October 2023

HS2

# PLANET Framework Model PFMv10a

## Demand Forecasting Report

Department for Transport

High Speed Two (HS2) Limited has been tasked by the Department for Transport (DfT) with managing the delivery of a new national high speed rail network. It is a non-departmental public body wholly owned by the DfT.

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# 1 Introduction

## 1.1 Background

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. A continual series of model development and updates to modelling assumptions ensures that the model uses the most up-to-date inputs upon which to base the Business Case. These updates include 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 PFM 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 using latest available data for demand forecasting. This report sets out the revised exogenous demand forecasts that have been included within PFMv10a, summarises the adopted forecasting approach, and analyses the change in demand forecasts from the previous model release.

## 1.2 Modelled scenarios

1.2.1 Several modelling scenarios are referenced in the documents associated with the PFM and modelling of the HS2 scheme:

- **Do Minimum**: in this scenario there is no HS2 scheme, and this forms the reference case against which the benefits and revenues of the various HS2 phases are assessed;
- **Phasing definition in PFM scenarios**: there are numerous Do Something future year scenarios available for modelling within PFMv10a:
  - **S1 (Phase 2ai)**: a phased opening scenario – the extent of the high-speed network is *Old Oak Common – Birmingham/Crewe/Glasgow,* with six services per hour operating from OOC;
  - **S2 (Phase 2a)**: the extent of the high-speed rail network is *London Euston – Birmingham/Crewe*, with 10 services per hour operating from Euston;
  - **S3 (Phase 2b Western Leg)**: this extends the high-speed rail network to Manchester and the connection to the West Coast Mainline via the Golborne link, with 11 services per hour operating from Euston and three services per hour from Birmingham Curzon Street; and,

- **S4 Phase 2b**: the full high-speed rail network is in place from *London Euston – Birmingham – Manchester and Leeds* and connections to the West Coast, Midland and East Coast Mainlines, with 17 services per hour operating from Euston and six services per hour from Birmingham Curzon Street.

1.2.2 Full details of service patterns and modelling assumptions for each of these scenarios is included in the PFMv10a Assumptions Report.

1.2.3 The Value for Money (VfM) assessment of Phase 2b WL focuses on the case for the Western Leg of Phase 2b (from Crewe to Manchester and the North West). It assumes that Phase 2a is operational and involves the comparison of modelled benefits and revenues for the Phase 2a and Phase 2b WL scenarios.

## 1.3 Note structure

1.3.1 The remainder of this note is structured as follows:

- Chapter 2: Rail demand forecasting methodology;
- Chapter 3 : Forecast rail demand;
- Chapter 4: Forecast highway demand;
- Chapter 5: Forecast air demand;
- Chapter 6: Quality assurance; and
- Chapter 7: Summary.

# 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 Transport Analysis Guidance (TAG)[1] recommendations. More information on the adopted forecasting approach can be found in the latest PFM Model Description Report.

2.1.3 For the release of PFMv10a, there have been several significant updates to the demand forecasts which are discussed separately in this chapter:

- **Change in model base year**: all the PFM sub-models have been rebased from 2014/15 to 2018/19 journeys data. This not only changes the passenger demand patterns in the base year, but also the year from which growth is being forecast. In the PFMv9 release, for the 2014/15 base year, aggregate observed growth was applied to the base matrices to uplift from 2014/15 to 2018/19 using data from the Office for Rail and Road (ORR) before the PDFH forecasting approach was used to forecast into the future. While this attempted to use actual observed growth rather than PDFH forecasting, it could not take into account geographic variation in growth across key rail corridors. In PFMv10a, the update to a 2018/19 base year incorporates actual growth since 2014/15 and facilitates forecasting directly from the 2018/19 base year;
- **Updated second forecast year**: to maintain the economic appraisal approach, a window of 20 years from the point of appraisal needs to be maintained. With the point of appraisal now 2021/22, the second forecast year has moved to 2041/42; and
- **Revised demand drivers**: the December 2020 release of rail demand drivers have been used to develop new demand forecasts. The revised demand drivers

[1] https://www.gov.uk/guidance/transport-analysis-guidance-tag

include macro-economic drivers (e.g. GDP and employment) as well as inter-modal factors such as vehicle operating costs. An estimate of the impact of COVID-19 on macro-economic factors is also included in the forecasts.

2.1.4 Together, these updates 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 will present the updates that have been incorporated for each of the listed updates. Chapter 0 compares the forecast rail demand in PFMv9 and PFMv10a at an aggregate level as well as by key rail movements.

## 2.2 December 2020 demand driver forecasts

2.2.1 The DfT's December 2020 DDG set includes the latest forecasts at that time in terms of the economic outlook for the country in the short term and has been used in the demand forecasting for PFMv10a. This is informed by the November 2020 release of the Office for Budget Responsibility (OBR) Economic & Fiscal Outlook (EFO), which provides forecasts for GDP and employment. Population forecasts in the December 2020 DDGs are based on Office for National Statistics (ONS) national population forecasts.

2.2.2 The previous model release, PFMv9, used the June 2019 DDG set to forecast future year rail passenger demand; and since then, many of the other demand driver forecasts have also been updated to incorporate the latest assumptions.

2.2.3 The December 2020 DDG forecasts are presented in more detail in the remainder of this chapter and compared back to the June 2019 DDG forecasts to highlight the changes that have occurred since the rail demand forecasts were last updated within the PFM.

2.2.4 It should be noted that the impact on demand forecasts of changes in DDGs will differ by the specific demand drivers that are changing (i.e. some demand drivers have a bigger impact on demand forecasts than others).

### Macro-economic forecasts

2.2.5 The macro-economic forecasts for Great Britain (GB) are presented in Figure 2-1, Figure 2-2 and Figure 2-3 for GDP per capita, Employment, and Population respectively. The graphs show the comparison of the national forecasts between the June 2019 and December 2020 DDG sets. DDGs are indexed to 2010/11, but the figures show the change in DDGs between 2018/19 and 2041/42. It should also be noted that changes in the GDP, employment, and population DDGs will vary on a regional basis (see Table 2-1 and Table 2-2).

