Department for Transport

Updated Appraisal Report
Airport Capacity in the South East

Moving Britain Ahead

October 2017

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1. Introduction

1.1 On 2nd February 2017, the Government published the "Draft Airports National Policy Statement: new runway capacity and infrastructure at airports in the South East of England" (draft Airports NPS)[1] and the supplementary "Appraisal of Sustainability: Draft Airports National Policy Statement" (AoS)[2] for public consultation. This consultation closed on 25th May 2017.

1.2 These documents set out:

- the Government's policy in relation to the need for new airport capacity in the South East;
- the Government's preference for the Heathrow (LHR) Northwest Runway scheme to deliver additional airport capacity; and,
- the requirements the applicant will need to meet in order to secure development consent for the preferred scheme.

1.3 The Further Review and Sensitivities Report (FRSR) was published in October 2016[3] and provides supporting evidence for the draft Airports NPS and AoS. The FRSR built on the Airports Commission's (AC) final report,[4] providing, in some areas, an updated assessment of the impacts of expansion to provide greater assurance. It was complementary to the AC's evidence base, and should be considered alongside the AC's final report.

1.4 In the consultation document on the draft Airports NPS,[5] the Government explained it was undertaking further work to update its passenger demand forecasts, and that it would publish this information as soon as possible during the consultation. We were unable to publish this information as intended due to restrictions in place during the pre-election period. We have continued to develop the aviation model to incorporate the latest market data (2016) and to produce an updated set of demand forecasts.

1.5 As the forecasts are an input into the economic and strategic assessment set out in the FRSR, we have updated this analysis to understand how it may have changed. This report presents this updated analysis. In this respect, this report should be considered as an update to the FRSR, replacing the central impacts it sets out. As with the FRSR, it should be considered alongside the AC's final report (and supporting documents) and the updated AoS, and as supporting evidence to the updated draft Airports NPS[6] published alongside this report.

Updating the evidence base

1.6 As set out above, the department has undertaken a full update of the aviation model that was used by the AC, with refined methodologies and incorporating the latest market data and forecasts of key inputs, such as oil prices and long-run GDP. We used this model to produce updated forecasts of future aviation demand. Full detail on the model development and the latest forecasts can be found in the DfT17

[1] https://www.gov.uk/Government/publications/draft-airports-national-policy-statement
[2] https://www.gov.uk/Government/publications/appraisal-of-sustainability-for-the-draft-airports-national-policy-statement
[3] https://www.gov.uk/Government/publications/airport-expansion-further-review-and-sensitivities-report
[4] https://www.gov.uk/Government/publications/airports-commission-final-report
[5] https://www.gov.uk/Government/consultations/heathrow-expansion-draft-airports-national-policy-statement
[6] Revised Draft Airports National Policy Statement, available at: https://www.gov.uk/dft/heathrow-airport-expansion

aviation passenger demand forecasts report.[7] In this document we refer to these forecasts as "DfT17 forecasts".

1.7 As discussed in detail in the FRSR, the demand forecasts are an important input to the quantified economic impacts and strategic assessment presented in the draft NPS and AoS. We updated the economic and strategic assessment using the department's DfT17 forecasts, alongside other data updates, where appropriate. As in the FRSR, we present analysis for the three shortlisted schemes considered by the AC:

- A full length northwest runway at Heathrow Airport: "LHR Northwest Runway";
- An extended runway at Heathrow Airport: "LHR Extended Northern Runway"; and,
- A second runway at Gatwick Airport: "LGW Second Runway".

1.8 Since the FRSR was published, the department has also undertaken updates to the methodology for estimating the direct economic and wider economic impacts. These updates are reported in this document and further explained in Annex A.

1.9 The appraisal set out in the FRSR included monetised estimates of environmental impacts such as air quality, noise and carbon. As these vary with aviation demand, these impacts have been updated using DfT17 forecasts and some with revised methodologies, as explained later in this document. Underpinning these monetised impacts are updated quantified impacts – such as the number of households affected by noise, for example – which are presented in the revised AoS, published alongside this report.[8] The revised AoS also sets out a much wider assessment of the non-monetised impacts of expansion and, combined with this report, provides a fuller presentation of the evidence base supporting the draft Airports NPS.

1.10 The department has considered how best to reflect demand uncertainty. The AC produced a number of demand scenarios before settling on a central case. We take a similar approach, using updated higher and lower scenarios to provide a range for most of the impacts considered in this report.

1.11 We have updated an approach taken by the AC to look at alternative ways future carbon policy could address international aviation emissions. This also allows us to assess the impacts of expansion if aviation sector emissions were constrained.

1.12 Sections 2 and 3 of this report describe the DfT17 forecasts under no expansion and each of the three schemes, and sets out their impact on the UK's aviation connectivity. Sections 4 through 8 analyse the effect of the DfT17 forecasts and any methodological or data updates for each quantified economic impact. Section 9 then assesses the effect of these updates on the combined monetised costs and benefits. Section 10 presents scenario and sensitivity analyses to show a fuller range of possible impacts.

[7] UK Aviation Forecasts 2017, available at: https://www.gov.uk/Government/collections/uk-aviation-forecasts
[8] Appraisal of Sustainability: Draft Airports National Policy Statement, available at: https://www.gov.uk/dft/heathrow-airport-expansion

2. Updates to aviation demand forecasts

Demand forecasting

2.1 Passenger demand forecasts are important inputs to the appraisal as they are used to calculate the monetised impacts of the three shortlisted schemes. The AC forecast passenger journeys, runway and terminal impacts and air transport movements (ATMs) for the do minimum (counterfactual) scenario and for each of the three expansion options, using an updated version of the department's aviation model.

2.2 The aviation model is a sophisticated tool which forecasts demand and allocates it across UK airports. It can be used to estimate the impact on patterns of demand under the three expansion options. A number of independent reviews have been carried out to assess the suitability of the aviation model, concluding that it is robust and fit for purpose. Further information can be found in the FRSR (p.14).

2.3 To produce new forecasts, the department updated the aviation model with the latest market data (2016) and made a number of developments. Further detail on these can be found in the aviation forecasts update report[7].

2.4 The DfT17 forecasts use the same terminal and runway capacity assumptions for the three shortlisted schemes as the AC forecasts, for example, the input capacities, thereby implicitly including assumptions on whether capacity is used in fully segregated, partially segregated (Heathrow) or full mixed mode[9] (Gatwick). It is these forecasts which underpin the analysis presented in this report.

Demand Scenarios

2.5 The AC considered a range of potential views of the future (scenarios) to allow for forecasting uncertainty. A detailed description of these scenarios was published in the AC's technical report *Strategic Fit: Updated Forecasts*.[10] These scenarios reflected uncertainties over important macro-economic drivers of future passenger demand (such as "global growth"), as well as different operating models that could come to dominate the market (such as "low-cost is king").

2.6 On independent advice from the International Transport Forum (ITF) the AC, in its final report, presented its main findings using the "assessment of need" scenario, treating it as a "central case", as the ITF deemed it to be the most likely scenario. The AC used other scenarios to test its findings and conclusions about the merits of each scheme.

2.7 The department has taken a similar approach in developing scenarios for the DfT17 forecasts. We have updated the central case developed by the AC and modelled higher and lower scenarios to provide a range.

2.8 The AC's central case, "assessment of need", used central projections published by sources such as the Office for Budget Responsibility (OBR), the Organisation for Economic Cooperation and Development (OECD) and the International Monetary Fund (IMF), and assumes that there are no changes in airline business models. These assumptions are broadly consistent with the central scenario used in the department's 2013 aviation forecasts[7], and have been carried over to the DfT17 central case. The AC incorporated some updates to the department's 2013 aviation

[9] See Glossary for further explanation.
[10] https://www.gov.uk/Government/uploads/system/uploads/attachment_data/file/439687/strategic-fit-updated-forecasts.pdf

model, which have also been included in the 2017 version of the department's model[7].

2.9 The DfT17 central case is used to estimate most of the impacts presented in this report, and comparisons are made to the AC's assessment of need, carbon traded forecasts (Section 3) and the economic impacts presented in the FRSR (Sections 4 to 9).

2.10 The main drivers of the AC's scenario analysis have been updated, such as future GDP. We have developed high/low demand scenarios to reflect GDP variability, broadly based on the assumptions underpinning the AC's global growth and global fragmentation scenarios (more detail on the assumptions can be found in the DfT17 forecast report)[7].

2.11 Varying such assumptions has the biggest impact on the range of economic benefits across all schemes, so the high/low scenarios are helpful to show this variability. The sensitivity of the appraisal results and connectivity outcomes of these demand scenarios is discussed in section 10, along with a discussion of the AC's findings from its own scenario analysis.

The DfT17 forecasts

2.12 Figure 2.1 shows the DfT17 forecasts of national passenger demand at all the main UK airports in million passengers per annum (mppa) compared to the AC's demand scenario range, without expansion and taking account of capacity constraints. It shows how recent passenger growth has exceeded previous forecasts. This largely reflects unexpected falls in oil prices and the way in which they are passed onto passengers. Further out, national passenger demand is forecast to exceed the AC's highest demand scenario to about 2020, and stays higher than the AC's assessment of need, carbon traded forecasts until 2030, where after it follows the AC's assessment of need forecast.

2.13 Figure 2.2 compares the forecast range given by the AC's highest and lowest scenarios to the range given by the high and low scenarios in DfT17, without expansion. As with the central forecast, the DfT17 ranges start higher than the AC as the updated model takes account of recent aviation demand data. The low end of the range then broadly follows the low end of the AC's range. The DfT17 high end ends up slightly lower than the AC's, as it makes use of the OBR's latest long-term GDP forecasts, which are lower than those used in the AC analysis.

Figure 2.1 Terminal passengers at UK airports (mppa)

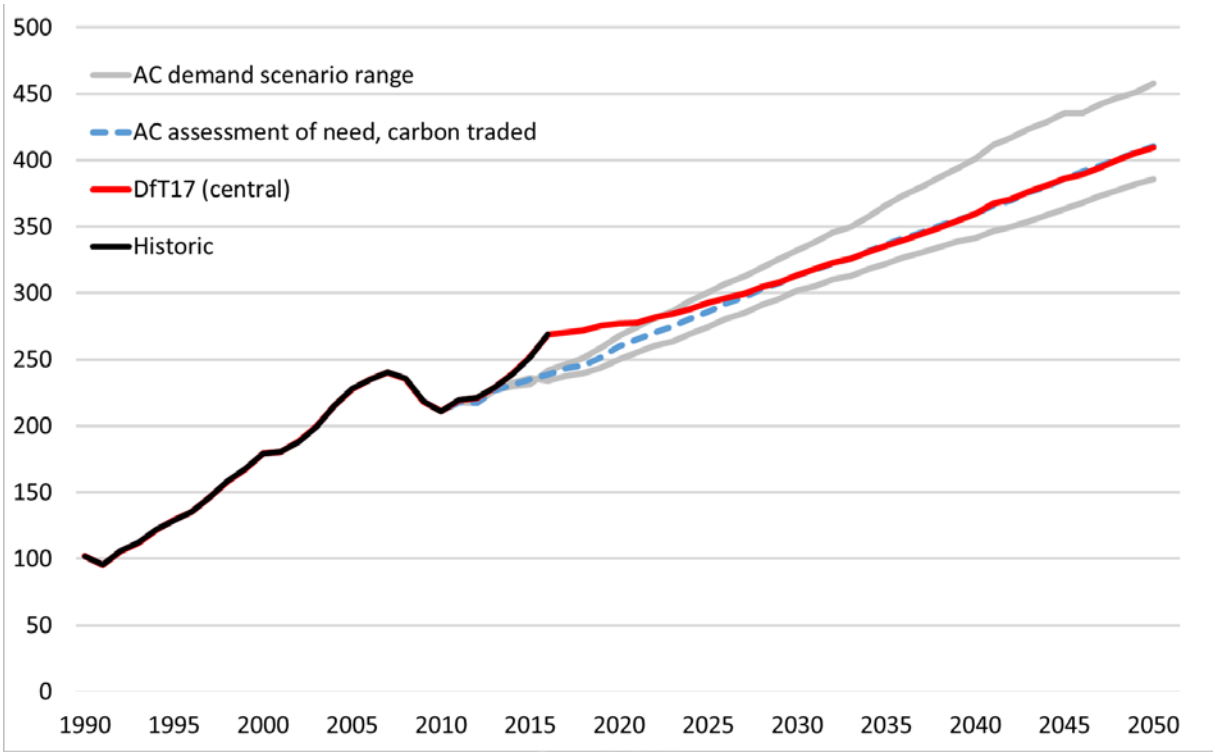
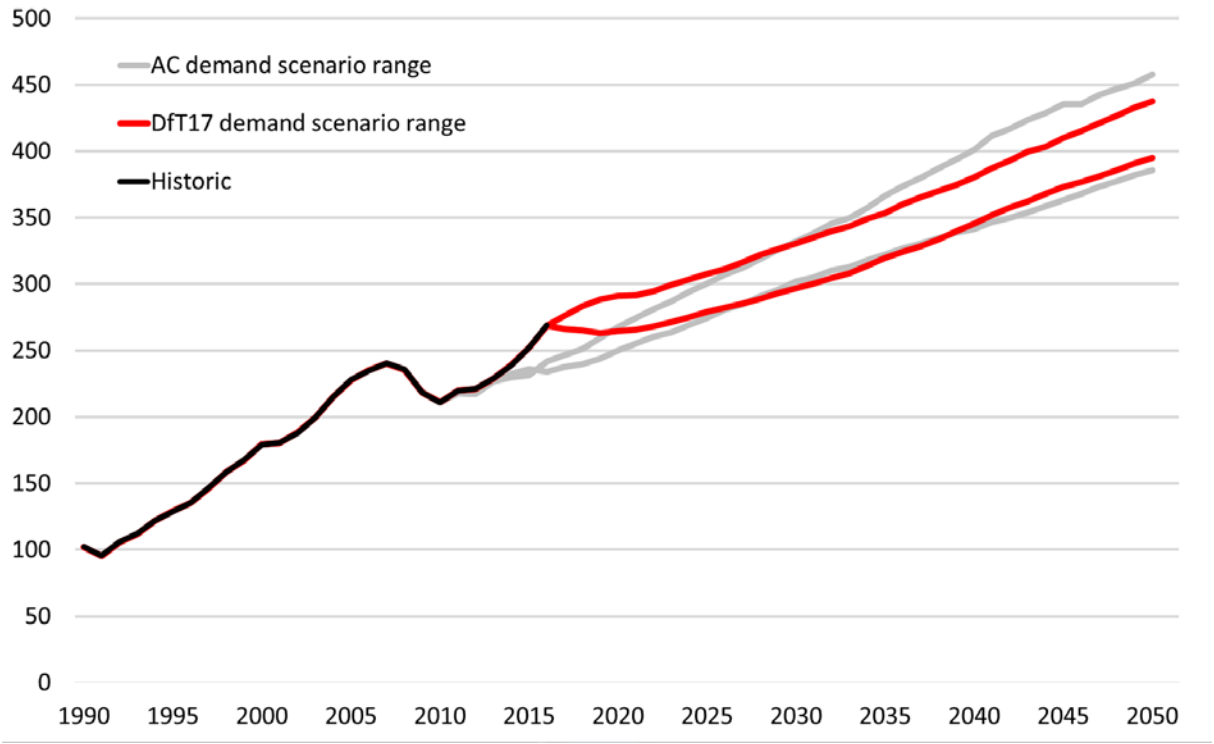


Figure 2.2 Terminal passengers at UK airports, demand range comparison (mppa)



Box 2.1 Demand forecasting and future carbon policy

We have made significant steps in developing international measures for addressing aviation carbon dioxide (CO_2) emissions, such as the recent agreement at ICAO for a global market based measure[11]. However, there remains uncertainty over climate change policy and international arrangements to reduce CO_2 and other greenhouse gases (GHGs). The AC devised two scenarios to reflect this uncertainty: carbon traded and carbon capped. In this assessment the department has followed the same approach.

The **carbon traded** scenario assumes aviation emissions are tackled at an international level. UK aviation is part of the EU Emissions Trading Scheme[12] until 2030 and then a fully functioning global carbon market thereafter. The scenario is reflected in the passenger demand modelling by using carbon values published by the Department for Business, Energy & Industrial Strategy (BEIS)[13] that reflect the forecast of the price of carbon credits under such an arrangement[14].

The effect of this is to reduce demand and lower emissions in the aviation sector over the forecast period, while also ensuring all emissions covered by the trading scheme remain at or below the cap set. In this report, the department has used the AC's formulation of the carbon traded scenario[15]. The only change has been to update the carbon price series to the latest edition published by BEIS[16].

In the **carbon capped** case, emissions from departing flights are limited under all scenarios, including no expansion, to 37.5 $MtCO_2$ in 2050[17]. The AC presented a number of ways in which this could be achieved, from imposing a much higher carbon price (which reduces aviation demand) to identifying a range of technological measures which could be employed at airports and by airlines to reduce CO_2 emissions. This latter approach is known as "abatement" and different measures are ordered lowest to highest according to their cost per tonne of CO_2 reduced, on a 'curve' known as a 'marginal abatement cost curve' (MACC).

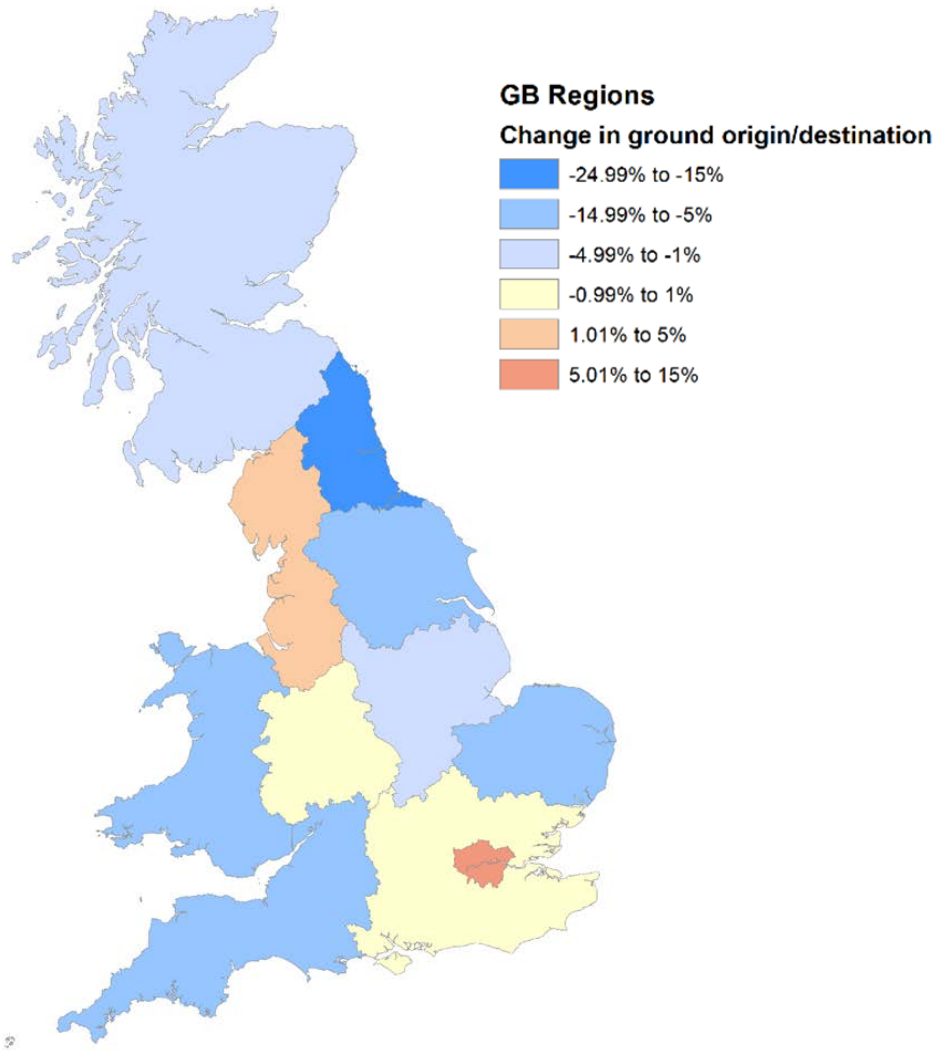
In producing a carbon capped scenario, the department has simplified the AC's analysis by presenting only a MACC approach. This takes account of updated research on the costs of abatement measures[18]. Under this approach, if expansion leads to CO_2 emissions above the 37.5$MtCO_2$ planning assumption, then further abatement effort is required to meet the assumption and its cost included in the appraisal. Further details of the abatement required under the different expansion scenarios, the measures used and their associated costs are provided in Box 8.1 of the Carbon section below.

