the generalised cost elasticities quoted in PDFH, on the basis that IVT makes up approximately 85% of generalised cost for long distance flows which do not involve an interchange.

Table 100. Rail IVT elasticities

	COMMUTE	BUSINESS	LEISURE
50-100 miles	-0.53	-0.69	-0.37
100-200 miles	-0.78	-1.03	-0.58
200-300 miles	-1.08	-1.49	-0.86
300-400 miles	-	-2.70	-1.46
400 + miles	-	-3.56	-1.89
PFM all distances > 50 miles	**-0.55**	**-1.07**	**-0.61**
PDFH v5 long distance	-0.8	-0.8	-0.8
PDFH v5.1 long distance to/from London	-1.15	-1.15	-1.15
PDFH v5.1 long distance non London	-1.0	-1.0	-1.0

10.6.24 It can be seen that the business elasticities are a good match to the updated PDFH figures, but rather higher than the previous version (v5). The commute and leisure elasticities in the model are below both versions of PDFH.

10.6.25 The benchmarking study, which included evidence from the rest of Europe, recommended elasticities to IVT of -1.3 to -1.5 for business and -0.9 to -1.0 for leisure. PFM elasticities are slightly below these figures.

10.6.26 As indicated above, we are not concerned regarding high elasticities for markets in which air has a significant market share – those above 300 miles.

Conclusions

10.6.27 Overall the revised PFM Model appears to give reasonable if conservative forecasts. The overall elasticity to rail journey time (the principal driver of increased demand) is slightly below most independent estimates, especially for leisure travel. This results mainly from a rather low abstraction from air and car.

10.6.28 The proportion of induced demand initially appears higher than the benchmark figures would suggest. However, when the much lower competition with air is taken into account in Britain, along with the extent of forecast air abstraction, the levels of induced demand look reasonable.

10.7 Realism Tests

10.7.1 Further to the above benchmarking exercise a number of realism tests have been undertaken to check the model performance. These were undertaken on future year Phase 1 and Y network tests. The tests undertaken were as follows:

- Test 1 - 10% added to all HS2 journey times;
- Test 2 - 5 minutes added to transit time between Old Oak Common and Birmingham Interchange;
- Test 3 - All rail fares increased by 20%; and
- Test 4 - 10% added to all rail journey times.

10.7.2 Table 101 shows the result on economics and demand of these tests at the Y network level compared to the standard Y model run in 2036.

Table 101. Results of the Realism Tests (Y 2036)

	TEST 1	TEST 2	TEST 3	TEST 4
Benefits	-10%	-6%	-1%	+10%
Revenue	-14%	-7%	+19%	+9%
Total HS2 Boarders	-7%	-3%	0%	+4%
Total Extraction from Air / Highway	-13%	-5%	0%	+8%
Total Generation	-12%	-7%	0%	+10%

10.7.3 The results of these tests show reasonable results which are in line with the test specification.

10.7.4 The 10% increase in all HS2 journey times has the biggest reducing impact on the demand as expected and the reduction in benefits is directly in line with the journey time increased. The 5 minutes between Old Oak Common and Birmingham Interchange also reduces demand and benefits.

10.7.5 The increase in rail fares test has no impact on demand and hardly any on benefits but the revenue increases in line with the fares increase.

10.7.6 The test in which 10% is added to the journey times of all rail shows more demand for HS2 services as expected and therefore higher benefits. The reason for this is that although the HS2 services are also longer the differential between HS2 and classic becomes greater.

10.7.7 These realism tests therefore show that the model is behaving in a sensible and explainable way for the tests being undertaken.

Glossary

TERM	DEFINITION
ACP	Analytical Challenge Panel
ASC	Alternative Specific Constant
ATOC	Association of Train Operating Companies
Biogeme	Software package for the development of discrete choice models by estimating by maximum likelihood
CA	Car Available
CAA	Civil Aviation Authority
CPI	Consumer Prices Index
Day1c	HS2 Phase 1, London to Birmingham
DfT	Department for Transport
DM	Do Minimum
DS	Do Something
ECML	East Coast Main Line
EDGE	Exogenous Demand Growth Estimator – Forecasting framework for rail demand growth in Great Britain
GDP	Gross Domestic Product (£)
GJT	Generalised Journey Time without crowding (mins)
GJTC	Generalised Journey Time with crowding (mins)
GJTCAE	Generalised Journey Time with crowding and Access/Egress (mins)
GOR	Government Office Regions
HAM	Heathrow Access Model
HSR	High Speed Rail
HS2	High Speed Two (the project)
HS2 Ltd	HS2 project promoter
Hybrid Bill	Consents process for major projects deemed to be in the national interest that also affect a large number of private interests

TERM	DEFINITION
IVT	In Vehicle Time (mins)
LASAM	London Airports Surface Access Model
LOS	Level of Service
LUL	London Underground Limited
Maximum Likelihood Estimation	A statistical estimation technique for more information see WebTAG Unit 3.5.6 and Section 8.4 'Modelling Transport' Ortuzar and Willumsen
MECC	Marginal External Cost of Cars (£)
MML	Midland Main Line
MOIRA	Rail forecasting software and database. Maintained on behalf of ATOC members for rail demand and revenue forecasting
MSA	Method of successive averages
MSOA	Middle Layer Super Output Areas (definition of geographical zones in the national census)
NAM	National Accessibility Model
NCA	Non Car Available
NGT	New Generation Transport
NRTS	National Rail Travel Survey
NTS	National Travel Survey
NTS LD	National Transport Survey Long Distance data
OD	Origin Destination
ONS	Office of National Statistics
PA	Production Attraction
PDFH	Passenger Demand Forecasting Handbook
PFM	Planet Framework Model
PLD	PLANET Long Distance Model
PLDz	PLANET Long Distance Model zone
PM	PLANET Midlands Regional Model
PN	PLANET North Regional Model
PS	PLANET South Regional Model
PT	Public Transport

TERM	DEFINITION
ROH	Rule of a half – method for estimating economic benefits
RPI	Retail Prices Index
SCM	Station Choice Model
SP	Stated Preference – a survey technique that extracts information on compromises people would make by setting up a series of alternative choices. This technique is frequently employed to get information on future transport developments.
TfL	Transport for London
TOC	Train Operating Company
Utility	Utility is the gain that a passenger gets from making their journey – see WebTAG Unit 3.10.3a 5.1.2-5.1.4 and Chapter 7 'Modelling Transport' Ortuzar and Willumsen
VDF	Volume Delay Function
VOC	Vehicle Operating Cost (£)
VoT	Value of Time (£/min)
WebTAG	Department for Transport issued guidance on modelling and evaluating transport schemes
WCML	West Coast Main Line
Wormhole	Factor application to transfer between PS and PLD 8.2
WP*X*	Work Package *X*
Y	HS2 Phase 2, Birmingham to Manchester and Leeds

Appendix A - Model Improvements - Scoping Exercise Findings

The components of the PLANET Modelling Framework which were considered as part of the model improvements programme were:

- PLANET Long Distance Demand Model and Rail Assignment;
- Station Choice Model; and
- The Appraisal Spreadsheets and process

In order to determine the model developments to be included in the updated model version, a scoping exercise was undertaken with the main issues identified primarily related to:

- The Demand Model;
- The Assignment Model; and
- The Station Choice Model (SCM).

To ensure that all potential improvements were assessed on a consistent basis, a sifting framework was developed incorporating a number of criteria. This also provided an auditable record of how conclusions were drawn as to which improvements should be taken forward. The improvements fall into four categories which comprise the four Steps of Model development undertaken during the development of PFM v4.3:

- Step 1: Minor Improvements to the model, including updated data or revised methodologies;
- Step 2: Improving the assignment procedure;
- Step 3: Re-calibration of the Station Choice Model; and
- Step 4: Re-estimation of the demand model.

There was also an update to the appraisal methodology undertaken through this process

The table below provides a summary of the improvements considered as part of the Scoping Study and during the project itself, identifying:

- Improvements that were agreed to be incorporated as part of the scoping phase;
- Improvements that were rejected at the scoping phase plus the reasons for their rejection; and
- Improvements that were agreed following the scoping phase.

Summary of Model Improvements Considered for this work package

POTENTIAL IMPROVEMENT	CATEGORY & CHAPTER	RECOMMENDATION	INCLUDED IN PFM V4.3
PS LUL crowding switched on	Model improvements	Post-Scoping Phase	Yes
Internal consistency of the model parameters	Parameter consistency	From Scoping Phase as described in section 2.2.2	Yes
Improved assignment process	Revised assignment procedure	From Scoping Phase as described in section 2.2.2	Yes
Revised access cost estimates inside London using the latest Railplan data	Station Choice Model updates	Post-Scoping Phase	Yes
Revised assumptions on the impact of future transport investments outside London on station access times	Station Choice Model updates	From Scoping Phase as described in section 2.2.2	Yes
Review including taxi as a separate access mode in the SCM	Station choice model updates	From Scoping Phase as described in section 2.2.2	No – review determined it was not feasible to estimate parameters for including taxi as a separate access mode
Re-calibrating the SCM based on the associated model changes	Station choice model updates	N/A	Yes
Ability to make a return journey in a day	Re-estimating the demand model parameters	From Scoping Phase as described in section 2.2.2	After investigation it was decided not to include this
Incorporate income segmentation into the demand matrices	Re-estimating the demand model parameters	Recommended; subject to timescale implications	After investigation it was decided not to implement this
Inclusion of destination choice	Re-estimating the demand model parameters	Not recommended	No
Improved integration between PS and PLD (‘wormhole’ factors)	Improved integration between PLD and PS	Post-Scoping Phase	Yes

POTENTIAL IMPROVEMENT	CATEGORY & CHAPTER	RECOMMENDATION	INCLUDED IN PFM V4.3
Implement an absolute pivot method rather than the existing incremental pivot approach	N/A	Not recommended	No – incremental approach retained
Including HS2 as a separate choice alternative	N/A	Recommended	No – future model development
Use Production / Attraction (PA) matrices rather than existing Origin-Destination	N/A	Recommended	No – future model development
Include a coach mode in the mode choice model	N/A	Not recommended	No
Converting the Station Choice Model into EMME	N/A	Not recommended	No

Appendix B File Locations and Changes for the Implementation of the Adjustments

1.1 Introduction

1.1.1 Table 1 shows which files have changed and how this was undertaken for each mocel correction described in section 3.2 of the main report

Table 1. Updates to Base Year Model

MODEL ELEMENT	DESCRIPTION	FILES UPDATED	IMPLEMENTATION
Station Choice Model Updates	Update to all PLD SCM files to the latest relevant versions used in the future year models Also includes setting all SCM output switches to on (1). Also includes: Salford and Meadowhall (Classic) stations as active. Only London north facing stations active	AccessCost.txt Input_Parameters.txt MZONE_SeqZone_lookup.txt OD_Distributions.txt PLD_stn_lookup.txt PM_SeqZone_lookup.txt PN_SeqZone_lookup.txt PS_SeqZone_lookup.txt StnAttributes.txt	Copy to \HS2\01PLD\01Base\01Base_Assign\Input
	Update to the PLD assignment network to connect the now active Salford and Meadowhall (Classic) stations to the rail network.	PLD_a_Base_net.in	Copy to \HS2\01PLD\01Base\01Base_Assign
Revised Ensemble for Wormhole Process	Update to PLD matrix ensemble ‘gs’ (“MM StationChoiceModel Ensemble”). Manual input required pre-run.	20120509_PLD_revised_GS_ensemble.in	Manual import to scenario 15000 in \HS2\01PLD\01Base\01Base_Assign
Changes to the Control Matrix	Updates to Planet Midland and Planet South control matrices.	PM_Control_Matrix.txt PN_Control_Matrix.txt	03PM\PMAM\MidTest\01DemandDB and 04PN\PNAM\NorthTest\01DemandDB

MODEL ELEMENT	DESCRIPTION	FILES UPDATED	IMPLEMENTATION
Removal of Access Leg Integration	Update various macros to turn off Access Leg Integration from the three regional models.	*PLANET South:* base_mc.mac elastic.mac SCM_AE_import.mac *PLANET Midlands:* 03assign.mac *PLANET North:* 03assign.mac	*PLANET South:* Copy to \HS2\02PS\Macros *PLANET Midlands:* Copy to\HS2\03PM\Macros *PLANET North:* Copy to \HS2\04PN\Macros
Price Level Adjustment Factors	Update to PLD price level adjustment factor to account for change in base year (to 2010).	setup.mac	Copy to \HS2\01PLD\Macros \Assign
Matrix Storage format in EMME	Some mf matrices in PLD were found to be stored in column-wise format (indicated by a “\c” flag) instead of the desired row-wise format. A batch and macro has been created to rectify this pre-run.	update_RowColwise.bat Row_Col_wise.mac	Copy to \HS2 Run batch file from this location
Station Choice Model Access Costs	Updates the access mode split to various stations. Previously some stations were inaccurately defined as 0% public transport access. Note there are different files for Day1c and Y tests.	AccessCost_DM.txt AccessCost_DS.txt	(DM) Copy to \HS2\01PLD\01Base\01Base_Assign\Input As ‘accesscost.txt’ (DS) Copy to \HS2\01PLD\02Base\02Base_Assign\Input And \HS2\01PLD\03Test\03Test_Assign\Input As ‘accesscost.txt’

Appendix C Future Year Access Time Changes

1.1 Introduction

1.1.1 Appendix C provides the detailed changes to the access file for the Station Choice Model as part of the change to the future year access times due to committed transport schemes being implemented. There were two key changes:

- Future transport schemes that enabled a zone to become accessible by public transport; and
- Access time changes due to the future transport schemes.

1.2 Changes in Public Transport Accessibility

Greater Manchester

1.2.1 PT accessibility was changed from 0 to 1 for the following mzones to/from Manchester Piccadilly, Manchester Victoria, Manchester Oxford Road, Salford Central and Manchester Airport.

- E02001226 (2170);
- E02001233 (2298);
- E02001234 (2299);
- E02001235 (2300);
- E02001238 (2303);
- E02001239 (2304);
- E02001240 (2306);
- E02001241 (2306);
- E02001242 (2307); and
- E02001245 (2310).

1.2.2 PT accessibility was changed from 0 to 1 for the following mzones to/from Manchester Piccadilly, Manchester Victoria, Manchester Oxford Road and Salford Central only:

- E02001199 (2143);
- E02001208 (2152);
- E02001211 (2155);
- E02001214 (2158); and
- E02001222 (2166).