2.2.6 The GDP-per-capita forecast has been significantly impacted at the national level by changes to the OBR's forecasting assumptions. Whilst the short-term impacts of the COVID-19 pandemic can be seen in the impact on GDP, this swiftly recovers. It is the long-term growth in GDP that has been significantly reduced, which was a revision prior to COVID-19. GDP is one of the strongest drivers of rail demand growth in the forecasting approach, so the lower long-term GDP growth rate will result in lower volumes of forecast rail demand.

2.2.7 At an aggregate level, the employment forecasts have not changed as significantly as the GDP forecasts between the June 2019 and December 2020 DDG sets. However, there is a noticeable reduction in the employment growth rate towards the end of the timeline, which will produce lower passenger rail demand forecasts, particularly for passenger flows dominated by the 'commute' journey purpose.

2.2.8 As with the GDP and employment forecasts, the population forecasts are also lower in the December 2020 DDGs than the June 2019 DDGs. As with the other drivers, this will also reduce the volume of forecast passenger rail demand.

Figure 2-1: UK national macro-economic forecast – GDP per capita (2010/11=100)

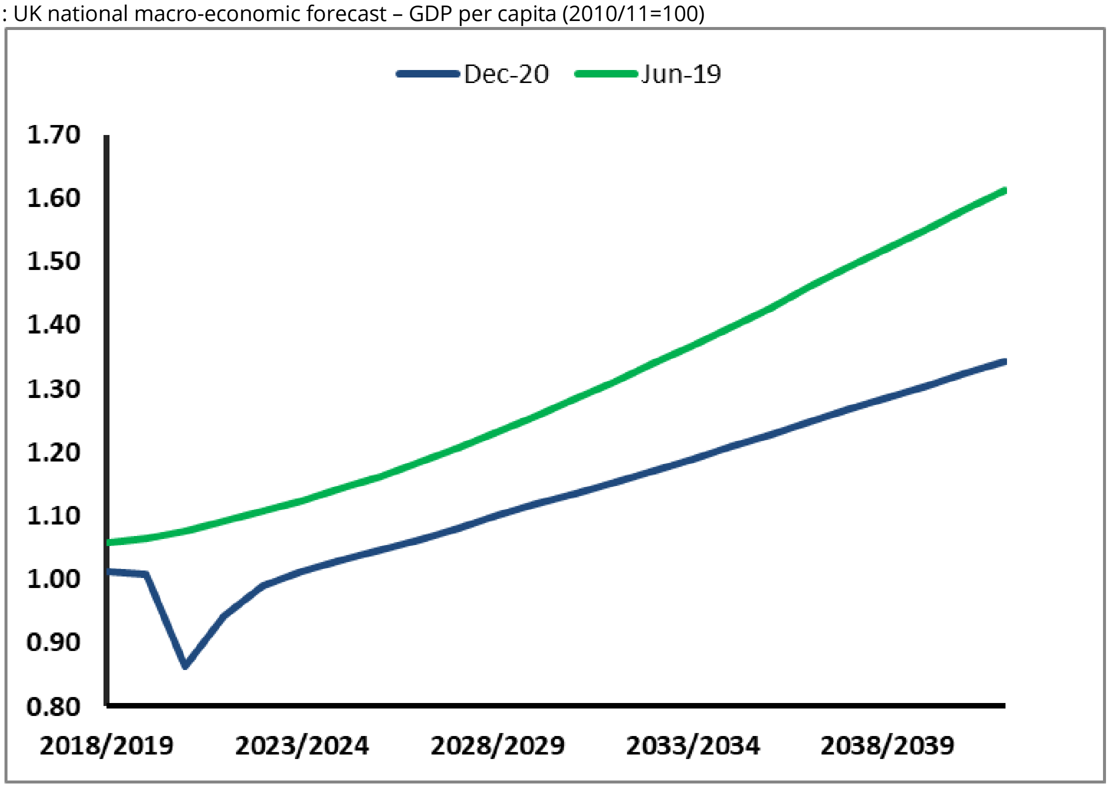


Figure 2-2: UK national macro-economic forecast – Employment (2010/11=100)

