Department for Transport

Further Review and Sensitivities Report

Airport Capacity in the South East

Moving Britain Ahead

October 2016

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Executive summary

Key findings

1. The department's review of the Airports Commission's (AC) final report[1] found that it is a sound and robust piece of evidence to which the Government can give significant weight in making a decision as to whether further airport capacity is required in the South East, and as to which of the three shortlisted schemes would best meet that requirement.
2. The review also identified a number of areas where further work could be helpful. This further analysis supports the AC's analytical approach and helps to give greater assurance to the areas raised for further consideration. The revised central case continues to use the majority of the AC's estimates of the impacts of the shortlisted schemes.
3. The Heathrow (LHR) Northwest Runway scheme is expected to deliver the greatest benefits to passengers and the wider economy, but it is the most expensive scheme with a greater impact on communities and the environment. The LHR Extended Northern Runway scheme is expected to provide lower benefits, but is also less expensive than the LHR Northwest Runway scheme. The Gatwick (LGW) Second Runway scheme also provides a lower benefit alternative, but at a lower cost than both Heathrow options.
4. The revised analysis set out in this report suggests that, as was the case for the AC's analysis, the net present values (NPVs) of all three schemes, generated by subtracting the monetised costs from the monetised benefits, are close. The NPVs of the two Heathrow schemes are subject to more uncertainty than the LGW Second Runway scheme. The LHR Northwest Runway delivers the highest NPV at the upper end of the central range, and the LGW Second Runway delivers the highest NPV at the lower end. This is due to the uncertainty surrounding scheme costs and surface access requirements as a result of airport expansion, which are still to be determined. The ranking of the schemes by NPV is dependent on a number of assumptions necessitated by these uncertainties.
5. The NPV provides the overall picture when the costs and benefits to different groups of society are added together. These impacts may also be of interest in their own right. For example, airport expansion is primarily a private sector investment and so the majority of the costs of all three schemes will initially fall to private businesses, whilst the benefits will include wider benefits to society. The AC considered what the net social benefit of each scheme would be – that is, all costs and benefits to society (including the direct impacts on the airlines using the expanded airport), but excluding the cost to the scheme promotor of construction (which would be a commercial decision). Out of the three schemes under consideration, the LHR Northwest Runway scheme is estimated to deliver the

[1] Available at https://www.gov.uk/government/publications/airports-commission-final-report

highest net social benefit, and would deliver these benefits sooner. The LHR Northwest Runway scheme is also found to deliver the highest benefits if the schemes are compared in terms of the Net Public Value measure, which considers only those impacts that are directly felt by the public (ie excluding the direct impacts on both the airport and the airlines that use it). The results for each of the schemes using these alternative metrics is set out in Table 7.2.

6. Each of these metrics should be considered alongside other quantified impacts that are not included in the NPV, for example the number of local jobs created and trade benefits, as well as non-monetised impacts, such as passenger experience.

Purpose of this Report

7. The main purpose of this report is to set out the monetised costs and benefits of the three shortlisted options for airport expansion in the UK to the economy, the environment, and society, as well as the impacts on local jobs. This report presents the AC's evidence, with commentary from the department's review where necessary. Where further work has been completed, either to supplement or replace the AC's analysis, this is also presented in order to give a comprehensive picture of the monetised impacts.
8. This report is intended to be read alongside the AC's final report and will be supplemented by the assessment of non-monetised impacts in the Appraisal of Sustainability (AoS) commissioned by the department to accompany the publication of a draft National Policy Statement (NPS), and which will be the subject of consultation once completed.
9. There is uncertainty about the future direction of the aviation sector, including the demand for travel and development of new technologies. There is also uncertainty about the costs of the airport capacity schemes; costs will become clearer as the chosen scheme is refined through the planning process and a more detailed scheme design is developed. While this report seeks to understand and reflect uncertainty where possible, it should be borne in mind that the monetised impacts will continue to change as the world moves on.

The Airports Commission's analysis

10. Because of the uncertainty over future levels of passenger demand and aviation business models, the AC considered the economic impacts of expansion for five alternative scenarios. In its final report, the AC focused on one central scenario, called the "assessment of need". Additionally, the AC presented its analysis under two alternative carbon regimes: "carbon-traded" and "carbon-capped".
11. The AC presented a monetised assessment for all three schemes, comparing passenger benefits (through lower fares, reduced delays and increased frequency, partially offset by corresponding reductions in airline profits), wider economic impacts, and government revenue through taxation, to disbenefits (environmental impacts such as noise and air pollution) and scheme costs (including surface access).