To simplify the analysis, we assume that the same carbon price is used for both carbon scenarios. This means that we would expect future aviation demand to be the same under both scenarios, as the same carbon price would have the same impact on supressing demand (with further specific measures making up the additional abatement required under the carbon capped scenario). **The associated passenger forecasts are therefore the same under both carbon traded and capped scenarios and so are the impacts set out in sections 3 to 9.** Where this is not the case because of, for example, the knock on effects of the abatement measures to other impact areas, this is noted in the relevant section.

[11] https://www.icao.int/environmental-protection/Pages/market-based-measures.aspx
[12] https://ec.europa.eu/clima/policies/ets_en
[13] BEIS Traded Carbon Values for Appraisal. See table 3 of 'Data Tables 1 – 19' available at: https://www.gov.uk/Government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal
[14] The main difference is that BEIS assume the EU ETS continues only until 2020, not 2030 and there is a transitional arrangement for 10 years until a comprehensive international carbon trading scheme is in place.

Regional and National Differences

Figure 2.3 Aviation passengers starting ground journey in each region in 2040, without expansion. Percentage change from the AC's assessment of need, carbon traded forecasts to the DfT17 central forecasts.



2.14 Figure 2.3 shows that more aviation passengers start or end their journey (i.e. by car or by rail) in London in 2040 under the DfT17 forecasts than in the AC's assessment of need, carbon traded forecasts. This is due to both the distribution of additional passengers seen between 2011 and 2016, and the expected differences in future population growth across regions.

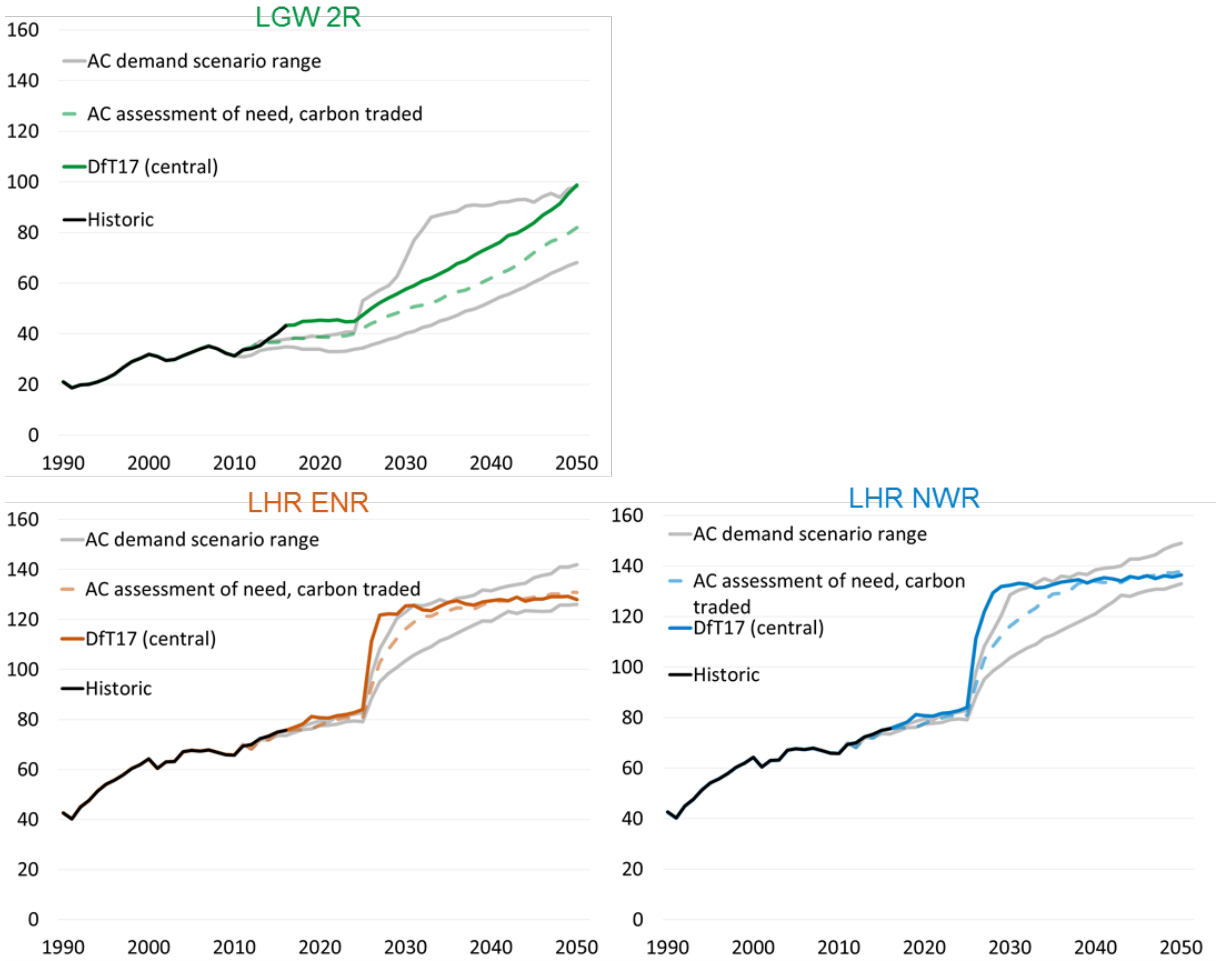
[15] For more info see https://www.gov.uk/Government/uploads/system/uploads/attachment_data/file/439687/strategic-fit-updated-forecasts.pdf page 55 onwards.
[16] BEIS Traded Carbon Values for Appraisal. See table 3 of 'Data Tables 1 – 19' available at: https://www.gov.uk/Government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal
[17] This is in line with the Committee on Climate Change's 'planning assumption where the UK's emissions from international departing flights are limited to 2005 levels in 2050. In 2005, emissions from international and domestic aviation were 35MtCO2 and 2.5MtCO2 respectively (see https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2015). This is the level they recommend is compatible with the UK achieving its statuary requirement of reducing emissions by 80% compared to 1990 levels by 2050.
See https://www.theccc.org.uk/archive/aws/IA&S/CCC_IAS_Tech-Rep_2050Target_April2012.pdf, p. 18 – 19.
[18] Carbon Abatement in UK Aviation: Final Report, available at: https://www.gov.uk/government/collections/uk-aviation-forecasts

2.15 The increased concentration of passenger demand around London is reflected in passenger traffic at London airports. Passenger demand at London airports consistently exceeds the AC's assessment of need, carbon traded forecasts throughout the modelled period, though the forecasts start to converge towards 2040.

2.16 Higher passenger demand in London means that London's airports will be full sooner without expansion than previously forecast. London's five major airports[19] are expected to be full by 2034 according to the DfT17 forecasts, with four out of five full by 2025, compared to 2036 and 2029 respectively under the AC's assessment of need, carbon traded forecasts. By 2050 demand at London's airports is expected to outstrip capacity by at least 34%, even on the department's low demand forecast, further reinforcing the case for change made in the draft Airports NPS.

2.17 Figure 2.4 shows passenger demand at both potentially expanded airports under the DfT17 forecasts, relative to the AC's demand scenario range.

Figure 2.4 Terminal passengers at the expanded airport (mppa)



2.18 Under the DfT17 forecasts, passenger demand at an expanded Gatwick is consistently above the AC's assessment of need, carbon traded forecasts and, by 2050, reaches the high end of the AC's demand scenario range.

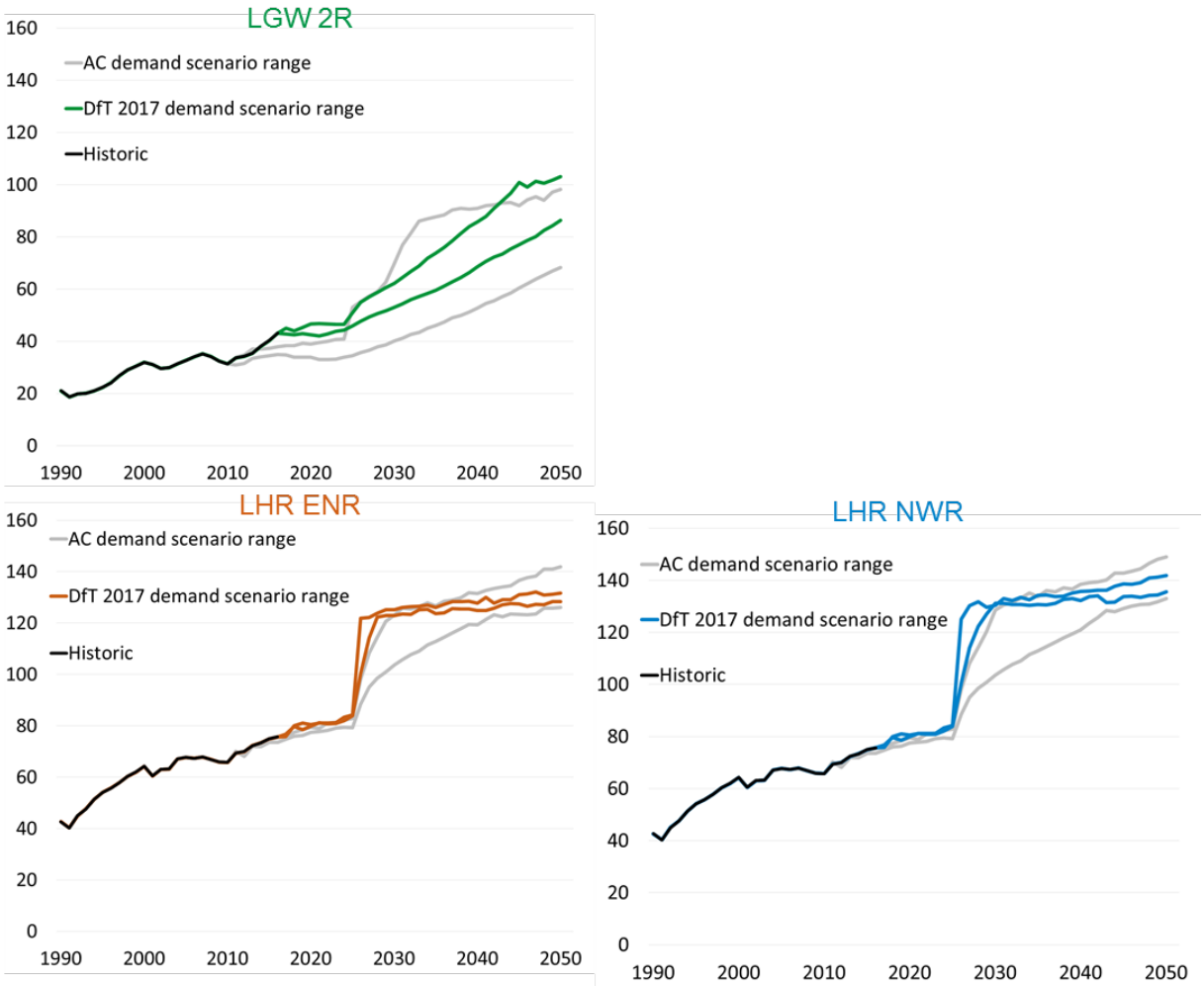
2.19 Under the LHR Northwest Runway scheme, Heathrow airport is expected to be full by 2028, compared to 2035 in the AC's assessment of need, carbon traded forecasts. This assumes no phasing of additional capacity, and no barriers to airlines making use of this capacity as soon as it becomes available. Heathrow's runways also fill up

[19] Gatwick, Heathrow, London City, Luton and Stansted

sooner under the LHR Extended Northern Runway scheme (2027 compared to 2032). This reflects the much higher pent up demand at Heathrow now found in the DfT17 forecasts. Without expansion the system is more constrained, and when additional capacity is built, this pent up demand is released, filling up the extra capacity quickly. Under both Heathrow expansion schemes, passenger demand is greater than the AC's demand scenario range immediately after expansion, but then by 2035 broadly similar to the AC's assessment of need, carbon traded forecasts.

2.20 Figure 2.5 compares the AC's demand ranges at the potentially expanded airport with the demand range of the DfT17 forecasts. At Heathrow, like the AC range, the DfT17 range is very narrow until expansion because the airport is already full. The range is much narrower after expansion because the DfT17 forecasts indicate much higher pent-up demand at Heathrow. This means even in the low scenario, the airport is expected to fill up much more quickly than shown by the AC's lowest scenario.

Figure 2.5 Terminal passengers at the expanded airport, demand range comparison (mppa)



2.21 Similarly at Gatwick, the AC and the DfT17 range is narrow until expansion as the airport fills up. The DfT17 forecast range continues to be much narrower after expansion, as the higher demand found in the DfT17 forecasts suggests Gatwick will be much busier even in the low demand scenario. This higher demand shown in the DfT17 forecasts also indicates that Gatwick could service even more passengers in the higher scenario than found in the AC's highest scenario after 2040.

2.22 We have used these higher demand scenarios to assess the effect of the expanded airport on local impacts, such as noise and air quality, to provide a “worst-case” assessment. The results are discussed in detail in the AoS.

3. Connectivity

3.1 Aviation is about connecting people – allowing businesses to reach new markets, find new suppliers and share knowledge globally, and allowing people to experience different cultures, meet friends and see family. The ability to provide these connections is ultimately dependent on the available capacity at UK airports, with an increase in this capacity allowing for more flights to more destinations worldwide.

3.2 While the concept of connectivity is simple to understand, it is not simple to measure, and can be approached in numerous ways. To assess connectivity impacts, this report considers the selection of metrics thought to best summarise how connectivity outcomes under the expansion schemes align with the strategic objectives for airport expansion, in terms of connections internationally across the UK.

International connectivity

3.3 The AC's forecasts showed that the LHR Northwest Runway scheme was expected to deliver the greatest increase in flights at the UK level, with the number of flights to long-haul destinations notably higher than under the other schemes. More flights means more opportunities to fly to the places people want to go, on a day and at a time that suits. By providing more frequent capacity for passengers and freight operators, international trade is facilitated and businesses and their staff encouraged to locate and remain in the UK. Table 3.1 shows that these differences are similar under the department's DfT17 forecasts[20], with the LHR Northwest Runway scheme continuing to deliver the greatest increase in flights.

Table 3.1 ATMs at UK airports, without expansion, and additional ATMs under each scheme, compared to no expansion (thousands)

		Total ATMs			Long Haul ATMs		
		2030	2040	2050	2030	2040	2050
AC Forecasts	No Expansion	2,561	2,848	3,213	280	315	364
	LGW Second Runway	+22	+54	+60	+4	+8	+15
	LHR Extended Northern Runway	+78	+104	+89	+27	+33	+25
	LHR Northwest Runway	+79	+125	+105	+27	+39	+33
DfT17 Forecasts	No Expansion	2,330	2,584	2,901	253	282	315
	LGW Second Runway	+11	+15	+77	+1	+8	+17
	LHR Extended Northern Runway	+110	+85	+88	+29	+37	+27
	LHR Northwest Runway	+129	+113	+111	+35	+43	+37

3.4 Compared to the AC's forecasts, the DfT17 forecasts show fewer total UK ATMs in the baseline of no expansion and across all schemes. This reflects updates to the aviation fleet mix model which forecasts the size of planes, and to load factors i.e.

[20] As discussed in Box 2.1, connectivity outcomes are the same under the DfT17 carbon traded and carbon capped cases

how many passengers travel on a particular flight. So, while passenger numbers are similar to the AC's forecasts, larger, and fuller planes, mean fewer flights are required.

3.5 The DfT17 forecasts show that the Heathrow expansion schemes deliver better international connectivity earlier on, with large increases in flights by 2030. By 2050, the department's updated forecasts find less difference between the Heathrow and Gatwick schemes for total ATMs, but Heathrow expansion continues to deliver substantially more long haul ATMs. These long haul flights are particularly important for connecting businesses to emerging markets, and account for the majority of air freight transported – a large proportion of total UK trade. This pattern of relative performance is also seen under the high and low forecast scenarios discussed in Section 10.

3.6 These additional flights are made possible by Heathrow's substantial transfer passenger market.[21] As with the AC's forecasts, the department's DfT17 forecasts show that Heathrow expansion results in an immediate and substantial increase of transfer passengers, providing the demand necessary for more frequent flights to destinations worldwide. Once Heathrow reaches capacity, the number of additional international passengers declines as they are displaced by direct UK origin and destination passengers.

3.7 The department's DfT17 forecasts show substantially stronger demand for services from Gatwick than previously observed, but the number of additional flights following expansion is less affected. Under the LGW Second Runway scheme, Gatwick is expected to remain a largely point-to-point airport, attracting few transfer passengers. Heathrow would continue to be constrained and therefore disadvantaged in comparison to competitor hubs which would lure away transfer passengers. This in turn would weaken the range and frequency of viable routes.

Seat Capacity

3.8 While ATMs provide an indicator of the frequency and capacity of available services, seat numbers provide further information on the capacity created. Under either Heathrow scheme the initial seat capacity increase in 2030 is significantly higher than under the LGW Second Runway scheme, as shown in Table 3.2. By 2050, expansion at Gatwick delivers comparable levels of additional seats to short haul markets, but Heathrow expansion continues to provide many more long haul seats. This seat data provides helpful context for Gatwick's lower expected ATM growth to 2040 – as flights from the airport have seen higher load factors and larger aircraft, fewer ATMs going forward are needed to deliver similar levels of passenger capacity.

[21] See Glossary for further explanation.

Table 3.2 International airline seats available at UK airports, without expansion, and additional seats under each scheme, compared to no expansion (millions)

		Short Haul			Long Haul		
		2030	2040	2050	2030	2040	2050
AC Forecasts	No Expansion	247	284	319	93	107	128
	LGW Second Runway	+1.3	+5.0	+10.1	+1.0	+2.7	+4.7
	LHR Extended Northern Runway	+10.0	+13.2	+9.8	+10.2	+12.7	+9.6
	LHR Northwest Runway	+10.0	+16.2	+12.9	+10.2	+15.0	+12.7
DfT17 Forecasts	No Expansion	253	295	335	82	93	107
	LGW Second Runway	+1.3	+5.2	+16.2	+0.9	+3.2	+4.6
	LHR Extended Northern Runway	+11.4	+13.2	+15.6	+11.2	+13.4	+8.5
	LHR Northwest Runway	+13.5	+15.8	+19.6	+13.1	+15.7	+11.7

3.9 Seat numbers, as well as directly reflecting passenger capacities, can be used to infer possible impacts on freight handlers[22]. Larger, wide-body aircraft can typically carry proportionately more bellyhold freight than single-aisle aircraft, so with greater seat provision we would expect greater capacity for imports and exports, putting downward pressure on costs and thus boosting trade and Gross Domestic Product (GDP) benefits. With expansion at Heathrow delivering the greatest number of seats (to long haul markets especially), we would expect greater potential for these benefits to be realised.

Destinations

3.10 Serving destinations at least daily is important because it allows customers and businesses to travel at a day and time that suits them. With increasingly global supply chains, high frequency services ensure businesses can quickly and reliably source parts, while providing consumers with express delivery services for finished goods. Table 3.3 shows that expansion at Heathrow would result in the largest increase in daily destinations served by UK airports, with especially strong growth in long haul routes.

3.11 Expansion under any of the three schemes is found to have a lesser impact on the total number of destinations offered by UK airports. While the number of destinations served is largely unaffected by expansion at Gatwick, either of the Heathrow schemes see slight increases in long haul destinations offset by slight falls in short haul destinations. Total modelled destinations are less helpful than those of a specified frequency, as they can include very infrequent modelled charter services that offer little in the way of true connectivity benefit.

[22] In the model, increases in seats occur because of larger planes. In practice, some increases in seats are possible by reconfiguring existing planes, and which would not therefore impact on available bellyhold space, although this increase would be small in comparison to the increases in seat capacity shown here.