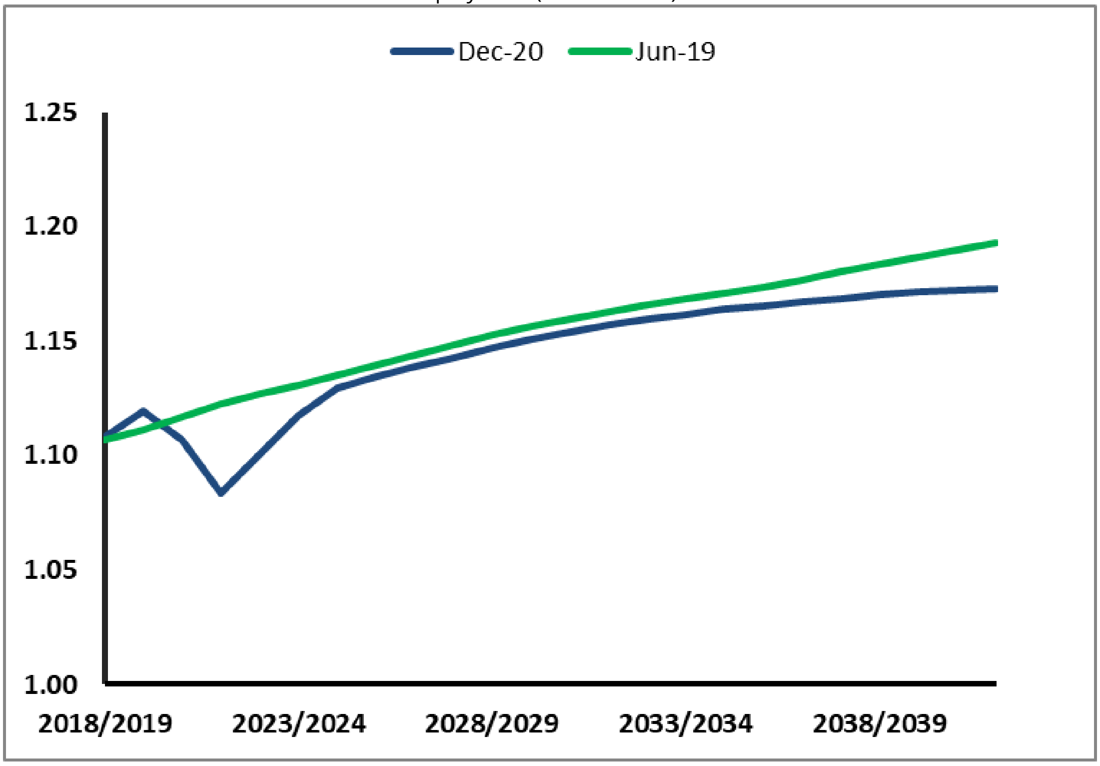
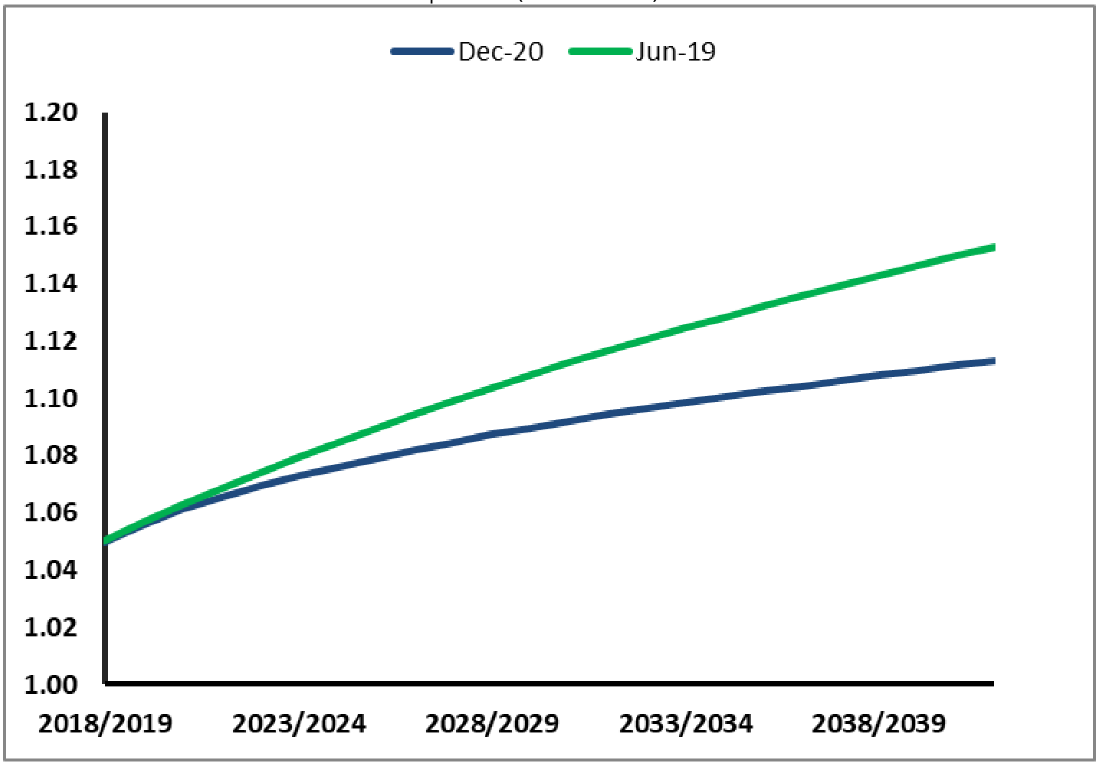



Figure 2-3: UK national macro-economic forecast – Population (2010/11=100)




2.2.9 The DfT disaggregates the national macro-economic forecasts using Centre for Economics and Business Research (CEBR) data and therefore the resulting passenger rail demand forecasts are impacted by regional changes in the macro-economic forecasts, as well as the national forecast growth rate between base and future year.

2.2.10 The regional forecasts for the macro-economic drivers are presented in Table 2-1 for 2029/30 and in Table 2-2 for 2041/42 for both sets of demand drivers to provide an indication of the changes in demand driver data at the regional level. Note that these tables are indicative, and the demand forecasts rely on the dynamic relationship between all demand drivers at disaggregate flow level.

2.2.11 In both forecast years the growth in GDP between 2018/19 and the forecast year is significantly lower in the December 2020 DDGs than in the June 2019 DDGs, although this does vary by region. The second forecast year is particularly impacted due to the reduction in the long-term GDP growth rate, which will have significant impacts on the volume of forecast passenger rail demand.

2.2.12 The employment and population DDGs are less heavily impacted than the GDP growth forecasts. However, the London region appears to be impacted more significantly than the other regions.

Table 2-1: Regional changes in macro-economic demand driver forecasts from 2018/19 to 2029/30

| **Region** | **GDP per Capita** | | | **Employment** | | | **Population** | | |
|---|---|---|---|---|---|---|---|---|---|
| **DDGs** | **Jun'19** | **Dec'20** | **Diff.** | **Jun'19** | **Dec'20** | **Diff.** | **Jun'19** | **Dec'20** | **Diff.** |
| East of England | 23% | 10% | -13% | 4% | 5% | 1% | 8% | 4% | -3% |
| East Midlands | 17% | 6% | -10% | 6% | 7% | 2% | 6% | 7% | 0% |
| London | 13% | 12% | 0% | 8% | 2% | -6% | 8% | 4% | -5% |
| North East | 19% | 10% | -9% | 2% | 2% | 1% | 2% | 2% | 0% |
| North West | 14% | 7% | -8% | 1% | 1% | -1% | 3% | 3% | 0% |
| Scotland | 20% | 15% | -4% | 3% | 2% | -1% | 2% | 2% | 0% |
| South East | 17% | 16% | -1% | 3% | 6% | 2% | 7% | 2% | -4% |
| South West | 11% | 9% | -2% | 7% | 4% | -2% | 7% | 6% | -1% |
| Wales | 18% | 8% | -10% | 2% | 1% | -1% | 2% | 2% | 0% |
| West Midlands | 10% | 9% | -1% | 6% | 6% | 0% | 6% | 6% | 0% |
| Yorkshire & Humber | 15% | 7% | -8% | 3% | 6% | 3% | 4% | 3% | -1% |
| Great Britain | 19% | 10% | -9% | 4% | 4% | -1% | 5% | 4% | -2% |
| Note that different DDGs for employment and population are used for different trip categories, which may differ from the figures in this table. Figures are rounded to the nearest 1%. | | | | | | | | | |