12. By presenting the disaggregated costs and benefits, the impact on different groups both within and outside of the aviation sector can be analysed. These are shown for the assessment of need, carbon-traded[2] scenario in Table ES.1.[3]

13. Table ES.1 presents the AC's findings that the LHR Northwest Runway scheme delivered the greatest benefits to passengers, public finances and the wider economy[4] net of environmental and airline disbenefits. On this basis it delivered the highest net social benefit and net public value, The Heathrow schemes are also more expensive. These costs would primarily fall to the scheme promoter as opposed to the taxpayer. The net differences between the schemes were small, but in the central scenario the LHR Northwest Runway scheme gave the highest NPV.

14. The AC found that the ordering of schemes by the NPV measure was subject to assumptions made, such as the scale of future demand and the carbon policy regime. When wider economic impacts are removed from the AC's analysis (departmental guidance recommends presenting results with and without wider economic impacts), the NPV of all schemes was found to fall significantly, with the LGW Second Runway scheme delivering the highest NPV.

15. When the impacts on passengers and society are considered, excluding the costs to the scheme promoter from construction, the LHR Northwest Runway scheme delivers the greatest net benefits.

Table ES.1 AC analysis of monetised impacts (present value, 2014 prices, £bn, assessment of need, carbon-traded scenario)[5]

	Gatwick Second Runway	Heathrow Extended Northern Runway	Heathrow Northwest Runway
Passenger benefits (lower fares, reduced delays and higher frequency of flights)	48.5	46.9	55.4
Government revenue	2.5	1.5	1.8
Wider economic impacts	8.1	10.0	11.5
Total benefits	**59.1**	**58.4**	**68.7**
Environmental costs (noise, air quality, carbon, biodiversity)	-1.5	-2.8	-2.7
Airline profit loss (net of reduced delays)	-40.8	-31.2	-38.0
Net social benefit (AC definition)	**16.8**	**24.4**	**28.0**
Scheme cost	-5.4	-10.4	-12.8
Surface access cost	-0.5	-3.7	-3.3

[2] This report presents carbon-traded impacts unless otherwise stated. This scenario uses assumptions that are consistent with current government policy and with the department's and HMT's appraisal methodology.
[3] The benefits to airlines from reduced delays have been aggregated in a slightly different manner in Table ES.1 to in the AC's Final Report so that they can be directly compared to the department's revised assessment in Table ES.2.
[4] In this report, impacts on the wider economy refer to 'wider economic impacts' as defined by departmental guidance. These do not capture all impacts to the economy, only indirect impacts that are not taken into account in private decision making. These are discussed in detail in chapter 5.
[5] The Net Present Value and Net Social Benefit metrics presented for all three schemes include the costs and benefits to non-UK residents. A sensitivity test has been undertaken which attempts to estimate UK-only variants of these metrics. Further information can be found in Annex 1.

Supplementary analysis and developments to the Airports Commission's assessment of monetised impacts

16. The department's review of the AC's final report found that the AC's approaches to monetising direct economic benefits and environmental impacts were robust. Estimates of these impacts have therefore remained unchanged from those presented in Table ES.1 above.

17. After reviewing the AC's analysis, a number of changes were made by the department to make the AC's assessment of costs more consistent with the government's appraisal guidance for transport projects, WebTAG, and with other parts of the AC's appraisal. The main adjustment to the scheme costs is that an accounting factor of 19% has been added to reflect the need to present costs and benefits in the same unit of account, to enable direct comparison. This is to ensure consistency with the other monetised impacts and does not imply that the observed cost will be higher than that estimated by the AC.

18. The department engaged with external experts to further refine the AC's methodology for estimating the wider economic impacts and the number of local jobs created that could follow expansion. Although it is recognised that there will be wider economic benefits from trade, these are no longer included in the central NPV, due to the risks of double-counting. These benefits are closely related to business passenger benefits as well as wider economic benefits from increased agglomeration, and further review has suggested that these cannot be deemed as additive to one another. Given the significant uncertainties that remain around the estimates of wider economic impacts, a range is now presented. The department also developed a revised methodology for estimating the number of new local jobs that may be delivered by expansion, which are now also presented as a range (see chapter 6).