Table 3.3 Destinations served at least daily by scheduled services, and at any frequency by all services, at all UK airports without expansion, and additional destinations served under each scheme compared to no expansion

		Daily Short Haul			Daily Long Haul			All Short Haul			All Long Haul		
		2030	2040	2050	2030	2040	2050	2030	2040	2050	2030	2040	2050
AC Forecasts	No Expansion	129	128	135	74	79	83	239	241	243	123	129	130
	LGW Second Runway	-1	+5	+8	+1	+2	+5	-1	0	+2	0	0	+1
	LHR Extended Northern Runway	+2	+7	+3	+7	+6	+9	-3	-1	0	+1	0	+3
	LHR Northwest Runway	+2	+7	+2	+7	+8	+9	-3	-1	0	+1	+1	+3
DfT17 Forecasts	No Expansion	115	121	129	62	66	69	242	244	247	117	120	122
	LGW Second Runway	-1	+4	+6	+2	+1	+3	-1	0	0	0	0	-1
	LHR Extended Northern Runway	+5	+8	+8	+14	+12	+11	-7	-4	-3	+4	+2	+1
	LHR Northwest Runway	+9	+9	+11	+16	+14	+12	-7	-5	-3	+5	+2	+2

3.12 It is important to consider not just the type of capacity created by expansion, but how, and by who, this capacity is used. Similar to the AC's forecasts, the updated forecasts show the Heathrow Northwest Runway delivers the greatest increase in terminal passengers throughout the modelled period, with notably higher passenger numbers in the short term, but with the LGW Second Runway scheme delivering a similar number of passengers by 2050. The increase in passenger numbers under each scheme is shown in Table 3.4 for both the AC's assessment of need, carbon traded forecasts and the department's updated central forecasts.

Table 3.4 Terminal passengers at UK airports, without expansion, and additional terminal passengers under each scheme, compared to no expansion (mppa)

		Terminal Passengers		
		2030	2040	2050
AC Forecasts	No expansion	314	360	411
	LGW Second Runway	+3	+8	+16
	LHR Extended Northern Runway	+17	+23	+20
	LHR Northwest Runway	+17	+27	+25
DfT17 Forecasts	No expansion	313	360	410
	LGW Second Runway	+3	+10	+23
	LHR Extended Northern Runway	+24	+22	+20
	LHR Northwest Runway	+29	+28	+26

3.13 Tables 3.5a to 3.5d break down the terminal passengers between UK and non-UK passengers, and whether passengers are flying direct or via a UK or foreign hub. The tables show that expansion at Heathrow reduces interlining at foreign hubs and enables the UK to attract more international transfer passengers, strengthening

Heathrow's hub status[23] and gaining the additional benefit of higher frequency of services.

3.14 Up to the 2040s, this leads to more UK origin and destination passengers under the LHR Northwest Runway scheme, especially those that make use of additional capacity at the expanded airport. By 2050 this reverses, with more origin and destination passengers under the LGW Second Runway scheme, due in part to the higher capacity assumed at Gatwick and constraints at Heathrow.

Table 3.5a Terminal passengers at UK airports, by destination and route without expansion, DfT17 forecasts (mppa)

	International passengers travelling to, or from, the UK			UK Domestic end to end	Non-UK International to International Interliners
	Direct	Domestic Interliners	International Interliners		
2016	196.2	7.8	7.5	31.3	23.9
2030	248.8	3.8	4.2	37.9	18.7
2040	301.0	2.0	3.0	42.5	11.4
2050	350.5	1.8	3.2	49.2	4.9

*Each domestic interlining trip generates three terminal uses – on (1) taking off from the origin airport, (2) landing and (3) taking off at the domestic hub. A full description of the approach taken to counting passengers is provided in the UK aviation forecasts report.

+ 2016 outputs are modelled, and therefore differ from the CAA's data, but within a small margin

Table 3.5b Additional terminal passengers at UK airports, by destination and route, under the LGW Second Runway scheme, compared to no expansion, DfT17 forecasts (mppa)

	International passengers travelling to, or from, the UK			UK Domestic end to end	Non-UK International to International Interliners
	Direct	Domestic Interliners*	International Interliners		
2030	-0.3	+1.6	+0.3	+0.0	+1.6
2040	+2.3	+2.2	+0.4	+0.2	+5.0
2050	+11.4	+2.8	-0.5	+1.0	+7.9

[23] See Glossary for explanation.

Table 3.5c Additional terminal passengers at UK airports, by destination and route, under the LHR Extended Northern Runway scheme, compared to no expansion, DfT17 forecasts (mppa)

	International passengers travelling to, or from, the UK			UK Domestic end to end	Non-UK International to International Interliners
	Direct	Domestic Interliners*	International Interliners		
2030	-1.9	+10.9	-0.7	-0.0	+15.8
2040	+2.3	+2.2	+0.0	+0.1	+17.7
2050	+8.0	+0.5	-0.7	+0.5	+11.5

Table 3.5d Additional terminal passengers at UK airports, by destination and route, under the LHR Northwest Runway scheme, compared to no expansion DfT17 forecasts (mppa)

	International passengers travelling to, or from, the UK			UK Domestic end to end	Non-UK International to International Interliners
	Direct	Domestic Interliners*	International Interliners		
2030	-2.7	+13.8	-0.7	+0.0	+18.6
2040	+2.0	+4.3	+0.0	+0.2	+21.1
2050	+9.4	+0.7	-0.8	+0.6	+15.8

Connectivity across the UK

3.15 Expansion is not just for the South East of England, as the whole of the UK will benefit from the enhanced connectivity on offer.

3.16 Table 3.6 shows that substantial numbers of passengers from outside of London and the South East will benefit from the improved international connectivity provided by expansion. It therefore remains the case that an expanded Heathrow will allow more passengers from across the UK to benefit from access to important international markets from the airport.

3.17 These reflect Heathrow's strong and improving connections to the UK's strategic road and rail networks, facilitating access for passengers and freight travelling from much of the UK. These figures also include passengers taking flights from their local airport and using Heathrow as a hub.

Table 3.6 International passenger trips from, or to, regions outside of London and the South East using Gatwick / Heathrow in 2040, and additional passenger trips under each scheme, compared to no expansion (mppa)

	AC Forecasts	DfT17 Forecasts
No expansion (Gatwick)	**5.4**	**4.3**
LGW Second Runway	+3.0	+3.8
No expansion (Heathrow)	**13.6**	**11.5**
LHR Extended Northern Runway	+4.5	+4.6
LHR Northwest Runway	+5.5	+5.9

3.18 The DfT17 forecasts show that without expansion, domestic services into London would come under increasing pressure with routes lost due to the more constrained nature of the London airport system. However, with expansion a total of five domestic routes from Heathrow are protected until 2050, two more than if expansion does not occur. Gatwick's seven modelled domestic routes are found to remain without expansion in the department's updated forecasts. [24] By contrast, the AC found that without expansion, the number of modelled domestic routes at Heathrow fell from seven to three by 2040. With expansion, one of these lost routes remained protected and Heathrow's other domestic links became busier. It is important to note that neither the DfT17 nor the AC forecasts take into account potential interventions to enhance domestic connectivity, as have been proposed by the scheme promoters (and discussed further in the draft Airports NPS)[25].

3.19 Without expansion, the DfT17 forecasts show that passenger numbers are expected to grow significantly at both London and non-London airports, although the forecast is for a few million more in London, and a few million less outside London than estimated under the AC's assessment of need, carbon traded forecasts. While expansion will also see some displacement of passengers from other airports to the London system, overall non-London airports continue to display strong growth in passenger numbers by 2050, as shown in Table 3.7. This growth reflects the expectation that connectivity will continue to improve across UK airports.

[24] Gatwick is actually found to have one fewer domestic route under expansion. This is not deemed to be significant and is a result of slightly different allocations of demand between two relatively nearby airports (Edinburgh and Glasgow).
[25] Revised Draft Airports National Policy Statement, p. 24 - 25

Table 3.7 Terminal passengers at UK airports, by London and non-London airports, DfT17 forecasts (mppa)

		2016	2030	2040	2050
No expansion	London airports	162	187	199	205
	Rest of UK	104	126	160	204
LGW Second Runway	London airports	162	192	220	249
	Rest of UK	104	124	150	183
LHR Extended Northern Runway	London airports	162	216	235	239
	Rest of UK	104	122	147	190
LHR Northwest Runway	London airports	162	222	241	248
	Rest of UK	104	121	146	187

+ 2016 outputs are modelled, and therefore differ from the CAA's data, but within a small margin

4. Direct economic impacts

4.1 Airport expansion as set out in the previous two sections is expected to enable more people to fly more frequently to destinations around the world. This improved connectivity benefits the wider economy as it facilitates increased trade and GDP, but it also provides direct benefits, particularly to passengers from improved journeys. This section considers the impacts that arise as a direct consequence of the DfT17 forecasts on passengers, airlines and Government.

Passenger benefits

4.2 The AC monetised three benefits to passengers from the shortlisted expansion schemes.

- **Lower fares:** when an airport is congested, there is a shortage of flights, which means that airlines can charge higher fares for passengers. Reducing congestion by increasing capacity will reduce fares.
- **Frequency benefits:** when an airport is expanded, airlines are able to offer more flights to the same destination at different times. Passengers therefore benefit from being more likely to be able to travel at their preferred time.
- **Reduced delays:** a congested airport will have a tighter schedule, which means it will be less able to recover from disruption e.g. from bad weather. Reducing congestion will mean fewer delays to passengers.

4.3 The aviation forecasts are a direct input into all of these components. Higher levels of demand lead to greater congestion within existing capacity constraints, and thus to greater benefits to passengers when additional capacity is provided. Passenger benefits have been updated with the latest forecasts from the aviation model.

4.4 As set out in the FRSR, the department has updated the appraisal values of time used as an input to the valuation of frequency benefits. In addition, the department refined its approach to allow frequency benefits attached to domestic flights to be estimated.

4.5 The department's updated estimates of disaggregated passenger benefits for each scheme are provided in Table 4.1, alongside those estimated using the AC's assessment of need, carbon traded forecasts for the 60 year appraisal period following expansion.[26] These results also apply to the updated carbon capped scenario.

4.6 Estimated passenger benefits associated with the Heathrow expansion schemes are higher than those estimated by the AC. The estimated frequency benefits are lower largely because the updated appraisal values of time for business passengers are lower than the equivalent figure used by the AC (more detail can be found in Annex A). Benefits from reduced delays are lower, partly because of the fall in appraisal values of time but also because after expansion, Heathrow is expected to fill up more quickly.

4.7 Estimated passenger benefits associated with the LGW Second Runway scheme are significantly higher than those estimated by the AC. This is primarily because of the

[26] The 60 year appraisal period runs from the assumed year of scheme opening (2025 to 2084 for LGW Second Runway, and 2026 to 2085 for the Heathrow expansion schemes).

higher demand forecasts for Gatwick, and its extra capacity from operating in mixed mode. With a second runway, 99 million passengers are forecast to use the airport by 2050, compared to 82 million under the AC's assessment of need, carbon traded forecasts. Higher demand does lead to reduced delay benefits, although the primary driver for the change in benefits from reduced delays is the fall in the appraisal values of time.

Table 4.1 Disaggregated cumulative passenger benefits by 2084/5 (present value, £bn, 2014 prices)[27]

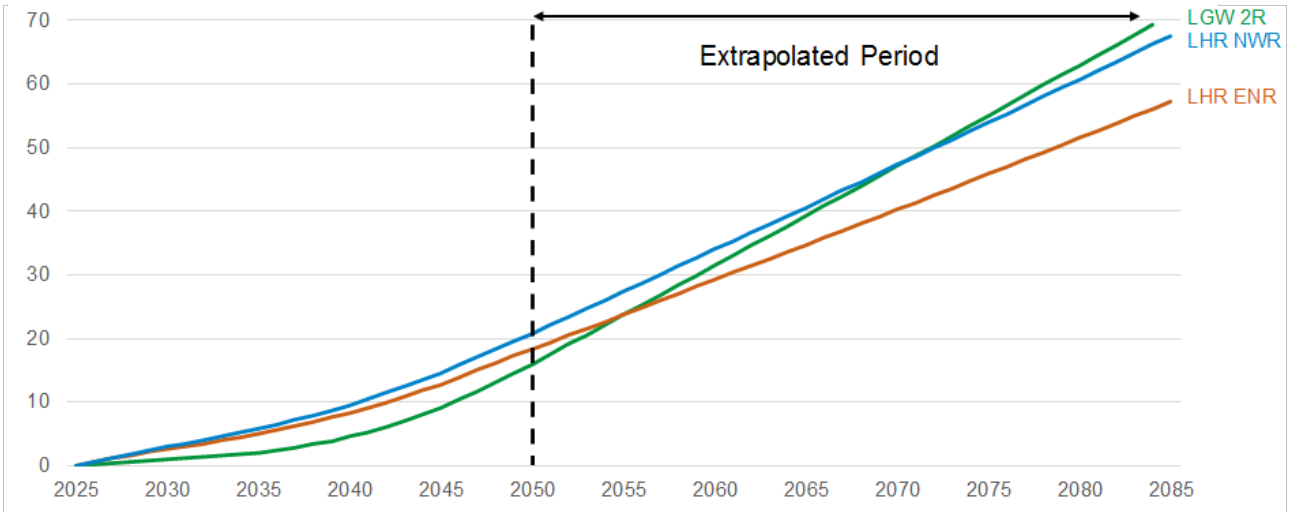
Passenger Benefits to 2084/5		Split by passenger type				Split by benefit type			
		UK Residents	Non – UK Residents	I to I	Total	Frequency benefits	Lower fares	Delays	Total
LGW Second Runway	FRSR (AC Forecasts)	33.9	12.9	1.7	48.5	3.2	43.9	1.4	**48.5**
	DfT17	45.3	21.8	2.3	69.4	4.0	64.5	0.8	**69.4**
LHR Extended Northern Runway	FRSR (AC Forecasts)	29.2	12.5	5.2	46.9	4.6	41.9	0.4	**46.9**
	DfT17	34.9	18.2	4.1	57.2	2.6	54.5	0.1	**57.2**
LHR Northwest Runway	FRSR (AC Forecasts)	34.2	14.6	6.5	55.4	5.7	49.2	0.6	**55.4**
	DfT17	40.8	21.2	5.5	67.6	3.0	64.3	0.2	**67.6**

4.8 Figure 4.1 presents estimated cumulative passenger benefits across the 60 year appraisal period to illustrate how cumulative passenger benefits associated with each scheme are expected to change across the modelled time period to 2050, and the extrapolated period thereafter.

4.9 As Heathrow continues to have more pent-up demand than Gatwick under the DfT17 forecasts, it remains the case that the Heathrow expansion schemes, in particular the LHR Northwest Runway scheme, will cumulatively provide more passenger benefits by 2050 than the LGW Second Runway scheme. However, the DfT17 forecasts indicate that passenger benefits will be slightly greater under the LGW Second Runway scheme, by about £1.5bn, when considered over the full 60 year appraisal period, although it is not until the 2070s before cumulative benefits are higher with expansion at Gatwick.

[27] I to I stands for international-to-international interliners i.e. passengers who are transferring via a UK airport with their origin and destination outside of the UK.

Figure 4.1 Cumulative passenger benefits by forecast year (present value, £bn, 2014 prices)



		2030	2040	2050	2084/5
LGW Second Runway	FRSR (AC Forecasts)	0.8	4.4	12.8	48.5
	DfT17	1.0	4.6	16.0	69.4
LHR Extended Northern Runway	FRSR (AC Forecasts)	2.1	8.7	16.7	46.9
	DfT17	2.6	8.3	18.3	57.2
LHR Northwest Runway	FRSR (AC Forecasts)	2.2	9.6	18.9	55.4
	DfT17	3.0	9.6	20.8	67.6

Airline and Government impacts

4.10 The AC also monetised the impacts of airport expansion on airlines and Government, which are derived from three components.

- **Airlines' profit impact:** When a congested airport expands, the profits of airlines operating out of that airport will be affected as the increase in supply means that they are no longer able to charge the higher fares they were able to charge passengers when the airport was congested. They are, however, able to recoup part of this from being able to serve more passengers once the airport is expanded, and can earn higher fares if the airport becomes constrained again.
- **Reduced delays to airlines:** The profit impact is partly offset by the reduction in delays that occur, which benefits airlines (as well as passengers).
- **Government revenue:** Additional Air Passenger Duty (APD) from increased passenger traffic and changes in Value Added Tax (VAT) revenue. The latter arises because additional passengers may be transferring their expenditure from goods and services which are subject to VAT to air fares, which are not subject to VAT.

4.11 The department's updated estimates of airline ('producer') and Government impacts for each scheme over a 60 year appraisal period are shown in Table 4.2, alongside those estimated using the AC's assessment of need, carbon traded forecasts. These figures are the same for the carbon capped scenario.

4.12 The estimated impacts on airlines are significantly larger than estimated by the AC, especially with expansion at Gatwick. This reflects the much higher short-term demand shown in the DfT17 forecasts. With a constrained system, this higher demand suggests airlines would be able to earn greater fare premiums. When additional capacity is then released, airlines lose this ability, and relative to the AC's

estimates, these losses would be greater. In the Heathrow case, however, the airport fills up quickly, meaning that airlines can again start charging additional fares, so the overall loss is lower. In the Gatwick case it takes longer to fill up, reducing the number of years when the system is constrained, and the opportunity for airlines again to earn fare premiums, and recoup some of the earlier losses.

Table 4.2 Disaggregated cumulative producer and Government impacts by 2084/5 (present value, £bn, 2014 prices)

		Impacts to 2084/5			
		Producer Profit Impact	Producer Delay Impact	Total Producer Impact	Government Revenue Impact
LGW Second Runway	FRSR (AC Forecasts)	-41.8	1.0	**-40.8**	**2.5**
	DfT17	-66.0	0.9	**-65.1**	**4.6**
LHR Extended Northern Runway	FRSR (AC Forecasts)	-31.6	0.3	**-31.2**	**1.5**
	DfT17	-46.6	0.2	**-46.4**	**2.9**
LHR Northwest Runway	FRSR (AC Forecasts)	-38.4	0.4	**-38.0**	**1.8**
	DfT17	-55.3	0.3	**-55.0**	**3.5**

5. Wider economic impacts

5.1 Airport expansion is transformational in nature and its impacts on the economy go beyond the direct effects on passengers, airports, airlines and the Government. Expansion brings businesses and people closer together and in turn has the potential to increase productivity.

5.2 It is important to note that while the department fully recognises the existence of wider economic impacts, it also recognises that the exact magnitude remains uncertain. The approach set out here is limited to capturing some of these impacts within a cost-benefit framework; this does not take account of other positive impacts on UK GDP that airport expansion would be expected to deliver.

5.3 The department's method for estimating wider economic impacts ('the cost-benefit approach') applied in the FRSR consisted of two components.

- **Agglomeration impacts:** These occur from business clusters forming around airports, including knowledge spillovers from labour pooling.
- **Increased business output:** This is the difference between the value to consumers and the cost to producers of the increased output resulting from lower input costs for businesses.

5.4 Since the publication of the FRSR, the department has carried out additional analytical work on wider economic impacts. As a result of this work, two methodological changes were made. Further information is provided in Annex A.

- **Exclusion of estimates for the agglomeration component**

  There are two agglomeration effects following airport expansion. The first relates to the effects of increased business clusters around the expanded airport, such as knowledge spillovers. This effect is generally positive, though is partly offset by reduced agglomeration around other airports from job relocation. The second relates to the agglomeration effects of increased congestion impact around the expanded airport from job relocation, and the reduced congestion impact around other airports. The congestion effect is generally negative, as increased congestion reduces agglomeration benefits. The FRSR only considered the effects of increased business clusters, such as knowledge spillovers.

- **Inclusion of estimates for a tax component**

  Changes in tax revenue occur from the redistribution of jobs across areas of the country that display different levels of productivity. The FRSR acknowledged this, and the department has now been able to produce estimates of this impact. Tax impacts are presented as a range due to uncertainty around the number of jobs that will relocate following expansion.