1.2.3 PT accessibility was changed from 0 to 1 for the following mzones to/from Manchester Airport only:

- E02001098 (1721);
- E02001099 (1722);
- E02001100 (1723);
- E02001102 (1725);
- E02001104 (1727);
- E02001105 (1728);
- E02001106 (1729);
- E02001107 (1730);
- E02001108 (1731);
- E02001109 (1732);
- E02001111 (1734);

- E02001112 (1735);
- E02001113 (1736);
- E02001114 (1737);
- E02001116 (1739);
- E02001119 (1742);
- E02001120 (1743);
- E02001121 (1744);
- E02001122 (1745);
- E02001124 (1747);
- E02001125 (1748);
- E02001126 (1749);
- E02001127 (1750);
- E02001128 (1751);
- E02001129 (1752);
- E02001130 (1753); and
- E02001131 (1754).

Birmingham

1.2.4 Highway accessibility was introduced for the MZones to/from Birmingham Snow Hill and Birmingham Moor St are listed below. The new zone to station movements which were set to be PT accessible are highlighted with "- PT accessible":

- E02002043 (1879);
- E02002044 (1880);
- E02002045 (1881);
- E02002046 (1882);
- E02002047 (1883) - PT accessible;
- E02002048 (1884);
- E02002049 (1885);
- E02002050 (1886);
- E02002051 (1887);
- E02002052 (1888);
- E02002053 (1889);
- E02002054 (1890);
- E02002055 (1891) - PT accessible;
- E02002056 (1892);
- E02002057 (1893);
- E02002058 (1894);
- E02002059 (1895) - PT accessible;
- E02002060 (1896) - PT accessible;
- E02002061 (1897) - PT accessible;
- E02002062 (1898) - PT accessible;
- E02002063 (1899);
- E02002064 (1900);
- E02002065 (1901) - PT accessible;
- E02002066 (1902);
- E02002067 (1903);
- E02002068 (1904) - PT accessible;
- E02002069 (1905);
- E02002070 (1906);
- E02002071 (1907);
- E02002072 (1908);
- E02002073 (1909);
- E02002074 (1910);
- E02002075 (1911);

- E02002076 (1912);
- E02002077 (1913);
- E02002078 (1914);
- E02002079 (1915); and
- E02002080 (1916).

1.2.5 In addition the following mzones were made PT accessible to Birmingham New St and HS Birmingham Central:

- E02002047 (1883);
- E02002055 (1891);
- E02002059 (1895);
- E02002060 (1896);
- E02002061 (1897);
- E02002062 (1898);
- E02002065 (1901);
- E02002068 (1904); and
- E02002079 (1915).

1.3 Changes to PT Access Times

1.3.1 Tables 1 to 3 show the access times changes for zones where the PT access time were updated from those in the existing model (PFM v3.0)

Table 1. List of Changes to PT Access Times – Do-Minimum

MODEL ZONE	STATION	PFM V3.0	PFM V4.3	ABS CHANGE	% CHANGE
69	Birmingham Snow Hill	80.0	70.0	-10.0	-13%
69	Birmingham New St	60.9	52.9	-8.0	-13%
80	Birmingham Snow Hill	65.1	64.5	-0.5	-1%
83	Birmingham Snow Hill	280.0	67.3	-212.7	-76%
83	Birmingham Moor St	272.0	68.9	-203.1	-75%
977	Leeds	98.8	72.6	-26.2	-27%
981	Leeds	79.1	71.9	-7.3	-9%
990	Leeds	75.5	60.9	-14.6	-19%
1013	Leeds	52.9	48.6	-4.3	-8%
1019	Leeds	62.8	46.2	-16.6	-26%
1058	Leeds	58.1	52.1	-6.0	-10%
1369	Manchester Airport	165.6	164.0	-1.6	-1%
1371	Manchester Airport	156.2	153.3	-2.9	-2%
1373	Manchester Airport	112.5	107.6	-4.9	-4%
1373	Manchester Oxford Rd	62.4	57.7	-4.8	-8%
1375	Manchester Airport	120.3	108.5	-11.8	-10%
1375	Manchester Oxford Rd	71.4	58.6	-12.8	-18%
1375	Manchester Victoria	52.4	45.4	-6.9	-13%

MODEL ZONE	STATION	PFM V3.0	PFM V4.3	ABS CHANGE	% CHANGE
1376	Manchester Oxford Rd	82.7	75.0	-7.7	-9%
1376	Manchester Piccadilly	55.3	53.0	-2.3	-4%
1376	Manchester Victoria	72.2	62.0	-10.2	-14%
1377	Manchester Oxford Rd	59.6	54.9	-4.7	-8%
1379	Manchester Victoria	62.6	57.1	-5.5	-9%
1393	Manchester Airport	104.4	86.0	-18.4	-18%
1393	Manchester Piccadilly	72.4	67.2	-5.2	-7%
1393	Manchester Victoria	78.8	69.9	-8.9	-11%
1397	Manchester Airport	103.8	70.2	-33.6	-32%
1397	Manchester Oxford Rd	70.1	58.9	-11.2	-16%
1397	Manchester Piccadilly	88.5	70.2	-18.2	-21%
1397	Manchester Victoria	99.9	63.3	-36.6	-37%
1397	Salford Central	77.1	75.8	-1.4	-2%
1399	Manchester Oxford Rd	63.7	59.0	-4.6	-7%
1399	Manchester Piccadilly	91.4	69.9	-21.5	-24%
1399	Manchester Victoria	93.6	62.7	-30.9	-33%
1399	Salford Central	87.0	77.4	-9.6	-11%
1402	Manchester Airport	82.1	74.9	-7.1	-9%
1402	Manchester Piccadilly	91.2	72.2	-19.0	-21%
1402	Manchester Victoria	92.9	65.4	-27.4	-30%
1402	Salford Central	85.2	82.5	-2.7	-3%
1403	Manchester Airport	85.2	72.5	-12.7	-15%
1403	Manchester Oxford Rd	63.1	60.7	-2.4	-4%
1403	Manchester Piccadilly	85.5	71.2	-14.3	-17%
1403	Manchester Victoria	93.6	65.1	-28.4	-30%
1403	Salford Central	87.9	79.5	-8.4	-10%
1406	Manchester Victoria	119.0	97.3	-21.7	-18%
1407	Manchester Airport	89.6	76.9	-12.7	-14%
1407	Manchester Oxford Rd	76.9	66.5	-10.4	-13%
1407	Manchester Victoria	96.0	70.2	-25.8	-27%
1407	Salford Central	90.4	87.1	-3.3	-4%
1408	Manchester Airport	90.0	60.0	-30.1	-33%
1408	Manchester Oxford Rd	70.5	69.7	-0.7	-1%
1408	Manchester Piccadilly	95.9	84.2	-11.7	-12%

MODEL ZONE	STATION	PFM V3.0	PFM V4.3	ABS CHANGE	% CHANGE
1408	Manchester Victoria	103.5	72.9	-30.6	-30%
1408	Salford Central	104.8	103.7	-1.1	-1%
1409	Manchester Oxford Rd	70.8	69.0	-1.8	-3%
1409	Manchester Victoria	90.0	72.8	-17.2	-19%
1411	Manchester Airport	71.7	58.4	-13.2	-18%
1411	Manchester Piccadilly	93.4	88.8	-4.7	-5%
1411	Manchester Victoria	109.8	76.7	-33.2	-30%
1412	Manchester Airport	74.9	54.8	-20.1	-27%
1412	Manchester Oxford Rd	74.8	74.5	-0.2	0%
1412	Manchester Piccadilly	101.1	89.5	-11.7	-12%
1412	Manchester Victoria	109.0	78.2	-30.9	-28%
1412	Salford Central	104.6	101.6	-2.9	-3%
1413	Manchester Victoria	119.0	84.5	-34.5	-29%
1414	Manchester Airport	47.7	47.0	-0.7	-2%
1414	Manchester Oxford Rd	84.6	82.4	-2.1	-3%
1414	Manchester Victoria	123.0	86.1	-36.9	-30%
1414	Salford Central	112.1	111.4	-0.7	-1%
1415	Manchester Airport	55.6	53.4	-2.3	-4%
1415	Manchester Victoria	105.0	79.8	-25.2	-24%
1416	Manchester Victoria	119.8	92.0	-27.8	-23%
1417	Manchester Victoria	97.5	92.1	-5.4	-6%
1461	Manchester Airport	98.0	80.4	-17.6	-18%
1465	Manchester Airport	90.4	75.8	-14.6	-16%
1465	Manchester Oxford Rd	91.9	79.6	-12.3	-13%
1465	Manchester Piccadilly	116.8	82.6	-34.3	-29%
1465	Manchester Victoria	124.1	68.3	-55.8	-45%
1465	Salford Central	108.1	98.3	-9.8	-9%
1469	Manchester Victoria	136.6	116.3	-20.3	-15%
1475	Manchester Victoria	132.5	123.0	-9.6	-7%
1516	Nottingham	68.9	68.9	0.0	0%
1523	Nottingham	52.0	49.3	-2.7	-5%
1526	Nottingham	66.8	62.3	-4.5	-7%
1681	Nottingham	64.2	50.7	-13.5	-21%
1714	Nottingham	73.9	73.9	0.0	0%

MODEL ZONE	STATION	PFM V3.0	PFM V4.3	ABS CHANGE	% CHANGE
1715	Derby	160.2	149.2	-11.0	-7%
1716	Nottingham	73.5	62.0	-11.5	-16%
1721	Manchester Oxford Rd	157.3	143.1	-14.2	-9%
1722	Manchester Victoria	142.0	135.1	-6.8	-5%
1723	Rochdale	78.6	54.6	-24.0	-31%
1723	Manchester Oxford Rd	148.3	94.6	-53.6	-36%
1723	Manchester Victoria	164.2	86.6	-77.6	-47%
1723	Salford Central	177.2	136.9	-40.3	-23%
1727	Rochdale	136.3	91.9	-44.3	-33%
1728	Manchester Oxford Rd	134.8	119.4	-15.4	-11%
1728	Manchester Victoria	113.8	99.5	-14.4	-13%
1729	Manchester Victoria	112.9	105.2	-7.6	-7%
1730	Manchester Oxford Rd	138.8	119.6	-19.2	-14%
1730	Manchester Victoria	115.1	99.7	-15.4	-13%
1731	Rochdale	113.3	64.0	-49.3	-44%
1731	Manchester Oxford Rd	127.5	84.2	-43.4	-34%
1731	Manchester Piccadilly	119.0	97.9	-21.1	-18%
1731	Manchester Victoria	110.8	69.6	-41.2	-37%
1732	Rochdale	110.7	104.2	-6.5	-6%
1732	Manchester Oxford Rd	128.2	125.6	-2.6	-2%
1734	Rochdale	88.6	62.1	-26.6	-30%
1734	Manchester Oxford Rd	108.8	83.2	-25.6	-24%
1734	Manchester Piccadilly	97.7	95.9	-1.8	-2%
1734	Manchester Victoria	100.5	68.1	-32.4	-32%
1736	Rochdale	98.0	68.6	-29.4	-30%
1736	Manchester Oxford Rd	105.7	76.8	-29.0	-27%
1736	Manchester Victoria	96.9	61.3	-35.6	-37%
1737	Rochdale	85.0	70.9	-14.1	-17%
1737	Manchester Oxford Rd	97.2	72.1	-25.2	-26%
1737	Manchester Victoria	90.0	57.9	-32.1	-36%
1739	Rochdale	111.8	102.1	-9.7	-9%
1739	Manchester Oxford Rd	128.2	125.3	-2.9	-2%
1739	Manchester Victoria	109.0	106.0	-3.0	-3%
1742	Manchester Oxford Rd	133.9	116.3	-17.7	-13%

MODEL ZONE	STATION	PFM V3.0	PFM V4.3	ABS CHANGE	% CHANGE
1742	Manchester Victoria	114.8	98.3	-16.5	-14%
1743	Rochdale	90.6	72.5	-18.1	-20%
1743	Manchester Oxford Rd	105.2	71.9	-33.3	-32%
1743	Manchester Piccadilly	87.4	81.3	-6.0	-7%
1743	Manchester Victoria	75.7	57.7	-18.0	-24%
1744	Rochdale	78.7	67.8	-11.0	-14%
1744	Manchester Oxford Rd	103.9	77.3	-26.7	-26%
1744	Manchester Victoria	91.9	62.8	-29.1	-32%
1745	Manchester Oxford Rd	112.0	109.6	-2.3	-2%
1747	Rochdale	102.1	75.6	-26.5	-26%
1747	Manchester Oxford Rd	105.6	69.8	-35.7	-34%
1747	Manchester Piccadilly	87.7	78.9	-8.8	-10%
1747	Manchester Victoria	87.1	55.6	-31.4	-36%
1747	Salford Central	102.7	96.4	-6.3	-6%
1748	Rochdale	90.2	74.5	-15.7	-17%
1748	Manchester Oxford Rd	88.5	67.6	-21.0	-24%
1748	Manchester Victoria	62.6	53.4	-9.2	-15%
1749	Rochdale	118.4	107.1	-11.3	-10%
1749	Manchester Oxford Rd	132.9	117.2	-15.7	-12%
1749	Manchester Victoria	122.7	99.2	-23.5	-19%
1750	Manchester Oxford Rd	107.9	102.5	-5.4	-5%
1750	Manchester Victoria	97.4	86.1	-11.4	-12%
1751	Rochdale	111.3	77.1	-34.2	-31%
1751	Manchester Oxford Rd	94.4	66.7	-27.7	-29%
1751	Manchester Victoria	74.9	53.0	-21.9	-29%
1752	Rochdale	108.8	79.3	-29.4	-27%
1752	Manchester Oxford Rd	75.6	63.7	-11.9	-16%
1752	Manchester Victoria	66.8	49.5	-17.3	-26%
1753	Rochdale	131.6	122.6	-9.0	-7%
1753	Manchester Oxford Rd	107.7	100.9	-6.7	-6%
1753	Manchester Victoria	96.0	83.5	-12.6	-13%
1754	Rochdale	126.0	120.1	-6.0	-5%
1754	Manchester Victoria	83.4	80.9	-2.4	-3%
1817	Rochdale	54.0	41.6	-12.4	-23%

MODEL ZONE	STATION	PFM V3.0	PFM V4.3	ABS CHANGE	% CHANGE
1818	Rochdale	66.2	44.2	-22.1	-33%
1819	Rochdale	94.2	50.1	-44.2	-47%
1821	Rochdale	50.2	43.5	-6.7	-13%
1822	Rochdale	54.5	44.8	-9.6	-18%
2158	Manchester Airport	103.2	77.3	-25.9	-25%
2170	Manchester Airport	87.7	76.9	-10.8	-12%

1.3.2 The changes in the Day1C were the same as the Do-Minimum changes in Table 1 with the following additional changes in Table 2 below.