19. The department has made further changes to the central case to better reflect the uncertainty around the scope of the schemes and surface access designs. The AC estimated both a central case scheme cost and a "reduced scope" cost that considered plausible cost-saving design changes. Given that there is still considerable uncertainty around the precise designs that may be pursued in practice, at this stage it is appropriate to generate a range using the AC's two cost estimates for each scheme.

20. The surface access proposals set out in the AC's final report also reflected an early stage of development. In some cases the AC identified that there may be alternative ways to alleviate the additional congestion on surface access routes generated by airport expansion. Some surface access schemes may be required due to background increases in road or rail demand rather than as a result of airport expansion itself. In particular, costs included by the AC for M4 widening for both Heathrow schemes may not be incurred (because M4 congestion may be dealt with in different ways) and the congestion may not be attributable to airport expansion. A cost range, with and without the cost of M4 widening, has been used to reflect this uncertainty. The estimated costs for the Gatwick Second Runway scheme's surface access upgrades are unchanged.

21. After the department's changes, the revised central case suggests that the NPV ranges for the Heathrow schemes now overlap that for the Gatwick second runway scheme. Table ES.2 shows that whilst the LHR Northwest Runway scheme delivers the greatest direct and wider economic benefits, it is also the most expensive. The net differences are small, with LGW Second Runway delivering the highest NPV at the lower end of the range, and LHR Northwest Runway delivering the highest NPV at the upper end of the range in the central case.

22. In line with the AC, the LHR Northwest Runway scheme delivers the greatest benefits to passengers, government and the wider economy, net of environmental disbenefits and reduced airline profits. The revised net social benefits are summarised in Table ES.2 for the assessment of need, carbon-traded scenario. This table additionally shows the "net public value" of each of the three schemes, which excludes the airline profit loss (net of reduced delays) from the net social benefit calculation, and adds in the range of costs for potential surface access measures. This is therefore equivalent to the NPV, excluding the costs to airlines from lower fares and the costs of construction to the private sector.

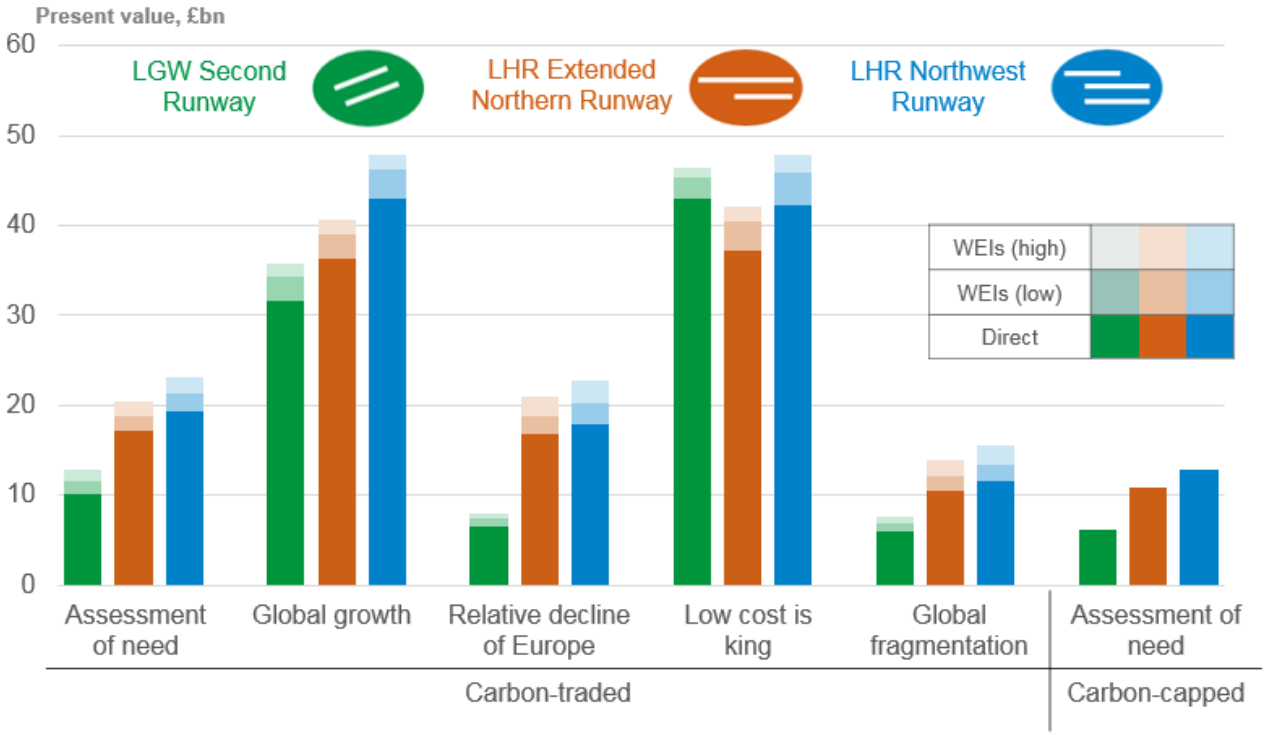
Table ES.2 The department's analysis of monetised impacts (present value, 2014 prices, £bn, assessment of need, carbon-traded scenario)[6]