5.5 The Government's transport appraisal guidance, WebTAG, advises that the negative impacts of increased congestion should be included alongside the positive effects of increased business clusters for the agglomeration component to be analytically robust. As no robust estimates are available for the congestion impacts associated with job relocation following expansion at either airport, the department has not included estimates for the agglomeration impact in this update. While we could still include the agglomeration benefits, which we can estimate robustly, this would overstate the benefits as we cannot estimate the accompanying congestion dis-benefits robustly. The department recognises that an agglomeration component

including both of these effects should be included in the analysis, but it is unclear whether excluding both would have a positive or negative net impact on each scheme, though it is likely to be small either way.

5.6 In addition to the above, the lower bound of the job elasticity, which was used in the FRSR to forecast agglomeration impacts, and is now used to forecast tax impacts, has been reduced from 0.05 to 0.02.[28] This implies a less significant relocation of jobs, an assumption that reflects findings from recent literature and expert advice to the department.

5.7 Tax impacts are driven by the job redistribution induced by the change in passengers using each airport in the UK as a result of expansion, while business output impacts are derived from direct economic benefits to UK business passengers.

5.8 The department's updated estimates of cumulative wider economic impacts for each scheme are shown in Table 5.1, alongside those presented in the FRSR, for the 60 year appraisal period following expansion. These results are the same for the updated carbon capped scenario.

5.9 Compared to the FRSR results, business output estimates are broadly the same, and are of similar magnitude across all schemes.

5.10 The tax impact estimates show that the expected increase in tax revenue is significantly larger for the Heathrow expansion schemes. This is partly because Heathrow's catchment area displays higher average levels of density and productivity compared to Gatwick's catchment area, and partly because there is a more significant relocation of jobs under the Heathrow expansion schemes. In contrast, there is a negative range for Gatwick, as the forecasts suggest jobs move from high to low density/productivity areas, especially in later years when the system becomes more constrained.

5.11 The total estimates for wider economic impacts indicate that expansion at Heathrow, in particular under the LHR Northwest Runway scheme, would result in larger benefits to the wider economy than expansion at Gatwick.

Table 5.1 Cumulative wider economic impacts by 2084/5 (present value, £bn, 2014 prices)

		Net Agglomeration	Business Output	Tax Wedge	Total
LGW Second Runway	FRSR (AC Forecasts)	0.3 to 1.6	1.1	N/A	**1.4 to 2.7**
	DfT17	N/A	1.2	-1.1 to 0.1	**0.1 to 1.3**
LHR Extended Northern Runway	FRSR (AC Forecasts)	0.5 to 2.1	1.2	N/A	**1.7 to 3.3**
	DfT17	N/A	1.1	0.5 to 1.7	**1.6 to 2.7**
LHR Northwest Runway	FRSR (AC Forecasts)	0.7 to 2.5	1.4	N/A	**2.0 to 3.9**
	DfT17	N/A	1.2	0.5 to 1.9	**1.8 to 3.1**

[28] See Annex A for further detail and sources.

Trade

The FRSR presented indicative estimates of trade benefits from expansion. These are not included in the cost-benefit appraisal due to the risk of double counting impacts with business passenger benefits included in the direct economic impacts.

Due to uncertainty around the trade outcomes of airport expansion, two different approaches were used to calculate trade impacts. One is driven by passenger forecasts, whilst the other is driven by seat forecasts. These approaches remain unchanged and are further discussed in the FRSR.[29]

Table 5.2 compares the department's updated estimates of trade impacts to those presented in the FRSR. These estimates are the same for the carbon capped scenario.

For all schemes, the trade benefits estimated using the change in passenger numbers is higher than in the FRSR analysis, which is to be expected given the higher DfT17 forecasts. The LGW Second Runway scheme continues to provide a greater range for these benefits when considered over the 60 year appraisal period following expansion. As with direct economic benefits, however, expansion at Heathrow would deliver greater passenger-based trade benefits sooner. This is because the additional passengers expected from expansion at Gatwick, which drive trade benefits, do not appear until much later in the appraisal period, relative to the Heathrow schemes

Under the seat based analysis, the estimates for all schemes are again higher. The much greater increase in flights with expansion at Heathrow means the LHR Northwest Runway scheme continues to be expected to provide significantly greater trade benefits throughout the assessment period using this approach.

Table 5.2 Cumulative trade benefits by 2084/5 (present value, £bn, 2014 prices)

		Passenger based		Seat Based
		Business Passengers	All Passengers	All Seats
LGW Second Runway	FRSR (AC Forecasts)	6.9	13.1	43.0
	DfT17	10.9	20.0	59.5
LHR Extended Northern Runway	FRSR (AC Forecasts)	5.5	10.0	85.8
	DfT17	7.5	14.3	106.6
LHR Northwest Runway	FRSR (AC Forecasts)	6.6	11.9	108.3
	DfT17	8.8	16.7	130.9

[29] Further Review and Sensitivities Report, https://www.gov.uk/Government/publications/airport-expansion-further-review-and-sensitivities-report p33.

6. Local economy impacts

6.1 When an airport expands, local jobs directly linked to the airport are created due to the increase in airport operations. As well as these direct local jobs, indirect and induced jobs are also created. For example, new employees hired by the airport will purchase more goods and services in the local economy, which will create a need for new jobs to cater for this increasing demand. The new employees filling these jobs will also purchase more goods and services, creating a ripple effect.

6.2 To estimate the number of local jobs created due to additional passengers travelling through the expanded airport, the AC applied job to passenger ratios (JTPRs) to their passenger forecasts. In the FRSR, we looked again at the estimates produced by the AC and provided alternative local job estimates, which were both then used to inform the draft Airports NPS. We have revised these estimates of additional local jobs at the expanded airport using the DfT17 forecasts.

6.3 Table 6.1 compares the updated local jobs range for each scheme to those used to inform the draft Airports NPS. These results would also be the same for the carbon capped scenario. The table presents estimates as a range to reflect the uncertainty around the impact of expansion on local jobs. The updates have no impact on the order of the schemes, but they do show more jobs are expected sooner with all schemes, reflecting the higher demand shown in the DfT17 forecasts.

Table 6.1 Additional local employment at the expanded airport in forecast year (thousands of jobs)[30]

	Year	FRSR (AC Forecasts)	DfT17
LGW Second Runway	2030	5 to 13	9 to 21
	2050	19 to 44	25 to 60
LHR Extended Northern Runway	2030	38 to 77	48 to 97
	2050	33 to 66	31 to 63
LHR Northwest Runway	2030	38 to 77	57 to 114
	2050	39 to 78	39 to 78

6.4 The updated figures further support the view that expansion will create tens of thousands of jobs, and that more jobs are likely to be created by expansion at Heathrow. This follows because the additional capacity is forecast to be used more quickly following expansion at Heathrow and, importantly, because the types of services offered at an expanded Heathrow are likely to be more complex, particularly with the greater number of full service airlines expected to be operating there.

6.5 These jobs are not additional at the national level, as some jobs may have been displaced from other airports or other sectors. The department has not quantified the impact of the shortlisted schemes on national jobs.

[30] The FRSR incorrectly reports the lower bound for 2030 (under AC forecasts) as 38,720. The actual value is 37,828.

Employment-related housing impacts

As discussed above, estimates of additional local jobs from airport expansion are presented as a range to reflect the inherent uncertainty in the analysis, and the dependency on a number of assumptions. The relationship between additional local jobs from expansion and the housing demand it might create is uncertain and it too depends on many assumptions. This is further compounded by the fact that there is inherent uncertainty in passenger forecasts themselves which both the additional job estimates and additional housing estimates are reliant upon. As such it is very difficult to form a definitive view on the number of additional houses required, but it is possible that expansion may increase the demand for local housing and so some further increase in housing provision would be required.

Any expansion related increase in demand should be seen in the wider context of housing demand going forward. For example, many local authorities are facing increasing demand for housing due to population growth and changing household patterns, regardless of airport expansion and the potential new workers it could bring to the area. Set against this, any pressures placed upon the locality due to expansion are likely to be small and could be dispersed across the surrounding areas. Local authorities will assess and plan for the development needed in their areas - including housing - through the local plan making process.

7. Costs of construction

7.1 Broadly speaking there are two main areas of capital costs associated with airport expansion: the capital expenditure required for completion of the new runways and terminals (referred to as “scheme costs”); and the capital expenditure required to ensure surface access capacity can meet the extra demand of passengers travelling to and from the expanded airport (referred to as “surface access costs”).

7.2 The first column in Table 7.1 shows the department’s revised capital expenditure estimates, as reported in the FRSR, under the AC’s assessment of need, carbon traded forecasts. The presented range reflects the uncertainty around scheme scope (for all schemes) and the extent to which actions to mitigate M4 congestion should be attributed to expansion at Heathrow.

7.3 The second column shows the upper capital expenditure estimate for the high demand scenario under each scheme, which illustrates how the scale of capital expenditure costs varies with demand. The numbers shown are negative because they represent costs.

7.4 The scheme costs estimated using the AC’s forecasts do not vary significantly with demand for the Heathrow expansion schemes.

7.5 There is however, greater scheme cost variation with demand under the LGW Second Runway scheme, due primarily to terminal and parking costs being incurred sooner. The DfT17 forecasts of passenger demand at an expanded Gatwick are higher than the AC’s, which could indicate that costs might be higher than the central view set out in the FRSR. However, we continue to use the central costs to provide a consistent basis for comparison across the schemes.

7.6 Until a scheme is actively considered under the planning and regulatory systems, uncertainty will remain in relation to scheme costs. Scheme promoters will continue to refine the detailed designs of the scheme and surface access proposals in anticipation of and during subsequent processes. Given scheme options are still being considered and will be subject to consultation in due course, it is not currently possible to identify a firm scheme cost baseline for this analysis.

7.7 The Government has made clear that it expects HAL to continue working closely with airlines and its regulator (Civil Aviation Authority, CAA) to refine the scheme design to target landing charges (the charge the airport charges airlines to use the airport) as close to today’s level as possible. By way of illustration, the AC identified the scope for cost reductions, and these lower estimates are presented in Table 7.1, to form the lower part of the range.

Table 7.1 Cumulative scheme and surface access costs by 2084/5 (present value, £bn, 2014 prices)

	FRSR (AC's assessment of need, carbon traded forecasts)	AC's high demand forecasts*
LGW Second Runway	-6.9 to -7.0	-8.2
LHR Extended Northern Runway	-12.6 to -15.9	-15.9
LHR Northwest Runway	-14.3 to -18.4	-18.4

* Low-cost is king, carbon traded (LGW Second Runway) and global growth, carbon traded (Heathrow expansion schemes)

Surface access

The department has not made any further changes to the surface access scheme cost estimates considered in the central case from those published in the FRSR. The costs reflect uncertainty about the scope and design of the schemes. The economic analysis is based on the surface access schemes identified by the AC. The schemes identified by the AC included those required for the additional runway to be built and some to mitigate the potential impact of expansion.

Surface access cost estimates remain uncertain given schemes different stages of development, and whether and when schemes are required for expansion. Surface access costs continue to be presented as a range to reflect this uncertainty.

The department has not undertaken further modelling to assess the surface access scheme package proposed by the AC. Individual surface access schemes would be decided through the development of the airport's surface access strategy or the Government's existing transport investment processes. The relative net benefit or disbenefit of the final surface access package has not, therefore, yet been assessed.

Since the AC carried out its work, transport investment through the department's road and rail programmes has continued, as has the development of transport proposals that could impact on access to Heathrow Airport. For example, as part of the implementation of the Elizabeth Line project, options for increases in service levels from the originally planned four trains per hour to six or possibly eight trains per hour, and for the rail services to call at Terminal 5 are being developed. Such improvements will need to be taken into account as the airport's surface access strategy is developed. These projects, although not necessary for Heathrow expansion, would provide additional benefit to users accessing the airport.

8. Environmental impacts

Overview

8.1 Aviation forecasts are a key input to the monetised assessment of air quality, carbon and noise impacts. As discussed above, the DfT17 forecasts show higher demand than the AC's forecasts. While there is some difference in passenger demand at the national level - especially in early years relative to the AC's demand scenario range - this impact is particularly marked at airport level, where air quality and noise impacts are felt most. This section describes the updated analysis we have carried out to provide a complete assessment.

8.2 In order to update monetised impacts, additional modelling was required to understand and quantify the change in noise, air quality and carbon emissions that could occur with expansion under all three schemes. This section provides a high level summary of this work, focusing on the monetised outputs which form part of the appraisal. Details of the underlying analysis can be found in the AoS, published alongside this report.

8.3 This section only considers impacts where aviation forecasts are an input to the assessment, such as carbon, air quality and noise. We have not re-estimated biodiversity impacts and continue to use the AC's estimates.

Carbon

8.4 Aviation has a negative carbon impact on society through the effect of carbon emissions contributing to climate change. It is therefore important to assess the magnitude of these emissions and monetise the costs to society of the additional emissions created as a result of expansion.

8.5 The AC assessed the impacts of expansion on carbon emissions and the department found the analysis to be robust. The AC adopted two carbon policy regimes: carbon traded and carbon capped.

8.6 The carbon traded policy regime assumes that UK aviation emissions are part of a fully functioning global trading scheme and total global aviation emissions are limited in line with international stabilisation targets. The carbon capped policy regime assumes that total emissions from UK departing flights are capped at 37.5 $MtCO_2$ per annum in 2050, as per the planning assumption made by the Committee on Climate Change (CCC).

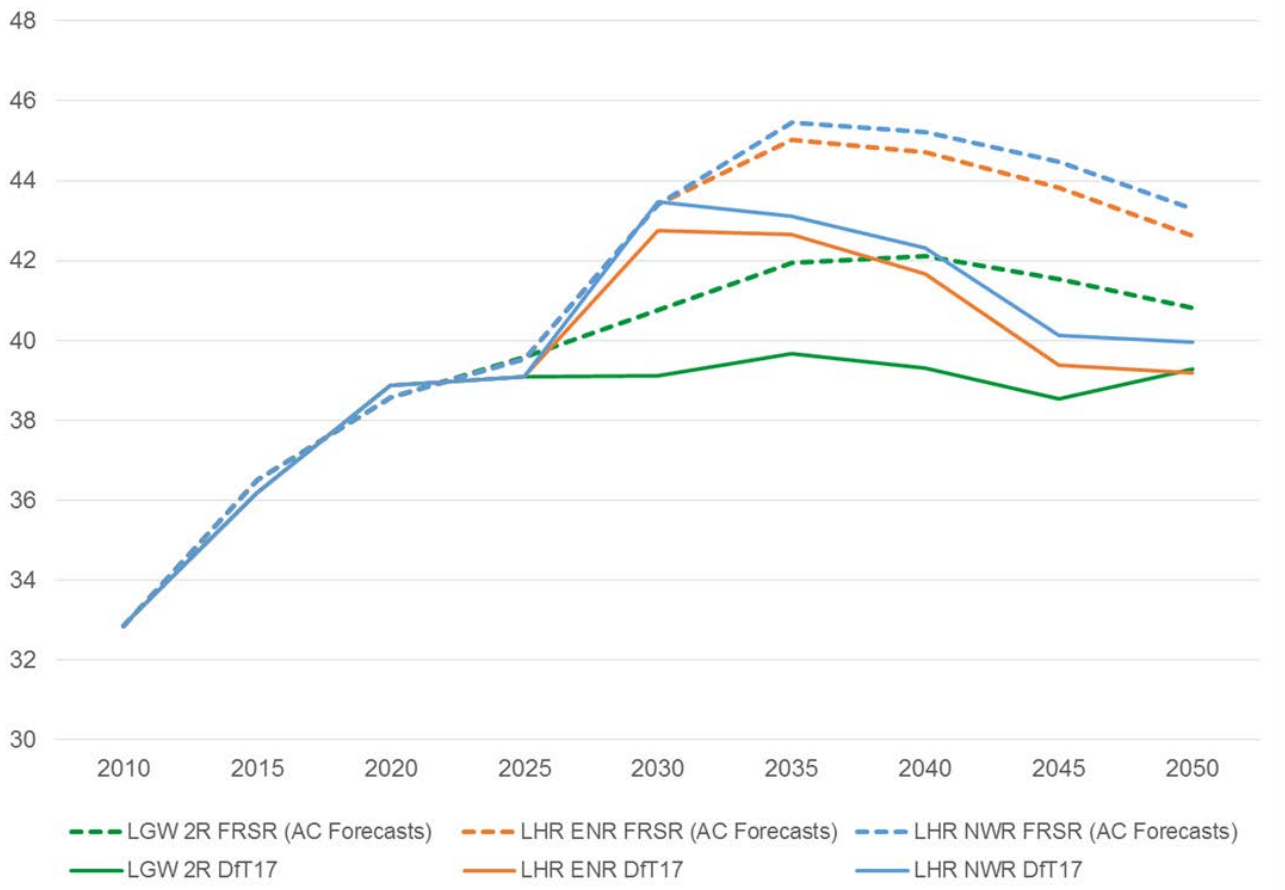
8.7 The AC considered the impact of airport expansion on emissions from four sources.

- **ATMs:** extra flights across UK airports will increase carbon emissions.
- **Airport operations:** emissions will be created from the additional heating and power required at airport buildings, as well as transporting new passengers, baggage and freight around the airport site.
- **Surface access:** increased passenger demand will cause an increase in emissions from more vehicles accessing airports.
- **Construction:** the construction required to provide the additional capacity and surface access infrastructure itself will also create additional carbon emissions.

Emissions from ATMs

8.8 The emissions from UK departing ATMs are shown in Figure 8.1 for both the DfT17 central forecasts and the AC's assessment of need, carbon traded forecasts.

Figure 8.1 Carbon emissions from UK departing flights ($MtCO_2$, DfT17 central forecast and AC assessment of need, carbon traded forecast)



8.9 Compared to the AC's assessment of need, carbon traded forecasts, emissions from aircraft are now forecast to be lower under all schemes in 2050. This decrease is explained mainly by the decrease in ATM kms shown in Section 3. In addition to this, there have been a number of updates to our CO_2 modelling including updating data on the composition of the aircraft fleet operating to and from the UK and the fuel it burns to fly given distances. The net effect of these updates is to reduce CO_2 forecasts. For more information on these updates, and CO_2 modelling more generally, see the DfT17 forecast report.[31]

8.10 Under the DfT17 forecasts, emissions remain broadly constant after Gatwick expansion, with improvements in fuel efficiency more than keeping pace with the slower growth in ATMs. Under either of the two Heathrow expansion schemes emissions are higher initially after expansion, as there is a larger increase in ATMs, particularly higher-emission long-haul flights. But emissions then fall after about 2030, so that by 2050 UK emissions under all three schemes are broadly equal.

[31] UK Aviation Forecasts 2017, Chapter 3 – CO_2 Emissions Modelling.

Carbon Capped

8.11 Under the carbon capped policy regime, emissions are constrained to 37.5 $MtCO_2$ in 2050. As described in Box 8.1, under our approach to carbon capped, this level is achieved through specific abatement measures. The measures chosen are those deemed most cost effective and practical to implement at a UK level in a recent study produced for DfT on the cost and potential for abating carbon in UK aviation.[32]

8.12 This approach is similar to the AC's Carbon Policy Sensitivity Test, which was an alternative carbon capped regime where emissions are limited in line with the CCC's planning assumption by using policy measures to increase the uptake of biofuels and improve airline operational efficiency.

8.13 In our carbon capped scenario, which is effectively an update of the AC's, we selected the most cost effective measures needed (that are practical to implement at a UK level) to abate enough carbon from the carbon traded scenario to reach the CCC's planning assumption. We assume that under our carbon capped scenario emissions are tackled through a combination of a carbon price (the same as that in the carbon traded scenario) and specific measures. As carbon trading is not permitted (by assumption) in this carbon capped case, the imposition of a carbon price for all flights would come from a different mechanism. Box 8.1 provides further explanation.

8.14 For the appraisal, under a carbon traded regime, global emissions are set at an internationally agreed level and any increase in UK aviation emissions would be offset elsewhere. Under a carbon capped regime, UK aviation emissions are capped at around 2005 levels in 2050.