Table 2. List of Additional Day1c Changes to PT Access Times from DM

MODEL ZONE	STATION	PFM V3.0	PFM V4.3	ABS CHANGE	% CHANGE
1883	HS Birmingham Central	88.6	86.8	-1.8	-2%
1895	HS Birmingham Central	79.1	78.7	-0.3	0%
1896	HS Birmingham Central	77.4	75.4	-2.0	-3%

1.3.3 The changes in the Y were the same as the Do Minimum changes in Table 1 with the following additional changes in Table 3 below.

Table 3. List of Changes to PT Access Times – Y Network

MODEL ZONE	STATION	PFM V3.0	PFM V4.3	ABS CHANGE	% CHANGE
69	Birmingham Snow Hill	80.0	70.0	-10.0	-13%
69	Birmingham New St	60.9	52.9	-8.0	-13%
80	Birmingham Snow Hill	65.1	64.5	-0.5	-1%
83	Birmingham Snow Hill	280.0	67.3	-212.7	-76%
83	Birmingham Moor St	272.0	68.9	-203.1	-75%
518	HS East Midlands	150.3	126.7	-23.6	-16%
519	HS East Midlands	140.4	126.1	-14.4	-10%
521	HS East Midlands	148.6	124.7	-23.9	-16%
524	HS East Midlands	140.6	115.4	-25.2	-18%
527	HS East Midlands	135.6	126.3	-9.3	-7%
778	HS East Midlands	57.6	38.3	-19.2	-33%
977	Leeds	98.8	72.6	-26.2	-27%

MODEL ZONE	STATION	PFM V3.0	PFM V4.3	ABS CHANGE	% CHANGE
981	Leeds	79.1	71.9	-7.3	-9%
990	Leeds	75.5	60.9	-14.6	-19%
1013	Leeds	52.9	48.6	-4.3	-8%
1019	Leeds	62.8	46.2	-16.6	-26%
1058	Leeds	58.1	52.1	-6.0	-10%
1369	Manchester Airport	165.6	164.0	-1.6	-1%
1371	Manchester Airport	156.2	153.3	-2.9	-2%
1373	Manchester Airport	112.5	107.6	-4.9	-4%
1373	Manchester Oxford Rd	62.4	57.7	-4.8	-8%
1375	Manchester Airport	120.3	108.5	-11.8	-10%
1375	Manchester Oxford Rd	71.4	58.6	-12.8	-18%
1375	Manchester Victoria	52.4	45.4	-6.9	-13%
1376	Manchester Oxford Rd	82.7	75.0	-7.7	-9%
1376	Manchester Piccadilly	55.3	53.0	-2.3	-4%
1376	Manchester Victoria	72.2	62.0	-10.2	-14%
1377	Manchester Oxford Rd	59.6	54.9	-4.7	-8%
1379	Manchester Victoria	62.6	57.1	-5.5	-9%
1393	Manchester Airport	104.4	86.0	-18.4	-18%
1393	Manchester Piccadilly	72.4	67.2	-5.2	-7%
1393	Manchester Victoria	78.8	69.9	-8.9	-11%
1397	Manchester Airport	103.8	70.2	-33.6	-32%
1397	Manchester Oxford Rd	70.1	58.9	-11.2	-16%
1397	Manchester Piccadilly	88.5	70.2	-18.2	-21%
1397	Manchester Victoria	99.9	63.3	-36.6	-37%
1397	Salford Central	77.1	75.8	-1.4	-2%
1399	Manchester Oxford Rd	63.7	59.0	-4.6	-7%
1399	Manchester Piccadilly	91.4	69.9	-21.5	-24%
1399	Manchester Victoria	93.6	62.7	-30.9	-33%
1399	Salford Central	87.0	77.4	-9.6	-11%
1402	Manchester Airport	82.1	74.9	-7.1	-9%
1402	Manchester Piccadilly	91.2	72.2	-19.0	-21%
1402	Manchester Victoria	92.9	65.4	-27.4	-30%
1402	Salford Central	85.2	82.5	-2.7	-3%
1403	Manchester Airport	85.2	72.5	-12.7	-15%

MODEL ZONE	STATION	PFM V3.0	PFM V4.3	ABS CHANGE	% CHANGE
1403	Manchester Oxford Rd	63.1	60.7	-2.4	-4%
1403	Manchester Piccadilly	85.5	71.2	-14.3	-17%
1403	Manchester Victoria	93.6	65.1	-28.4	-30%
1403	Salford Central	87.9	79.5	-8.4	-10%
1406	Manchester Victoria	119.0	97.3	-21.7	-18%
1407	Manchester Airport	89.6	76.9	-12.7	-14%
1407	Manchester Oxford Rd	76.9	66.5	-10.4	-13%
1407	Manchester Victoria	96.0	70.2	-25.8	-27%
1407	Salford Central	90.4	87.1	-3.3	-4%
1408	Manchester Airport	90.0	60.0	-30.1	-33%
1408	Manchester Oxford Rd	70.5	69.7	-0.7	-1%
1408	Manchester Piccadilly	95.9	84.2	-11.7	-12%
1408	Manchester Victoria	103.5	72.9	-30.6	-30%
1408	Salford Central	104.8	103.7	-1.1	-1%
1409	Manchester Oxford Rd	70.8	69.0	-1.8	-3%
1409	Manchester Victoria	90.0	72.8	-17.2	-19%
1411	Manchester Airport	71.7	58.4	-13.2	-18%
1411	Manchester Piccadilly	93.4	88.8	-4.7	-5%
1411	Manchester Victoria	109.8	76.7	-33.2	-30%
1412	Manchester Airport	74.9	54.8	-20.1	-27%
1412	Manchester Oxford Rd	74.8	74.5	-0.2	0%
1412	Manchester Piccadilly	101.1	89.5	-11.7	-12%
1412	Manchester Victoria	109.0	78.2	-30.9	-28%
1412	Salford Central	104.6	101.6	-2.9	-3%
1413	Manchester Victoria	119.0	84.5	-34.5	-29%
1414	Manchester Airport	47.7	47.0	-0.7	-2%
1414	Manchester Oxford Rd	84.6	82.4	-2.1	-3%
1414	Manchester Victoria	123.0	86.1	-36.9	-30%
1414	Salford Central	112.1	111.4	-0.7	-1%
1415	Manchester Airport	55.6	53.4	-2.3	-4%
1415	Manchester Victoria	105.0	79.8	-25.2	-24%
1416	Manchester Victoria	119.8	92.0	-27.8	-23%
1417	Manchester Victoria	97.5	92.1	-5.4	-6%
1461	Manchester Airport	98.0	80.4	-17.6	-18%

MODEL ZONE	STATION	PFM V3.0	PFM V4.3	ABS CHANGE	% CHANGE
1465	Manchester Airport	90.4	75.8	-14.6	-16%
1465	Manchester Oxford Rd	91.9	79.6	-12.3	-13%
1465	Manchester Piccadilly	116.8	82.6	-34.3	-29%
1465	Manchester Victoria	124.1	68.3	-55.8	-45%
1465	Salford Central	108.1	98.3	-9.8	-9%
1469	Manchester Victoria	136.6	116.3	-20.3	-15%
1475	Manchester Victoria	132.5	123.0	-9.6	-7%
1511	HS East Midlands	125.1	110.8	-14.3	-11%
1516	Nottingham	68.9	68.9	0.0	0%
1516	HS East Midlands	128.7	107.0	-21.7	-17%
1522	HS East Midlands	102.8	92.0	-10.8	-11%
1523	Nottingham	52.0	49.3	-2.7	-5%
1523	HS East Midlands	158.4	91.4	-67.0	-42%
1524	HS East Midlands	131.7	99.7	-31.9	-24%
1525	HS East Midlands	138.1	109.1	-29.0	-21%
1526	Nottingham	66.8	62.3	-4.5	-7%
1526	HS East Midlands	152.9	104.3	-48.5	-32%
1681	Nottingham	64.2	50.7	-13.5	-21%
1681	HS East Midlands	177.6	94.4	-83.3	-47%
1688	HS East Midlands	174.5	166.3	-8.3	-5%
1712	HS East Midlands	100.8	87.2	-13.6	-14%
1714	Nottingham	73.9	73.9	0.0	0%
1715	Derby	160.2	149.2	-11.0	-7%
1715	HS East Midlands	81.9	38.6	-43.3	-53%
1716	Nottingham	73.5	62.0	-11.5	-16%
1716	HS East Midlands	79.2	59.7	-19.5	-25%
1717	HS East Midlands	125.4	99.3	-26.0	-21%
1718	HS East Midlands	89.5	39.0	-50.5	-56%
1719	HS East Midlands	63.2	49.7	-13.5	-21%
1720	HS East Midlands	132.7	45.4	-87.3	-66%
1721	Manchester Oxford Rd	157.3	143.1	-14.2	-9%
1722	Manchester Victoria	142.0	135.1	-6.8	-5%
1723	Rochdale	78.6	54.6	-24.0	-31%
1723	Manchester Oxford Rd	148.3	94.6	-53.6	-36%

MODEL ZONE	STATION	PFM V3.0	PFM V4.3	ABS CHANGE	% CHANGE
1723	Manchester Victoria	164.2	86.6	-77.6	-47%
1723	Salford Central	177.2	136.9	-40.3	-23%
1727	Rochdale	136.3	91.9	-44.3	-33%
1728	Manchester Oxford Rd	134.8	119.4	-15.4	-11%
1728	Manchester Victoria	113.8	99.5	-14.4	-13%
1729	Manchester Victoria	112.9	105.2	-7.6	-7%
1730	Manchester Oxford Rd	138.8	119.6	-19.2	-14%
1730	Manchester Victoria	115.1	99.7	-15.4	-13%
1731	Rochdale	113.3	64.0	-49.3	-44%
1731	Manchester Oxford Rd	127.5	84.2	-43.4	-34%
1731	Manchester Piccadilly	119.0	97.9	-21.1	-18%
1731	Manchester Victoria	110.8	69.6	-41.2	-37%
1732	Rochdale	110.7	104.2	-6.5	-6%
1732	Manchester Oxford Rd	128.2	125.6	-2.6	-2%
1734	Rochdale	88.6	62.1	-26.6	-30%
1734	Manchester Oxford Rd	108.8	83.2	-25.6	-24%
1734	Manchester Piccadilly	97.7	95.9	-1.8	-2%
1734	Manchester Victoria	100.5	68.1	-32.4	-32%
1736	Rochdale	98.0	68.6	-29.4	-30%
1736	Manchester Oxford Rd	105.7	76.8	-29.0	-27%
1736	Manchester Victoria	96.9	61.3	-35.6	-37%
1737	Rochdale	85.0	70.9	-14.1	-17%
1737	Manchester Oxford Rd	97.2	72.1	-25.2	-26%
1737	Manchester Victoria	90.0	57.9	-32.1	-36%
1739	Rochdale	111.8	102.1	-9.7	-9%
1739	Manchester Oxford Rd	128.2	125.3	-2.9	-2%
1739	Manchester Victoria	109.0	106.0	-3.0	-3%
1742	Manchester Oxford Rd	133.9	116.3	-17.7	-13%
1742	Manchester Victoria	114.8	98.3	-16.5	-14%
1743	Rochdale	90.6	72.5	-18.1	-20%
1743	Manchester Oxford Rd	105.2	71.9	-33.3	-32%
1743	Manchester Piccadilly	87.4	81.3	-6.0	-7%
1743	Manchester Victoria	75.7	57.7	-18.0	-24%
1744	Rochdale	78.7	67.8	-11.0	-14%

MODEL ZONE	STATION	PFM V3.0	PFM V4.3	ABS CHANGE	% CHANGE
1744	Manchester Oxford Rd	103.9	77.3	-26.7	-26%
1744	Manchester Victoria	91.9	62.8	-29.1	-32%
1745	Manchester Oxford Rd	112.0	109.6	-2.3	-2%
1747	Rochdale	102.1	75.6	-26.5	-26%
1747	Manchester Oxford Rd	105.6	69.8	-35.7	-34%
1747	Manchester Piccadilly	87.7	78.9	-8.8	-10%
1747	Manchester Victoria	87.1	55.6	-31.4	-36%
1747	Salford Central	102.7	96.4	-6.3	-6%
1748	Rochdale	90.2	74.5	-15.7	-17%
1748	Manchester Oxford Rd	88.5	67.6	-21.0	-24%
1748	Manchester Victoria	62.6	53.4	-9.2	-15%
1749	Rochdale	118.4	107.1	-11.3	-10%
1749	Manchester Oxford Rd	132.9	117.2	-15.7	-12%
1749	Manchester Victoria	122.7	99.2	-23.5	-19%
1750	Manchester Oxford Rd	107.9	102.5	-5.4	-5%
1750	Manchester Victoria	97.4	86.1	-11.4	-12%
1751	Rochdale	111.3	77.1	-34.2	-31%
1751	Manchester Oxford Rd	94.4	66.7	-27.7	-29%
1751	Manchester Victoria	74.9	53.0	-21.9	-29%
1752	Rochdale	108.8	79.3	-29.4	-27%
1752	Manchester Oxford Rd	75.6	63.7	-11.9	-16%
1752	Manchester Victoria	66.8	49.5	-17.3	-26%
1753	Rochdale	131.6	122.6	-9.0	-7%
1753	Manchester Oxford Rd	107.7	100.9	-6.7	-6%
1753	Manchester Victoria	96.0	83.5	-12.6	-13%
1754	Rochdale	126.0	120.1	-6.0	-5%
1754	Manchester Victoria	83.4	80.9	-2.4	-3%
1817	Rochdale	54.0	41.6	-12.4	-23%
1818	Rochdale	66.2	44.2	-22.1	-33%
1819	Rochdale	94.2	50.1	-44.2	-47%
1821	Rochdale	50.2	43.5	-6.7	-13%
1822	Rochdale	54.5	44.8	-9.6	-18%
2158	Manchester Airport	103.2	77.3	-25.9	-25%
2170	Manchester Airport	87.7	76.9	-10.8	-12%

Appendix D SCM Improvements

1. INTRODUCTION

1.1.1 Appendix J describes the improvements made in the Station Choice Model (SCM) in PFM v4.3.

1.2 Station Access Time Improvements

1.2.1 Access/egress costs in PFM v3 were obtained from the National Accessibility Model (NAM). NAM is the model used by the Department for Transport (DfT) to calculate travel times to essential services (the Core Accessibility Indicators). The same modelling approach was adopted to obtain access times between MZones and stations for HS2 station choice modelling outside London (the routing algorithm allows a maximum highway distance of 200 km and a maximum public transport access time of 120 minutes).

