HS2

PFMv9 Demand Forecasting Report

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Department for Transport

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1.1.1 The PLANET Framework Model (PFM) is the primary tool for forecasting HS2 demand and calculating the associated benefits and revenue to support the HS2 Business Case. Since the release of PFMv7.1 the process of model development has continued as modelling assumptions are revised and updated, as well as the release of new economic growth forecasts.

1.1.2 One of the key inputs to the PFM are the future year demand forecasts. These are estimated for the rail mode for all sub-models, as well as the highway and air modes for the PLANET Long Distance (PLD) sub-model. Further information on the structure and modelling approach of the PFM can be found within the Model Description Report.

1.1.3 HS2 Ltd commissioned the preparation of a revised set of future year rail demand forecasts for use within the PFM. This report sets out the revised exogenous demand forecasts that have been included within PFMv9, summarises the adopted forecasting approach, and analyses the change in demand forecasts from the previous model release.

1.2 Note Structure

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2 Rail Demand Forecasting Methodology

2.1 Introduction

2.1.1 Rail demand forecasts are calculated using an established forecasting system which applies the mathematical framework set out in the Passenger Demand Forecasting Handbook (PDFH). This system utilises macro-economic forecasts (such as Gross Domestic Product (GDP), population, and employment) and uses inter-modal competition elements (such as car vehicle costs) to grow base year rail demand for the forecast years.

2.1.2 Using this methodology, the future year rail demand depends upon both the level of base year demand and a series of demand driver generator (DDG) forecasts which are released by the Department for Transport (DfT) using the latest economic outlook and TAG recommendations. More information on the adopted forecasting approach can be found in the latest PFM Model Description Report.

2.1.3 Since the release of PFMv7.1, there have been several significant updates to the demand forecasts which are discussed separately in this chapter:

- Growth in Base Demand: The Office for Rail and Road (ORR) publishes statistics of recorded growth in rail demand which has been used to identify observed growth 2014/15 and 2018/19. These uplifts have been applied to the base matrices for 2014/15 and have been incorporated into the forecasting to better represent the forecast demand;
- Updated Second Forecast Year: In order to maintain the economic appraisal approach, an appraisal window of 20 years from the point of appraisal needs to be maintained. With the point of appraisal now 2019/20, the second forecast year has also moved from 2037/38 to 2039/40;
- PDFHv6: A new release of the PDFH contains new guidance on how to forecast rail demand. This includes new guidance elasticities as well as demand drivers that were not in the previous version of the guidance marking a significant shift in methodology; and,
- Revised Demand Drivers: The June 2019 release of rail demand drivers have been used to develop new demand forecasts. The revised demand drivers include macro-economic drivers (e.g. GDP and employment) as well as inter-modal factors such as vehicle operating costs.

2.1.4 These updates cumulatively have a significant impact on the forecast demand that is input to the PFM and make isolating the impacts of individual updates complex. The following sections provides an overview of each update.

2.2 Recorded Growth in Rail Demand Since 2014/15

2.2.1 As the year of appraisal moves further from the base year for rail demand, latest observed data is used to ensure that the level of demand within the PFM is as up to date as possible. As such, for PFMv7.1 and for PFMv9, the Base demand is uplifted from 2014/15, to 2016/17 and 2018/19 respectively, using observed data published by the Office of Rail and Road (ORR). Table 12.6 on the ORR data portal reports growth by distinct rail markets which have been mapped to PFM sub-models as shown in Table 1.

Table 1: Mapping of PFM sub-models to ORR markets

PFM Sub-Model	ORR Market
PLANET Long Distance	Long Distance
PLANET South*	London and South East
PLANET Midlands	Regional
PLANET North	Regional
*PLANET South also covers the area of the South West, however the growth for London and South East has been applied to all of PLANET South. This should not significantly affect the appraisal of HS2.	

This methodology is applied to the PFMv9 update, with uplift factors calculated or each of the sub-models according to the ORR markets shown in Table 1. The uplifts applied have been calculated using the data included in Table 12.6 on the ORR data portal. These uplifts are shown in Table 2 and compared with similar uplifts used in PFM v7.1. (Note that at the time of PFMv7.1 forecasting, only a high-level growth trend was available and so this was used equally across all sub-models.)

Table 2: Growth in observed rail demand by sub-model from 2014/15

PFM Sub-Model	PFMv7.1 Growth to 2016/17	PFMv9 Growth to 2018/19
PLANET Long Distance	6.0%	9.3%
PLANET South	6.0%	5.4%
PLANET Midlands	6.0%	7.7%
PLANET North	6.0%	7.7%

2.2.2 The new growth factors have been applied in PFMv9 and provide a new platform from which to forecast rail demand.

Accounting for change in car availability between 2014/15 and 2018/19

2.2.3 The rail demand for the PLD, PLANET Midlands (PM) and PLANET North (PN) sub-models are segmented by car availability, and therefore the rail demand for trips which have the use of car as an alternative mode is presented in a separate matrix from trips which do not have car as an available alternative.

2.2.4 Car availability is forecast within TEMPRO, which designates - out of the total number of households across Great Britain – the number of households which have access to a car, or number of cars; as well as those with no access to a car. This forecast over time is used within the PDFH mathematical framework to forecast future year rail demand. Car availability is forecast to increase over time as household income increases and more households have access to a car.

2.2.5 To reflect increased car availability over the period 2014/15 to 2018/19, demand must be redistributed from the non-car available (NCA) matrices to the car available (CA) matrices within each sub-model. This process is used within the forecasting approach to consider the change in car availability from the base year to the future year.