	Gatwick Second Runway	Heathrow Extended Northern Runway	Heathrow Northwest Runway
Passenger benefits (lower fares, reduced delays and higher frequency of flights)	48.5	46.9	55.4
Government revenue	2.5	1.5	1.8
Wider economic impacts	1.4 – 2.7	1.7 – 3.3	2.0 – 3.9
Total benefits	**52.4 – 53.7**	**50.1 – 51.7**	**59.2 – 61.1**
Environmental costs (noise, air quality, carbon, biodiversity)	-1.5	-2.8	-2.7
Airline profit loss (net of reduced delays)	-40.8	-31.2	-38.0
Net social benefit (AC definition)	**10.1 – 11.4**	**16.1 – 17.7**	**18.6 – 20.4**
Scheme cost	-6.4 – -6.3	-12.0 – -10.7	-14.9 – -12.9
Surface access cost	-0.6	-3.9 – -1.9	-3.4 – -1.4
Net Present Value	**3.1 – 4.5**	**0.2 – 5.1**	**0.2 – 6.1**
Net Public Value	**50.3 – 52.2**	**43.5 – 48.9**	**53.1 – 58.4**

23. Figure ES.1 shows the range of direct[7] economic impacts as estimated by the AC, and the wider economic impacts as estimated by the department, for the various AC demand scenarios. Figure ES.1 shows that the LHR Northwest Runway has the greatest direct economic benefits in five out of the six scenarios presented.

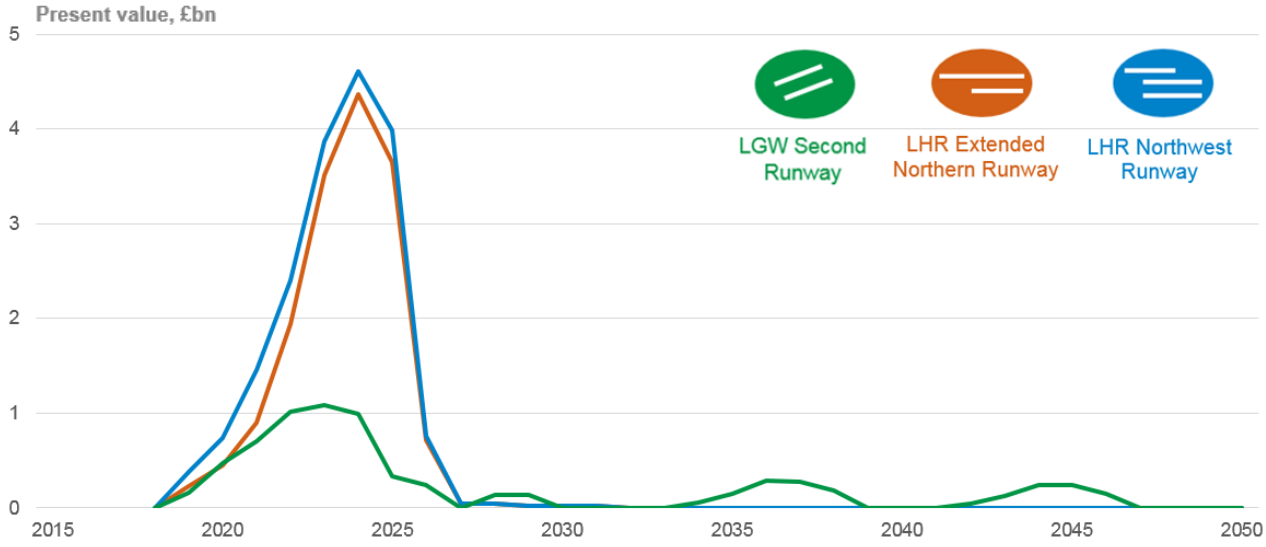
[6] The Net Present Value, Net Social Benefit and Net Public Value presented for all three options include costs and benefits to non-UK residents. A sensitivity test has been undertaken which attempts to estimate UK-only variants of these metrics. Further information can be found in Annex 1.
[7] Direct impacts are defined as passenger and government revenue benefits net of the fall in airline profits from lower fares