1.2.2 NAM used the public transport network and service pattern from the National Public Transport Data Repository (NPTDR[1] , 31 October 2009) database of transport services, and the highway network from Ordnance Survey Integrated Transport Network (ITN). To better reflect highway travel times, Trafficmaster ITN link speed data provided by the DfT was used for modelling the highway access times, replacing the NAM highway times.

1.2.3 The outputs from NAM were:

- highway access time (in minutes);
- public transport access time - walk time (in minutes);
- public transport access time - wait time (in minutes);
- public transport access time - in-vehicle time (in minutes); and
- access distance (in metres).

1.2.4 Output data from NAM is considered to have the following issues:

- DfT's Trafficmaster data included the whole of England and only a small part of Wales and Scotland. Typical link speeds by road type were used for access journey time calculations for areas where Trafficmaster data was not available (Motorways 100 kph, A roads 70 kph, B roads 60 kph and Minor roads 50 kph)
- public transport timetable data for Scotland was not as comprehensive as the English equivalent; thus lower accuracy was expected of the public transport access times for Scotland
- current travel times were used in the NAM modelling (although manual adjustments can be made to reflect future year networks);
- car parking costs and times are not included; and
- zero wait is assumed for the first PT access mode.

1.2.5 We made the following modifications to the National Accessibility Model (NAM) data:

- to avoid very short highway times (20 seconds is in the NAM data for one flow), we added 10 minutes to all highway times; this reflects getting into car, parking and getting to station;

[1] http://data.gov.uk/dataset/nptdr

- we assumed that for distances of up to 1 km, walk is used instead of public transport. The walk times came from NAM data and are converted to distances based on PLD walk speed of 4.8km/h;
- for trips longer than 1 km we have created a boarding penalty for public transport access that varies according to distance, starting from 5 minutes and increasing up to 30 minutes. 30 minutes is equivalent to the boarding penalty in the assignment part of the PLD model and is applied for trips over 30km. For trips less than 30km the boarding penalty is calculated by linear interpolation. The boarding penalty is added to the public transport in vehicle times;
- 10 minutes have been added to PT wait time to allow for the initial wait time that has not been included in the NAM dataset;
- we have checked the access times from high NRTS demand zones to stations of interest with 'Transport Direct', the national journey planning website to ensure that they are sensible and where required, manual adjustments have been made. The stations for which we adjusted Public Transport (PT) access times include Manchester Piccadilly, Manchester Airport, Warrington Bank Quay, Runcorn, Wigan North Western, Stockport, Macclesfield, Sheffield, Meadowhall, Nottingham, Derby, York and Leeds;
- to balance between station choice and mode choice an adjustment was made on the car access costs in key areas of interest such as Manchester, Liverpool, Sheffield and East Midlands. Introducing different Alternative Specific Constants (ASCs) for different types of stations and purposes would be the recommended way of addressing the issue. However, due to time constraints and the additional run times that would incur it was deemed appropriate to adjust the highway access times to the stations affected based on the relationship between demand and access costs: this has an identical effect on demand as adjusting ASCs; and
- In addition we adjusted the journey times for the PLD zones in the East Midlands to take account of the introduction of a Red Arrow bus service between Derby and Nottingham and committed extension of the NET services in Nottingham. We calculated the expected journey times for the new services and compared them to the NAM data. We then used the lowest value of the two in the data file. We looked at all of the zones with NET or Red Arrow stops together with the neighbouring zones. We included walk time as well as the expected in vehicle times to calculate the journey time using the Red Arrow and additional NET services.

1.2.6 In London, Transport for London's public transport model, Railplan, was used to provide generalised cost of access between Railplan model zones and stations. Railplan adopts the following weighting factors for elements of access times:

- walk time = 2.0;
- wait time = 2.5; and
- in-vehicle time = 1.0.

1.2.7 The assumption in the model for London stations is that access to HS2 is primarily made through public transport. Access by car is not modelled for London zones.

1.2.8 In London Railplan gives crowded journey times. Outside London, the alternative specific constants (ASC) include approximate assessment of highway congestion. The SCM assumes no change in congestion or crowding in future years.

1.2.9 As part of the improvements to the SCM, the access costs were revised:

- To take into account revised data from Railplan, including updating the access times to Heathrow Airport;

- Following a review of committed future transport scheme across the HS2 corridors, to ensure that access times better reflected any intended future changes to station access times; and
- Following a validation exercise of station access times against other data sources.

Revised Railplan Data

1.2.10 PFM v3.0 used Railplan data from the 2010 Strategic Railplan model. The 2010 Strategic Railplan model is a morning peak model only; whereas the SCM is an all-day model. In addition to this assumptions have changed about the HS2 scheme, particular with regards to access to Old Oak Common and there are upgrades to services within London.

1.2.11 The access time information in the SCM was therefore revised with data from the Regional Railplan v6.2 model, which contains 2013 data. The changes include:

- A move from Strategic Railplan 4.0 zoning system to Regional Railplan 6.2, which results in a different and more disaggregate zone set within the GLA area (around 4,000 zones compared with 1,500);
- Updated forecast years - previous access costs related to 2016, access costs included in PFM v4.1 are for 2026 (Day1c) and 2031 (Y);
- Improved station connectivity at Tottenham Court Road, Kings Cross St Pancras and Paddington provided by CrossRail;
- Adjustments to South West Trains HLOS1 services; and
- Enhanced Croydon Tramlink service.

1.2.12 Regional Railplan provides a much more disaggregated zoning system compared with Strategic Railplan and the SCM. Hence assumptions were made as to how the access cost data should be aggregated to the SCM zoning system. Several conversion methods were tested. The option implemented was Average Regional Cost, which is a weighted cost of the constituent Regional zone portions within the SCM zone. As an example, SCM zone 2865 has within its boundary 6.6% of Regional zone 1685, 40.2% of zone 1691 and 0.2% of zone 1987 by area. Thus the cost for SCM zone 2865 to station 5 (Euston) is:

$$GJT_{2865,5} = \frac{(0.066DEM_{1685,5} * GJT_{1685,5}) + (0.402DEM_{1691,5} * GJT_{1691,5}) + (0.002DEM_{1897,5} * GJT_{1897,5})}{(0.066DEM_{1685,5} + 0.402DEM_{1691,5} + 0.002DEM_{1897,5})}$$

where

$DEM_{Z,5}$ is the Demand from Railplan zone Z to Euston (5)

$GJT_{Z,5}$ is the Generalised Journey Time from Railplan zone Z to Euston (5)

1.2.13 This approach assumes that the demand in each Regional zone is uniformly distributed.

1.2.14 As well as updating the Railplan data with the latest available data (Regional Railplan 6.2) analysis was also undertaken to determine whether access costs should be averaged across the three different time periods for Railplan (AM peak, Inter-peak and PM peak) or whether only AM peak access costs should continue to be used.

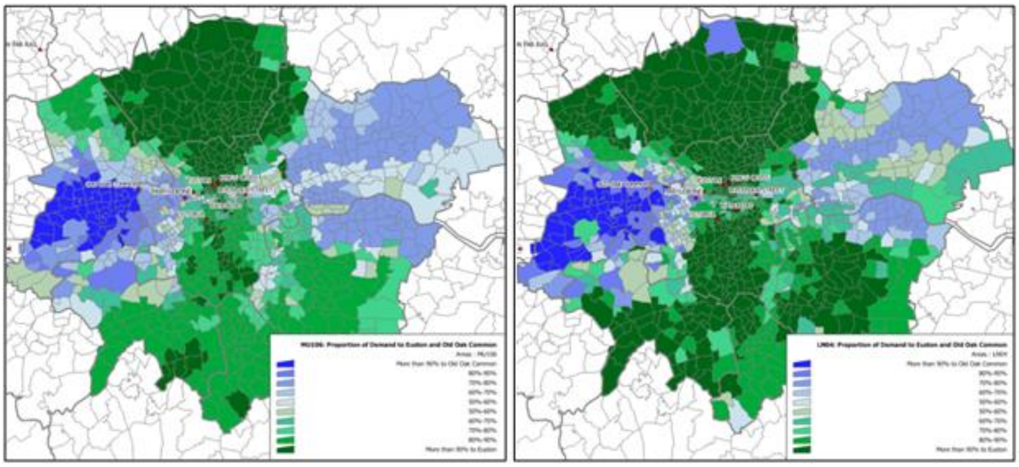
1.2.15 A series of stand-alone base SCM model runs were undertaken to determine whether using just the AM peak access cost information or taking other time periods made any significant difference to the results. Table 1 shows there are no significant differences in the percentages of people using the London stations. Hence, access cost data continues to be based on AM peak data only.

Table 1. London Station Shares from Stand Alone Model Runs Using Railplan Costs

STATION	DIRECTION	BASE MODEL	AM PEAK	INTER-PEAK	PM PEAK
Euston	Outbound	46%	45%	46%	45%
	Inbound	49%	47%	48%	47%
St Pancras	Outbound	16%	17%	18%	17%
	Inbound	15%	17%	16%	17%
King's Cross	Outbound	26%	25%	25%	25%
	Inbound	25%	26%	25%	26%
Marylebone	Outbound	3%	4%	4%	4%
	Inbound	3%	4%	4%	4%
Paddington	Outbound	10%	9%	9%	9%
	Inbound	8%	6%	7%	6%

1.2.16 The independent study investigating the updating of Railplan Access/Egress data showed that the changes to the Railplan data generally made Euston more attractive. There are some additional zones in East London that now find Euston more attractive as the HS2 Euston Square link provides improved access to locations on the Hammersmith and City and District lines as shown below.

PFM v3.0 PFM v4.3



1.2.17 It also showed that the new access times led to a reduction in economic benefits and revenue. The access time changes also impact on the demand split between the HS2 stations in London with the proportion of passengers boarding at Old Oak Common falling from 38% to 34% as passengers switch to using Euston.

Updated Future Access Times

1.2.18 In PFM v3.0 access times in the SCM remained constant in future years. As part of the model enhancements, a desk research review was undertaken to identify committed transport schemes in areas that will impact on HS2 services. The schemes that were considered and where access times were adjusted included:

- Manchester Metrolink Extensions;
- Midland Metro Extension;
- Nottingham NET Phase 2 Extensions;
- Red Arrow Coach services in the East Midlands;
- Leeds New Generation Transport (NGT); and
- New stations at Apperley Bridge and Kirkstall Forge.

1.2.19 The methodology used to update the access/egress times for each scheme is described below. The SCM uses the same information for access times and egress times using same mode to each station for ease we will refer to this as access time in the following text. The following general rules were applied for all of the updated access times:

- Access times were only updated if the total generalised journey time (GJT) was less than the GJT currently in the model; and
- If the new PT wait times were less than 10 minutes they were set to 10 minutes as there are no PT wait times less than 10 minutes in the existing SCM access times files.

1.2.20 Changes were only made to the station choice model input files and no changes were made to the network or transport services coding in the PLD model. The networks within PLD should represent the long distance network and not include the type of local transport networks updated in the access/egress costs. The same changes to access times were included for both the Do Minimum and Do Something data sets as these are not changes that are scheduled regardless of HS2.

Manchester Metrolink Extensions

1.2.21 The station choice model has been updated to reflect the future extensions to the Manchester Metrolink.

1.2.22 New GJTs were calculated for these extensions to Rochdale, East Didsbury, Ashton-under-Lyne and Manchester Airport. The extension to Port Salford was not included in the update as it is not a committed scheme.

1.2.23 New zone to station GJTs were estimated for zones served by the new extensions for the following stations:

- Manchester Piccadilly;
- Manchester Victoria;
- Manchester Oxford Road;
- Salford Central;
- Rochdale; and
- Manchester Airport.

1.2.24 New GJTs were estimated for all stations on the following Metrolink routes: Piccadilly - Ashton-under-Lyne, Monsall - Rochdale (the Monsall - Oldham section opened on 13th June 2012) and Firswood - East Didsbury/Manchester Airport (the Firswood - St Werburgh's Road opened on 7th July 2011).

1.2.25 For zones directly served by the tram extensions the following methodology was used to estimate access times:

- The IVT was estimated as an average across all tram stops within each zone to each rail station;
- Wait time was based on half the headway (if wait time < 10 mins it was set to 10 mins); and
- Walk time was based on distance from tram stop to rail station and an assumed 5 min walk from the PLD zone station.

1.2.26 The following methodology was used for zones which are adjacent to zones which contain a Metrolink stop:

- Calculate distance between zone centroid and zone centroid of zone with Metrolink stop;
- If the distance between zone centroids was less than 800 metres it was assumed passengers will walk to the Metrolink station with a journey time equal to the distance divided by a walk speed of 5km/h;
- If the distance between zone centroids is greater than 800 metres passengers were assumed to walk to a bus stop and take a bus to the tram stop in the adjacent zone with the IVT estimated based on the distance and an average speed of 30km/h;
- Walk time was based on distance from tram stop to rail station and an assumed 5 min walk from the PLD zone to bus stop;
- Wait time was based on half the headway of the tram service and bus service (if wait time < 10 mins it was set to 10 mins); and
- An additional boarding penalty was added to the GJT when using a bus to transfer onto a tram.

1.2.27 Boarding penalties are included in the station choice model as part of the IVT value access times file. The boarding penalties are a function of total trip distance which are based on the highway trip distance sourced from the National Accessibility Model (NAM). The total boarding penalty for a particular trip is given by the average number of boards multiplied by the boarding penalty.

1.2.28 For Manchester Victoria, Manchester Piccadilly, Manchester Airport and Rochdale GJTs were calculated from the zones to the tram stops directly serving these stations.