2.2.6 A matrix of factors is produced based on TEMPRO data to redistribute demand from the NCA matrices to the CA matrices. The redistribution factors calculate the proportion of households without access to a car in 2018/19 and compare this with the same proportion in 2014/15 to derive a factor to apply to the NCA demand matrices. This factor is less than one for all segments of the PLD, PM and PN sub-models, and redistributes rail demand in the NCA matrices to the CA matrices using the following formulae:

- For PM and PN, multiply the NCA matrix by the (origin) redistribution factor, and add to the CA matrix the NCA matrix multiplied by 1 minus the (origin) redistribution factor, i.e.
  - New CA matrix = CA matrix + NCA matrix*(1-factor)
  - New NCA matrix = NCA matrix*factor
- For PLD, as "from home" and "to home" demand is separated, the demand matrices need to be multiplied by the average of the origin and destination redistribution factors, i.e.
  - New CA from = CA from + (NCA*(1-(origin factor + destination factor)/2)/2)
  - New CA to = CA to + (NCA*(1-(origin factor + destination factor)/2)/2)
  - New NCA = NCA* (origin factor + destination factor)/2

2.3 Updating the Forecast Years

2.3.1 The first forecast year in PFM v9 has been moved from 2026/27 to 2029/30, to reflect the current delivery-into-service date for the first phase of the scheme.

2.3.2 The economic appraisal of HS2 requires there to be a 20-year forecasting horizon from the point of appraisal over which to measure the benefits of the scheme. This is consistent with the economic appraisal approach for investments in rail infrastructure. The 20-year appraisal horizon begins at the point the economic appraisal is being conducted i.e. the present financial year. In order to maintain the 20-year economic appraisal horizon, the second forecast year for PFMv9 required updating from 2037/38 in PFMv7.1, to 2039/40 in PFMv9.

2.3.3 This involves not only changing the year to which the rail demand forecasts are made, but also making sure that the model contains all the parameters required e.g. vehicle operating costs are year specific in PFM inputs.

2.4 PDFHv6 and WebTAG Guidance Update

2.4.1 Since the release of PFMv7.1, a new release of PDFH (v6) has resulted in changes to the rail demand forecasting guidance recommended by WebTAG and the DfT. The new guidance not only includes revisions to recommended elasticity values, it also recommends some material changes to use of demand drivers that includes use of new drivers. The update to the guidance is a combination of advice from the latest version of PDFH and the Rail Demand Forecasting Estimation (RDFE) study.

2.4.2 The revised guidance affects elasticities applied to demand drivers, in several cases reducing the elasticities which makes rail demand less sensitive to changes.

Elasticities to changes in rail fares have also changed having previously been based upon PDFHv4 (as per previous guidance).

2.4.3 In addition to the changes in elasticities, the revised guidance introduces some new demand drivers such as Employment Index, Participation, and GJT Trend, and revises the significance of other demand drivers for some flows, such as Car Availability.

2.4.4 The cumulative impact of these changes to the demand forecasting methodology and the forecast demand drivers, has a material impact on the volumes and patterns of demand growth relative to previous forecasts. Given the complexity and dynamism within the forecasting, it is not simple to untangle which change has contributed to some significant changes in the demand forecasting.

2.4.5 It is recommended that for further detailed information on the updates to the forecasting guidance, please consult WebTAG and PDFH directly.

2.5 Demand Driver Updates

2.5.1 The DfT's June 2019 DDG set includes the latest forecasts at that time in terms of the economic outlook for the country in the short-term. This is informed by the March 2019 release of the Office for Budget Responsibility (OBR) Economic & Fiscal Outlook, which provides forecasts for GDP and employment.

2.5.2 PFMv7.1 used the December 2016 DDG set to forecast future year rail demand; and since then many of the other demand driver forecasts have also been updated to incorporate the latest assumptions. A comparison between the data used within the two sets of DDGs is presented in Table 3 and Table 4..

Table 3: Changes to Macro-Economic DDGs between December 2016 and June 2019

Demand Driver	December 2016 DDG	June 2019 DDG
GDP	CEBR October 2016 forecasts constrained to: **OBR Economic & Fiscal Outlook November 2016 to 2020/21.** **Beyond 2020/21 short term forecasts are extrapolated.** NOTE: this is input to the forecasting process as GDP Per Capita using the	CEBR March 2019 forecasts constrained to: **OBR Economic & Fiscal Outlook March 2019.** NOTE: this is input to the forecasting process as GDP Per Capita using the Population assumptions below.

Demand Driver	December 2016 DDG	June 2019 DDG
	Population assumptions below.	
Population	NTEMv6.2 constrained to CEBR October 2016, constrained at a national level by: **ONS Principle Population forecast 2014 (Released November 2015) for 2015 – 2020.** **After 2020 short term forecasts are extrapolated.**	NTEMv7.2 constrained to CEBR March 2019, constrained at a national level by: **ONS Population data up to 2017 taken from ONS estimates.** **ONS Principal Population forecast 2016 based (released Nov 2017) from 2018.**
Employment	NTEMv6.2 constrained to CEBR October 2016 forecasts constrained to: **OBR Economic & Fiscal Outlook November 2016 to 2020/21.** **Beyond 2020/21 short term forecasts are extrapolated.**	NTEMv7.2 constrained to CEBR March 2019 forecasts constrained to: **OBR Economic & Fiscal Outlook March 2019.**
Participation	This driver is part of new forecasting guidance from PDFHv6 and so was not included in the previous set of demand drivers.	This driver contains the number of workers and working age population by NTEMv7.2 zone.
Workers	This driver is part of new forecasting guidance from PDFHv6 and so was not included in the previous set of demand drivers.	This contributes to the participation driver. Workers means workplace based employment. Taken from Tempro (NTEMv7.2) and then constrained to CEBR regions (Mar 2019), then constrained to OBR national employment (March 2019).
Working Age Population	This driver is part of new forecasting guidance from PDFHv6 and so was not included in the previous set of demand drivers.	This contributes to the participation driver. Taken from Tempro (NTEMv7.2) and constrained to CEBR (Mar 2019) and then national from ONS population projections (2016).