Figure ES.1 Direct and wider economic impacts (WEIs) in the AC's demand scenarios (present value, 2014 prices, £bn)



24. The costs of the LHR Northwest Runway scheme are also the highest, followed by the LHR Extended Northern Runway and, by some distance, the LGW Second Runway scheme. Figure ES.2 displays the costs of the three options under the AC's full scheme scopes until the year 2050.

Figure ES.2 Annual discounted financial costs (full AC scheme scopes, present value, £bn, 2014 prices)



25. Further sensitivity analysis on a range of inputs and assumptions has been undertaken by the department. Sensitivity testing helps to determine the resilience of results to changes in these inputs and assumptions, providing assurance for the

central case. The results are discussed in chapter 9, and support the findings of the central case.

1. Introduction

Appraisal approach

1.1 The Airports Commission set out its approach to the appraisal of the three shortlisted options in its appraisal framework, which was published for consultation in spring 2014. The AC then undertook its appraisal of the three shortlisted options, which it published in autumn 2014 in its consultation announcement. Following the consultation, the AC undertook further analysis and published its final report in summer 2015, where it presented its overall appraisal and recommendation.

1.2 As part of this appraisal, the AC monetised the economic, social and environmental impacts of its shortlisted expansion options relative to the counterfactual of none of the options being pursued. This report presents the monetised impacts published by the AC and, where relevant, further analysis undertaken by the department since summer 2015. The AC also completed a non-monetised assessment of the impacts of expansion. These are an important part of the appraisal, but not the topic of this report. The department has commissioned an Appraisal of Sustainability that considers these non-monetised impacts further and will be published as part of a national consultation on a draft NPS.

1.3 The AC's appraisal is generally based on the guidance set out in the Treasury Green Book and the department's appraisal guidance (WebTAG).[8] It covers a period of 60 years from the scheme opening and all values are presented in real (inflation adjusted) 2014 prices. Impacts have been discounted based on Green Book guidance, to reflect the fact that society values costs and benefits today more highly than it does in the future.

1.4 There are impacts of expansion quantified by the AC that are not included in departmental guidance, and these were explored to provide a more comprehensive understanding of the schemes' likely effects. Additional approaches were required as although detailed guidance exists for surface modes of transport, it does not currently capture all of the complexity associated with assessing an increase in aviation capacity, such as:

- air transport delays
- flight frequencies
- agglomeration (the advantage of business clusters, being close to transport links and a dynamic work force)
- trade.

1.5 The methodology used for the further analysis undertaken by the department was to build on the existing evidence base developed by the AC through sensitivity

[8] Available at https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent & https://www.gov.uk/guidance/transport-analysis-guidance-webtag

analysis, and where possible to replace or augment areas of lower analytical assurance.

Capacity options

1.6 The three shortlisted capacity options assessed in this report are based on the scheme designs as set out in the AC's final report. The scheme promoters are still developing their proposals and they may evolve differently in detail from those currently being proposed. This continuing process is likely to have an impact on the costs and benefits reported here.

Demand forecasts

1.7 The AC's passenger demand forecasts are important inputs to the appraisal. The AC estimated passenger journeys, runway and terminal impacts and air transport movements for the do minimum (counterfactual) scenario and each of the three expansion options. These forecasts are an input used to calculate the monetised impacts of the options, including the impacts on passenger benefits, airline profits, government revenue, the wider economy, and noise.

1.8 The AC appraisal 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*.[9]

1.9 As a result of independent advice from the International Transport Forum, the AC used the "assessment of need" scenario as the starting point for its analysis of impacts, testing those results against other scenarios as appropriate. In this scenario, future demand is primarily determined by central projections published by sources such as the Office for Budget Responsibility, OECD and IMF and assumes that there are no changes in airline business models. This is broadly consistent with the central scenario used in the department's most recent aviation forecasts.