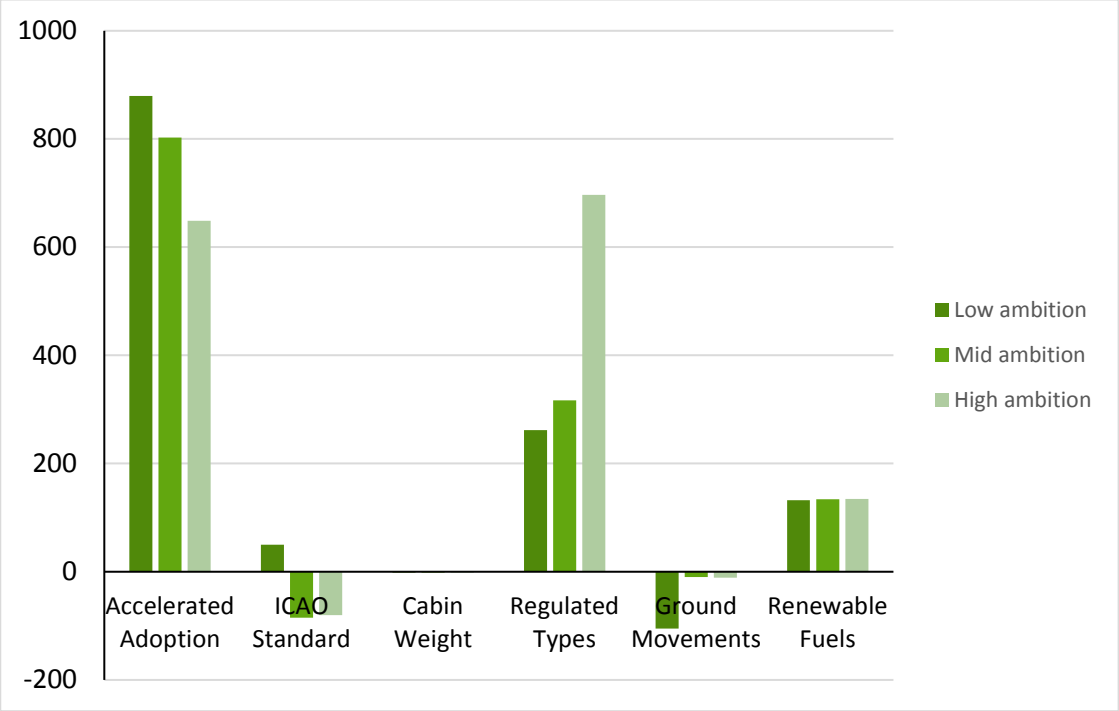
8.15 In summary, this analysis provides further support for the AC's assessment that any of the three schemes scheme could be delivered within the UK's obligations under the Climate Change Act, as confirmed in the draft Airports NPS.

[32] Carbon Abatement in UK Aviation: Final Report.

Box 8.1 Carbon capped – Marginal Abatement Cost analysis

The department commissioned Ricardo Energy & Environment, a consultancy, to assess the cost and abatement potential of a range of policy measures to reduce emissions from UK aviation. The focus of the project was on measures that could be implemented at a UK level and that would not require international cooperation to come into effect.

Figure 8.2 Cost effectiveness of carbon abatement policies (£/tCO2 saved)



In selecting measures, one consideration is cost-effectiveness. Figure 8.2 shows the cost per tonne of CO_2 saved of measures to reduce CO_2 emissions (abatement) from the Ricardo study. The costs are "net costs", including costs such as R&D, and taking account of benefits such as reduced fuel costs. These net costs are divided by the CO_2 savings the measures are expected to deliver when deployed. This provides a £ per Mt CO_2 saved figure which can be used to compare the cost-effectiveness of each measure.

In selecting measures we have also considered implementation, as whilst in principle all measures could be implemented unilaterally, some are more practical than others. Combining these considerations, we selected two measures for inclusion in our carbon capped scenario that together could achieve the abatement required to meet the CCC's planning assumption. These were:

- action to encourage more efficient ground movements; and
- increased use of renewable fuels (for example, achieved through regulation).

The first of these would involve the UK Government working with airlines and airports to encourage the use of single engine taxiing. We assume that by 2030 and beyond 95% of planes departing UK airports adopt this practice. Figure 8.2 shows that this measure has a negative cost, which implies that it is cost effective for operators to adopt it regardless. That they're not implies that there are barriers to the uptake of this measure that were not accounted for in the study. Under this

policy the Government would work with airports and airlines to identify and overcome these barriers. The costs of this action are assumed to cancel out the fuel cost savings obtained from implementing it so the net cost to society as a whole is assumed to be zero.

The second measure would involve including a certain percentage of renewable fuel in aviation fuel supply, using an approach similar to the road transport fuel obligation (RTFO). Any measure would be designed to ensure that the feedstock is sustainable, such as municipal waste or low carbon waste fossil fuels, to deliver substantial lifecycle CO_2 savings of at least 70%. Such a scheme would be consistent with the aims for the future of the RTFO to include aviation and focus on advanced fuels, as set out in the Government's recent consultation.[33] The costs of the measure are calculated as the difference between the cost of renewable fuel and the cost of regular aviation fuel, minus the cost saving achieved from airlines needing to buy fewer carbon permits. The details of the abatement impacts and costs of the two measures are given in table 8.1 below:

Table 8.1 Carbon savings and cost of selected abatement measures

	Measure	CO_2 Saving ($MtCO_2$ in 2050)	Cost (present value, £bn, 2014 prices)
LGW Second Runway	Ground movements	0.3	0*
	Mandatory renewable fuel (9% in 2050)	1.4	-0.6
	Total	1.8	-0.6
LHR Extended Northern Runway	Ground movements	0.3	0*
	Mandatory renewable fuel (9% in 2050)	1.4	-0.6
	Total	1.7	-0.6
LHR Northwest Runway	Ground movements	0.3	0*
	Mandatory renewable fuel (12% in 2050)	2.3	-1.0
	Total	2.6	-1.0

*Fuel cost savings are assumed to be cancelled out by costs to government, airlines, and airports of implementing measure.

This scenario is not intended as a statement of future policy or a definitive conclusion on the most cost effective measures that are available. There is significant uncertainty around the results of the study and the conclusions that are drawn. A number of policy measures are likely to be available and the scenario is merely intended to illustrate the kinds of measures that could be used and the likely magnitude of their costs.

Emissions from surface access, airport operations, and construction

8.16 The department has updated the AC's estimates of the carbon impacts from additional trips to and from the airport and from airport operations, and their

[33] https://www.gov.uk/Government/consultations/renewable-transport-fuel-obligation-proposed-changes-for-2017

associated monetised values, using outputs from the DfT17 forecasts. The department has not updated the carbon impacts from construction, as the scheme plans on which we are basing the analysis have not changed since the AC's final report and FRSR. Further detail on the methodology can be found in Annex A.

8.17 In this update, the department used outputs from its surface access models based on the updated aviation forecasts. Other methodology changes the department has made include: assessing emissions from staff journeys to and from the airport, and separating bus and coach journeys in order to apply specific carbon emission factors to these trips.

8.18 Carbon emissions from airport operations includes emissions from electricity, other fuel[34] and gas. Emissions from gas have not been updated as a data input was not available. Thus the department has made a best estimate of the AC's gas CO_2 impact (from Airport Operations figures published in the AC final report and FRSR) and included this in the total for Airport Operations carbon emissions (Table 8.1).

8.19 The updated figures for surface access and airport operations, as well as the AC's figures for construction are presented in Table 8.2. These impacts only account for changes in emissions at an expanded Heathrow or an expanded Gatwick, and do not account for any reduction in emissions at non-expanded airports.

Table 8.2 Cumulative carbon impacts by 2084/5 under AC's assessment of need, carbon traded forecasts (present value, £m, 2014 prices)

		Carbon assessment findings, change in $MtCO_2$* over the appraisal period				Value of monetised carbon impacts (present value, £m, 2014 prices)			
		Surface access	Airport operations	Construction*	**Total**	Surface access	Airport operations	Construction	**Total**
LGW Second Runway	**FRSR (AC Forecasts)**	10.1	1.1	3.9	**15.1**	-650.5	-71.0	-146.6	**-868.1**
	DfT17	9.6	1.2	3.9	**14.8**	-444.8	-67.5	-146.6	**-658.8**
LHR Extended Northern Runway	**FRSR (AC Forecasts)**	6.3	2.1	10.1	**18.5**	-393.8	-125.2	-229.6	**-748.6**
	DfT17	7.6	2.2	10.1	**19.9**	-355.2	-114.7	-229.6	**-699.5**
LHR Northwest Runway	**FRSR (AC Forecasts)**	7.4	2.6	11.3	**21.2**	-467.7	-155.9	-253.0	**-876.7**
	DfT17	9.1	2.7	11.3	**23.1**	-420.4	-144.7	-253.0	**-818.0**

*Construction emissions are calculated as $MtCO_2(e)$

8.20 Over the 60 year appraisal period, carbon emissions from surface access and airport operations have increased in the DfT17 forecasts for the LHR Extended Northern Runway and LHR Northwest Runway schemes. The inclusion of employee trips in addition to higher passenger forecasts in this update have driven this increase. Carbon emissions from airport operations under the LGW Second Runway scheme are higher in this update, however, the surface access emissions under this scheme are lower than previously forecast. This may be due to the lower carbon emission factor per passenger for coach trips, and a high proportion of passengers travelling to Gatwick travel by coach. Construction carbon emissions are the same as previously assessed in the AC's work and the overall non-flight carbon emissions are higher, for the LHR Extended Northern Runway and LHR Northwest Runway schemes.

8.21 The value of monetised carbon emissions is lower under all three schemes, for both surface access and operations. This results in a lower overall present value for monetised non-flight carbon emissions over the 60 year appraisal period, for all three schemes, compared to the values published in the FRSR. Carbon price forecasts are

[34] Other data inputs are available at: 2016 Summary Report (Gatwick) http://www.gatwickairport.com/business-community/community-sustainability/sustainability/sustainability-reports/ and 2016 Sustainability Report (Heathrow) http://www.heathrow.com/file_source/Company/Static/PDF/Communityandenvironment/Sustainabilty-Performance-Report-2016.pdf

revised in regular DfT and BEIS updates, and these reflect the most up to date values.

Air quality

8.22 Emissions of air pollutants are created by aircraft, airport operations and surface access, and these all have an impact on air quality. At the local level, poor air quality has an adverse effect on health, quality of life, and the functioning of ecosystems. Emissions and concentrations of air pollutants are also of concern nationally.

8.23 The aviation forecasts are an input to the estimation of air quality impacts. Higher passenger demand growth results in a greater number of ATMs, higher fuel consumption, and greater resulting emissions of air pollutants from aircraft, airport, and surface access sources.

8.24 The AC monetised the impact on air quality from increasing airport capacity under each scheme for both the assessment of need, carbon traded scenario and the demand scenario that results in the greatest likely air quality impact. For the LHR Extended Northern Runway scheme and the LHR Northwest Runway scheme the high demand scenario is the global growth demand scenario under a carbon traded policy regime. For the LGW Second Runway scheme, the high demand scenario is the low cost is king demand scenario under a carbon traded policy regime.

8.25 The AC's approach estimated the aggregated effect of nitrogen dioxide and particulate matter concentrations. Since the AC's final report, the Department for Environment, Food and Rural Affairs (Defra) has published new guidance allowing the direct effect of exposure to nitrogen dioxide to be quantified and monetised.[35] This sets out an approach of valuing changes in pollutant concentrations directly, as well as updating the estimates of damage costs associated with these pollutants.

8.26 The FRSR provided a sensitivity test of the impact of using the latest guidance on the estimated air quality impacts of each scheme for the high demand scenario only. [36] The air quality valuation for each scheme using this revised approach and the AC's forecasts is reported in Table 8.3 alongside the AC's previous estimates.

Table 8.3 Cumulative monetised air quality impacts by 2084/5 under the AC's forecasts (present value, £bn, 2014 prices)

	FRSR*	FRSR sensitivity+ (based on latest Defra guidance)		
	Total	PM_{10}	NO_2	Total
LGW Second Runway	**-0.2**	-0.03	-0.02	**-0.05**
LHR Extended Northern Runway	**-0.5**	-0.06	-0.02	**-0.08**
LHR Northwest Runway	**-0.8**	-0.07	-0.03	**-0.10**

* estimated for the AC's assessment of need, carbon traded forecasts
\+ estimated for the AC's high demand forecasts

[35] https://www.gov.uk/guidance/air-quality-economic-analysis
[36] Further Review and Sensitivities Report, https://www.gov.uk/Government/publications/airport-expansion-further-review-and-sensitivities-report p72. The high demand scenario is low-cost is king, carbon traded for the LGW Second Runway scheme and global growth, carbon traded for the Heathrow expansion schemes.

8.27 The monetised impacts under the revised approach are much lower than the AC's original estimates presented in the FRSR, despite the damage costs being higher, though the proportional difference between schemes remains comparable. This reflects the use of the dispersion modelling in the revised approach, which better maps the relationship between emissions and concentrations, and so provides an improved approach to identifying impacts on affected populations.

8.28 We have updated the assessment and economic valuation of air quality impacts using DfT17 forecasts for both aviation passenger and surface access demand. The monetisation relies on revised estimates of the impact of expansion on air quality. Further detail on this methodology and the results for the reanalysis of air quality impacts can be found in the update to air quality re-analysis report,[37] published alongside this report. These impacts are further set out in the AoS.

8.29 Table 8.4 below sets out the updated monetised values of air quality impacts, which are also the same for the carbon capped scenario. These make use of the scaling factors developed for the air quality reanalysis to adjust the values presented in the Table 8.3. The results show that while air quality impacts are now higher (reflecting higher demand at all three schemes), they are still lower than the AC's estimates due to the revised methodology. LHR Northwest Runway has the greatest impact, but for all three schemes these costs are very small in comparison with the benefits and other impacts considered in the economic appraisal.

Table 8.4 Cumulative monetised air quality impacts by 2084/5, DfT17 high demand forecasts (present value, £bn, 2014 prices)

	Total
LGW Second Runway	-0.05
LHR Extended Northern Runway	-0.11
LHR Northwest Runway	-0.15

Noise

8.30 Airport expansion creates a negative noise impact on the area surrounding the expanded airport. Exposure to noise caused by increased flight activity around an airport is an annoyance, can disturb sleep and can also affect cardiovascular health.

8.31 The monetised health impact of noise is based on the population exposure over the full day accounting for health and annoyance impacts at differing noise levels. The noise predictions are sensitive to a number of outputs from the aviation model including the number of ATMs and the composition of the aircraft fleet mix.[38]

8.32 Following updates to the aviation demand forecasts and corresponding ATM forecasts, a key input to aviation noise modelling, the department commissioned

[37] Appraisal of Sustainability: Draft Airports National Policy Statement. Appendix A-8: Air Quality.
[38] https://www.gov.uk/Government/uploads/system/uploads/attachment_data/file/372442/5-noise--national-assessment.pdf

updates to the local noise forecasts associated with the shortlisted options. Further detail of these updates can be found in the revised AoS.

8.33 The ground based noise assessment and the national noise forecasts have not been updated. The ground based noise assessment is based on the layout of the airport and the general expected operations within. The aviation demand forecasts are not an input to the modelling of ground noise and therefore the AC's assessment of ground noise is still reliable. Whilst the updated aviation demand forecasts will affect the national noise forecasts, the negative noise impacts due to airport expansion are focused largely on the expanded airport, therefore we have focused our resource on updating the local noise exposure forecasts. This means some positive impacts of reduced noise at other airports have not been captured.

8.34 The AC previously modelled a high number of noise scenarios across the three shortlisted schemes. The noise impacts presented below use the central demand scenario in order to provide estimates consistent with the rest of the appraisal. A higher demand scenario is used in the revised AoS to test worst-case impacts.

8.35 Table 8.5 presents the monetised health estimates across the three shortlisted schemes. The impacts in terms of population exposure, area exposure and noise sensitive buildings (schools, hospitals and places of religious worship) are provided in the revised AoS.

Table 8.5 Cumulative monetised noise impacts by 2084/5 under DfT17 forecasts, central estimates (present value, £bn, 2014 prices)

		Total
LGW Second Runway	FRSR (AC Forecasts)	-0.4
	DfT17	-0.2
LHR Extended Northern Runway	FRSR (AC Forecasts)	-1.4
	DfT17	-0.3
LHR Northwest Runway	FRSR (AC Forecasts)	-1.0
	DfT17	-0.6

8.36 The results are sensitive to the inputs of the noise modelling, which include: aviation demand and fleet mixes, flight paths, airspace assumptions and population forecasts for the ground area exposed. Monetised results are also sensitive to the weightings given to the different impacts and the noise threshold for some impacts taking effect. The methodology for monetisation is based on the WebTAG noise module which follows guidance published by the World Health Organisation and Defra.

8.37 Monetised noise impacts are consistently greater under the Heathrow expansion schemes due to the more densely populated surrounding area. The LHR Northwest Runway scheme presents the highest level of noise impact of the three shortlisted options, although the impact is lower than estimated by the AC. While demand is forecast to be higher earlier on, revised aircraft fleet assumptions lead to noise improvements that more than offset this increase, leading to lower estimates overall.

8.38 In the AC's analysis, LHR Extended Northern runway led to higher monetised costs than LHR Northwest runway because the scheme cannot deliver the same degree of noise respite for residents. In the DfT17 forecasts, this lack of noise respite at LHR Extended Northern runway is more than offset by the increase in noise from higher demand expected at LHR Northwest runway.

8.39 All three schemes have the potential for significant negative noise impacts. The draft NPS lays out supporting measures expected of the scheme promoters to help mitigate impacts.

9. Combined impact of costs and benefits

Summary metrics

9.1 The FRSR made use of a range of summary metrics when aggregating the economic impacts of airport expansion, which are discussed further in Box 9.1. These allowed the monetised impacts for each scheme to be combined in different ways to inform the assessment of each scheme.

9.2 While useful, these metrics do not tell the whole story. Not all impacts can be monetised, so these metrics should be considered alongside the wider strategic case for expansion. For example, improved connectivity outcomes leading to more freight, more trade and boosting GDP, while delivering additional jobs in the local area. LHR Northwest Runway continues to be the best scheme to deliver these strategic benefits.

9.3 When considering the metrics it is also worth bearing in mind:

- The assumptions on whether capacity is used in segregated or mixed mode. Different modes would restrict or increase capacity; more capacity could lead to higher total benefits, but could also lead to greater disbenefits, and vice versa.
- Across the schemes, costs and benefits follow different time profiles and fall on different groups - explore these differences further below.

Box 9.1 Project appraisal metrics

The NPV provides the overall picture when all costs and benefits are added together. Its use is recommended in WebTAG for schemes which do not impact on the broad transport budget.

The net social benefit and net public value metrics exclude some of the private impacts of expansion in order to isolate societal and public impacts.

The benefits and costs of expansion are also helpful to show impacts on different groups.

Figure 9.1 Project appraisal metrics components

	Total benefits to passengers and the wider economy	Net social benefit (AC definition)	Net Present Value	Net public value
Passenger benefits (lower fares, reduced delays and higher frequency of flights)	✓	✓	✓	✓
Government revenue	✓	✓	✓	✓
Wider economic impacts	✓	✓	✓	✓
Environmental costs (noise, air quality, carbon, biodiversity)		✓	✓	✓
Airline profit loss (net of reduced delays)		✓	✓	
Surface access cost			✓	✓+
Scheme cost			✓	
Carbon abatement cost *		✓	✓	

+ Net public value considers surface access costs that might be faced by government. As the determination of who will pay for surface access schemes is yet to be made, this ranges from £0 (if promoters were to pay for everything) to the full cost of all identified surface access schemes.

* Included under a carbon capped policy future only. Carbon abatement costs are fully internalised under a carbon traded policy future.

Updating metrics with the latest forecasts

9.4 Table 9.1 reproduces the analysis presented in the FRSR. Table 9.2 updates the analysis using the DfT17 forecasts and revised methodologies, as discussed in this report.