Demand Driver	December 2016 DDG	June 2019 DDG
PopIndex	This driver is part of new forecasting guidance from PDFHv6 and so was not included in the previous set of demand drivers.	Contains info from pop as above, from workers as above, car ownership as above, Occupation and sector are from CEBR.
EmpIndex	This driver is part of new forecasting guidance from PDFHv6 and so was not included in the previous set of demand drivers.	Contains info from employment as above, from workers as above, car ownership as above, Occupation and sector are from CEBR. Age is from 2016 based population projections.

Table 4: Changes to Modal Competition DDGs between December 2016 and June 2019.

Demand Driver	December 2016 DDG	June 2019 DDG
Car Cost	Data based on unpublished car cost figures	Based on unreleased WebTAG databook.
Bus Fare & Bus Service	DfT Local Forecasts to 2049/50	Data provided by DfT Local Economics.
London Underground Fares	RPI+0% 2014 – 2016, RPI+1% all other years. Nominal freeze applied 2017 – 2020	RPI+0% 2014 – 2016, RPI+1% all other years. Nominal freeze applied 2017 – 2020
Car Availability	NTEMv6.2	NTEMv7.2
National Rail Fares	RPI+0% 2014 – 2020; RPI+1% from 2021 onwards	RPI+0% 2014 – 2020; RPI+1% from 2021 onwards
Car & Bus Journey Times	TAG Databook December 2015	Based on WebTAG databook May 2019.

3 Forecast Rail Demand

3.1 Introduction

3.1.1 The June 2019 DDG set has been used within EDGE to forecast future year rail demand for 2029/30 and 2039/40 from 2018/19 and applied to the base year matrices grown by observed rail demand growth since 2014/15.

3.1.2 This chapter presents the impacts to the future year rail demand for each of the sub-models contained within the PFM, by comparing the resulting future year demand forecasts with the forecasts from the demand matrices produced from the December 2016 DDGs which were included in PFMv7.1. The comparisons within this chapter compare the demand forecast for PFMv9 directly against the demand forecast for PFMv7.1 as output from the EDGE process.

3.1.3 The changes to demand drivers outlined in the previous chapter show that there are some significant changes to individual drivers which are expected to influence the matrices put into the model.

3.1.4 In general, one would expect an increase in demand between the PfMv7.1 2026/27 matrix and PfMv9 2029/30 matrix based on annual background growth, not just the change in demand drivers.

3.2 Impacts to the PLANET Long Distance (PLD) Rail Demand

Impacts on the PLD Future Year Matrix Totals

3.2.1 Table 5 presents the changes to the PLD future year Do Minimum rail demand matrix totals as a result of using the June 2019 DDG data set to forecast rail demand from the Base to 2029/30 for PfMv9. Overall there is a net 5% change in PLD future year rail demand at an aggregate level. This may primarily be attributed to the fact that he first forecast year is 3 years later in PfMv9 than in PfMv7.1. All journey purposes experience an increase in demand, although the increase in Commute demand is slightly lower than for other journey purposes.

Table 5: Change in the future year total Do Minimum PLD rail demand for the first forecast year

	PFMv7.1 (2026/27)	PFMv9 (2029/30)	Difference	% Difference
Commuting Non-Car Available	12,818	14,096	1,278	10%
Commuting Car Available from Home	50,916	54,400	3,484	7%
Commuting Car Available to Home	50,670	54,190	3,520	7%
Business Non-Car Available *	-	-	-	-
Business Car Available from Home	86,199	91,753	5,554	6%
Business Car Available to Home	66,865	71,055	4,190	6%
Leisure Non-Car Available	45,389	49,558	4,169	9%
Leisure Car Available from Home	108,650	114,799	6,149	6%
Leisure Car Available to Home	81,128	85,490	4,362	5%
Sub-Totals				
Commute	114,404	122,686	8,282	7%
Business	153,064	162,808	9,744	6%
Leisure	235,167	249,846	14,679	6%
Total	502,635	535,341	32,706	7%
* The Business Non-Car Available trip purpose has zero demand; but the matrix total reporting is retained for completeness.				

3.2.2 Table 6 presents the changes to the PLD future year Do Minimum rail demand matrix totals as a result of using the June 2019 DDG data set to forecast rail demand from the Base to the second forecast year. Overall there is forecast to be a 2% decrease in rail demand in the second forecast year which is notable given that in PFMv9 the second forecast year is later than in PFMv7.1 which would ordinarily imply more growth. This is the result of the changes in the forecasting methodology introduced by PDFHv6, as well as revisions to the demand drivers.