1.2.29 For Manchester Oxford Road passengers were assumed to travel by tram to St Peter's Square and then walk to Manchester Oxford Road. This walk time was calculated using the distance between St Peter's Square from Google maps (322m) and an average walk speed of 5km/h which gave an estimated walk time of 3.84 minutes.

1.2.30 For Salford Central passengers travelling to and from the south were assumed to alight at the St Peter's Square Metrolink stop and catch a bus to Salford Central from Albert Square. Using the GMPTE Journey Planner it was found that there are 18 buses per hour during the day between Albert Square with an average journey time of 4.67 minutes and the walk time from St Peter's Square to Albert Square was estimated as 4.56 minutes. Passengers accessing Salford Central from the north were assumed to board/alight at Manchester Victoria and walk between the two stations. The walk distance was calculated as 966m using Google maps which assuming a walk speed of 5km/h leading to a walk time of 11.59 minutes.

1.2.31 The Metrolink extensions also made PT accessible for certain zone to station movements as a result of the tram extensions. The PT availability was set to 1 for particular zone-to-station movements and the GJTs were estimated using the methodology outlined in the bullet points.

Midland Metro Extension

1.2.32 New GJTs were estimated for the following stations accessible by Midland Metro following the extension from the current terminus at Birmingham Snow Hill to Birmingham New Street and the increase in frequency from 6tph to 8tph along the entire route:

- Birmingham New Street;
- Birmingham Snow Hill;
- Birmingham Moor Street; and
- HS Birmingham.

1.2.33 The Midland Metro extension from Birmingham to Snow Hill was coded in the station choice model using the following methodology for zones directly served by Midland Metro:

- The IVT was estimated as an average across all tram stops within each zone to each rail station;
- Wait time was based on half the headway (if wait time < 10 mins it was set to 10 mins); and
- Walk time was based on distance from tram stop to rail station and an assumed 5 min walk from the PLD zone station.

1.2.34 Passengers for Birmingham Snow Hill and Birmingham New Street were assumed to use the tram stops adjacent to these stations. Passengers for Birmingham Moor St and HS Birmingham passengers were assumed to use the tram stop on Corporation St and walk to the stations from there which was estimated to take 5.8 minutes using an average walk speed of 5km/h and the 483m distance measured in Google maps.

1.2.35 In addition it was decided to add the MZones[2] within PLD zone 176 (Sandwell) to those which have access to Snow Hill and Moor St stations. A map showing the Sandwell PLD zone is shown in Figure 1.

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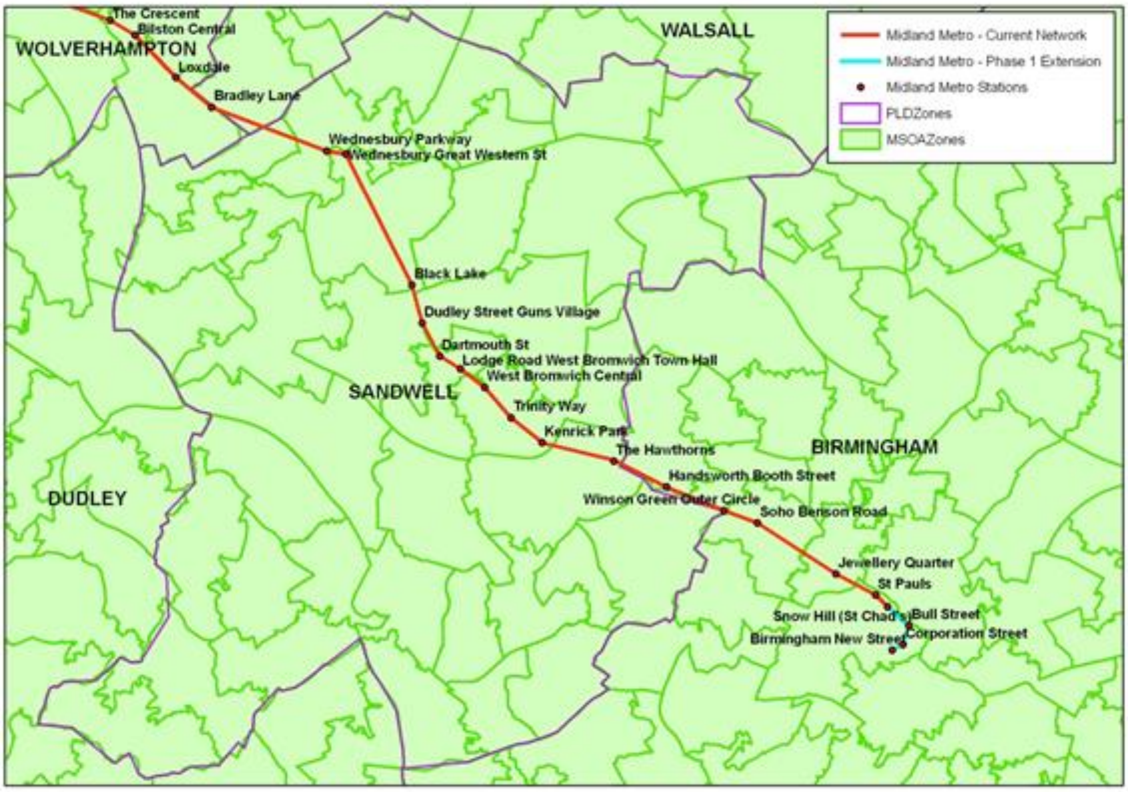
[2] MZones are the zones used in the SCM. For the core area outside London the MZones are the Middle Layer Super Output Areas (MSOA) as derived from the Census data. For within London the MZones in the SCM correspond to the Strategic Railplan zones.

Figure 1. Sandwell PLD Zone and Midland Metro Network



1.2.36 Highway access times from/to these stations were estimated for all of the MZones within PLD zone 176. These access times were based on a -3.35 min adjustment to the values for Birmingham New Street. This adjustment was calculated from the difference between access times for New Street, Snow Hill and Moor St for MZone E02001873 which lies in between PLD zone 176 and the city centre.

1.2.37 PT times from the MZones within PLD zone 176 were calculated for the zones which are directly served by Midland Metro or where their border is very close to a Midland Metro station using the same methodology outlined in the bullet points above.

1.2.38 In addition it was found that the access times for Snow Hill and Moor Street stations from/to MZone E02002876 which is adjacent to Birmingham City Centre had been coded with the maximum PT journey times of 200 minutes. It was decided to code the access times from/to these stations with the same PT walk, wait and IVT as Birmingham New Street.

Red Arrow and Nottingham NET Extensions

1.2.39 GJTs were calculated for the Red Arrow Coach services which operate between Chesterfield and Nottingham via Derby. In the future these services are expected to stop at HS East Midlands. Access times to the following stations were calculated for trips using Red Arrow services:

- Nottingham;
- Derby; and
- HS East Midlands.

1.2.40 The GJTs were calculated using the following methodology:

- IVTs were calculated using the bus timetable. It was assumed that when HS East opens the Red Arrow services will stop there;

- Red Arrow services operate with a headway of 30 minutes giving a wait time of 15 minutes; and
- Walk times were assumed to be 5 minutes from the zone to the station and 1 minute from the bus stop to Derby and HS East Midland stations. For Nottingham, passengers were assumed to walk the 1300m and 900m between the Red Arrow service stop and the bus and rail stations respectively.

1.2.41 The following methodology was used for zones which are adjacent to zones containing a coach stop:

- Calculate distance between zone centroid and coach stop;
- If the distance between the zone centroid and coach stop was less than 800 metres passengers it was assumed passengers will walk to the coach station with a journey time equal to the distance divided by a walk speed of 5km/h;
- If the distance between the zone centroid and coach stop is greater than 800 metres passengers were assumed to walk to a bus stop and take a bus to the coach stop in the adjacent zone with the IVT estimated based on the distance and an average speed of 30km/h;
- Walk time to be based on distance from coach stop to rail station and an assumed 5 min walk from the PLD zone to bus stop;
- Wait time was based on half the headway of the coach service and any preceding bus service (assumed to be 10 minutes) and if wait time of the bus service was less than < 10 mins it was set to 10 mins; and
- An additional boarding penalty is added to the GJT when using a bus to transfer onto a tram.

1.2.42 Access times were also calculated for Nottingham NET Phase 2 extensions using a similar methodology as for Manchester Metrolink for the following stations:

- Derby;
- Nottingham; and
- HS East Midlands

1.2.43 It was assumed that Nottingham NET would be extended from its planned terminus at Toton Park & Ride to HS East Midlands if HS2 is built. It was assumed that the journey time between the two stations would be 2 minutes.

1.2.44 Where GJTs were calculated for both Red Arrow and Nottingham NET for a particular improvement the lower of the two calculated GJTs was used to update the access times in the PLD model.

Leeds New Generation Transport (NGT)

1.2.45 This NGT is a scheme to introduce trolley bus routes from the north west and south east of the city into the city centre. The following methodology was used to estimate new GJTs for zones directly served by or where a station was close to the border of a zone with a station.

- The IVT was estimated as an average across all NGT stops within each zone to each rail station;
- Wait time was based on half the headway (if wait time < 10 mins it was set to 10 mins); and
- Walk time was assumed to be 5 min from the PLD zone station and 1 min from the NGT stop to Leeds station.

1.2.46 It was assumed that the trolley bus scheme would not have a significantly large catchment area given the already high level of bus services and new GJTs were not estimated for zones which are adjacent to the trolleybus routes.

New Stations at Apperley Bridge and Kirkstall Forge

1.2.47 The new stations were assigned to an MZone and the following methodology was used to estimate access times to Leeds station:

- Locate the new stations in MZones and extract the average IVT from these stations to Leeds station from the future timetable ;
- Wait time was based on half the headway based on a half hourly service; and
- Walk time was assumed to be 5 min from the PLD zone station and 1 min at Leeds station.

1.2.48 There were also zones adjacent to those containing the new stations which were identified as being accessible from the new stations. It was assumed that passengers would use buses to access the stations from these zones and the following assumptions were made to estimate journey times:

- IVT based on the distance between the MZone centroid and the station divided by an average speed of 30 km/h;
- Headway was assumed to be 15 minutes with an average wait times of 7.5 minutes, which was set to the minimum 10 mins; and
- It was assumed passengers would walk 5 minutes on average to a bus stop.

1.2.49 It was found that when the generalised journey times were calculated for the two new stations total GJTs were greater than those in the previous version of the model and therefore there were no updates made to the access times in the PLD model.

1.3 Validation of Station Access Times within the SCM

1.3.1 In addition to the update of the Railplan data and the future year station access times within the SCM, a wider review of the access times was undertaken. This was undertaken in two stages:

- Comparison of station shares to ensure consistency with observed data in key areas of the model; and
- Review and validate the impact of local transport schemes on the station shares.

Review of Station Shares

1.3.2 A review of the station catchment areas for the East Midlands and South Yorkshire had already been undertaken in February 2012 as part of the development of PFM v3. These areas were significant in choosing the location of potential HS2 stations. The aim of the review in WP2 was to compare the share of demand between London and PLD stations in each area to ensure that the percentage of London trips originating or terminating at non-London PLD stations broadly reflected observed data, such as that in 2010/11 National MOIRA (as April 2012) and the 2005/6 National Rail Travel Survey (NRTS).

1.3.3 Should the shares not be within 5% then the station access times by mode were adjusted to better reflect the observed data.

1.3.4 The following areas were reviewed for PFM v4.3:

- Wider Birmingham area including:
  - Birmingham New St

- Birmingham International
- Coventry
- Sandwell and Dudley
- Wolverhampton
- Crewe/Stafford area including:
- Crewe
- Stafford
- Stoke-on-Trent
- Lichfield Trent Valley

- Wider Liverpool area including:
  - Liverpool
  - Runcorn
  - Runcorn East
  - St Helens Central
  - St Helens Junction
  - Widnes
  - Wigan North Western
  - Warrington Central
  - Warrington Bank Quay

- Wider Preston area including:
  - Preston
  - Blackpool
  - Burnley Manchester Rd

- Darlington/Middlesbrough Area including:
  - Darlington
  - Middlesbrough
  - Stockton
  - Hartlepool

- Wider Leeds area including:
  - Leeds
  - Bradford Interchange
  - Bradford Foster Square
  - Halifax
  - Wakefield Westgate

1.3.5 These areas were selected to ensure that all of the MZones connected to HS2 had been reviewed.

1.3.6 From the review for PFM v4.3 the following changes were identified to the station catchment areas:

- Sunderland: PLD 189 (Sunderland) in PFM v4.3 only has PT access to Sunderland station (167), which is consistent with PT catchment area guidelines within the SCM Model Development Report3 ;
- Birmingham: access to Sandwell & Dudley station (99) is no longer allowed for PLD zone 5 (Birmingham); and

[3] SCM Model Development Report, V2.3 August 2012, MVA Consultancy and Mott MacDonald

- Liverpool: access to Warrington Bank Quay (130) and Warrington Central (131) is no longer allowed for PLD (116) Liverpool.

1.3.7 These changes were made to improve the fit of the station shares in the base model against NRTS data for trips to/from London for the access mode (PT / highway) and 2010/11 MOIRA data for the station shares.

1.3.8 Implementing the changes outlined in 6.3.6 improved the station shares to London as shown in Tables 2 to 4 for Sunderland, Birmingham and Liverpool respectively. Note that this review of station shares was undertaken using PFM v3.0; hence the model information refers to PFM v3.0 in the tables below. It was not considered that the model version would materially affect the results of the choice of stations as this is driven by the SCM.