Table 2-2: Regional changes in macro-economic demand driver forecasts from 2018/19 to 2041/42

| Region | GDP per Capita | | | Employment | | | Population | | |
|---|---|---|---|---|---|---|---|---|---|
| DDGs | Jun'19 | Dec'20 | Diff. | Jun'19 | Dec'20 | Diff. | Jun'19 | Dec'20 | Diff. |
| East of England | 61% | 35% | -26% | 8% | 11% | 3% | 13% | 7% | -6% |
| East Midlands | 47% | 26% | -21% | 11% | 10% | 0% | 11% | 11% | 0% |
| London | 40% | 32% | -8% | 10% | 4% | -6% | 15% | 5% | -9% |
| North East | 53% | 32% | -20% | 1% | 2% | 2% | 4% | 3% | -1% |
| North West | 42% | 23% | -19% | 2% | 2% | 0% | 6% | 6% | -1% |
| Scotland | 52% | 40% | -11% | 3% | 0% | -4% | 4% | 2% | -1% |
| South East | 49% | 43% | -6% | 3% | 5% | 2% | 12% | 4% | -8% |
| South West | 37% | 27% | -9% | 14% | 7% | -6% | 12% | 10% | -2% |
| Wales | 51% | 30% | -21% | 8% | 4% | -4% | 3% | 3% | 0% |
| West Midlands | 35% | 26% | -9% | 11% | 8% | -3% | 10% | 10% | -1% |
| Yorkshire & Humber | 43% | 25% | -18% | 12% | 13% | 0% | 7% | 5% | -2% |
| Great Britain | 53% | 32% | -20% | 8% | 6% | -2% | 10% | 6% | -4% |
| Note that different DDGs for employment and population are used for different trip categories, which may differ from the figures in this table. Figures are rounded to the nearest 1%. | | | | | | | | | |

### Modal competition forecasts

2.2.13 The change in modal competition drivers as a result of the demand driver update between June 2019 and December 2020 DDGs are presented in this section. The figures compare the forecasts for the set of flows between London and the Rest of the UK outside of the South East, as this flow category represents a significant proportion of passenger demand and benefits for the HS2 scheme within the PLD model.

2.2.14 Car costs are forecast to reduce at a similar rate in the December 2020 and June 2019 DDGs for long distance flows to and from London (Figure 2-4), whereas Figure 2-5 shows that car journey time is forecast to be higher in the December 2020 demand drivers.

2.2.15 Higher car costs will result in more demand for rail because the cost of the competing mode is higher than in the previous forecast. Higher car journey times will make cars less attractive because it implies there will be more congestion in the future than previously thought.

Figure 2-4: Inter-modal competition – Car cost forecasts

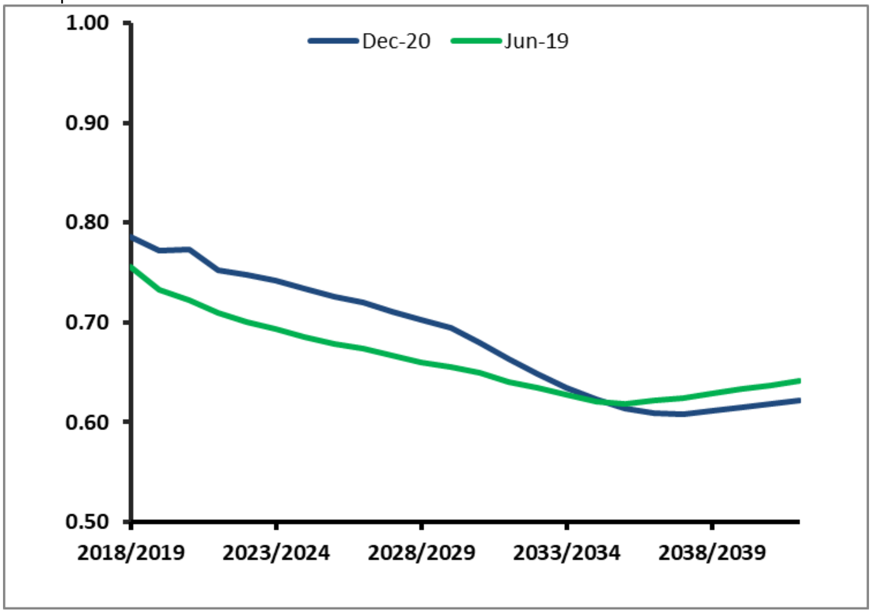
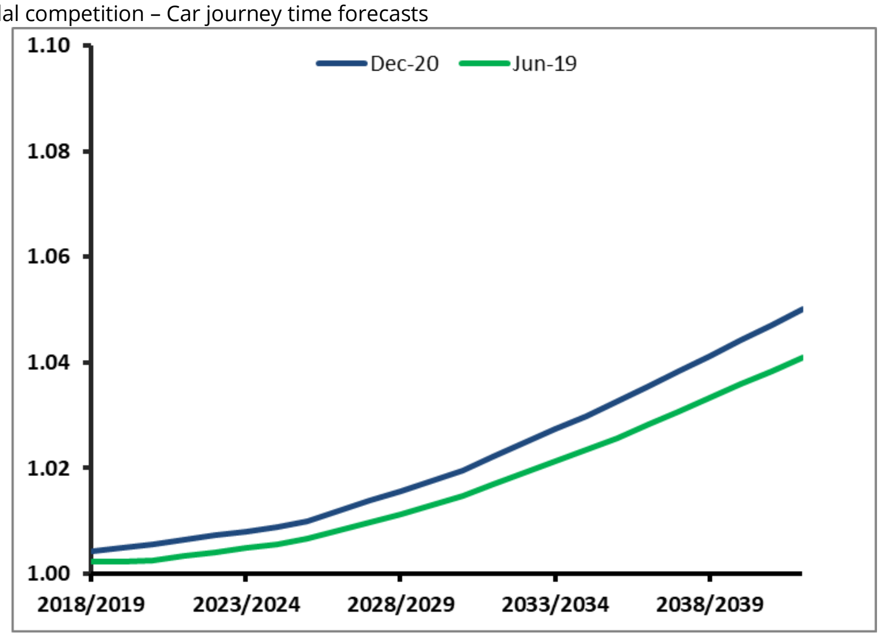