Table 6: Change in the future year total Do Minimum PLD rail demand for the second forecast year

	PFMv7.1 (2037/38)	PFMv9 (2039/40)	Difference	% Difference
Commuting Non-Car Available	13,515	14,448	933	7%
Commuting Car Available from Home	59,099	58,853	-246	0%
Commuting Car Available to Home	58,870	58,659	-211	0%
Business Non-Car Available *	-	-	-	-
Business Car Available from Home	109,372	105,181	-4,191	-4%
Business Car Available to Home	85,201	81,344	-3,857	-5%
Leisure Non-Car Available	52,060	54,508	2,448	5%
Leisure Car Available from Home	136,089	132,703	-3,386	-2%
Leisure Car Available to Home	102,287	99,046	-3,241	-3%
Sub-Totals				
Commute	131,484	131,959	475	0%
Business	194,573	186,525	-8,048	-4%
Leisure	290,435	286,257	-4,178	-1%
Total	616,493	604,741	-11,752	-2%
* The Business Non-Car Available trip purpose has zero demand; but the matrix total reporting is retained for completeness.				

Impacts on Key Rail Movements

3.2.3 The impact of the reforecasting for key movements is presented in Table 7 for the first forecast year. Table 7 shows total daily trips in both directions from the EDGE demand forecasts.

Table 7: Change in demand for key rail movements in PLD for 2026/27 (PfMv7.1) & 2029/30 (PfMv9)

	PFMv7.1 (2026/27)	PFMv9 (2029/30)	Difference	% Difference
Central London - Birmingham	11,744	12,275	531	5%
Central London - Manchester	10,396	10,998	602	6%
Central London - Leeds	6,257	6,547	290	5%
Central London - Glasgow	1,887	1,963	76	4%
Central London - Liverpool	4,115	4,272	157	4%
Central London - Newcastle	3,482	3,703	221	6%
Central London - Edinburgh	3,552	3,796	244	7%
Birmingham - Manchester	1,455	1,524	69	5%
Birmingham - Glasgow	196	202	6	3%
Birmingham - Leeds	481	494	13	3%
Birmingham - Newcastle	221	234	13	6%
Birmingham - Edinburgh	206	211	5	2%
Manchester - Glasgow	522	543	21	4%
Leeds - Newcastle	893	939	46	5%

3.2.4 Table 8 shows the impact of the new EDGE demand forecasts on key zone to zone movements for HS2 for the second forecast year. The levels of growth observed on these flows in the second forecast year is notably lower than in the PFMv7.1.

Table 8: Change in demand for key rail movements in PLD for 2037/38 (PfMv7.1) & 2039/40 (PfMv9)

	PFMv7.1 (2037/38)	PFMv9 (2039/40)	Difference	% Difference
Central London - Birmingham	15,492	13,868	-1,624	-10%
Central London - Manchester	13,506	12,452	-1,054	-8%
Central London - Leeds	8,139	7,362	-777	-10%
Central London - Glasgow	2,483	2,205	-278	-11%
Central London - Liverpool	5,344	4,782	-562	-11%
Central London - Newcastle	4,443	4,180	-263	-6%
Central London - Edinburgh	4,556	4,286	-270	-6%
Birmingham - Manchester	1,782	1,769	-13	-1%
Birmingham - Glasgow	243	235	-8	-3%
Birmingham - Leeds	596	576	-20	-3%
Birmingham - Newcastle	271	275	4	2%
Birmingham - Edinburgh	255	245	-10	-4%
Manchester - Glasgow	642	634	-8	-1%
Leeds - Newcastle	1,075	1089	14	1%

3.3 Impacts on PLANET South (PS) Forecast

3.3.1 Table 9 presents the changes to the PS future year matrix totals as a result of using the June 2019 DDG data set to forecast rail demand from the base of 2018/19 to 2029/30. Overall there is a 6% change in the PS future year rail demand.

Table 9: Change in future year PS rail demand for 2026/27 (PfMv7.1) & 2029/30 (PfMv9)

	PFMv7.1 (2026/27)	PFMv9 (2029/30)	Difference	% Difference
Business PA	1,720,903	1,859,392	138,489	8%
Business AP	36,990	40,631	3,641	10%
Leisure PA	187,234	183,188	(4,046)	-2%
Leisure AP	11,734	12,395	661	6%
Commute PA	191,778	189,111	(2,667)	-1%
Commute AP	22,350	24,346	1,996	9%
Sub-Totals				
Business	1,757,892	1,900,024	142,132	8%
Leisure	198,968	195,583	(3,385)	-2%
Commute	214,128	213,457	(671)	0%
Total	2,170,988	2,309,063	138,075	6%
PA = Production Attraction AP = Attraction to Production				

3.3.2 Table 10 presents the resulting changes to the PS future year matrix totals for the second forecast year. Overall there is a 9% increase in total PS rail demand. PLANET South demand growth will be strongly influenced by different demand drivers due to spatial extent and elasticities to the long-distance matrices in PLD and hence we see different patterns in change.

Table 10: Change in future year PS rail demand for 2037/38 (PfMv7.1) & 2039/40 (PfMv9)

	PFMv7.1 (2039/40)	PFMv9 (2039/40)	Difference	% Difference
Business PA	1,844,291	2,110,378	266,087	14%
Business AP	40,049	46,018	5,969	15%
Leisure PA	244,816	216,277	(28,539)	-12%
Leisure AP	14,974	14,637	(337)	-2%
Commute PA	242,099	220,504	(21,595)	-9%
Commute AP	27,553	28,543	990	4%
Sub-Totals				
Business	1,884,341	2,156,396	272,055	14%
Leisure	259,789	230,915	(28,874)	-11%
Commute	269,652	249,048	(20,604)	-8%
Total	2,413,783	2,636,358	222,575	9%
PA = Production Attraction AP = Attraction to Production				

3.4 Impacts on PLANET Midland (PM) Forecasts

3.4.1 Table 11 presents the changes to the PM future year matrix totals as a result of using the June 2019 DDG data set to forecast rail demand from the base year of 2018/19 to 2029/30. Overall there is a 5% increase in PM future year rail demand, which is reflected across all journey purposes. This is associated more with the increase in forecast year rather than the demand drivers.