Table 2. Mode Shares before and after Review of Station Catchment Areas in North East

STATION	MOIRA 2010	PFM V3.0 RUN BEFORE	DIFFERENCE BEFORE	PFM V3.0 RUN AFTER	DIFFERENCE AFTER
Newcastle	53%	56%	3%	55%	2%
Sunderland	3%	0%	-3%	2%	-1%
Durham	15%	17%	1%	17%	1%
Darlington	22%	21%	-1%	21%	-1%
Middlesbrough	4%	4%	0%	4%	0%
Hartlepool	2%	1%	-1%	1%	-1%

Table 3. Mode Shares before and after Review of Station Catchment Areas in West Midlands

STATION	MOIRA 2010	PFM V3.0 RUN BEFORE	DIFFERENCE BEFORE	PFM V3.0 RUN AFTER	DIFFERENCE AFTER
Birmingham New Street	35%	31%	-4%	34%	-1%
Birmingham International	13%	13%	0%	14%	1%
Coventry	25%	20%	-6%	20%	-5%
Wolverhampton & Sandwell & Dudley	7%	15%	8%	11%	4%
Crewe	7%	7%	1%	8%	1%
Stafford	4%	6%	1%	6%	2%

STATION	MOIRA 2010	PFM V3.0 RUN BEFORE	DIFFERENCE BEFORE	PFM V3.0 RUN AFTER	DIFFERENCE AFTER
Litchfield Trent Valley	6%	2%	-4%	2%	-4%
Stoke-on-Trent	4%	6%	3%	6%	3%

Table 4. **Mode Shares before and after Review of Station Catchment Areas in the Liverpool Area**

STATION	MOIRA 2010	PFM V3.0 RUN BEFORE	DIFFERENCE BEFORE	PFM V3.0 RUN AFTER	DIFFERENCE AFTER
Liverpool including St Helen's Junction & Runcorn	63%	60%	-4%	62%	-1%
St Helen's Central	0.2%	0%	0%	1%	0%
Warrington & Runcorn East	11%	15%	4%	12%	1%
Wigan North Western	9%	10%	1%	10%	1%
Widnes	0%	0%	0%	0%	0%
Chester	16%	15%	-1%	15%	-1%

1.3.9 As part of the exercise in parameter consistency, the weight associated with the walk time between stations has been changed. This caused more passengers to be sent to Moor St and Snow Hill stations in Birmingham where their first action was to use the walk link to Birmingham New St to take the train. To prevent people using walk links to another Birmingham station to catch their train we have added 6 minutes to Moor St walk times and 10 minutes to Snow Hill walk time in the access cost file for all of the MZones which have access to these two stations.

1.3.10 In addition the walk links listed in Table 5 have been changed within the PLD coding for PFM v4.3. The walk links have been doubled so that the generalised time in minutes is not affected by the change in the weighting.

Table 5. Table of the Walk Link Lengths in PFM v3.0 and v4.3 and The Implied Walk Time

WALK LINK	PFM V3.0 – DISTANCE KM	PFM V3.0 - TIME (GJT MINS)	PFM V4.3 DISTANCE KM	PFM V4.3TIME (GJT MINS)
Birmingham Snow Hill to New Street	0.9	43.2	1.8	43.2
Birmingham Moor Street to Snow Hill	0.81	38.88	1.72	38.88
Birmingham Moor Street to New Street	0.5	24.0	1	24.0
Birmingham Moor Street to Curzon St	0.2	9.6	0.4	9.6
Birmingham New Street to Curzon St	0.6	28.8	1.2	28.8
Manchester Interchange – Manchester Airport	NA	NA	**0.8**	19.2
Birmingham Interchange – Birmingham International	Transit link IVT 6 mins, 30 min board 6 min wait	42	**1.08**	25.92
Meadowhall HS2 – Meadowhall Barnsley	NA	NA	**0.3**	7.2
Meadowhall HS2 – Meadowhall Rotherham	NA	NA	**0**	0
Meadowhall Barnsley – Meadowhall Rotherham	NA	NA	**0.3**	7.2
Leeds HS2 – Leeds Classic	NA	NA	**0.2**	4.8
Salford to Manchester Oxford Rd	1.6	76.8	3.2	76.8

Appendix E Demand Model Estimation Data

1.1 Introduction

1.1.1 Appendix E provides more detailed information about the data used in the estimation of the demand model parameters used in PFM v4.3. In particular it:

- describes the processing of the NTS data;
- explains how the PFM Level of Service (LOS) has been processed into a suitable format for the model estimations; and
- documents the sources used to account for real changes in modal costs over the 2002-2010 period in the estimations.

1.2 Processing of the NTS Data

1.2.1 Disaggregate records of the choices made by individuals are used for model estimation. The choice data used to estimate the new PFM demand models has been taken from the 2002-2010 NTS surveys. The NTS surveys provide long-distance (LD) trip data suitable for model estimation, with LD trips in the NTS defined as all trips with a one-way distance of 50 miles and above. The LD data available from the NTS is provided by both the standard 1-week diary survey used in the NTS to record information on trips of all lengths, and trips collected from a dedicated LD travel recall survey. The recall period was 3 weeks for the 2002-2005 NTS surveys; this was reduced to 1 week for the 2006-2010 surveys due to concerns about recall error over a 3 week period. When the NTS data is used to estimate frequency models, we use both the diary and recall data, but weights are used to take account of the impact of recall error in total trip making in the recall survey. Both the recall and diary data are used to estimate the mode choice models.

1.2.2 The modelling unit for the new PFM demand models is full LD home-based tours. A full LD tour is a series of linked long-distance journeys starting and finishing at the same home-location. A primary destination is identified for each tour which defines the purpose of the most distant destination visited.

1.2.3 Table 1 summarises the total numbers of tour legs and trips observed in the 2002-2010 NTS LD data. Note that when calculating total tour legs and trips, each full tour comprises two tour legs.

Table 1. Tour Legs and Trips Totals by Type and Survey Type

	DIARY		RECALL		TOTAL	
HB Full tours, simple	19,502	61.3%	32,236	76.0%	51,738	69.7%
HB Full tours, complex	867	2.7%	708	1.7%	1,575	2.1%
HB Outward half tours	6,947	10.9%	7,952	9.4%	14,899	10.0%
HB Return half tours	6,060	9.5%	6,255	7.4%	12,315	8.3%
NHB trips associated with full tours	1,336	2.1%	1,075	1.3%	2,411	1.6%
NHB trips associated with half tours	4,458	7.0%	2,153	2.5%	6,611	4.5%
Unlinked NHB trips	4,130	6.5%	1,473	1.7%	5,603	3.8%
Total tour legs/trips	**63,669**	**100.0%**	**84,796**	**100.0%**	**148,465**	**100.0%**

1.2.4 Overall full tours account for just over 70% of trips, however this figure is noticeably lower in the diary data where significantly more NHB trips are observed. Half tours account for a significant proportion of trips (18.3% in total), however only full tours have been included in the final model estimations as it our experience that half tours are associated with higher levels of reporting error compared to full tours, and the samples of full tours are sufficiently large to accurately estimate sensitivities to generalised time changes.

1.2.5 It is noted that the models are applied incrementally relative to base matrices that include both home-based and non-home-based travel, and that make no distinction between full and complex tours. Thus while the sensitivities to generalised time changes are estimated from the 70% of trips that can be associated with full home-based tours, these sensitivities are used to predict changes relative to the base matrices that include all home-based and non-home-based travel.

1.2.6 The detailed purpose codes recorded in the NTS data have been aggregated into the three model purposes as follows:

- Commute tours are tours made to work primary destinations (NTS purpose code 0);
- Business tours are tours made to primary destinations visited in the course of work (NTS purpose code 1); and
- Other travel tours are tours made to all other primary destinations (all other NTS purpose codes).

1.2.7 It is noted that with this purpose definition, education tours are classified as other travel and there is no reclassification of commute tours greater than 80 miles to other (the approach used in earlier versions of PFM). This purpose definition is consistent with the revised definitions being used in the WP1 work. In the LDM and earlier versions of PFM, education tours were classified together with commute.

1.2.8 To determine the ‘main’ mode used for tour legs involving two or more LD trips[1], the following mode hierarchy has been applied across the modes used for each of the LD trips made during the tour leg:

- Air;
- Rail;
- Bus/coach;
- Car; and
- Other.

1.2.9 This mode hierarchy means that if car is used to access a public transport mode, for example an individual driving to an airport to catch a flight, the public transport mode is represented as the main mode. Tours with main mode ‘bus/coach’ and ‘other’ are excluded from the PFM demand models. The tour characteristics for the outward tour leg, e.g. main mode, are used to model the mode for the tour as a whole.

1.2.10 The tour building analysis yields samples of LD tours for model estimation with one-way distances of 50 miles and above. Of the 53,313 full tours presented in Table E.1 above, 2,054 were excluded because of missing or inaccurate zoning information, leaving 51,259 tours available for model estimation. The LD tour samples in principle available for model estimation for the three PFM travel purposes are summarised in Table 2.

Table 2. Full LD Tours by Type, 2002-2010 NTS Data

	DIARY		RECALL		TOTAL	
Commute	3,145	16.3%	4,031	12.6%	7,176	14.0%
Business	3,033	15.7%	5,140	16.1&	8,173	15.9%
Other	13,141	68.0%	22,769	71.3%	35,910	70.1%
Total	**19,319**	**100.0%**	**31,940**	**100.0%**	**51,259**	**100.0%**

1.2.11 It should be noted a significant number of these tours were subsequently dropped from the analysis because they are made entirely within one of the PLANET regional models, e.g. long-distance commuting made within the PLANET South model area. Furthermore, the tour totals presented in Table 2 are for tours made on all days of the week, and as the PFM is a weekday only model weekend tours[2] have been excluded from the estimations. A significant fraction of other travel tours depart on a weekday and return over the weekend, these have been retained in the estimations with a weight of 0.5 applied, similarly tours that depart at the weekend and return on a weekday have been retained in the estimations with a weight of 0.5.

1.2.12 The rail mode shares are higher in the 2006-2010 data compared to the 2002-2005 data, particularly for commuting. Therefore separate sets of mode constants have been estimated for the 2002-2005 and 2006-2010 periods. It is noted that these increases in rail mode share were still observed when this analysis was restricted to the diary data to control for the possible impact of the change in recall period from 1 week (2002-2005 data) to 3 weeks (2006-2010 data). Therefore the observed increase in rail mode share in the total NTS LD data (diary plus recall) is not a result of the change in recall period.

[1] Note that each individual trip has to be over 50 miles in length to be recorded in the NTS LD data.

[2] Specifically, tours where both the outward and return legs are made at the weekend.

1.3 Level of service data

1.3.1 The available LOS data reflects travel conditions in the base year (2010/2011 UK financial year). The choice data in the model estimations spans the 2002 to 2010 period, and there have been some significant changes in LOS for some modes over this period, in particular for rail where the West Coast Mainline upgrade had a significant impact. These changes are partially accounted for by estimating separate mode constants for the first four years (2002 to 2005) and the last five years (2006 to 2010) of the NTS LD data.

1.3.2 It is noted that the WP1 work has delivered new base matrices defined in PA format. However, it was not possible to supply PA LOS from these PA base matrices within the timescales available for the current work because generating PA LOS requires significant reprogramming of the PFM model. To work with tours in model estimation, the trip-based LOS available from PFM v3.81 was used. For the Non Car Available segment, the LOS was used without adjustment for the outward tour leg and transposed for the return tour leg. For the Car Available segment 'car available from' LOS was used for the outward tour leg from the home to the primary destination and 'car available to' LOS was used for the return tour leg from the primary destination back to the home again.

1.3.3 It is possible that the demand model parameters will be re-estimated once the PA format LOS is available. The main benefit of the move to PA-based LOS is that for the Car Available segment, moving to PA removes the need for separate 'car available from' and 'car available to' segments because with PA-based LOS car availability is specified at the home (production) end. This reduces the number of model segments and therefore the run times for model applications.

1.3.4 For rail, logsum composite generalised journey time (GJTC) measures were supplied by MVA from the station choice model (the SCM, which predicts access mode and station choice), defined at the 235 PFM zone level. In PFM v3.0, crowding was not included in these composite GJTC measures, and so separate crowding matrices were supplied for inclusion in model estimation. In PFM v3.8.1, crowding was included in the SCM and so forms part of the composite GJTC measure from the SCM. Fares are not included in the SCM, and so separate fare matrices at the PFM zone level have been supplied for use in model estimation. The other LOS components included in the composite GJTC are rail in-vehicle time, access and egress time, walk time, wait time and boardings. By using the composite GJTC directly in the estimation of the demand models, consistency in the relative weightings of the rail GJTC components is ensured between the SCM and demand models.

1.3.5 An important feature of the application of the SCM is that when the outputs are aggregated from the 3692 station zone level to the 235 PFM zone level, demand weighted average components are calculated and non-zero values are only output if there is non-zero demand in the rail PFM zone level base matrices. This means that rail LOS is only available for those movements where trips are observed in the PFM base matrices, and therefore for movements where no trips are observed in the base matrices the rail mode is unavailable in the model estimations.

1.3.6 For car, distance and time skims have been supplied separately for commute, business and other purposes. No information on tolls, e.g. for travel on the M6 Toll or one of the Dartford crossings, is available from the skims.

1.3.7 For air, in-vehicle time, frequency, wait time, access and egress time and fare skims have been supplied separately for business and other purposes. Air is not modelled for commute travel. All air trips are assumed to be in the car available segment.

1.3.8 The LOS supplied from PFM is defined in the 235 zone system. The LD choice data available from the NTS uses a 406 district level zone system at the home end, and a 146 Unitary Authority (UA) and County zone system at the non-home end.

1.3.9 The 406 districts can be aggregated up to form the 235 PFM zones, and therefore each home zone can be allocated a unique PFM zone, and it was straightforward to determine the relevant LOS information to use.

1.3.10 At the non-home end, a process was required to convert from the 235 PFM zone system to the more aggregate 146 UA-County zone system. The correspondence between the PFM and UA-County zoning is less straightforward. Three of the UA-County zones are external to the area modelled in PFM (specifically the Orkney, Shetland and Western Isles). The correspondence between the 235 PFM zones and the remaining 143 UA-County zones is defined as follows:

- For 79 PFM zones, there is a one-to-one mapping between the PFM and UA-County zoning, and therefore the PFM LOS can be used directly.
- For 16 PFM zones, there is a one-to-many mapping to 30 different UA-County zones, with up to five UA-County zones mapping to a single PFM zone. For these cases, the LOS for the more aggregate PFM zone in which each UA-County zone lies was used directly.
- For 140 PFM zones, there is a many-to-one mapping to 34 UA-County zones, with up to nine PFM zones mapping to a single UA-County zone. For these zones, LOS to the UA-County zone was calculated as a weighted average of the LOS to each PLD zone that lies within the UA-County zone. The LOS averaging used total employment for commute and business and total population for the other travel purpose.

1.3.11 2010 employment and population information for the LOS averaging was extracted from TEMPRO version 6.2, and aggregated from the detailed TEMPRO zones to the PFM zone level. Note that this LOS averaging step is not needed for model application because all calculations are undertaken at the PFM zone level.