Table 9.1 Monetised impacts under the AC's assessment of need, carbon traded forecasts (present value, £bn, 2014 prices)

	LGW Second Runway	LHR Extended Northern Runway	LHR Northwest Runway
Passenger benefits	48.5	46.9	55.4
Government revenue	2.5	1.5	1.8
Wider economic impacts	1.4 to 2.7	1.7 to 3.3	2.0 to 3.9
Total benefits to passengers and the wider economy	**52.4 to 53.7**	**50.1 to 51.7**	**59.2 to 61.1**
Environmental disbenefits	-1.5	-2.8	-2.7
Airline profit loss	-40.8	-31.2	-38.0
Net social benefit	**10.1 to 11.4**	**16.1 to 17.7**	**18.6 to 20.4**
Scheme cost	-6.4 to -6.3	-12.0 to -10.7	-14.9 to -12.9
Surface access cost	-0.6	-3.9 to -1.9	-3.4 to -1.4
Net Present Value	**3.1 to 4.5**	**0.2 to 5.1**	**0.2 to 6.1**
Net public value	**50.3 to 52.2**	**43.5 to 48.9**	**53.1 to 58.4**

Table 9.2 Monetised impacts under the DfT17 central, carbon traded forecasts and revised methodologies (present value, £bn, 2014 prices)

	LGW Second Runway	LHR Extended Northern Runway	LHR Northwest Runway
Passenger benefits	69.4	57.2	67.6
Government revenue	4.6	2.9	3.5
Wider economic impacts	0.1 to 1.3	1.6 to 2.7	1.8 to 3.1
Total benefits to passengers and the wider economy	**74.1 to 75.3**	**61.7 to 62.8**	**72.8 to 74.2**
Environmental disbenefits*	-0.9	-1.2	-1.6
Airline profit loss	-65.1	-46.4	-55.0
Net social benefit	**8.1 to 9.3**	**14.1 to 15.3**	**16.2 to 17.5**
Scheme cost (AC forecasts)	-6.4 to -6.3	-12.0 to -10.7	-14.9 to -12.9
Surface access cost (AC forecasts)	-0.6	-3.9 to -1.9	-3.4 to -1.4
Net Present Value ^	**1.0 to 2.4**	**-1.8 to 2.7**	**-2.2 to 3.3**
Net public value ^	**72.6 to 74.4**	**56.6 to 61.7**	**67.8 to 72.6**

* All impacts other than air quality are modelled for the central demand scenario. Air quality is monetised using the high demand scenario. These impacts are relatively very small, so do not impact on the summary metrics.
^ Scheme and surface access costs are based on AC forecasts.

9.5 Total benefits to passengers and the wider economy are greater under all schemes, largely due to an increase in passenger demand under the DfT17 forecasts. Updating the appraisal values of time for business passengers reduces Heathrow's benefits from more frequent flights and reduced delays by around £3bn, which partially offsets the increase in total benefits under Heathrow expansion. Updating the methodology

for monetising wider economic impacts has reduced the estimated benefits to the wider economy across all schemes.

9.6 There is now an overlap between the total benefit ranges for the LGW Second Runway scheme and the LHR Northwest Runway scheme, with only about £1billion separating the schemes across the whole 60 year appraisal period. The LHR Extended Northern Runway scheme continues to deliver the lowest benefits to passengers and the wider economy.

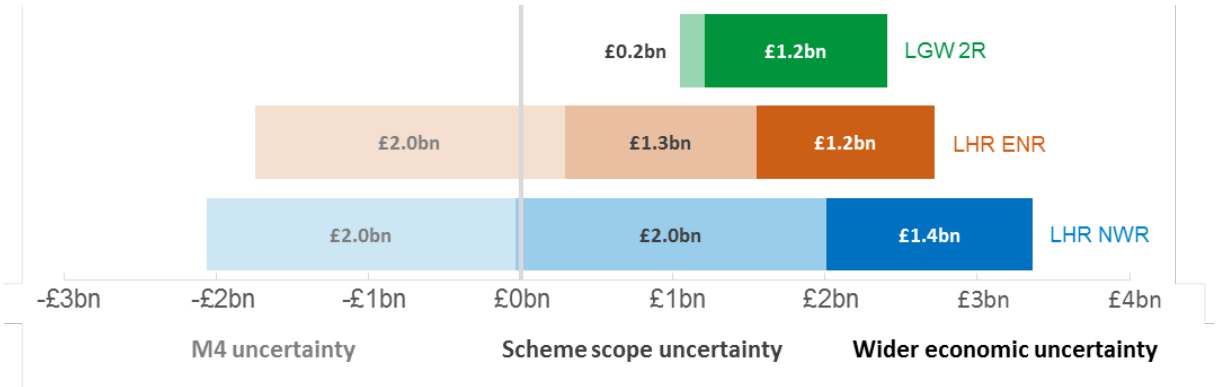
9.7 The net public value metric is also greater across all three schemes. Gatwick expansion especially benefits from higher passenger benefits, while Heathrow expansion has relatively higher environmental disbenefits and a greater range of surface access costs. Taken over the whole 60 year period, the LGW Second Runway scheme could lead to greater monetised net public value.

9.8 Airline disbenefits are now estimated to be much higher because, without expansion, profits are forecast to be higher than before. With expansion, airlines lose the ability to set higher fares and this is reflected in higher airline losses. These losses are still outweighed by benefits to pasengers as theory suggests, but the difference is smaller than in the previous analysis.

9.9 The effect of this is to reduce the net benefits of all schemes (relative to the FRSR analysis) and the impact is most notable under the LGW Second Runway scheme (which is forecast to fill up more slowly than the other schemes, preventing airlines from earning higher fares once the airport fills up again). As a consequence, Heathrow expansion continues to deliver greater net social benefits than Gatwick expansion, albeit lower than in the FRSR analysis.

9.10 As all schemes experience similar relative changes in disbenefits as well as benefits, the three NPVs continue to overlap, as shown in Figure 9.2, though they are all lower than before because of the increase in airline disbenefits. At the bottom end of the range, this results in a negative NPV for the Heathrow expansion schemes. The range is very sensitive to the assumptions used for scheme costs, which are more uncertain than at Gatwick. Using the AC's lower cost estimates, LHR Northwest Runway could deliver the highest NPV (the upper end of the range); if we use the highest cost estimates, then LGW Second Runway could deliver a higher NPV (the lower end of the range).[39]

Figure 9.2 Scheme Net Present Value under the DfT17 central, carbon traded forecasts, with key areas of uncertainty (£bn, 2014 prices)



[39] Further Review and Sensitivities Report, DfT, Figure 7.1, available at: https://www.gov.uk/Government/publications/airport-expansion-further-review-and-sensitivities-report

Carbon capped metrics

9.11 Table 9.2 looks at the aggregated impacts of expansion under a carbon traded future, where international aviation emissions are addressed by transitioning to a fully functioning global trading scheme. Under this assumption, all emissions will need a carbon permit, the cost of which ('carbon abatement costs') is included in the analysis through its impact on fares, lowering demand.

9.12 This report has also considered the impact of a carbon capped future where aviation emissions are constrained to 37.5 Mt CO_2 in 2050, met through a combination of carbon pricing and specific mitigation measures. Under this assumption, the aviation industry would face additional carbon abatement costs, which would be greater under a future with expansion.

9.13 In the carbon capped case, the benefits delivered by the scheme are unchanged as the underlying demand forecasts are the same as in the carbon traded case. This also means that the expected environmental and airline dis-benefits are also unchanged. In addition, the connectivity differences between the schemes also hold true. In this carbon capped scenario, airport expansion would deliver the same significant benefits and connectivity improvements for the UK.

9.14 Carbon abatement costs under each scheme are presented in Table 9.3 and have been deducted from the Net Present Value and net social benefit metrics presented in Table 9.2. The abatement costs under the Heathrow expansion schemes are greater than those under the LGW Second Runway scheme. The reduction in NPVs and net social benefits, relative to the carbon traded metrics, is therefore greater for Heathrow expansion. The scheme ordering for each metric, however, remains the same. This analysis suggests that even when emissions are constrained, all schemes could still deliver positive impacts.

Table 9.3 Appraisal metrics under the DfT17 central, carbon capped forecasts and revised methodologies (present value, £bn, 2014 prices)

	LGW Second Runway	LHR Extended Northern Runway	LHR Northwest Runway
Carbon abatement costs	-0.6	-0.6	-1.0
Total benefits to passengers and the wider economy *	**74.1 to 75.3**	**61.7 to 62.8**	**72.8 to 74.2**
Net social benefit	**7.5 to 8.7**	**13.6 to 14.7**	**15.2 to 16.6**
Net Present Value ^	**0.5 to 1.9**	**-2.4 to 2.1**	**-3.1 to 2.3**
Net public value ^ *	**72.6 to 74.4**	**56.6 to 61.7**	**67.8 to 72.6**

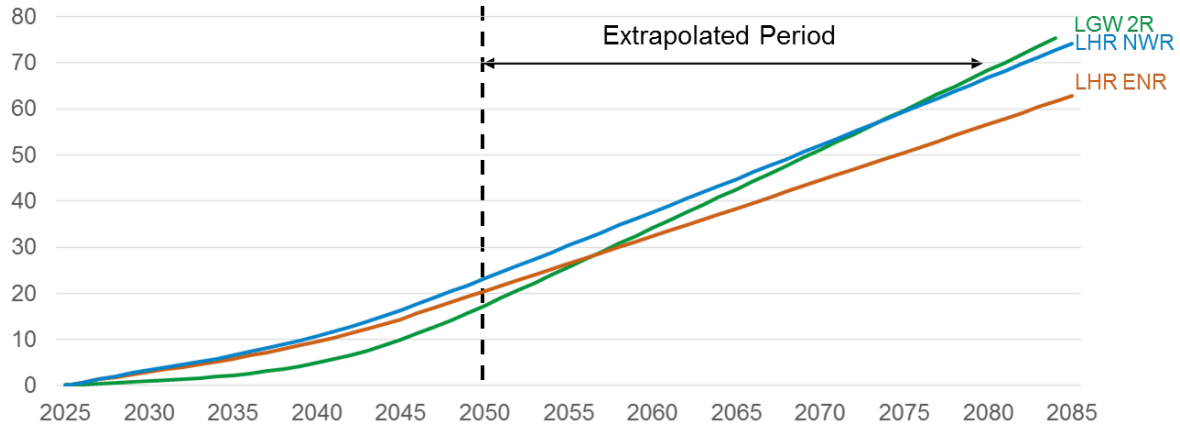
* As abatement costs aren't incorporated into the total benefits and net public value metrics, the estimates remain the same as under the carbon traded assumption.
^ Scheme and surface access costs are based on AC forecasts.

Economic benefits over time

9.15 Figure 9.3 presents the discounted cumulative benefits to passengers and the wider economy across the 60 year appraisal period to illustrate how cumulative passenger benefits associated with each scheme are expected to change across the modelled time period to 2050, and the extrapolated period thereafter.

9.16 As Heathrow continues to have more pent-up demand than Gatwick under the new forecasts, it remains the case that the benefits to passengers and the wider economy will be realised more quickly under Heathrow expansion, in particular the LHR Northwest Runway scheme. For example, it is not until the late 2070s before expansion at Gatwick delivers greater cumulative benefits than the LHR Northwest Runway scheme.

Figure 9.3 Cumulative benefits to passengers and the wider economy by forecast year (present value, £bn, 2014 prices) [40]



		Total benefits to passengers and the wider economy			
		2030	2040	2050	2084/5
LGW Second Runway	FRSR (AC Forecasts)	0.9	4.9	14.3	52.4 to 53.7
	DfT17	1.0	4.9	17.3	74.1 to 75.3
LHR Extended Northern Runway	FRSR (AC Forecasts)	2.4	10.0	19.0	50.1 to 51.7
	DfT17	3.0	9.4	20.5	61.7 to 62.8
LHR Northwest Runway	FRSR (AC Forecasts)	2.5	11.0	21.5	59.2 to 61.1
	DfT17	3.3	10.7	23.2	72.8 to 74.2

UK-only metrics

9.17 WebTAG advises that, where possible, the costs and benefits of UK and non-UK passengers should be identified separately. The benefits of each scheme to UK passengers, non-UK passengers starting or ending their journey in the UK, and international-to-international interliner passengers (those transferring via a UK airport with their origin and destination outside of the UK) have been identified and presented in Section 4.

9.18 Presenting Table 9.2 at the UK-only level requires the attribution of airline and scheme costs to UK and overseas residents, which can only be done with a low level of analytical assurance. The department undertook this exercise as a sensitivity in the FRSR, but concluded that incorporating impacts to both UK and overseas residents is the most appropriate and internally consistent approach.[41]

9.19 Total benefits to passengers and the wider economy, and the net public value, of each scheme can still be identified at UK-level with higher levels of analytical assurance. Neither metric includes airline or scheme costs which could be attributable to non-UK residents. Figure 9.4 presents discounted cumulative benefits

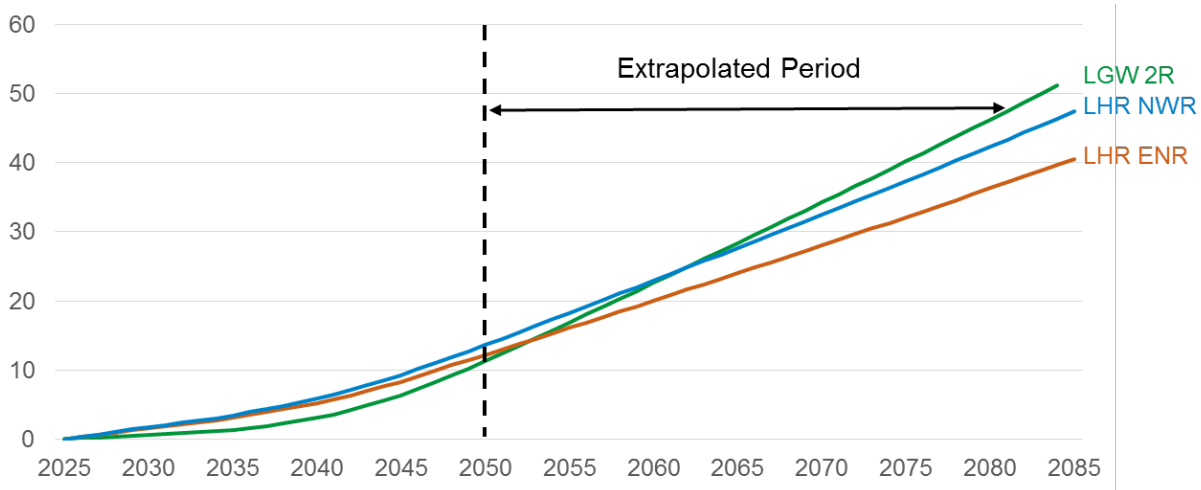
[40] For illustrative purposes, the chart in Figure 9.3 shows total benefits to passengers and the wider economy using the upper end of the wider economic impact range. The full range for 2084/5 is shown in the table.
[41] Further Review and Sensitivities Report, DfT, Table A.18, available at: https://www.gov.uk/Government/publications/airport-expansion-further-review-and-sensitivities-report

to UK passengers and the wider economy across the appraisal period, and the cumulative UK net public values at the end of the 60 year appraisal period.

9.20 As there are a greater number of non-UK passengers under Heathrow expansion, the effect of isolating impacts to UK-only passengers is greater for Heathrow expansion than the LGW Second Runway scheme. The LHR Northwest Runway scheme has the greatest total benefits to passengers and the wider economy in the modelled period to 2050. It is not until the 2060s that Gatwick expansion delivers greater cumulative benefits to UK passengers and the wider economy.

9.21 Similarly, while over the whole period UK-only net public value is greater under the LGW Second Runway scheme, the Heathrow expansion schemes deliver greater net value to the UK public in the period to 2050, and especially earlier on.

Figure 9.4 UK-only cumulative benefits to passengers and the wider economy by forecast year, and UK-only net public value by 2084/5 (present value, £bn, 2014 prices) [42]



		Cumulative benefits to passengers and the wider economy				Net public value
		2030	2040	2050	2084/5	2084/5
LGW Second Runway	FRSR (AC Forecasts)	0.6	3.5	10.2	37.8 to 39.1	35.7 to 37.6
	DfT17	0.6	3.1	11.3	50.0 to 51.2	48.5 to 50.3
LHR Extended Northern Runway	FRSR (AC Forecasts)	1.3	5.8	11.7	32.4 to 34.0	25.8 to 31.2
	DfT17	1.6	5.3	12.2	39.4 to 40.6	34.4 to 39.4
LHR Northwest Runway	FRSR (AC Forecasts)	1.3	6.4	13.2	38.1 to 39.9	32.6 to 37.9
	DfT17	1.7	5.9	13.6	46.1 to 47.4	41.0 to 45.8

[42] For illustrative purposes, the chart in Figure 9.4 shows total benefits to passengers and the wider economy using the upper end of the wider economic impact range. The full range for 2084/5 is shown in the table.

10. Scenario and Sensitivity Analysis

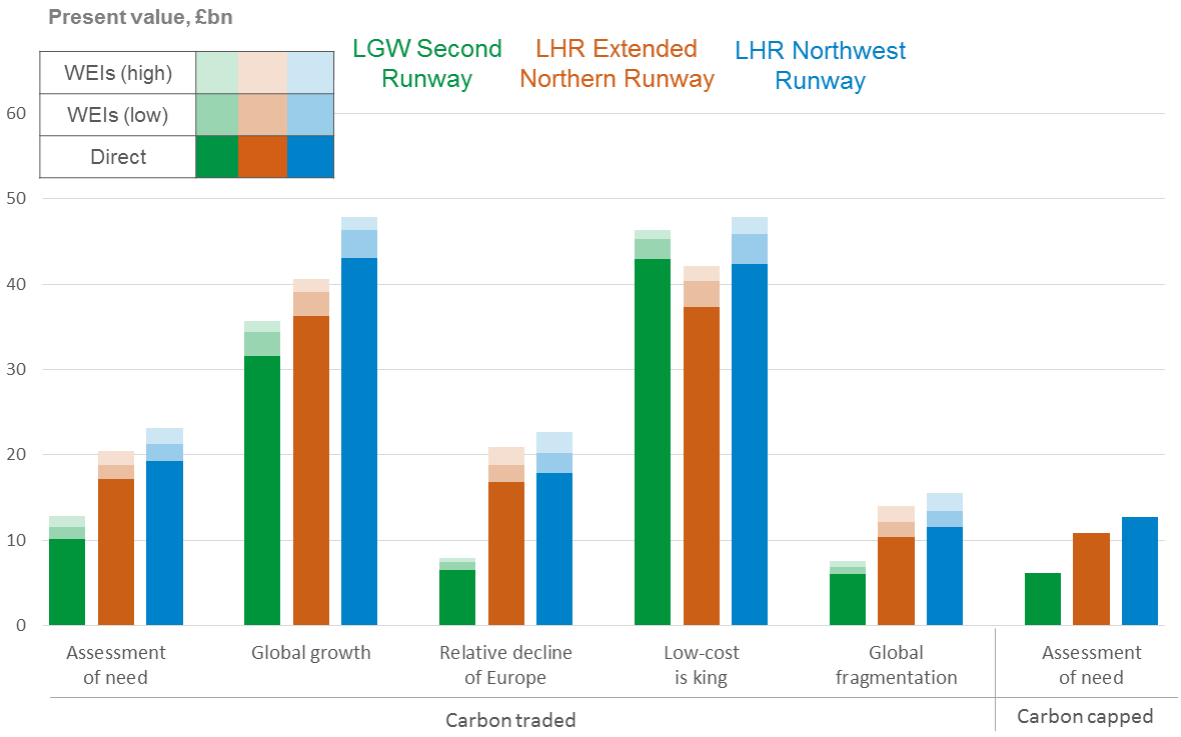
Demand scenario analysis

10.1 Future aviation demand is inherently uncertain, but how it could evolve may have a significant impact on the results presented in this report. It is therefore important to consider a range of future demand scenarios when analysing the impacts of each scheme. In the AoS, we have used higher demand scenarios in order to understand what the possible "worst-case" (before mitigation) environmental impacts could be. In this section, we discuss the variability demand scenarios can lead to in economic impacts and connectivity outcomes.

10.2 The AC looked at a range of scenarios, which allow for uncertainty around levels of future aviation demand and carbon policy. A description of these scenarios is published in the AC's technical report: "Strategic Fit: Forecasts".[43] These reflected not just demand uncertainty, but also uncertainty over future carbon policy.

10.3 Figure 10.1 shows the direct and wider economic impacts estimated by the AC for their demand scenario range. The variation in these monetised impacts under the AC's forecasts reflects the uncertainty in looking at just one demand scenario and carbon policy regime.