Table 11: Change in future year PM rail demand for 2026/27 (PfMv7.1) & 2029/30 (PfMv9)

	PFMv7.1 (2026/27)	PFMv9 (2029/30)	Difference	% Difference
Business CA	63,347	65,833	2,486	4%
Business NCA	10,649	12,355	1,706	16%
Leisure CA	5,429	5,568	139	3%
Leisure NCA	830	946	116	14%
Commute CA	5,989	6,149	160	3%
Commute NCA	933	1,067	134	14%
Sub-Totals				
Business	73,996	78,188	4,192	6%
Leisure	6,258	6,515	257	4%
Commute	6,922	7,216	294	4%
Total	87,176	91,918	4,742	5%
CA = Car Available NCA = No Car Available				

3.4.2 Table 12 presents the resulting changes to the PM future year matrix totals for the second forecast year. Overall there is a 3% decrease in total PM rail demand in the second forecast year, which is primarily focused on Business journey purposes.

Table 12: Change in future year PM rail demand for 2037/38 (PfMv7.1) & 2039/40 (PfMv9)

	PFMv7.1 (2037/38)	PFMv9 (2039/40)	Difference	% Difference
Business CA	75,064	71,093	(3,971)	-5%
Business NCA	11,608	13,307	1,699	15%
Leisure CA	6,774	6,388	(386)	-6%
Leisure NCA	951	1,082	131	14%
Commute CA	7,435	7,080	(355)	-5%
Commute NCA	1,064	1,225	161	15%
Sub-Totals				
Business	86,672	84,400	(2,272)	-3%
Leisure	7,725	7,470	(255)	-3%
Commute	8,499	8,305	(194)	-2%
Total	102,897	100,174	(2,723)	-3%
CA = Car Available NCA = No Car Available				

3.5 Impacts on PLANET North (PN) Forecasts

3.5.1 Table 13 presents the changes to the PN future year matrix totals as a result of using the June 2019 DDG data set to forecast rail demand from the base of 2018/19 to 2029/30. Overall there is a 2% increase in PN future year rail demand, primarily focused on Business. This reflects the similar trends observed in other PLANET models.

Table 13: Change in future year PN rail demand for 2026/27 (PfMv7.1) & 2029/30 (PfMv9)

	PFMv7.1 (2026/27)	PFMv9 (2029/30)	Difference	% Difference
Business CA	103,663	103,990	327	0%
Business NCA	21,226	23,842	2,616	12%
Leisure CA	7,248	7,247	(1)	0%
Leisure NCA	1,344	1,501	157	12%
Commute CA	12,492	12,565	73	1%
Commute NCA	2,474	2,786	312	13%
Sub-Totals				
Business	124,889	127,832	2,943	2%
Leisure	8,592	8,748	156	2%
Commute	14,966	15,351	385	3%
Total	148,447	151,932	3,485	2%
CA = Car Available NCA = No Car Available				

3.5.2 Table 14 presents the resulting changes to the PN future year matrix totals for the second forecast year. Overall, there is a 4% decrease in total PN rail demand, with reductions across all journey purposes.

Table 14: Change in future year PN rail demand for 2037/38 (PfMv7.1) & 2039/40 (PfMv9)

	PFMv7.1 (2037/38)	PFMv9 (2039/40)	Difference	% Difference
Business CA	117,459	108,851	(8,608)	-7%
Business NCA	21,962	24,847	2,885	13%
Leisure CA	8,798	8,140	(658)	-7%
Leisure NCA	1,491	1,678	187	13%
Commute CA	14,966	14,152	(814)	-5%
Commute NCA	2,708	3,125	417	15%
Sub-Totals				
Business	139,422	133,698	(5,724)	-4%
Leisure	10,288	9,818	(470)	-5%
Commute	17,673	17,277	(396)	-2%
Total	167,384	160,792	(6,592)	-4%
CA = Car Available NCA = No Car Available				

4 Forecast Highway Demand

4.1 Introduction

4.1.1 The highway mode within the PFM exists within the PLD sub-model, and represents long-distance travel by car, as well as some shorter distance trips that could potentially shift to high-speed rail with the introduction of the HS2 scheme.

4.1.2 Future year highway demand for PLD is derived by forecasting from a base year level of highway demand. As part of the development of PFMv9 since the release of PFMv7.1, the Base year highway matrices have been completely rebuilt using data from Highways England's (HE) Regional Traffic Models (RTMs). The base highway demand matrices are now of a higher standard than in previous model releases and from a common data source. The methodology and implementation of the base highway matrix rebuild is outlined in the Model Description Report.

4.1.3 In addition to the highway demand contained within the PLD demand matrices, local highway demand is also represented on the highway network as preloads to give a more accurate representation of the level of highway demand on the network. This preload demand is not able to mode shift. Highway preloads are also forecast from the base year to the designated future years.

4.1.4 This chapter details the methodology used to forecast both the highway demand matrices and the highway preloads from the base year level of demand in 2014/15 to the forecast years of 2029/30 and 2039/40 for the PLD model. This chapter also discusses the derivation of the future highway occupancy factors.

4.2 Future Year Highway Demand Forecasting

Methodology

4.2.1 The forecasting approach for the highway mode applies furness targets derived from the DfT's Trip End Model Program TEMPro to the 2014/15 base highway matrices to obtain future year highway forecasts for the designated forecast years.

4.2.2 This approach is consistent with the forecasting approach used in previous versions of the PFM without making use of the same processing system. Instead a spreadsheet-based approach has been utilised to calculate the highway demand forecasts.