1.4 Cost information

1.4.1 Car costs were calculated using the procedure set out in WebTAG Unit 3.5.6, Values of Time and Vehicle Operating Costs (October 2012). This unit provides formulae that allow total car costs (both fuel and non-fuel costs) to be calculated as a function of OD average speed in 2010 values and prices[3] . In model estimation, car costs have been calculated separately for each PA pair, using the distance and time skims from the highway assignment to determine the speed. Using the procedures set out in Unit 3.5.6, adjustments have been made to the 2010 car cost parameters to allow car costs to be calculated for each year in the 2002-2009 period. However, it is noted that the cost calculations do not take account of changes in speeds due to congestion over time.

1.4.2 Rail and air fares are defined in 2010/11 UK financial year values in 2002 prices. For model estimation the fares have been inflated to 2010/11 prices using the annual RPI CHAW index[4] , and adjusted in real terms to match the year of the NTS observation.

1.4.3 To calculate real changes in rail fares over time, data on average long-distance rail fares was assembled from the Office of Rail Regulation website. This is shown in Table 3 below.

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[3] Strictly the car cost formulae given in Unit 3.5.6 are intended to be applied on a link rather than OD basis. However, many studies actually implement these formulae on an area-wide basis and so the OD implementation used in this study is relatively detailed.

[4] http://www.ons.gov.uk/ons/rel/cpi/consumer-price-indices/september-2012/index.html, accessed 22 October 2012.

Table 3. Real Terms Changes in Rail Fares 2004-2010

YEAR	LONG DISTANCE FLOWS, ALL-TICKET INDEX	RPI INDEX (CHAW)	REAL CHANGE FACTOR RELATIVE TO 2010
2004	100.0	186.7	0.851
2005	104.7	192.0	0.867
2006	113.2	198.1	0.908
2007	120.7	206.6	0.929
2008	128.6	214.8	0.952
2009	139.4	213.7	1.037
2010	140.7	223.6	1.000

Source: Office of Rail Regulation, National Rail Trends Portal: http://dataportal.orr.gov.uk/displayreport/report/html/7cff3127-a5cc-4173-ac78-016db2339811 Accessed 22 Oct 12.

1.4.4 As the data series assembled from ORR does not go back to before 2004, it is assumed that 2002 and 2003 rail fares are the same in real terms as the 2004 values (i.e. the 0.851 adjustment relative to 2010 from Table E.3 is applied to 2002 and 2003 as well as to 2004).

1.4.5 To take account of real changes in air fares over time, information from the CAA air passenger survey was used. The information extracted from the CAA data, and the calculated real changes in air fares, are summarised in Table 4.

Table 4. Real Terms Changes in Domestic Air Fares 2002-2010

YEAR	NOMINAL AVERAGE ONE-WAY FARE (£)	RPI INDEX (CHAW)	REAL CHANGE FACTOR RELATIVE TO 2010
2002	59.47	176.2	1.317
2003	56.77	181.3	1.222
2004	56.19	186.7	1.174
2005	55.26	192.0	1.123
2006	59.51	198.1	1.172
2007	59.90	206.6	1.131
2008	60.49	214.8	1.099
2009	57.53	213.7	1.050
2010	57.32	223.6	1.000

Source: analysis undertaken by Olivia Christophersen of DfT using CAA air passenger survey.

1.4.6 Note that in contrast to rail fares, air fares have declined in real terms over the 2002-2010 period. Growth in low-cost airlines will explain part of these changes.

1.4.7 The values of time (VOTs) used in the estimations to convert monetary costs into generalised time units have also been specified in 2010/11 prices, and adjusted in real terms to match the year of the NTS observation.

Appendix F SCM Day Trip Parameter Results

1.1 Introduction

1.1.1 Appendix F provides results from a stand-alone SCM model run with and without the day trip parameter to understand what impact the day trip parameter has on the distribution of PLD to PLD demand to station to station demand.

1.1.2 The analysis in Appendix F is based on PFM v4.1, including the day trip parameter and a stand-alone SCM model run removing the day trip parameter. Results are provided for a set of pre-defined 26 PLD zones.

1.2 Day Trip Parameter

1.2.1 The day trip factor takes the form of additional GJTC minutes added to the GJTC from origin MZone to destination MZone when it is not possible to make a return journey within a day. It is expected that with the day trip more passengers would be attracted to HS2 services.

1.2.2 The day trip factor applies to business and leisure and does not affect commuting. The day trip factor for business starts at 2.5 hours for a single trip whilst the leisure is only 2 hours. Both ramp up over an hour period to approximately a max of 37 minutes. The 'journey time' used to determine whether day trip factor is applied is:

access GJT + long distance IVT + long distance wait time + egress GJT

1.3 Results of the Model Runs

1.3.1 The proportion of passengers going to each origin station and destination station was compared. This comparison was undertaken for all of the possible combinations of station combinations and also in terms of the passengers going to the origin station and going to the destination station.

1.3.2 The results which are provided in the tables below generally show that where there is the possibility of a HS2 station, the majority of passengers will choose it. When the day trip factor is included in the GJTC the proportion of passengers going to the station rises only by a small proportion. For the PLD pairs the maximum change is approximately 4%.

1.3.3 Two example PLD zone pairs are presented in Table F1 and F2 followed by the full table of results.

Central London to Coventry

1.3.4 There is a PLD to PLD in-vehicle time of 51.4 minutes between the PLD zones. The origin stations are the six north facing London stations. With the day trip Euston attracts 1% more from St Pancras.

1.3.5 There is more movement at the destination station. With the day trip HS Birmingham Interchange attracts 2% more passengers for business and leisure. Fewer passengers are going to Coventry. Coventry attracts 72% of leisure demand and 55% of business demand, with the majority of the remainder going to Birmingham Interchange.

1.3.6 This analysis shows that, as expected, the HS2 station is attracting a higher share of passengers with the day trip. This is shown in Table 1 below..

Table 1. Change in Station Shares with Day Trip Factor Removed: Central London to Coventry PLD Zone Pair

Origin Station	Demand Share with Day Trip			Change in Demand Share with Day Trip Removed			Destination Station	Demand Share with Day Trip			Change in Demand Share with Day Trip Removed		
	Business	Commute	Leisure	Business	Commute	Leisure		Business	Commute	Leisure	Business	Commute	Leisure
London Paddington	8%	9%	7%	0%	0%	0%	Birmingham International	0%	1%	0%	0%	0%	0%
London St Pancras International	2%	4%	3%	0%	0%	1%	HS Birmingham Interchange	40%	32%	24%	-2%	0%	-2%
HS Old Oak Common	7%	6%	5%	0%	0%	0%	Coventry	55%	63%	72%	2%	0%	3%
London Euston	80%	78%	82%	0%	0%	-1%	Nuneaton	1%	1%	1%	0%	0%	0%
London Kings Cross	1%	2%	2%	0%	0%	0%	Rugby	3%	3%	2%	0%	0%	0%
London Marylebone	1%	2%	1%	0%	0%	0%							

Leicester to Liverpool

1.3.7 The second example is Leicester to Liverpool for which there is a long distance in-vehicle time of 141.9 minutes between the PLD zones. This is shown in Table 2 below.

Table 2. Change in Station Shares with Day Trip Removed: Leicester to Liverpool PLD Zone Pair

Origin Station	Demand Share with Day Trip			Change in Demand Share with Day Trip Removed			Destination Station	Demand Share with Day Trip			Change in Demand Share with Day Trip Removed		
	Business	Commute	Leisure	Business	Commute	Leisure		Business	Commute	Leisure	Business	Commute	Leisure
Leicester	68%	86%	79%	0%	0%	0%	Liverpool Lime Street	74%	83%	80%	4%	0%	4%
HS Toton (East Midlands)	24%	7%	16%	0%	0%	0%	Runcorn	16%	10%	12%	-2%	0%	-2%
Rugby	8%	7%	5%	0%	0%	0%	St Helens Junction	1%	0%	1%	0%	0%	0%
							Wigan North Western	2%	1%	2%	0%	0%	0%
							Widnes	5%	4%	4%	-1%	0%	-1%
							Chester	2%	1%	1%	0%	0%	0%

1.3.8 As expected the origin MZone is Leicester and there is no movement with the day-trip factor included.

1.3.9 For the destination zones introducing the day trip factor takes 4% of trips away from Liverpool station and passengers choose Runcorn or Widnes instead. Both Runcorn and Widnes are on the HS2 service pattern to Liverpool, but have shorter in-vehicle times.

1.3.10 This change in alighting station was investigated further by examining the cost data. The journey time between Runcorn and Liverpool are between the start of the day-trip being added to journey time and the end of day trip being added to journey time. Therefore the day trip accentuates the difference in long distance IVT making Runcorn more attractive than Liverpool depending on the relative access costs between the two stations.

1.3.11 This is the equivalent of somebody driving to Runcorn in early morning to return late evening whilst people are choosing to go to Liverpool, may be by local trains later on in the day, returning the next day.

1.3.12 There are very few places where such an issue is likely to occur as there needs to be two close PLD stations. We investigated Birmingham Interchange and Birmingham Central and found that the day trip had not made any significant change in the shares of the two stations.

1.3.13 Table 3 below presents a summary of the results for the two stations investigated.

Table 3. Generalised Journey Time Differences to Liverpool and Runcorn with and without Day Trip Factor

DESTINATION STATION	IVT	WAIT TIME	DAY TRIP	IVT + WAIT TIME	IVT + WAIT TIME + DAY TRIP
Liverpool	163	17	37	180	217
Runcorn	123	21	14	144	156

Appendix G Day Trip Parameter Coding SCM

1.1 Introduction

1.1.1 As part of the demand model estimation, the day trip parameter was coded into the Station Choice Model. Appendix G describes the changes to the SCM, undertaken in PFM v4.1, in order to incorporate the day trip parameter. Note that in PFM 4.3, the day trip functionality is not used.

1.2 Coding of the Day Trip Parameter within the Station Choice Model

1.2.1 The inclusion of the day trip adjustment is a function of the total journey time. Journey time is represented as long distance rail in-vehicle-time + long distance rail wait time + access/egress generalised time. In effect the day trip adjustment is an add-on to the total GJT calculation in the SCM.

1.2.2 Four new input parameters were introduced into the input parameters file. The values come from the 'Analysis of LDM SP Data' note.

beta_daytrip_bus = -0.21575

beta_daytrip_lei = -0.16935

beta_railIVT_bus = -0.005787

beta_railIVT_lei = -0.004459

1.2.3 Two constants were created which define the costs points beyond which the day trip factors are applied:

Bus_Daytrip_mins=150

lei_daytrip_mins = 120

1.2.4 The methodology is that the day trip factor is a disbenefit added to longer trips, and is applied to all trips except commuting trips. The introduction of HS2 may reduce GJT such that the trip GJT reduces below the parameter and trips become more likely.

1.2.5 This is a code change to the GJT function in the SCM. The following section applies to business passengers:

```
if a = 1, 4 or 7

  then if ((gjt_ivt[i][j]+gjt_ivt[j][i] + gjt_wait[i][j] + gjt_wait[j][i])/2 + access_gt[i][p] + egress_gt[j][q]) > bus_daytrip_mins

      then dayTripIVT = ((((gjt_ivt[i][j]+gjt_ivt[j][i] + gjt_wait[i][j] + gjt_wait[j][i])/2 + access_gt[i][p] + egress_gt[j][q])-bus_daytrip_mins)/60

        if dayTripIVT<=1

          then dayTripIVT = dayTripIVT*beta_daytrip_bus/beta_railIVT_bus

          else dayTripIVT =1*beta_daytrip_bus/beta_railIVT_bus

        end if
```

```
Stn_GJT[i][j] = Stn_GJT[i][j]+dayTripIVT

        end if

    end if
```

1.2.6 The following text applies to leisure passnegers

```
if a = 2, 5 or 8

    then if (gjt_ivt[i][j]+gjt_ivt[j][i] + gjt_wait[i][j] + gjt_wait[j][i])/2 + access_gt[i][p] + egress_gt[j][q])> lei_daytrip_mins

        then dayTripIVT = (gjt_ivt[i][j]+gjt_ivt[j][i] + gjt_wait[i][j] + gjt_wait[j][i])/2 + access_gt[i][p] + egress_gt[j][q] - lei_daytrip_mins)/60

            if dayTripIVT<=1

                then dayTripIVT =dayTripIVT*beta_daytrip_lei/beta_railIVT_lei

                else dayTripIVT = 1*beta_daytrip_lei/beta_railIVT_lei

            end if

            Stn_GJT[i][j] = Stn_GJT[i][j]+dayTripIVT

        end if

    end if
```

where a trip is travelling from station i in MZone p to station j in MZone q

1.2.7 The value of access_gt and egress_gt changes for each of the different business and leisure purposes. It also changes where the journey begins or ends in London:

- Business/leisure car available from is calculated twice - where access_gt represents highway access (with the exception of trips starting in London) and separately where access_gt represents pt access. In both cases egress_gt is pt egress;
- Business/leisure car available to is calculated twice - where egress_gt represents highway egress (with the exception of trips ending in London) and separately where egress_gt represents pt access. In both cases access_gt is pt access; and
- Business/leisure non car available is calculated once – both access_gt and egress_gt are pt trips.

1.2.8 The daytrip factor ends up as part of the access/egress component of GJT, but otherwise the skims produced will not change.

Appendix H Revised Demand Model Macro Changes

1.1 Introduction

1.1.1 A summary of the macro changes required to implement the re-estimated demand model is contained in Table 1.

Table 1. Macro Changes to Incorporate the Revised Demand Model

MODEL ELEMENT	DESCRIPTION	FILES UPDATED	IMPLEMENTATION
Rebase model to 2010/2011	Remove rail fare deflator to 2002 prices	Setup.mac	01PLD\Macros\Assign
Rebase model to 2010/2011	Calculate vehicle operating costs in 2010/2011 prices Revise calculation of vehicle operating costs	Voc.mac	01PLD\Macros\Assign
Rebase model to 2010/2011	Remove value of time deflator to 2002 prices	Modesplit1.mac	01PLD\Macros\Modesplit
Re-estimated demand model	Introduction of re-estimated demand model parameters	Modepslit1.mac	01PLD\Macros\Modesplit
Calculation of	Calculation of distance based value of time by purpose	Modeplit1.mac	01PLD\Macros\Modesplit
Re-estimated demand model	Update to generalised cost calculations	Modeplit2.mac / modesplit5.mac	01PLD\Macros\Modesplit
	Inclusion of business NCA demand segment	Modesplit2.mac/ modepsolti5.amc / hslmarker.mac	01PLD\Macros\Modesplit
Rail composite costs passed from	Copy do minimum composite costs to do something directory	Modesplit0.mac	01PLD\Macros\Modesplit
	Batches in composite costs from SCM into EMME databanks	04import_pld.mac	01PLD\Macros
	Modify demand model cost averaging process so that uses composite costs.	msa01.mac / msa02.mac	01PLD\Macros\MSA

Appendix I Values of Time used in Demand Models

1. INTRODUCTION

1.1.1 Appendix I documents the Values of Time (VoTs) used for the estimation and application of the demand models. Separate sections are presented for commute and other travel, and for business, as different sources were used for the VoTs for these two sets of purposes.