Figure 2-5: Inter-modal competition – Car journey time forecasts




2.2.16 Figure 2-6 shows higher growth in bus/coach costs in the June 2019 DDG set than in the December 2020 DDG set, which will contribute to higher future year passenger rail demand growth, as the increase in the cost of taking the bus will be higher than previously forecast.

2.2.17 The bus/coach journey time forecast comparison in Figure 2-7 shows higher growth in bus journey times in the December 2020 DDGs. However, PDFH recommended elasticity values for these drivers are very small, so it is expected that the changes in these drivers will have a negligible impact when applied within the forecasting methodology.

Figure 2-6: Inter-modal competition – Bus/coach costs

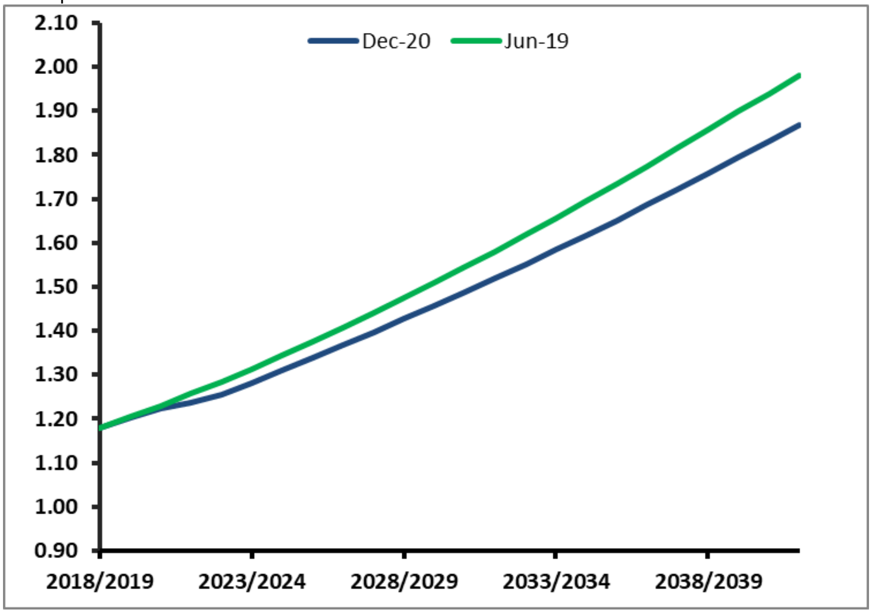
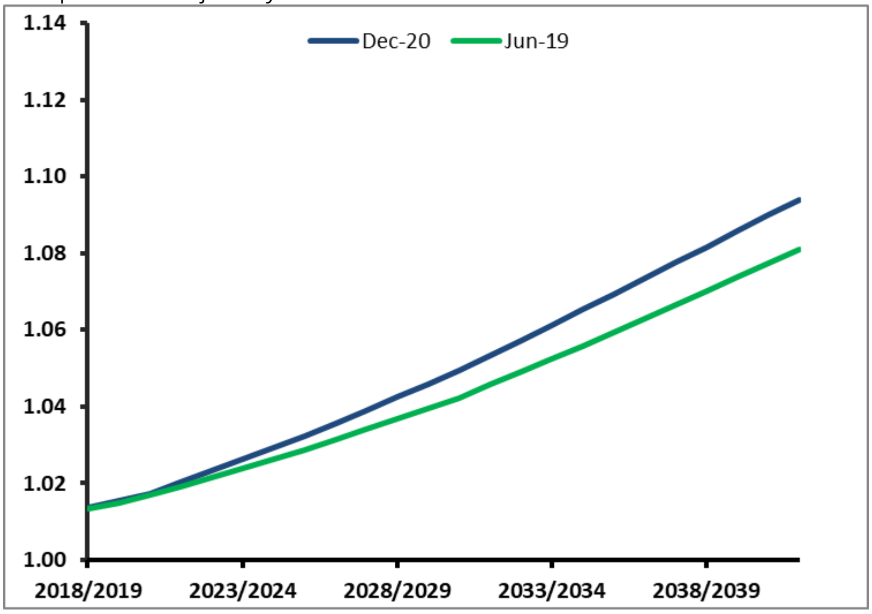



Figure 2-7: Inter-modal competition – Bus journey time forecasts




2.2.18 As with the macro-economic drivers, the actual impact of the change in demand driver forecasts is driven by the growth in the driver between the base year and specified future year, as well as regional changes in the demand driver forecasts.

2.2.19 A summary of the change in inter-modal competition demand drivers is presented in Table 2-3 for both forecast years. This table compares the change in demand drivers between 2018/19 and the new forecast years for both sets of demand drivers. The table shows minor changes in the forecast growth in most demand drivers but more significant differences in growth for car costs and bus costs. The forecast growth in costs is lower in the December 2020 DDGs which would typically make those modes more competitive and thus reduce forecast passenger rail demand.