4.2.3 The overall methodology for forecasting highway demand in PFMv9 has not changed from the methodology used in PFMv7.1.

TEMPRO data

4.2.4 Data from TEMPro was obtained using TEMPro version 7 with data set versions 7.2 across the entire country. Trip ends were obtained by time period for car driver and car passenger combined and were obtained for weekday AM Peak, Inter Peak, PM peak and Off-Peak time periods.

4.2.5 The purposes within TEMPro were mapped to the PLD journey purposes as shown in Table 15.

Table 15: TEMPRO to PLD Journey Purpose Mappings

TEMPRO Journey Purpose	PLD Journey Purpose
HB Work	Commute
HB Employer's Business	Business
HB Education	Education
HB Shopping	Leisure
HB Personal Business	Leisure
HB Recreation/Social	Leisure
HB Visiting friends and Relatives	Leisure
HB Holiday/Day Trip	Leisure
NHB Work	Commute
NHB Employers Business	Business
NHB Education	Education
NHB Shopping	Leisure
NHB Personal Business	Leisure
NHB Recreation/Social	Leisure
NHB Holiday/Day Trip	Leisure
It should be noted that Education is not a PLD purpose and was not included in the later calculations.	

4.2.6 The PFM 20-year appraisal horizon designates that the PFM is used to forecast the impact of the HS2 scheme for the years 2029/30 and 2039/40. Trip ends were therefore downloaded in the standard format from TEMPro for all combinations of the above purposes, time periods and car availability for 2014, 2015, 2029, 2030, 2039, and 2040.

4.2.7 The trip ends downloaded from TEMPRO were combined into 24hr financial year trip ends (by PLD purpose) using the following formulation:

(AM + IP + PM + OP)YEAR1 * 275/365 + (AM + IP + PM + OP)YEAR2 * 90/365

4.2.8 Once aggregated by financial year, the trip ends were mapped from TEMPro zones to PLD zones. Finally, the aggregated totals for 2029/30, and 2039/40 were divided by the totals for 2014/15 to calculate a set of growth factors by purpose at PLD zone level.

Highway Matrix Forecasting

4.2.9 Once the financial year trip end growth factors were developed, they were passed to a furnessing process which was built using spreadsheet techniques. This process undertakes the following steps for each purpose:

- (1) Firstly, a single step is undertaken where the derived pattern from the base year matrix is multiplied by both the production and attraction trip ends to get the 0th iteration matrix for the forecast year. Each zone is then scaled to get the correct production trip end;
- (2) Attraction trip end ratios are then produced and applied to the matrix, this is then averaged with the matrix produced in the step above;
- (3) Next production trip end ratios are produced and applied to the matrix, this is then averaged with the matrix produced in the previous step; and
- Steps (2) and (3) are then repeated for 100 iterations.

4.2.10 This process produces a forecast matrix for each modelled purpose – commute, business and leisure - within PLD. This process was carried out for both the full and masked matrices to produce a full set of future year highway demand forecasts. For each modelled purpose, a high level of convergence was achieved by 100 iterations.

Resulting Highway Demand Forecast Growth

4.2.11 The resulting future year highway demand forecast growth for PFMv9 following the methodology described in the previous sections is presented in Table 16 and compared to PFMv7.1 forecasts.

4.2.12 Overall growth rates from the Base year to the forecast are broadly consistent with previous levels of growth forecast for PFMv7.1, with growth in leisure trips being higher than business and commute purposes.

Table 16: Growth in highway demand forecasts from the Base Year

PFMv7.1	PFM v7.1 Growth from Base (2014/15)		PFM v9 Growth from Base (2014/15)	
	To 2026/27	To 2037/38	To 2029/30	To 2039/40
Commute	6%	11%	4%	9%
Business	7%	13%	8%	14%
Leisure	10%	18%	9%	16%
Total	9%	16%	8%	14%

4.3 Future Year Highway Preload Flows

4.3.1 In PFM, short-distance trips and goods vehicles are represented as pre-loaded flows on the PLD highway network as it is assumed that these trips will not transfer onto the strategic rail network. This ensures that the total modelled link flows in the PLD highway model lead to realistic travel costs for use in the demand model. Future year preloads are calculated by forecasting the base year preloads.

4.3.2 Base year highway preloads are calculated by subtracting the total assigned volumes for the highway network link in the base year model from the observed count value for that link. This process is documented in full in the PFM model description report.

Factoring Base Preloads for Future Years

4.3.3 The methodology used to calculate the future year preloads is consistent with that followed for previous versions of the model and utilises the DfT's National Transport Model (NTM) traffic forecast component of the Road Transport Forecasts 2018 (RTF18).

4.3.4 RTF18 is a new forecasting approach for the NTM compared to previous version RTF15 in which different forecast scenarios are developed motivated by uncertainty around how some trends will carry on into the future as well as uncertainty around the key economic and demographic inputs. Scenario 1 within RTF18 has been utilised in order to perform the preload factoring. A description of scenario 1 as provided by the DfT is as follows:

In scenario 1 we assume the number of trips per person declines from 2011 to 2016 and then remains constant to 2051. We also assume that historic relationships between incomes, costs and travel expenses continue into the future. We use Office for Budget Responsibility (OBR) and Department for Business, Energy and Industrial Strategy (BEIS) central forecasts for future changes in incomes and fuel prices. This scenario includes implemented, adopted or agreed policies only. This is broadly in line with the assumptions used in scenario 1 in RTF15 with updates to more recent data and evidence.