1.2 Commute and other travel

1.2.1 For commute and other travel, VoTs from Section 11.4 of WebTAG Unit 3.12.2 (February 2007, Consultation Status) were used. WebTAG 3.12.2 gives a function that allows VoTs to be calculated as a function of distance and the household income of the traveller. As the final demand models do not include income segmentation, average incomes (in 2010/11 financial year prices) have been calculated from the samples of individuals observed to make long-distance tours in the 2002-10 National Travel Survey (NTS) data used for the estimation of the frequency and mode choice models.

1.2.2 The VoT relationship used for the estimations is as follows:

$$VoT = G^{0.8} K \left[\frac{\beta_t}{\beta_c} \right] \left(\frac{Inc}{Inc_0} \right)^{\eta_{inc}} \left(\frac{D}{D_0} \right)^{\eta_c}$$

where: *G* is the real growth in GDP/capita relative to 1994
0.8 is the elasticity of VOT to GDP/capita for non-work travel
K is an inflation correction between 1994 and the modelled year
Inc is the household income in thousands of pounds
the remaining parameters are defined in Table 1 below

Table 1. Commute and Other Travel Value of Time Function Parameters

PARAMETER	COMMUTE	OTHER TRAVEL
β_t (time parameter)	-0.10098	-0.082918
β_c (cost(distance) parameter)	-0.024729	-0.022275
Inc_0	35 x K	35 x K
D_0	7.58	7.58
η_{inc} (income elasticity)	0.358773	0.156806
η_c (cost (distance) elasticity	0.421305	0.314727

Source: Table A6, WebTAG Unit 3.12.2 (February 2007, consultation status)

1.2.3 Distances are expressed in miles, incomes in thousands of pounds and the VoTs given by the formula are in pence per minute.

1.2.4 It should be noted that the $G^{0.8}$ term in the equation above is not present in the formula given in WebTAG Unit 3.12.2. When the VoT formula given in WebTAG 3.12.2 was calibrated, it was assumed that apart from corrections for the price level in which income is measured (the *K* terms), the VoT relationships could be taken as temporally stable, so that they could be applied to data for years other than the one in which the underlying data was collected (end-1994). However, for the work in this project John Bates advised that as time has passed, subsequent analysis of more recent NTS data revealed the assumption of temporal stability to be invalid, and therefore the VOT formula was adjusted to account for real growth in GDP/capita relative to 1994. The $G^{0.8}$ term implements this real growth adjustment.

1.2.5 To implement the *G* terms, ideally information on growth in GDP/capita from Table 3a of WebTAG 3.5.6 (October 2012) would have been used. However, that table only provides GDP/capita growth from 2002 onwards, and a GDP/capita series was required that goes back to the 1994 base year for the VoT formula. WebTAG 3.5.6 references data produced by ONS as the source of their GDP/capita growth series, and therefore this series was sourced to calculate the *G* terms in the modified formulation. Table 2 summarises the GDP/capita figures assembled and the *G* terms calculated to define the real terms growth in GDP relative to 1994.

Table 2. GDP/capita Growth Series

YEAR	RPI (CHAW INDEX)	K
1994	16,835	1.000
2002	21,287	1.264
2003	22,012	1.308
2004	22,543	1.339
2005	23,017	1.367
2006	23,479	1.395
2007	24,172	1.436
2008	23,777	1.412
2009	22,687	1.348
2010	22,921	1.362

Source: Table IHXW, United Kingdom National Accounts, The Blue Book, 2012 Edition. Office for National Statistics.

1.2.6 It is noted that for GDP/capita growth over the 2003-2010 period, the annual growth in GDP/capita implied by these figures does not exactly match the GDP/capita growth figures given in Table 3a of WebTAG Unit 3.5.6. Although WebTAG Unit 3.5.6 cites Table IHXW as the source of their real growth in GDP/capita figures, the study team were unable to match their values exactly using the GDP/capita figures given in Table IHXW.

1.2.7 The inflation factors used to implement the VoT formula are given in Table 3. It is noted that the estimations worked with car costs and PT fares defined in 2010/11 prices for all years of the 2002-2010 NTS data.

Table 3. Inflation Factors K

YEAR	RPI (CHAW INDEX)	K
1994	144.1	1.000
2010/11	226.5	1.572

Source: *Table IHXW, United Kingdom National Accounts, The Blue Book, 2012 Edition. Office for National Statistics.*

1.2.8 The average incomes in 2010/11 prices used to calculate VoTs for estimation were £60,091 for commute and £45,583 for other travel. These average incomes were calculated from the samples of individuals observed to make long-distance commute and other travel tours in the 2002-2010 NTS data used to estimate the frequency and mode choice models.

1.2.9 VoTs were supplied at average tour distances from the mode choice estimations for use in the Station Choice Model estimations. These VoTs are summarised in Table 4.

Table 4. Station Choice Model VoTs (2005 values in 2010 prices)

	COMMUTE	OTHER TRAVEL
Mean tour distance (miles)	104.1	150.8
VoT (p/min)	25.1	18.4

1.2.10 To calculate VoTs in implementation, the $G^{0.8}$ term to convert from 1994 and 2010 values was pre-calculated as $1.362^{0.8} = 1.280$, and from Table 3 the *K* term to convert from 1994 to 2010/11 prices is 1.572. The implementation formula is then:

$$VoT = 2.012 * G^{0.8}\left[\frac{\beta_t}{\beta_c}\right]\left(\frac{Inc}{Inc_0}\right)^{\eta_{inc}}\left(\frac{D}{D_0}\right)^{\eta_c}$$

where: VoTs are given in 2010/11 prices

G is the real growth in GDP/capita relative to 2010

all other terms are defined in Table 1 above

1.3 Business

1.3.1 It is noted that WebTAG 3.12.2, the source of distance damped VoTs for commute and other travel, does not provide a VoT relationship for business travel.

1.3.2 Frequency and mode choice models were developed using two different business VoT relationships, the first used WebTAG VoTs modified with a distance elasticity of 0.184, the second used a distance-damped relationship calibrated to the long distance model (LDM) stated preference (SP) data with a distance elasticity of 0.36. The final models used the LDM SP VoTs.

WebTAG VoTs

1.3.3 The all-modes VOT from WebTAG 3.5.6 of 28.56 £/hr in 2010 prices and values was used as the starting point. There is no information on the variation in business VOT with distance available from WebTAG, and therefore an elasticity of business VoT to distance was imported from PDFH Section B4.8, which gives an elasticity of 0.184 (as referenced in note IN5, Consistency of Model Parameters). This elasticity was used making the assumption that the elasticity of an all-mode business VoT to distance is equal to the elasticity of rail VoT to distance. The VOT for a given distance in 2010 prices and values was then calculated from the following relationship:

$$VoT = VoT_0\left[\frac{D}{D_0}\right]^{0.184}$$

where: VoT_0 is the mean all-modes VoT of 28.56 £/hr

D is the trip distance in miles

D_0 is the average distance for business trips of all distances of 20.2 miles (from 2002-2010 NTS data)

1.3.4 VoTs were calculated from this relationship for use in the Station Choice Model estimations. At the mean tour distance of 154.9 miles the business VoT in 2005 values and 2010 prices was 70.1 p/min.

LDM SP VoTs

1.3.5 Later in the model development work it was decided to move to using LDM SP VoTs. The LDM SP data allows VoTs to be calculated from behavioural data that is specific to long-distance travel. At the same time, it was decided to move to a higher distance elasticity of 0.36 (consistent with the commute value given in Table 1) in preference to the rail-specific value of 0.184.

1.3.6 The higher 0.36 distance elasticity is highly consistent with analysis of the valuation of travel time savings for business travellers that was subsequently published by ITS Leeds[1]. ITS regressed 171 business valuations to distance, a time trend and other important dummy variables. These regressions yielded a distance elasticity of 0.35.

1.3.7 The SP models for business have been estimated using the following functional form for the contribution of cost to utility:

$$\beta_{cost} c_m D^{\alpha}$$

where: β_{cost} is the cost parameter

c_m is the cost for mode m

D is the one-way distance in miles

α is the distance elasticity of -0.36

[1] Wardman, M., R. Batley., J. Laird, P. Mackie, T. Fowkes, G. Lyons, J. Bates and J. Eliasson (2013) Valuation of Travel Time Savings for Business Travellers, prepared for the Department of Transport by the Institute for Transport Studies, University of Leeds.

1.3.8 As time enters utility in a linear form the implied VoTs can then be calculated as:

$$VoT = \frac{\beta_{IVT}}{\beta_{cost} D^{\alpha}}$$

where: β_{IVT} is the in-vehicle time parameter estimated from the SP data (across rail, car and air modes)

1.3.9 The cost and time parameters estimated from the LDM business SP data are summarised in Table 5.

Table 5. Station Choice Model VoTs (2005 values in 2010 prices)

PARAMETER	VALUE
β_{IVT}	-0.00638
β_{cost}	-0.00073

1.3.10 The prices in the LDM SP data and were expressed in 2008 values. Therefore RPI adjustments were applied to convert to 2010/11 UK financial year prices. Adjustments were also applied to take account of real terms growth in VOT between the different years of NTS data included in the model estimations (2002 to 2010).

1.3.11 The implied VOTs for application in the RP models can be calculated as:

$$VOT = 1.054 * G \frac{\beta_{IVT}}{\beta_{cost} D^{\alpha}}$$

where: G is the real growth in GDP/capita relative to 2010

1.054 is a factor to convert the SP VoTs into 2010/11 prices

Appendix J – Costs for Other Parts of the Model Generated by the SCM

The SCM creates GJT which is passed to the Demand model. Other parts of the model e.g. the Heathrow model still need PLD to PLD costs by component which are calculated by the SCM as demand weighted averages. As part of PfMv4.3 these equations have been changed to be the average of the two directions.

An example of this is IVT from Origin PLD zone I to destination PLD zone J, which is calculated as:

$$PLD\_to\_PLD\_IVT_{IJ} = \frac{\sum_{mn}(demand\_SC\_PLD_{IJmn} \times \left(stn_{to_{stn_{IVT}}}{}_{mn} + stn_{to_{stn_{IVT}}}{}_{nm}\right)/2)}{\sum_{mn} demand\_SC\_PLD_{IJmn}}$$

where $PLD\_to\_PLD\_IVT_{IJ}$ is the demand-weighted IVT over all origin station/destination station combinations m to n where m is a station within the Origin PLD I and n is the station in the Destination PLD J

$demand\_SC\_PLD_{IJmn}$ is the demand allocated to station m from station n for movements between PLD zone I and PLD zone J

$stn\_to\_stn\_ivt_{mn}$ is the station to station in-vehicle time between station m and station n

The other components of composite cost are calculated in the same way:

- PLD_to_PLD_walk;
- PLD_to_PLD_wait;
- PLD_to_PLD_boards;
- PLD_to_PLD_rail;
- PLD_to_PLD_crowd; and
- PLD_to_PLD_fare.

These average weighted costs are also still available as outputs of the SCM and can be used for analysis alongside some other potentially useful model outputs. These outputs are not used in the calculation of model benefits.

The equation for PLD_to_PLD_accessEgress (demand weighted PLD to PLD average access/egress cost) did not need to be updated as the changes are already included in the components from which it is calculated eg PLD_to_PLD_IVT (demand weighted PLD to PLD average in vehicle time) etc. The difference between trip weighted costs and the PLD to PLD composite cost GJTC (PLD_to_PLD_GJTCAE) is in the calculation of PLD_to_PLD_accessEgress which is calculated as:

$$
\begin{aligned}
PLD\_to\_PLD\_accessEgress_{IJ} \\
&= PLD\_to\_PLD\_GJTCAE_{IJ} - \left(GJTC\_IVT\_wt \times PLD\_to\_PLD\_IVT_{IJ}\right) \\
&- \left(GJTC\_walk\_wt \times PLD\_to\_PLD\_walk_{IJ}\right) \\
&- \left(GJTC\_wait\_wt \times PLD\_to\_PLD\_wait_{IJ}\right) \\
&- \left(GJTC\_boards\_wt \times PLD\_to\_PLD\_boards_{IJ}\right) \\
&- \left(GJTC\_crowd\_wt \times PLD\_to\_PLD\_crowd_{IJ}\right)
\end{aligned}
$$

Where

$PLD\_to\_PLD\_GJTAEC_{IJ}$ is PLD to PLD GJTCAE from origin PLD zone I to destination PLD zone J

$PLD\_to\_PLD\_IVT_{IJ}$ is PLD to PLD in-vehicle-time from origin PLD zone I to destination PLD zone J

$PLD\_to\_PLD\_walk_{IJ}$ is PLD to PLD walk as interchange from origin PLD zone I to destination PLD zone J

$PLD\_to\_PLD\_wait_{IJ}$ is PLD to PLD wait time from origin PLD zone I to destination PLD zone J

$PLD\_to\_PLD\_Boards_{IJ}$ is the number of PLD to PLD boards from origin PLD zone I to destination PLD zone J

$PLD\_to\_PLD\_crowd_{J}$ is PLD to PLD crowded time from origin PLD zone I to destination PLD zone J

GJTC_ivt_wt is the in vehicle time weight applied as part of the modelled GJTC

GJTC_walk_wt is the interchange walk weight applied as part of the modelled GJTC

GJTC_wait_wt is the wait weight applied as part of the modelled GJTC

GJTC_boards_wt is the board time weight applied as part of the modelled GJTC

GJTC_crowd_wt is the crowd time weight applied as part of the modelled GJTC

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