Figure 110.1 Cumulative direct and wider economic impacts by 2084/5, AC scenarios (present value, 2014 prices, £bn)



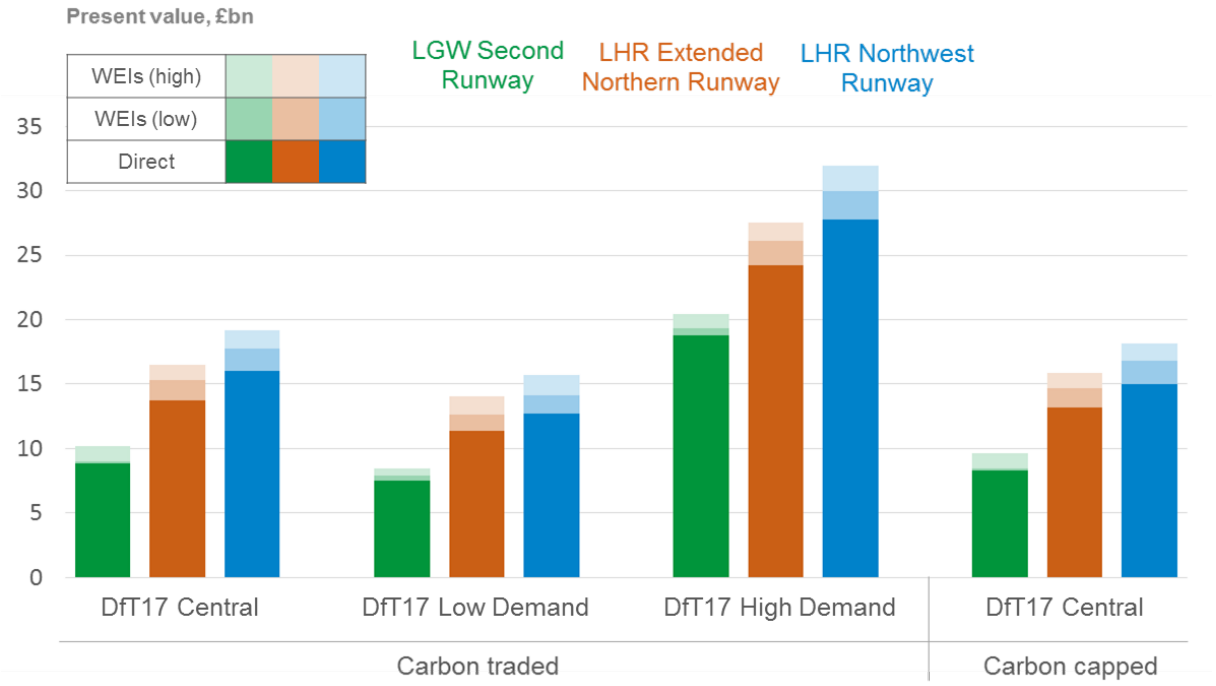
10.4 As set out in Section 2, the department has produced two scenarios alongside the central scenario (comparable to the AC's assessment of need scenario). These are a "low demand" scenario based on a simplified version of the AC's global fragmentation scenario, and a "high demand" scenario based on the AC's global

[43] Airports Commission final report: Strategic Fit Forecasts, available at: https://www.gov.uk/Government/publications/airports-commission-final-report-strategic-fit

growth scenario. We have also looked at a carbon capped scenario. Figure 10.2 shows the direct and wider impacts associated with these scenarios.

10.5 These scenarios also show significant variability, although less so than the AC range due to the narrower range in the demand forecasts. The figures are also lower than the AC's because while benefits have risen, so too have airline losses, as explained in Section 9. Like the AC's findings however, the scenarios show, on this metric, LHR Northwest Runway scheme delivers the greatest net economic benefits.

Figure 110.2 Cumulative direct and wider economic impacts by 2084/5, DfT17 scenarios (present value, 2014 prices, £bn)



Connectivity

10.6 In addition to economic impacts, it is important to consider how connectivity outcomes can vary under the different demand scenarios.

10.7 The AC found considerable variability in both the baseline number of total and long haul ATMs, and the number of additional ATMs delivered by expansion. This variability is substantially higher for the Gatwick expansion scheme than either of the Heathrow expansion schemes – with particularly small improvements in connectivity under Gatwick expansion in the Global Fragmentation scenario. Likewise, Gatwick's connectivity outcomes are substantially improved under the low-cost is king scenario, delivering the greatest increase in total ATMs throughout the modelled period. However, even in this scenario, Heathrow expansion continues to deliver more long haul flights in the shorter term, and Gatwick expansion delivers only slightly more by 2050.

10.8 Taken together, the scenarios show that the LHR Northwest Runway scheme is expected to deliver greater connectivity outcomes under the broadest range of possible futures – with these outcomes being particularly resilient to lower than expected future demand growth. Notably, Heathrow expansion consistently results in early growth in the number of ATMs, and growth in flights to long haul destinations.

10.9 Tables 10.1 and 10.2 present connectivity impacts of the high and low DfT17 demand scenarios. Tables 10.3 and 10.4 present the same information for the AC demand scenarios.

Table 10.1 ATMs at UK airports, without expansion, and additional ATMs under each scheme for DfT17 high and low scenarios, compared to no expansion (thousands)

		ATMs			Long Haul ATMs		
		2030	2040	2050	2030	2040	2050
DfT17 Forecasts (low)	No Expansion	2,218	2,471	2,814	238	260	287
	LGW Second Runway	+12	+18	+56	+2	+6	+15
	LHR Extended Northern Runway	+107	+89	+85	+26	+31	+34
	LHR Northwest Runway	+138	+122	+105	+32	+36	+42
DfT17 Forecasts (high)	No Expansion	2,434	2,707	3,054	269	311	375
	LGW Second Runway	+36	+72	+106	+5	+15	+12
	LHR Extended Northern Runway	+124	+102	+135	+32	+34	+20
	LHR Northwest Runway	+137	+125	+142	+35	+42	+26

Table 10.2 Terminal passengers at UK airports, without expansion, and additional terminal passengers under each scheme for DfT17 high and low scenarios, compared to no expansion (mppa)

		Terminal Passengers		
		2030	2040	2050
DfT 2017 Forecasts (low)	No expansion	297	346	395
	LGW Second Runway	+3	+5	+18
	LHR Extended Northern Runway	+23	+20	+23
	LHR Northwest Runway	+30	+25	+27
DfT 2017 Forecasts (high)	No expansion	331	381	437
	LGW Second Runway	+5	+16	+24
	LHR Extended Northern Runway	+24	+22	+23
	LHR Northwest Runway	+27	+28	+26

Table 10.3 ATMs at UK airports, without expansion, and additional ATMs under each scheme for the AC's carbon traded demand scenarios, compared to no expansion (thousands)

		ATMs			Long Haul ATMs		
		2030	2040	2050	2030	2040	2050
AC Assessment of Need	No Expansion	2,561	2,848	3,213	280	315	364
	LGW Second Runway	+22	+54	+60	+4	+8	+15
	LHR Extended Northern Runway	+78	+104	+89	+27	+33	+25
	LHR Northwest Runway	+79	+125	+105	+27	+39	+33
AC Global Growth	No Expansion	2,684	3,118	3,446	307	367	449
	LGW Second Runway	+47	+100	+174	+10	+25	+33
	LHR Extended Northern Runway	+93	+67	+120	+31	+31	+28
	LHR Northwest Runway	+107	+92	+181	+33	+37	+38
AC Relative decline of Europe	No Expansion	2,547	2,846	3,240	285	322	388
	LGW Second Runway	+57	+72	+74	-1	+6	+12
	LHR Extended Northern Runway	+74	+87	+35	+16	+17	+17
	LHR Northwest Runway	+92	+105	+83	+19	+20	+21
AC Low-cost is King	No Expansion	2,684	3,118	3,442	307	367	444
	LGW Second Runway	+191	+260	+367	+19	+29	+38
	LHR Extended Northern Runway	+78	+68	+130	+22	+25	+30
	LHR Northwest Runway	+100	+93	+163	+29	+32	+34
AC Global Fragmentation	No Expansion	2,492	2,773	3,141	264	292	330
	LGW Second Runway	-9	+25	+30	+2	+5	+8
	LHR Extended Northern Runway	+50	+87	+67	+16	+27	+27
	LHR Northwest Runway	+51	+102	+94	+16	+28	+34

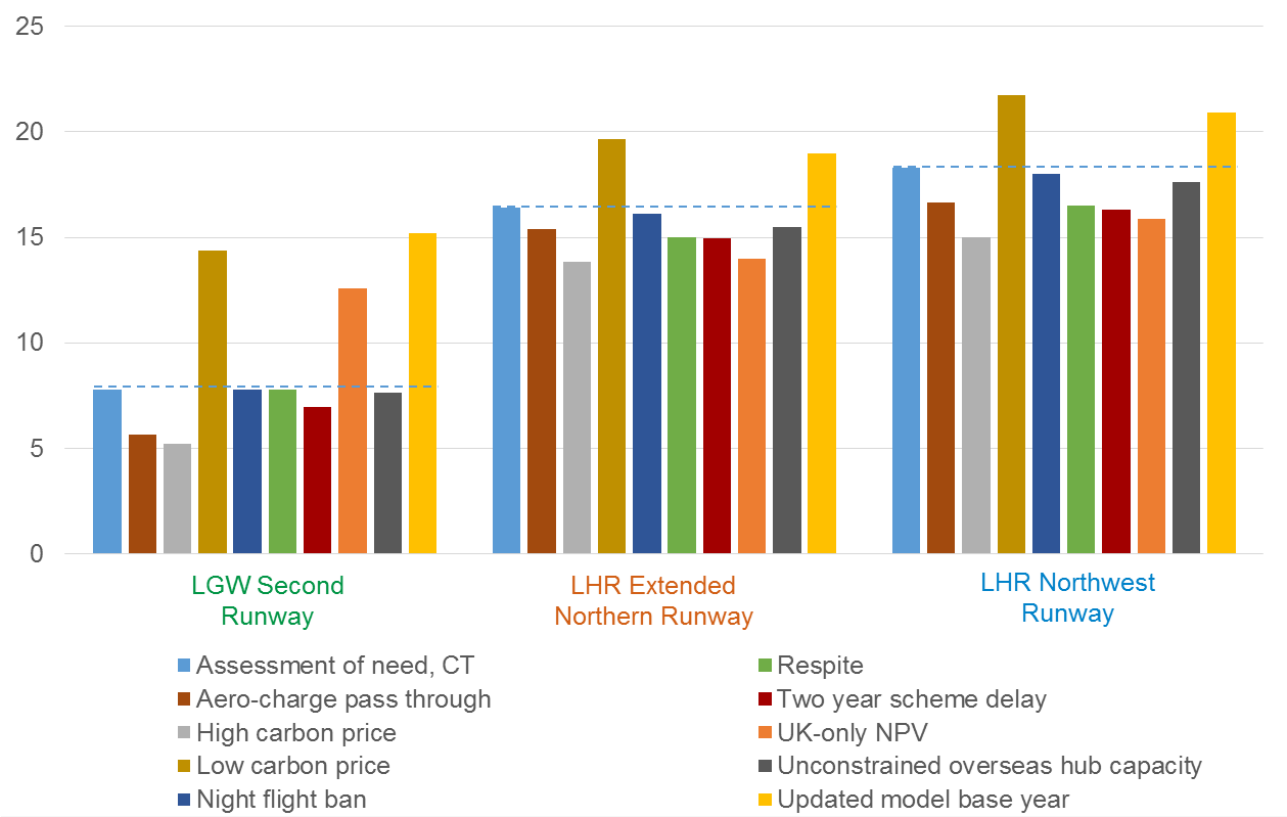
Table 10.4 Terminal passengers at UK airports, without expansion, and additional terminal passengers under each scheme for the AC's carbon traded demand scenarios, compared to no expansion (mppa)

		Terminal passengers		
		2030	2040	2050
AC Assessment of Need	No Expansion	**314**	**360**	**411**
	LGW Second Runway	+3	+8	+16
	LHR Extended Northern Runway	+17	+23	+20
	LHR Northwest Runway	+17	+27	+25
AC Global Growth	No Expansion	**332**	**401**	**457**
	LGW Second Runway	+7	+18	+31
	LHR Extended Northern Runway	+22	+21	+34
	LHR Northwest Runway	+23	+25	+39
AC Relative decline of Europe	No Expansion	**313**	**362**	**418**
	LGW Second Runway	+2	+5	+13
	LHR Extended Northern Runway	+13	+14	+14
	LHR Northwest Runway	+15	+18	+17
AC Low-cost is King	No Expansion	**332**	**401**	**458**
	LGW Second Runway	+18	+28	+41
	LHR Extended Northern Runway	+15	+17	+31
	LHR Northwest Runway	+21	+22	+36
AC Global Fragmentation	No Expansion	**302**	**347**	**397**
	LGW Second Runway	+1	+4	+9
	LHR Extended Northern Runway	+10	+18	+18
	LHR Northwest Runway	+10	+19	+23

Sensitivity analysis

10.10 In addition to demand variability, there are a number of other uncertainties which affect the analysis. This inevitably leads to the need to make assumptions. To address this, the AC undertook a number of sensitivity tests. Section 9 of the FRSR reports these tests and also discusses several additional sensitivity tests undertaken by the department. Detailed results can be found in Annex 1 of the FRSR.

Figure 10.3 Direct economic benefits quantified through the central case (FRSR) and DfT further sensitivities (present value, 2014 prices, £bn)



10.11 The analysis presented in this report makes the same set of central assumptions as set out in FRSR. We recognise the uncertainty around these. The sensitivity tests presented in the FRSR, addressing some of this uncertainty, are useful to help understand the range of impacts expansion could bring. While we have not updated these tests using DfT17 forecasts, the results presented in the FRSR show the relative impact of each sensitivity for each scheme against the central case.

10.12 Figure 10.3 (taken from the FRSR), sets out the results of these tests. The FRSR sets out the challenges of modelling these tests, but collectively they are they are helpful in illustrating the variability of these benefits relative to the central case, which is a lot lower than the variability from the demand scenarios shown above.

10.13 The sensitivities can be broadly grouped into those that affect demand, and those that affect capacity. We have undertaken both types to check the updated model is producing the same relative results between schemes as the version used by the AC.

Gatwick Capacity

10.14 The main analysis assumes a two runway Gatwick would operate in mixed mode throughout the period, maximising its capacity. This sensitivity test examines the impact of reducing capacity at Gatwick to reflect operating in segregated mode.

10.15 For this sensitivity, it has been assumed that capacity at a two runway Gatwick operating in segregated mode would be 520,000 ATMs per year. Table 10.5 below

summarises the benefits associated with the sensitivity test, compared with the central case of 560,000 ATMs per year.

Table 10.5 The impact on passengers, airlines, and government revenue (excluding delay benefits) of lower aviation capacity at Gatwick under the LGW Second Runway scheme, DfT17 forecasts (present value, 2014 prices, £bn)

	Central Case (Gatwick 560k)	Sensitivity (Gatwick 520k)
Passenger benefits	68.5	61.4
Airline profit loss	-66.0	-58.2
Government revenue	4.6	3.9
Partial net benefits total	**7.1**	**7.1**

10.16 Comparing the sensitivity test with the central case, passenger benefits are estimated to fall by about £7bn over the appraisal period. Airline profit losses reduce by approximately the same amount, so that the sum of passenger benefits, airline profit loss, and Government revenue impact, remains about the same in the sensitivity test as in the central case. There would also be further small dis-benefits in relation to delays, and wider impacts that have not been included in this sensitivity test.

Phasing of Capacity at Heathrow

10.17 This sensitivity test examines the effect of phasing of capacity. Unlike in the central case, the increase in capacity at LHR is assumed not to happen instantly – it is brought in gradually over 10 years. This sensitivity test is only applied to LHR Northwest Runway, as phasing would not affect the LGW Second Runway scheme. The phasing of capacity affects passenger demand forecasts and scheme benefits.

10.18 The table below shows the effect on scheme benefits of the phasing of capacity at LHR Northwest Runway, for the AC's forecasts and for the updated DfT17 forecasts. The impact on passenger benefits is small because the change affects only a relatively small proportion of the appraisal period, at a time when there is spare capacity in London.

Table 10.6 The impact on passenger benefits (excluding delay benefits) of phasing capacity at Heathrow over a ten year period (present value, 2014 prices, £bn)

	AC Forecasts			DfT 2017		
	Assessment of Need	Phased Capacity	Change	Central	Phased Capacity	Change
LHR Northwest Runway	54.8	53.5	-1.3	67.3	66.9	-0.5

Zero Carbon Price

10.19 This sensitivity test examines the impact on demand, and scheme benefits, of assuming a zero carbon price, rather than the values from BEIS that are in the central case.

10.20 The effect of this sensitivity test on scheme benefits is shown in the table below. The table shows the results for this sensitivity test using the AC's forecasts and using DfT's updated forecasts (DFT17).

Table 10.7 The impact on passengers, airlines, and government revenue (excluding delay benefits) of a zero carbon price, DfT17 forecasts (present value, 2014 prices, £bn)

		Passenger benefits	Government revenue	Airline profit loss	Carbon externality	Partial net benefit total
LGW Second Runway	AC Forecasts	95.5	6.2	-81.5	-6.6	**13.6**
	DfT 2017	110.5	7.5	-96.7	-6.4	**14.9**
LHR Extended Northern Runway	AC Forecasts	79.9	4.4	-59.7	-9.6	**15.0**
	DfT 2017	87.2	5.4	-68.9	-7.2	**16.4**
LHR Northwest Runway	AC Forecasts	91.5	5.2	-69.6	-11.8	**15.2**
	DfT 2017	97.7	6.1	-78.0	-8.7	**17.1**

10.21 Table 10.8 shows the estimated change in passenger benefits, under the sensitivity test assuming a zero carbon price. There is an increase in passenger benefits, which is offset by an increase in airline profit loss.

Table 10.8 Change in passenger benefits (excluding delay benefits) under a zero carbon price, DfT17 forecasts (present value, 2014 prices, £bn)

	AC Forecasts			DfT 2017		
	Assessment of Need	Zero Carbon Price	Change	Central	Zero Carbon Price	Change
LGW Second Runway	47.1	95.5	48.4	68.5	111.0	42.0
LHR Extended Northern Runway	46.4	79.9	33.4	57.1	87.2	30.1
LHR Northwest Runway	54.8	91.5	36.6	67.3	97.7	30.3

Glossary

Term	Definition
AC	The Airports Commission
AC's demand scenario range	This range is produced from six of the cases considered by the AC. These are the AC's carbon traded forecasts under all five demand scenarios, and the AC's assessment of need, carbon capped forecasts.
AC's final report	The Airports Commission's final report, published in July 2015.
AC's forecasts	The aviation forecasts used in the AC's final report, FRSR, and the draft Airports NPS and AoS, both published February 2nd 2017.
Agglomeration	The advantage of business clusters, such as being close to transport links and a dynamic work force.
Aircraft loads	Passengers per aircraft
Airport capacity constraints	The extent to which airports are constrained, either by runway capacity or terminal capacity.
Airport expansion	When an airport increases its runway capacity or terminal capacity.
Assessment of need	One of the AC's five demand scenarios. Future demand is primarily determined by central projections published by sources such as the Office for Budgetary Responsibility, OECD and IMF.
AoS	Appraisal of Sustainability, published with the draft Airports NPS alongside this report.
APD	Air Passenger Duty
Appraisal period	The period over which costs and benefits are assessed.
AQ	Air Quality
ATM	Air transport movement. Landings or take offs of aircraft engaged in the transport of passengers or freight on commercial terms.
Baseline/do minimum	The scenario of adding no new runway capacity as assessed in the AC's interim report.
BEIS	Department for Business, Energy and Industrial Strategy
CAA	The Civil Aviation Authority
Capacity constrained	Modelling case where passenger and ATM demand must not exceed available future capacity where no significant additional runway or terminal capacity is added.
Capacity unconstrained	Modelling case where passenger and ATM demand is not limited by runway or terminal capacity.
Carbon policy regime	Either one of the two carbon policy scenarios used by the AC (carbon capped and carbon traded), each of which represents a different approach for managing the CO_2 emissions from aviation in the future.
Carbon policy sensitivity test	An alternative carbon policy regime where emissions are capped in line with the CCC's planning assumption.