4.3.5 The forecasts for car and other vehicle travel by road type in England and Wales as provided by RTF18 scenario 1 are presented in Table 17. It should be noted that the DfT provide forecasts for 2010 – 2040 in five-yearly intervals. The forecasts for other years have been derived by interpolation of these values. Motorway, trunk and principal road forecasts are used. A total is calculated from these road types and a growth factor calculated from 2014/15 to 2029/30 and 2039/40.

4.3.6 The growth in total traffic from 2014/15 for car and other vehicles is applied to the corresponding base year preload value to obtain future year highway preloads. These values are assigned to the future year highway networks and input to the forecast PFM.

Table 17: RTF18 traffic forecasts in billion vehicle miles by road and vehicle type

	Year	Motorway	Trunk	Principal	Total	Growth in Total Traffic from 2015
Cars	2015	46	26	73	226	
	2030	56	32	84	265	17%
	2040	62	35	90	286	27%
Other Vehicles	2015	16	8	17	58	
	2030	18	9	20	67	17%
	2040	20	10	22	75	30%

4.4 Future Year Highway Occupancy Factors

4.4.1 The future year highway occupancy factors are unchanged from the base year highway occupancy factors. The base year factors have been applied in the future year following advice from the DfT contained within the report 'Understanding and Valuing Impacts of Transport Investment; October 2015'.

5 Forecast Air Demand

5.1 Introduction

5.1.1 The air mode within the PFM exists within the PLD sub-model and represents domestic travel by air within Great Britain for Business and Leisure journey purposes. Since the release of the previous model version, the DfT has updated their aviation model with renewed assumptions and forecast data. In addition, the change in forecast years has required the creation of demand and supply matrices for both 2029/30 and 2039/40.

5.1.2 The remainder of this chapter presents the methodology to process the output data from the DfT's Aviation Model into inputs for the PFM, along with the resulting air demand and supply side forecasts.

5.2 Future Year Air Demand Forecasts

5.2.1 The approach to updating the air demand and supply has been adjusted for the release of PFMv9. The new approach involves using a Base/Do Nothing air demand matrix from the DfT's Aviation Model and converting it to the PFM zoning system.

5.2.2 Forecast air demand is calculated by using aviation forecasts from the DfT Aviation model published on the DfT's website to grow base demand to forecast year levels. The forecast supply has been provided for the forecast years from the DfT's Aviation model.

5.2.3 This approach differs from the PFMv7.1 approach which used outputs from the DfT's Aviation models directly as inputs to the PFM for both supply and demand.

5.2.4 The resulting air demand forecasts for first and second forecast years are presented in Table 18 and compared back to those used within PFMv7.1.

Table 18: Future Year Air Demand Forecasts

Matrix	First Forecast Year			Second Forecast Year		
	PFMv7.1	PFMv9	Change (%)	PFMv7.1	PFMv9	Change (%)
Business	19,621	18,467	-6%	24,867	22,129	-11%
Leisure	15,512	17,088	10%	19,310	20,142	4%
Total	35,133	35,555	1%	44,177	42,270	-4%

5.2.5 Given the differences in years between PFMv7.1 and PFMv9, under normal circumstances one would expect PFMv9 to have a higher volume of demand, however Business demand is clearly expected to increase at a slower rate in the latest forecasts, whereas Leisure is due to increase at a higher rate than previously forecast.

5.2.6 The growth in air demand from the base year 2014/15 is presented in Table 19. Overall there is ~20% growth in the air demand by 2029/30 and ~43% growth in air demand forecasts by 2039/40. There is considerably higher demand growth forecast for leisure than for business.

Table 19: Growth in Air demand forecasts from Base Year

Matrix	2014/15	2029/30	2039/40	Growth from Base	
				To 2029/30	To 2039/40
Business	16321	18,467	22,129	13%	36%
Leisure	13202	17,088	20,142	29%	53%
Total	29523	35,555	42,270	20%	43%

5.2.7 A comparison between the air demand forecasts for PFMv7.1 and PFMv9 has been carried out at GOR sector level for the second forecast year in order to understand if there are greater changes in the distribution of future year air demand. This showed that the most significant changes in demand occur on flows between Scotland to/from the London and East-Anglia. These changes are the largest in magnitude terms and are key flows for HS2 and are the product of the new forecasts from the DfT's Aviation model.

5.3 Air Supply Forecasts

5.3.1 The PLD model requires the following data in order to be able to derive air transit lines that model air trips on domestic flights within mainland UK:

- Headway: air headways were calculated from the aviation supply data which the DfT supplied. The aviation supply matrices included the number of flights per year between each modelled airport in PLD model for each forecast year;
- Business fares, updated fares data for business trips has not been provided by the DfT;
- Leisure fares, updated fares data for leisure trips has not been provided by the DfT; and

- Journey time data, this data has also not been provided by the DfT.

5.3.2 The flights per year data is converted to flights per day using the same annualisation factor that is used in the air demand derivation, and the airports are mapped to nodes within the PLD network to identify the route within the model that each transit line will take.

5.3.3 Table 20 shows the airports that are modelled within the PFM. The following assumptions are applied in the processing of the aviation supply data:

- The annualisation factor was assumed to be 313;
- The number of minutes per day was assumed to be 960 (i.e. flights only take place during the 16hour day modelled in PLD); and,
- Any airport-airport flows with a headway larger than 1200 minutes, i.e. less than one flight a day, were not included in PLD.