1.10 Although some stakeholders have criticised the AC's demand forecasts (see Box 1.1) the department's review found the forecasts to be robust. Therefore, the assessment of need scenario is used for the central case presented in the first six chapters of this report. The sensitivity of the appraisal results to the other demand scenarios is discussed in chapter 8.

[9] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/439687/strategic-fit-updated-forecasts.pdf

Box 1.1 Aviation demand forecasting: modelling approach and criticisms

Two major components of the department's aviation modelling suite that were updated and used by the AC were:

- the National Air Passenger Demand Model (NAPDM or "Demand Model") which forecasts the demand for air travel before taking account of airport capacity constraints
- the National Air Passenger Allocation Model (NAPAM or "Allocation Model") which allocates this demand to airports, taking into account capacity constraints.

These models are described in greater detail in the AC report *Strategic Fit: Updated Forecasts* (2015).

The department's aviation model has been used, updated, tested and scrutinised - internally within the department and externally - for over a decade. It was extensively peer reviewed in 2011 and found to be fit for purpose. In 2013 the Government Actuary Department (GAD) found that: "*The quality assurance for this model has been to a high standard*."

Along with its own quality assurance processes, the AC published a discussion paper on demand forecasting at the beginning of its work and made a number of model developments in response to comments, including the detailed modelling of foreign hubs.

During its consultation process, the AC received a number of criticisms relating to its demand forecasts, and particularly to the forecasts at individual airports made in the "Allocation Model". The AC responded to these criticisms in chapter 6 of its final report. Subsequently, Sir Howard Davies also responded in a letter to the Rt. Hon. Patrick Mcloughlin, Secretary of State for Transport, firmly rebutting the criticism and citing the independent reviews of the forecasts commissioned from Professor Schaeffer of UCL and the separate review from the OECD. In particular, the OECD report found that:

"*the various trends in the AC's traffic forecasts … are plausible, and that the various points raised by the consultees do not provide persuasive evidence that the airport allocation model is biased. The forecasts provide, in our view, a valid basis for the AC to compare the impacts and relative merits of different options for investment in additional capacity at London's airports*."

The department has considered the concerns raised and the AC's response, and agrees that the demand forecasts are sufficiently robust to be used as inputs to the monetised appraisal.

1.11 The AC also considered two potential carbon policy futures: carbon-traded and carbon-capped. This report presents carbon-traded impacts unless otherwise stated. The carbon-traded case uses assumptions that are consistent with current government policy and with government appraisal methodology.

1.12 The AC's approach to modelling the carbon-capped scenario uses carbon price assumptions that are higher than the central values published by the Department of Energy and Climate Change (DECC) for appraisal. The carbon-capped scenario is helpful for understanding the varying effects of constraining aviation CO_2 emissions on aviation demand and the impact on the case for airport expansion, but was described by the AC as "unrealistic in future policy terms". The AC's carbon-capped appraisal results are discussed further in chapter 8.

Structure of this report

1.13 Chapters 2 through 5 of this report set out the quantified costs and benefits that feed into the calculation of scheme NPVs, net social benefits and net public values presented in chapter 7. Chapter 6 considers further local impacts that have been quantified but do not feed into the scheme NPVs. Chapters 8 and 9 consider other scenarios and sensitivities to test the robustness of the central case to changes in assumptions.

1.14 The impacts explored in this report are shown in Figure 1.1.

Figure 1.1 Overview of quantified impacts

	Impact	Central case revised since AC Final Report?
Direct economic	Costs of construction	Yes
	Passenger, producer and government impacts	No
Environmental	Air quality impacts	No
	Biodiversity impacts	No
	Carbon impacts	No
	Noise impacts	No
Wider	Wider economic impacts	Yes
Local	Local economy impacts	Yes

2. Costs of construction

2.1 The construction of a scheme creates a number of costs that would be borne, in the first instance, by the promoter and its investors, but which over time could eventually be passed through to its customers (airlines and potentially passengers) through charges that may be subject to regulation.

2.2 The AC presented its cost estimates in chapter 7 of its final report, as well as in underlying reports in the commercial viability module of its appraisal framework. These supplementary reports are available on the cost and commercial viability section of the AC website.[10] As well as the central cost estimates, the AC presented scenarios and sensitivities, including possible cost reductions for each of the three shortlisted options.