Table 2-3: Change in inter-modal competition demand driver forecasts

| Inter-Modal Demand Driver | 2018/19 to 2029/30 | | | 2018/19 to 2041/42 | | |
|---|---|---|---|---|---|---|
| DDGs | Jun'19 | Dec'20 | Diff. | Jun'19 | Dec'20 | Diff. |
| Growth in Car Journey Time | 1% | 1% | 0% | 4% | 5% | 1% |
| Growth in Car Cost Price | -13% | -12% | 2% | -15% | -21% | -6% |
| Growth in Car Owning Households (GB) | 10% | 10% | 0% | 17% | 17% | 0% |
| Growth in Bus Costs | 28% | 24% | -4% | 68% | 58% | -10% |
| Growth in Bus Journey Time | 3% | 3% | 1% | 7% | 8% | 1% |
| Growth in Bus Headway | 1% | 1% | 0% | 1% | 1% | 0% |
| Growth in Rail Fares | 7% | 7% | 0% | 39% | 39% | 0% |
| Figures are rounded to the nearest 1%. | | | | | | |

# 3 Forecast rail demand

## 3.1 Introduction

3.1.1 The December 2020 DDG sets have been used in the DfT's EDGE software to forecast future year rail demand for PFMv10a. As set out at the beginning of the previous chapter, there have been several significant changes to the rail demand matrices and forecasting methodology between the releases of PFMv9 and PFMv10a. This chapter presents the forecast rail passenger demand within PFMv10a compared to PFMv9. When comparing the volume of forecast rail passenger demand it is important to consider:

- **Rebasing**: the PFM has been rebased for PFMv10a and so the base matrices represent a different year. The PFMv10a base matrices will typically have an extra 4 years of observed passenger demand between 2014/15 and 2018/19, as well as a different distribution of trips at zone to zone level in the base year;
- **Methodology**: the re-basing necessitated changes to the forecasting approach whereby observed growth in rail demand between 2014/15 and 2018/19 was applied to 2014/15 base matrices in PFMv9 prior to forecasting. This step is no longer required in PFMv10a, the forecasting is applied from the 2018/19 base;
- **Disaggregate impacts**: Comparing matrix totals can be difficult when there can be significant differences at the disaggregate/flow level within a demand matrix; and
- **Constraining growth**: Previous forecasting reports have typically reported unconstrained rail demand growth whereby forecast growth is reported without the constraint of crowding on the rail network. This report compares volumes of demand once they have been constrained by crowding on the rail network within the PFM Do Minimum scenario. Reporting volumes of rail passenger demand which has been forecast using DDGs and constrained by crowding on the rail network gives a more realistic representation of the volumes of rail passenger demand forecast in the Do Minimum scenarios.

## 3.2 Impacts on the PLANET Long Distance (PLD) rail demand

### PLD aggregate demand

3.2.1 The forecast rail passenger demand is presented in Table 3-1 for PFMv9 and Table 3-2 for PFMv10a. The tables show that in the first forecast year, at an aggregate level, there is forecast to be around 8% less rail demand in PFMv10a than in PFMv9, whereas in the second forecast year, the reduction is greater at around 13% less demand, even with an extra two years of growth to 2041/42 in PFMv10a.

3.2.2 It is important to be cautious in drawing conclusions based on changes in the aggregate volume of demand, because patterns can be different at the disaggregate level. However, these changes in aggregate demand volumes are consistent with the analysis of the DDGs in the previous chapter, which concluded that demand growth using the December 2020 DDGs is significantly reduced when compared to the June 2019 DDG forecasts. As the next section shows, the patterns of rail passenger growth between 2014/15 and 2018/19, and then to the forecast years, are different at a key flow level.

Table 3-1: Forecast long distance daily rail passenger demand in PFMv9 Do Minimum scenario

| PFMv9 | 2014/15 | 2029/30 | 2039/40 | Growth from base | |
|---|---|---|---|---|---|
| | | | | To 2029/30 | To 2039/40 |
| Commute | 96,327 | 127,344 | 135,268 | 32% | 40% |
| Business | 118,347 | 171,460 | 191,990 | 45% | 62% |
| Leisure | 186,676 | 260,295 | 294,341 | 39% | 58% |
| Total | 401,350 | 559,099 | 621,599 | 39% | 55% |

Table 3-2: Forecast long distance daily rail passenger demand in PFMv10a Do Minimum scenario

| PFMv10a | 2018/19 | 2029/30 | 2041/42 | Growth from base | |
|---|---|---|---|---|---|
| | | | | To 2029/30 | To 2041/42 |
| Commute | 99,417 | 113,313 | 113,926 | 14% | 15% |
| Business | 128,068 | 159,154 | 170,831 | 24% | 33% |
| Leisure | 200,719 | 239,708 | 256,888 | 19% | 28% |
| Total | 428,204 | 512,176 | 541,645 | 20% | 26% |

## 3.3 Impacts on PLANET South (PS) forecasts

3.3.1 The PS rail demand matrices were completely updated for PFMv10a using data from Transport for London (TfL)'s Railplan model, having not been fully rebuilt for a number of years, and so there were significant changes in the volume of demand and how it is spatially distributed. Table 3-3 presents the changes to the forecast growth in PLANET South rail demand for PFMv9 and Table 3-4 for PFMv10a.

3.3.2 There is a sizeable reduction in forecast growth in both forecast years between PFMv9 and PFMv10a. The regional model passenger demand is dominated by commuters. The December 2020 DDGs forecast lower levels of growth in employment than the June 2019 DDGs and so there is significantly less growth in passenger rail demand for commuting. Business and leisure demand growth is impacted by lower forecast growth rates for population and GDP.