5.3.4 The following assumptions were applied in deriving the associated journey time and fare for any new transit lines that had not previously been modelled:

- Every flight has the same journey time as its reverse flight; if a journey time was missing for one forecast year but available in the other, the journey time was approximated using this value;
- Each airport in London has the same journey time to/from other airports outside of London; and,
- The fares data previously provided by the DfT was derived using a distance function therefore where fares were missing for new transit line, the fare was approximated using the fare corresponding to a flight of similar length.

Table 20: Mainland UK Airports Modelled within PLANET Long Distance

Airport	IATA	Airport	IATA
Aberdeen Airport	ABZ	Liverpool Airport	LPL
Birmingham Airport	BHX	London City Airport	LCY
Bristol Airport	BRS	Luton Airport	LTN
Cardiff Airport	CWL	Manchester Airport	MAN
East Midlands Airport	EMA	Newcastle Airport	NCL
Edinburgh Airport	EDI	Newquay Airport	NQY
Exeter Airport	EXT	Norwich Airport	NWI
Gatwick Airport	LGW	Plymouth Airport	PLH
Glasgow Airport	GLA	Southampton Airport	SOU
Heathrow Airport	LHR	Stansted Airport	STN
Humberside Airport	HUY	Blackpool Airport	BLK
Inverness Airport	INV	Prestwick Airport	PIK
Leeds/Bradford Airport	LBA		

6 Third Forecast Year

6.1.1 The established process for using the PFM is to forecast for two future year scenarios, modelling three different phases of the scheme. The outputs for each phase and modelled year are combined in an economic appraisal template which calculates the forecast benefits and revenue of the scheme.

6.1.2 The economic appraisal of the scheme measures the benefits from the opening of the first phase of the project to 60-years after the opening of the final phase of the scheme. Because the PFM is only used to model two forecast years the economic appraisal process can used to extrapolate the benefits beyond the second forecast year for the remainder of the appraisal period (i.e. allowing growth in line with population).

6.1.3 PFMv9 has incorporated a third forecast year ten years after the second forecast year. This is to provide a longer-term forecast for the economic appraisal that incorporates the benefit components and demand impacts of the PFM that cannot be fully captured ‘off model’ in the economic appraisal. This in turn allows an improved assessment of the 30 year appraisal sensitivity that is required to inform the Economic Case.

Development of the Third Forecast Year

6.1.4 A third forecast year has been developed using the same demand drivers as were provided for the first and second forecast years as well as the same elasticity inputs to the model. Year specific parameters for the PFM inputs have been produced using a consistent approach as for the other two forecast years, specifically vehicle operating costs, and fares growth policy.

6.1.5 The following tables present the exogenous unconstrained rail demand forecast growth for all sub-models of the PFM, from the second forecast year to the third forecast year. These forecasts show that the Business and Leisure demand segments are forecast to grow by 10-19% between the 2039/40 and 2049/50, whereas the Commute demand segments shows varying growth dependent on the sub-model. Commute will be more susceptible to forecast rates of growth in employment with differing outlooks across the regional models.

Table 21: Forecast Do Minimum rail demand matrices – Growth 2039/40 to 2049/50

	2039/40 - 2049/50 PLD Growth	2039/40 - 2049/50 PS Growth	2039/40 - 2049/50 PM Growth	2039/40 - 2049/50 PN Growth
Commute	9%	13%	-4%	8%
Business	14%	16%	13%	19%
Leisure	16%	16%	10%	15%
Total	14%	14%	-2%	10%

Table 22: PLD Forecast Do Minimum air and highway demand matrices – Growth 2039/40 to 2049/50

	2039/40-2049/50 Difference
Highway Demand Total	6%
Air Demand Total	15%

7 Quality Assurance

7.1.1 This section details the Quality Assurance undertaken on the model development documented within this note. It provides details on the checks that have been undertaken in relation to the theory, the implementation and the results of the changes. There are standard levels of checking used on model versions:

- **Yellow Check** – This includes checks of the setup of model runs, checks that model run outputs have been produced correctly and checks that results from the model are sensible through the key indicators form;
- **Orange Check** – This is a more detailed check of the model inputs and outputs, and changes to model code (macros and batch files, etc.);
- **Red Check** – This involves a more wide-ranging QA of all aspects of the model with associated check logs. This also details checks of the key files within the modelling framework; and,

7.1.2 Further to these types of check, additional checks can be performed by HS2 Ltd themselves, HS2 Ltd's auditor or via an independent peer review. These are documented separately.

7.1.3 The base and future year matrices that have been created within this round of model development have been subjected to Yellow and Orange level of checking, as the resulting future year matrices will be used as inputs to PFMv9.

7.1.4 In addition, HS2 Ltd's independent auditors have performed further checks on the base and future year matrices to ensure the validity of the resulting forecast matrices which will be used within the PFM.

7.1.5 Following the Quality Assurance procedures described above it is recommended that the future year matrices are fit for the purpose of forecasting future year rail demand impacts for the HS2 scheme.

8 Conclusions

8.1.1 The update to the demand forecasts has involved not only updates to the demand drivers themselves as in previous updates, but also a significant change to the forecasting methodology with the change in guidance from WebTAG and PDFHv6, and the update to NTEM7.2 zoning structure.

8.1.2 There have been significant changes to the forecasting methodology between PFMv7.1 and PFMv9, including in national guidance, as well as in the changes to the forecast years. This makes direct comparison between the two forecasts less clear-cut given the significant changes, however the levels of forecast demand are in line with previous model versions given the changes implemented.

8.1.3 A third forecast year has been developed for this model version as an optional sensitivity test within the Reference Case model.

8.1.4 Given the level of Quality Assurance and checking that has been undertaken on the forecasting methodology, it has been determined that the outputs are suitable for use by HS2 Ltd. in PFM v9.

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