Carbon capped	A carbon policy regime in which the CO_2 emissions from flights departing UK airports are limited to the CCC planning assumption of 37.5 $MtCO_2$ in 2050.
Carbon traded	A carbon policy regime which incorporates measures to ensure that an increase in the CO_2 emissions from flights departing UK airports as a results of airport expansion does not lead to an increase in CO_2 emissions at the international level.
CCC	The Committee on Climate Change
Charter flights	Flights run as needed, often by package holiday operators used for leisure trips. These are not part of an airline's regular schedule.
Climate Change Act	The Climate Change Act 2008 set a target for total UK greenhouse gas emissions to be reduced by 80 per cent by 2050, relative to a 1990 baseline.
CO_2	Carbon dioxide
Concentration (air quality context)	The level of pollutants in the atmosphere.
DCO	Development Consent Order
Defra	Department for Environment, Food and Rural Affairs
Demand scenario	One of five exclusive aviation demand scenarios defined by the AC and implemented in the department's aviation model.
DfT / 'the department'	Department for Transport
Direct effects	Effects which are a direct consequence of changes at the airport (i.e. not including 'knock-on' impacts).
Draft Airports NPS	Draft Airports National Policy Statement: new runway capacity and infrastructure at airports in the South East of England. Published for consultation alongside this report.
ELFAA	European Low Fares Airline Association
Emissions	In a climate change context, emissions refer to the release of greenhouse gases and/or their precursors and aerosols into the atmosphere over a specified area and period of time.
Extrapolated period	The period from 2051 to 2085 over which the aviation forecasts are extrapolated so that appraisal can be based on a 60 year period, as advised by Government appraisal guidance.
FRSR	Further Review and Sensitivities Report, published in October 2016.
GDP	Gross Domestic Product
Global fragmentation	One of the AC's five demand scenarios. This scenario sees economies close themselves off by adopting more conditional and interventionist national policies. As a result, there is a decline in GDP growth rates for all world regions, coupled with higher operating costs. This results in lower passenger demand growth rates.
Global Growth	One of the AC's five demand scenarios. This scenario sees higher global growth in demand for air travel. It adopts higher GDP growth forecasts for all world regions, coupled with lower operating costs.
GVA	Gross Value Added

Hub-and-spoke network	In hub-and-spoke networks, airlines and alliances route their traffic through one or more key airports (‘hubs’), with feeder traffic (transfer passengers) from other airports in the network (the ‘spokes’) supplementing local origin and destination traffic at the hubs.
IMF	International Monetary Fund
Indirect effects	Effects generated by the activities of the airport’s supply chain.
Induced effects	Effects generated by activities related to those directly or indirectly associated with the airport.
International to international interliners (transfer passengers)	Passengers who are travelling via a UK airport with both their origin and ultimate destination outside the UK.
IPS	International Passenger Survey
JTPR	Job to passenger ratios
Low-cost is king	One of the AC’s five demand scenarios. This scenario sees the low-cost carriers strengthening their position in the short-haul market and capturing a substantial share of the long-haul market. As with the global growth scenario, it also sees GDP growth rates for all world regions and lower operating costs, resulting in higher passenger demand growth rates.
LGW	Gatwick Airport (IATA code)
LGW Second Runway	Gatwick Airport Second Runway, the scheme promoted by Gatwick Airport Limited.
LHR	Heathrow Airport (IATA code)
LHR Extended Northern Runway	Heathrow Airport Extended Northern Runway, the scheme promoted by Heathrow Hub Limited.
LHR Northwest Runway	Heathrow Airport Northwest Runway, the scheme promoted by Heathrow Airport Limited.
Load factor	The proportion of seats on a flight used by passengers.
Long-haul	‘Long-haul’ depicts a destination (or route) to or from a country that is not listed as part of the group of countries defined as ‘Western Europe’ (or ‘short-haul’).
Low cost carrier	Low cost carriers apply a business model that relies on reducing operating costs (for example, by using dense economy-only seating, not providing free in-flight meals, facilitating connections to other flights, discouraging carriage of hold baggage) to provide passengers with relatively cheap tickets – EasyJet, Ryanair, Jet 2 and scheduled Thomson services in the department’s model.
Mixed mode	Operations which allow runways to be used for scheduled arrivals or departures during a given time period; this may apply to all or some runways at an airport.
Model base year	The year from which the majority of underlying model data is taken, and the first year of model output.
Model validation year	The year against which aviation forecasts are validated against CAA statistics and survey data.

Modelled period	The period through to 2050 over which the aviation forecasts are modelled.
Mppa	Millions passengers per annum
$MtCO_2$	Million tonnes of carbon dioxide
Origin-destination marker	Origin and destination market is a measure of how attractive an airport or city is to air traffic. The size of an origin-destination market for a particular location is measured by adding passenger demand for using airport(s) at that location to fly somewhere else (the origin) and passenger demand for getting to that location as the ultimate destination (the destination).
Outturn data	The actual values found at the end of a period of activity, rather than those that were expected or calculated earlier.
NAPAM ('Allocation Model')	National Air Passenger Allocation Model, a model within the department's aviation demand modelling suite. NAPAM allocates the unconstrained demand output from NAPDM to airports, taking into account capacity constraints.
NAPDM ('Demand Model')	National Air Passenger Demand Model, a model within the department's aviation demand modelling suite. NAPDM forecasts the aggregate national demand for air travel before allocating to airports in NAPAM and taking account of airport capacity constraints.
Net Present Value	A metric for assessing the impact of a scheme where all monetised costs are subtracted from monetised benefits.
Net Public Value	A metric for assessing the impact of a scheme where all monetised costs are subtracted from monetised, excluding those felt by the private sector.
Net social benefit	A metric for assessing the impact of a scheme where all monetised costs are subtracted from monetised benefits, excluding costs of construction.
NTEM	National Trip End Model
OBR	Office for Budget Responsibility
OECD	Organisation for Economic Co-operation and Development
Pent-up demand	In an airport context, a situation in which the market demand for flights from a particular airport is greater than the market supply.
Point-to-point	Direct connection between two destinations.
PV	Present value. The current value of future costs and benefits ‘discounted’ to today’s value. Also referred to as discounted value. This is to reflect that society places greater value on the benefits and costs incurred today, than those incurred in the future.
Relative decline of Europe	One of the AC’s five demand scenarios. This scenario sees higher relative growth of passenger demand in emerging economies in the future compared to the growth in the developed world. It adopts higher GDP growth rates for newly industrialised and developing countries, and a strengthened position of Far and Middle Eastern aviation hubs and airlines.
Runway capacity	The number of ATMs (arrivals + departures) that are able to take place on an airport's runways across a specified period of time.

Scheduled carriers	In the department's aviation demand modelling suite, scheduled carriers refer to only those scheduled carriers that are not low-cost carriers.
Scheme	One of three proposals shortlisted by the AC for runway expansion.
Seat-kilometre	The number of kilometres travelled by an aircraft multiplied by the number of seats.
Segregated mode	Where a runway can only be used either for arrivals or departures during a given time period; this may apply to all or some runways at an airport (partial segregation).
Short-haul	'Short-haul' has been defined as 'Western Europe', which comprises the following groups of countries: Andorra; Austria; Belgium; Bosnia and Herzegovina; Cape Verde; Croatia, Cyprus, Czech Republic; Denmark; Estonia; Faroe Islands; Finland; France; Germany; Gibraltar; Greece; Greenland; Hungary; Iceland; Ireland; Italy; Latvia; Lithuania; Luxembourg; Macedonia; Malta; Republic of Moldova; Monaco; Montenegro; Netherlands; Norway; Poland; Portugal; San Marino; Serbia; Slovakia; Slovenia; Spain; Sweden; Switzerland; Turkey; United Kingdom. This is consistent with the definition of 'Western Europe' used in the department's aviation model suite.
Spot price	The current market price at which an asset is bought or sold.
Surface access	Land-based forms of transport used to access airports.
Terminal capacity	The annual number of terminal passengers that are able to use an airport's terminals across a specified period of time.
Terminal passenger	A person joining or leaving a commercial passenger aircraft at an airport.
Transfer traffic	Passengers connecting between their origin airport and destination airport through an intermediate airport.
VFR market	Visiting friends and relatives market.
WebTAG	Department for Transport appraisal guidance.

Annex A: Economic appraisal, data and methodology updates

Direct economic impacts

A.1 Alongside the use of the department's interim forecasts, the primary update in relation to the estimates of direct economic impacts made since the AC analysis, relates to appraisal values of time. This reflects new CAA survey data and updated values published in WebTAG (the department's appraisal guidance). The methodology underpinning this is set out in the Annex to the FRSR. The appraisal values of time impact the estimated benefits from changes in frequency of flights and the duration of delays.

Business values of time

A.2 The updates to the appraisal values of time have lowered the business values of time associated with most airports, particularly at Heathrow for UK passengers. At Heathrow, business passengers' estimated values of time have fallen from £54.98 per hour (AC forecasts) to £43.84 per hour (the department's interim forecasts) in 2008 prices and values. They have fallen from £45.12 per hour (AC forecasts) to £39.55 per hour (the department's interim forecasts) at Gatwick.

Leisure values of time

A.3 There is a single value of time that is applied to all leisure passengers irrespective of their chosen airport. As part of this update, this value of time has been reduced from £6.03 per hour to £4.59 per hour in 2008 prices and values. This reflects updates made in WebTAG.

A.4 For UK residents, all appraisal values of time are grown using values set out in WebTAG. For non-UK residents, foreign GDP per capita growth rates are taken from the sources set out in Table A.5.

Other updates to economic benefits

A.5 The department has also further refined its estimate of benefits to passengers travelling on domestic flights, by improving estimates of loadings. This contributes to the calculation of frequency benefits for such passengers, which are now included in the benefits calculations.

A.6 The estimated carbon savings resulting from lower delays have been updated, using the same carbon values as used in the latest demand modelling.

Conversion to 2014 prices

A.7 The department turned all estimates into 2014 prices using the latest GDP deflator outturn figures sourced from WebTAG. These have been revised from the AC analysis due to changes in the published historic GDP deflator estimates. These revised figures have been used where new economic appraisal analysis has been undertaken.

Wider economic impacts

A.8 As outlined in Section 5 of the main report, the department have made two methodological changes to measuring WEIs. These are:

- the inclusion of tax impact estimates; and,
- the exclusion of agglomeration impact estimates.

A.9 Given the uncertainty associated with estimating wider economic impacts, different calculation approaches have been proposed over time. The preferred methodology is likely to continue to evolve over time with further developments in evidence about how these impacts should be appraised.

Tax impacts

A.10 As labour productivity varies by area, (e.g. it is generally higher in London than in the rest of the country), relocating workers may lead to a change in their productivity. If so, part of this productivity change will be captured by Government through taxation.

A.11 Developing an approach to the estimation of the tax impact of airport expansion is particularly challenging as there are a number of factors affecting differences in productivity and pay across the country – e.g. local area densities, local labour demand, local job types, workers' inherent characteristics, skills, and education. It is therefore difficult to predict the magnitude of the change in productivity that will be experienced by those workers that relocate in response to airport expansion. Given these difficulties this impact was not estimated for the FRSR.

A.12 Since the publication of the FRSR, the department has undertaken further work in this area and has tested two alternative approaches to the estimation of the tax impact.

A.13 One approach focuses on the 'place' effect. Specifically, it assumes that workers' productivity will not increase/decrease to the average level of productivity of the area to which they move. However, to the extent that the area they move to is more/less 'dense' than the area they move from, their productivity will increase/decrease accordingly.

A.14 The second approach is the standard WebTAG approach - equation 4.4 from WebTAG unit A2.1[44] - and conflates 'people' and 'place' effects, as workers' productivity increases/decreases to the average level of productivity of the area to which they move.

A.15 The standard WebTAG approach is less granular as it is based on productivity levels at each location across all sectors – construction, manufacturing, consumer services, producer services, and other – while the first approach considers only sectors whose employment is expected to be affected by airport expansion (consumer services and producer services).

A.16 Despite their conceptual differences, application of these approaches to the airport expansion case delivers similar tax impact estimates. While the (narrow) estimated range under Gatwick expansion is driven by the choice of approach, the much larger ones for Heathrow expansion schemes are driven by the choice of job elasticity (which ranges from 0.02 to 0.15).

[44] https://www.gov.uk/Government/publications/webtag-tag-unit-a2-1-wider-impacts

Agglomeration impacts

A.17 Job relocation can similarly have an impact on agglomeration clusters. In the FRSR, the department produced forecasts for agglomeration that considered the productivity benefits that could be felt by increasing the concentration of workers around an expanded airport. However the department recognises that relocating jobs will also affect congestion on the local transport network, with more people living and working around an expanded airport. This could have a negative impact on agglomeration.

A.18 The latest updates to the Government appraisal guidance for transport projects, WebTAG, advises that both these competing forces should be considered for agglomeration forecasts to be considered analytically robust, where job relocation occurs.

A.19 Airport expansion will influence the location decisions of businesses and employees over a large area and there is large uncertainty over exactly where any new jobs will be located and over the associated congestion impacts. Ideally estimates of these impacts would be made with the help of a fully-fledged transport model, however such an approach was not feasible within the timescales available for analysis.

A.20 Additionally there is uncertainty about how the local population will change, as the additional jobs could be filled by new employees moving into the area, or by local residents who had previously been economically inactive. All of these factors will influence the pattern of trips and congestion we might see on the transport network.

In the absence of a transport model, and due to the uncertainty surrounding the net productivity impact of these competing forces, the department has decided to exclude agglomeration estimates from the wider economic impacts analysis.

Non-flight carbon emissions

Surface Access

A.21 Surface Access outputs (highway and public transport trips for airport passengers and staff) estimated using the DfT's surface access models and updated DfT17 aviation forecasts, have been used to assess the potential impacts of expansion on non-flight carbon emissions.

Department for Transport's surface access models

A.22 DfT has two surface access mode choice models in its aviation suite. SoSERAS (updated version of the South East Regional Air Services model) produces hourly mode split air passenger demand forecasts for surface access to and from Gatwick and Heathrow airports. It uses DfT's GB district level annual demand forecasts, and estimates the number of air passengers (and vehicles if travelling by road) from each district, going to and from Gatwick and Heathrow by mode, per hour. A parallel model, SoSERASe, provides a similar function for airport employees for both Gatwick and Heathrow.

A.23 The two models use the same baseline assumptions about surface access road and public transport networks based on committed and funded schemes by the Government, as documented by the AC in their final report, and in forecasting airport

expansion related surface access trips, the models have used assumptions based on the surface access schemes proposed by the AC.[45]

A.24 The surface access models reflect some level of highway congestion. They take into account impacts of highway congestion based on base year traffic master data, with growth in traffic using current WebTAG car journey time data. Rail crowding is reflected in the base year but the models do not account for any additional crowding after that. These model limitations could influence passenger and staff travel choices and therefore the number of highway and public transport trips.

A.25 There is some uncertainty over the exact surface access package that could be implemented. This could include further highway schemes, and/or it could include specific mitigation measures by the promoter. The nature of the package could affect the mode share (more road or rail trips for example), which could have a higher or lower impact on emissions. In this analysis, for Heathrow expansion, we have included a Southern Rail Access scheme in addition to the baseline; we have not included any highway schemes. The Southern Rail Access scheme would be expected to encourage more rail trips relative to it not being included.

A.26 Given the uncertainty over the package, future congestion and the way users would respond to different interventions, it is possible that emissions could be higher or lower than estimated under these assumptions.

Non-flight carbon assessment surface access inputs

A.27 Surface access trips derived from DfT17 forecasts (central scenario) were used to feed into the non-flight carbon assessment. The central scenario was used to maintain consistency with the AC's analysis. Surface access trips were converted from hourly to annual[46] and provided from the scheme opening year for each expansion option as presented in the tables below for both highway and public transport trips.

A.28 Other methodology changes include:

- The department assessed carbon emissions from passenger as well as staff trips, but not from freight, due to insufficient data being available
- The surface access trips were disaggregated between bus and coach in order to assign specific carbon emission factors[47] to bus and coach trips.
- The surface access model outputs are based on the last mode used for the journey. As Underground trips cannot be taken from beyond a certain perimeter, the analysis chose a cut-off point, and assumed that the remainder of reported underground journeys were taken by regular rail.

A.29 Staff and passenger trips surface access forecasts were modelled for years 2025, 2026, 2030, 2040 and 2050, as this is the last forecasted year provided in the model. The department interpolated these results to obtain forecasts for intermediate years, and extrapolated from 2050, in order to obtain forecasts for the 60 year appraisal period.

[45] https://www.gov.uk/Government/uploads/system/uploads/attachment_data/file/440316/airports-commission-final-report.pdf, p.154, 158, 159.
[46] SoSERAS and SoSERASe's hourly demand are converted at daily and annual level based on arrival and departure profiles collected in passenger and staff survey at each airport.
[47] BEIS GHG reporting: conversion factors 2017, https://www.gov.uk/Government/publications/greenhouse-gas-reporting-conversion-factors-2017 ,Sheet "Business Travel – land".

Table A.1 Annual highway vehicle trips (car and taxi) by passengers and employees at Gatwick, DfT17 central forecasts (millions)

	Highway vehicle trips				
	2025	2026	2030	2040	2050
No Expansion	23.7	23.2	23.0	24.0	23.8
LGW Second Runway	24.7	25.5	28.5	35.0	43.8

Table A.2 Annual highway vehicle trips (car and taxi) by passengers and employees at Heathrow, DfT17 central forecasts (millions)

	Highway vehicle trips			
	2026	2030	2040	2050
No Expansion	57.5	59.4	62.7	66.3
LHR Extended Northern Runway	67.7	75.2	78.2	82.1
LHR Northwest Runway	67.7	77.7	80.7	85.5

Table A.3 Annual public transport trips by passengers and employees at Gatwick, DfT17 central forecasts (millions)

	Public transport trips				
	2025	2026	2030	2040	2050
No Expansion	24.0	24.4	24.8	27.7	29.5
LGW Second Runway	25.0	26.9	30.9	40.4	54.6

Table A.4 Annual public transport trips by passengers and employees at Heathrow, DfT17 central forecasts (millions)

	Public transport trips			
	2026	2030	2040	2050
No Expansion	41.3	43.6	48.8	53.4
LHR Extended Northern Runway	51.1	58.1	64.5	70.4
LHR Northwest Runway	51.1	60.1	66.6	73.4

Airport Operations

A.30 Airport operations covers carbon emissions from electricity, gas and other fuel used at the airport. The AC developed a methodology for estimating these emissions. For this update, the department has attempted to apply this methodology to all 3 shortlisted schemes. This ensures a consistent approach, both across schemes and with prior analysis, to enable meaningful comparisons.

A.31 In the AC's methodology no scope was made for future improvements in energy efficiency. While we stick with this assumption, we are aware that energy efficiency and reducing carbon emissions are concerns of airport operators. We therefore gave both HAL and GAL the opportunity to provide carbon offset figures. Where we received these, they were deducted from carbon emissions for each year in the appraisal period. In practice, this does not affect the additional carbon from airport operations at an expanded airport as it is assumed this offset will occur regardless of expansion. Note that if energy efficiency improved or greater use of carbon offsets was made over time then this could reduce carbon emissions (both in the baseline and with expansion scenario) below the estimates presented in this report.

A.32 In order to produce an updated assessment of the carbon impact from electricity use and fuel use at the airport, the department used energy use figures provided by GAL[1] and HAL[2]. For electricity use and other fuel use, energy-use drivers were assigned (passenger numbers and ATMs, respectively). The department calculated a ratio between these two, and multiplied this across the passenger and ATM forecasts, for each year in the appraisal period. Due to insufficient information available, the department has not updated the carbon emissions from gas used at the airport. Instead, for gas we report our best estimation of the AC's carbon emission numbers from gas use.

[1] http://www.gatwickairport.com/business-community/community-sustainability/sustainability/sustainability-reports/
[2] http://www.heathrow.com/file_source/Company/Static/PDF/Communityandenvironment/Sustainabilty-Performance-Report-2016.pdf