Table 3-3: Forecast PS AM-peak period rail passenger demand in PFMv9 Do Minimum scenario

| PFMv9 | 2014/15 | 2029/30 | 2039/40 | Growth from base | |
|---|---|---|---|---|---|
| | | | | To 2029/30 | To 2039/40 |
| Business | 151,233 | 205,792 | 239,218 | 36% | 58% |
| Leisure | 168,026 | 223,178 | 257,101 | 33% | 53% |
| Commute | 1,523,840 | 1,963,098 | 2,201,441 | 29% | 44% |
| Total | 1,843,099 | 2,392,068 | 2,697,760 | 30% | 46% |

Table 3-4: Forecast PS AM-peak period rail passenger demand in PFMv10a Do Minimum scenario

| PFMv10a | 2018/19 | 2029/30 | 2041/42 | Growth from base | |
|---|---|---|---|---|---|
| | | | | To 2029/30 | To 2041/42 |
| Business | 174,682 | 202,756 | 222,435 | 16% | 27% |
| Leisure | 186,975 | 212,962 | 232,739 | 14% | 24% |
| Commute | 1,747,558 | 1,928,613 | 2,053,804 | 10% | 18% |
| Total | 2,109,215 | 2,344,331 | 2,508,978 | 11% | 19% |

## 3.4 Impacts on PLANET Midland (PM) forecasts

3.4.1 Table 3-5 presents the changes to the growth in rail demand for PLANET Midland for PFMv9 and Table 3-6 for PFMv10a. Since the regional matrices are dominated by commuters, the growth is heavily impacted by the employment demand drivers, which are lower in the December 2020 DDGs.

Table 3-5: Forecast PM AM-peak period rail passenger demand in PFMv9 Do Minimum scenario

| PFMv9 | 2014/15 | 2029/30 | 2039/40 | Growth from base | |
|---|---|---|---|---|---|
| | | | | To 2029/30 | To 2039/40 |
| Business | 5,014 | 6,342 | 7,244 | 26% | 44% |
| Leisure | 5,568 | 7,036 | 8,071 | 26% | 45% |
| Commute | 61,807 | 76,120 | 81,876 | 23% | 32% |
| Total | 72,388 | 89,498 | 97,191 | 24% | 34% |

Table 3-6: Forecast PM AM-peak period rail passenger demand in PFMv10a Do Minimum scenario

| PFMv10a | 2018/19 | 2029/30 | 2041/42 | Growth from base | |
|---|---|---|---|---|---|
| | | | | To 2029/30 | To 2041/42 |
| Business | 6,348 | 7,206 | 7,655 | 14% | 21% |
| Leisure | 6,197 | 7,032 | 7,515 | 13% | 21% |
| Commute | 73,726 | 85,040 | 83,083 | 15% | 13% |
| Total | 86,270 | 99,278 | 98,253 | 15% | 14% |

## 3.5 Impacts on PLANET North (PN) forecasts

3.5.1 Table 3-7 presents the changes to the growth in rail demand in PLANET North for PFMv9 and Table 3-8 for PFMv10a. Since the regional matrices are dominated by commuters, the growth is heavily impacted by the employment demand drivers which are lower in the December 2020 DDGs.

Table 3-7: Forecast PN AM-peak period rail passenger demand in PFMv9 Do Minimum scenario

| PFMv9 | 2014/15 | 2029/30 | 2039/40 | Growth from base | |
|---|---|---|---|---|---|
| | | | | To 2029/30 | To 2039/40 |
| Business | 7,046 | 8,640 | 9,673 | 23% | 37% |
| Leisure | 12,394 | 15,171 | 17,034 | 22% | 37% |
| Commute | 109,556 | 125,813 | 131,184 | 15% | 20% |
| Total | 128,996 | 149,624 | 157,891 | 16% | 22% |

Table 3-8: Forecast PN AM-peak period rail passenger demand in PFMv10a Do Minimum scenario

| PFMv10a | 2018/19 | 2029/30 | 2041/42 | Growth from base | |
|---|---|---|---|---|---|
| | | | | To 2029/30 | To 2041/42 |
| Business | 8,805 | 9,450 | 9,719 | 7% | 10% |
| Leisure | 10,697 | 11,535 | 11,925 | 8% | 11% |
| Commute | 131,724 | 135,049 | 131,595 | 3% | 0% |
| Total | 151,226 | 156,034 | 153,239 | 3% | 1% |

# 4 Forecast highway demand

## 4.1 Introduction

4.1.1 The highway mode within the PFM exists within the PLD sub-model, and primarily represents long-distance (>50 miles) travel by car that could potentially shift to high-speed rail with the introduction of the HS2 scheme.

4.1.2 As part of the development of PFMv10a, the model was rebased from 2014/15 to 2018/19. The rail demand matrices were rebuilt using the latest available dataset. For the highway demand matrices, more recent data was not available and so the previous 2014/15 base highway demand matrices were uplifted to 2018/19 using growth factors from the DfT's Trip End Model Program (TEMPro). These then formed the new 2018/19 base from which to forecast future levels of highway demand.

4.1.3 Future year highway demand for PLD is derived by forecasting from a base year level of highway demand. 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 2018/19 to the forecast years for the PLD model.

## 4.2 Future year highway demand forecasting

### Methodology

4.2.1 The forecasting approach for the highway mode applies traffic growth forecasts derived from TEMPro to the 2018/19 base highway matrices to obtain future year highway forecasts for the designated forecast years. This approach is consistent with the forecasting approach used in previous versions of the PFM.

### TEMPro data

4.2.2 Data from TEMPro was obtained using TEMPro version 7 with data set version 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.

4.2.3 The purposes within TEMPro were mapped to the PLD journey purposes as shown in Table 4-1.

Table 4-1: 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 employer's 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.<br>HB = Home Based; NHB = Non-Home Based | |

4.2.4 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 2041/42. Trip ends were therefore downloaded in the standard format from TEMPro for all combinations of the above purposes, time periods and car availability for 2018, 2019, 2029, 2030, 2041 and 2042.

4.2.5 The trip ends downloaded from TEMPro were combined into 24-hour 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

4.2.6 Once aggregated by financial year, the trip ends were mapped from TEMPro zones to PLD zones. Finally, the aggregated totals for 2029/30, and 2041/42 were divided by the totals for 2018/19 to calculate a set of growth factors by purpose at PLD zone level.

### Highway matrix forecasting

4.2.7 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 derive the 0th iteration matrix for the forecast year. Each zone is then scaled to provide 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.

4.2.8 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[2] 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 forecasts

4.2.9 The resulting future year highway demand forecasts for PFMv10a following the methodology described in the previous sections are presented in Table 4-2 for PFMv9 forecasts and in Table 4-3 for PFMv10a forecasts. As with the rail demand analysis, the tables contain the highway demand reported from the PFM in the Do Minimum scenario to provide a better representation of demand volumes following the constraining of growth[3]. As can be seen in the tables, the overall growth rates from the base year to the forecast are generally consistent with previous levels of growth forecast for PFMv9, with growth in leisure trips being higher than journeys being made for business and commute purposes.

Table 4-2: Growth in highway demand forecasts from the 2014/15 base year – PFMv9

| PFMv9 | 2014/15 | 2029/30 | 2039/40 | Growth from base | |
|---|---|---|---|---|---|
| | | | | To 2029/30 | To 2039/40 |
| Commute | 1,612,336 | 1,669,807 | 1,729,309 | 4% | 7% |
| Business | 775,504 | 829,799 | 868,469 | 7% | 12% |
| Leisure | 2,824,633 | 3,060,184 | 3,223,743 | 8% | 14% |

[2] Details on the masking of the demand matrices are contained within the PFMv10a Model Description Report.
[3] Constraining of the growth in highway trips refers to the process whereby congestion on the highway network reduces the level of growth because some journeys will no longer be made by highway because of congestion or mode switching.

| PFMv9 | 2014/15 | 2029/30 | 2039/40 | Growth from base | |
|---|---|---|---|---|---|
| | | | | To 2029/30 | To 2039/40 |
| Total | 5,212,473 | 5,559,790 | 5,821,521 | 7% | 12% |

Table 4-3: Growth in highway demand forecasts from the 2018/19 Base Year – PFMv10a

| PFMv10a | 2018/19 | 2029/30 | 2041/42 | Growth from base | |
|---|---|---|---|---|---|
| | | | | To 2029/30 | To 2041/42 |
| Commute | 1,657,469 | 1,678,652 | 1,813,683 | 1% | 9% |
| Business | 796,942 | 832,526 | 885,170 | 4% | 11% |
| Leisure | 2,902,925 | 3,068,665 | 3,311,466 | 6% | 14% |
| Total | 5,357,336 | 5,579,843 | 6,010,319 | 4% | 12% |

## 4.3 Future year highway preload flows

4.3.1 In PFM's long-distance model, short-distance car trips and trips by 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 long-distance rail network[4]. This ensures that the total modelled link flows in the PLD highway model produce realistic travel costs for use in the demand model. Future year preloads are calculated by forecasting growth of 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 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 4-4. It should be noted that the DfT provides forecasts for 2010 to 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 2018/19 to 2029/30 and 2041/42.

[4] There is an implicit transfer of trips between rail and highway for short-distance trips in the short-distance regional models, but this is primarily to local commuter services rather than long-distance, high-speed services.

4.3.5 The growth in total traffic from 2018/19 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 4-4: 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% |

# 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. 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 Air demand forecasts

5.2.1 The base year air demand has been obtained from the DfT's aviation model[5]. Following the rebasing exercise, the base year for domestic air demand is 2018/19 to be consistent with the rail and highway modes. Forecast air demand is calculated by using aviation forecasts from the DfT aviation model published on the DfT's website to grow base air demand to forecast year levels. The resulting air demand forecasts for first and second forecast years are presented in Table 5-1 and compared to those used within PFMv9. The first forecast year has not changed and so the air forecasts are very similar, whilst the second forecast year has changed from 2039/40 to 2041/42.

Table 5-1: Daily Air Passenger Demand Forecasts

| Matrix | Base Year | | | First Forecast Year | | | Second Forecast Year | | |
|---|---|---|---|---|---|---|---|---|---|
| | PFMv9 2014/15 | PFMv10a 2018/19 | Difference (%) | PFMv9 2029/30 | PFMv10a 2029/30 | Difference (%) | PFMv9 2039/40 | PFMv10a 2041/42 | Difference (%) |
| Business | 16,233 | 15,834 | -2% | 18,030 | 18,087 | 0% | 21,415 | 22,408 | 5% |
| Leisure | 13,325 | 14,863 | 12% | 15,017 | 15,770 | 5% | 17,900 | 19,166 | 7% |
| Total | 29,558 | 30,697 | 4% | 33,046 | 33,856 | 2% | 39,315 | 41,574 | 6% |

## 5.3 Air supply forecasts

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

[5] https://www.gov.uk/government/publications/uk-aviation-forecasts-2017

- **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;
- **Fares**: average air fares for business and leisure provided from the DfT aviation model for the base year and grown for the forecast years; and
- **Journey time**: data for the base year from the DfT's aviation model.

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. Table 5-2 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 1,200 minutes, i.e. less than one flight a day, were not included in PLD.

5.3.3 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 air 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 5-2: 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 |

| Airport | IATA | Airport | IATA |
|---|---|---|---|
| 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 Quality assurance

6.1.1 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.); and
- **Red Check**: this involves a more wide-ranging quality assurance of all aspects of the model with associated check logs. This also details checks of the key files within the modelling framework.

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

6.1.3 The 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 PFMv10a.

6.1.4 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 that will be used within the PFM.

6.1.5 The quality assurance procedures described above recommended that the future year matrices are fit for the purpose of forecasting future year rail demand impacts for the HS2 scheme.

# 7 Summary

7.1.1 The update to the demand forecasts has involved not only updates to the demand drivers themselves, but also to the methodology used to forecast demand. The patterns and volumes of demand within the model base years have also been significantly affected by the rebasing of the PFM from 2014/15 to 2018/19.

7.1.2 Typically, the PFMv10a rail passenger demand matrices in the base and forecast years contain a higher volume of demand along key flows for HS2 than the PFMv9 model. This is despite PFMv10a using December 2020 DDGs which forecast significantly lower growth rates in rail demand from the base into the forecast years. The initially higher volume of rail demand on PFMv10a flows is eroded relative to PFMv9 the further into the future that one forecasts, due to the lower levels of rail demand forecast by the December 2020 DDGs.

7.1.3 Significant levels of quality assurance, analysis, and checking have been undertaken throughout the re-basing and demand forecasting process. As such, we have confidence that the reporting and analysis contained within this report is consistent with the latest forecast assumptions and prior expectations following the re-base and updates to the forecasting approach.