2.3 As part of the department's further analysis undertaken since summer 2015, a number of revisions to the way the AC's costs feed into the appraisal have been implemented in order to make them more consistent with the department's appraisal guidance, WebTAG, and with other parts of the appraisal.

i. WebTAG requires that costs are uplifted using an indirect tax factor (of 1.19) to convert capital expenditure (capex) estimates into market prices to ensure consistency with other monetised elements of the appraisal expressed in market prices. This factor was not applied by the AC and so has been applied by the department to the AC scheme and surface access costs. This is to ensure consistency in terms of the unit of account with the monetised impacts and does not imply that the observed cost will be higher than that estimated by the AC.

ii. For the surface access impacts, WebTAG suggests that scheme costs and benefits should include capital costs, operating costs (opex), revenue, ongoing benefits (such as passenger benefits and wider economic impacts) and disbenefits (such as air quality and noise impacts). The AC calculated opex and replacement capex for surface access schemes, but not any additional benefits or disbenefits. For some surface access schemes, the net benefits could be positive, however this may not be the case for all schemes and therefore the overall impact is unclear. The AC included ongoing costs in its assessment, but not ongoing benefits, which were assessed qualitatively (see Box 2.1). For consistency, therefore, operating costs and replacement capex have been removed from the surface access costs in the central case. In line with the AC's approach, replacement opex and capex have not been included in the assessment of scheme costs.

[10] https://www.gov.uk/government/publications/airports-commission-final-report-cost-and-commercial-viability

Box 2.1: Assessing surface access impacts

Each of the shortlisted schemes is supported by an extensive surface access strategy. These build on planned transport improvements such as Crossrail and Thameslink, which are in construction and will be completed regardless of airport expansion, and will provide significant improvements in surface access to the airports. In addition, the Airports Commission assumed a number of schemes in its baseline that in their view were likely to be completed in the medium to longer term as part of normal road and rail investment programmes, regardless of airport expansion. These include schemes such as Western Rail Access to Heathrow and improvements to the Brighton Main Line.

Finally, the Commission identified a number of measures required for airport expansion. These are principally designed to allow for expansion of the airport and cater for increased numbers of airport users, but may also bring wider benefits for non-airport users.

These include road diversions to enable a new or extended runway to be built as well as localised enhancements to the existing road network to help manage congestion. Some of these schemes would be financed by the airport operator, where they are solely necessary for construction of the runway. In other cases the operator would pay a contribution towards a scheme where it would produce benefits for both airport and non-airport users. An example would be the proposed Southern Rail Access to Heathrow which would create a completely new rail link to the airport, but would also provide benefits for non-airport rail users.

The costs of the surface access schemes identified by the AC have been included in the economic analysis because the AC stated they are likely to be required for airport expansion. In some cases the schemes are designed to mitigate the impact of increased numbers of airport users, but the wider benefits of the schemes have not been captured. These benefits could include fare revenue, reduced congestion or crowding, journey time improvements for non-airport users and potential air quality improvements as a result of reduced congestion. In some cases there could be potential disbenefits to non-airport users from the expansion, such as increased congestion. Any evaluation of surface access impacts would therefore need to consider the net impact on both airport and non-airport users.

A key theme identified by the AC was the challenge that would arise as a result of increasing background demand growth ie from non-airport related journeys by commuters, intercity travellers and freight in London and the South East by 2030. These issues were anticipated to affect all three schemes, but potentially with a greater impact on the links serving Heathrow.

The AC report stated that on the strategic road network a number of links near Heathrow, particularly sections of the M4 closest to the airport which are already congested, may need improvement to cope with demand from expansion on top of anticipated background demand. Any enhancement of this nature would have benefits for non-airport users by reducing the potential impact of congestion due to increased numbers of airport users. While the cost of this work has been included in the AC's analysis, these potential benefits have not been captured. The net effect of this is therefore unclear.

The AC identified alternatives to some road infrastructure enhancements such as measures to manage demand. Airport operators' efforts in delivering increases in

the share of airport passengers using public transport will be vital in minimising the impact of increased numbers of airport users on the road network.

2.4 There remains some uncertainty over whether all of the surface access schemes included in the AC's estimate of costs are required as a direct result of expansion. For example, the M4 is already congested and the pressure on that corridor is expected to continue to grow with or without Heathrow expansion, as background demand continues to grow as a result of population increases and economic growth. Airport users are a relatively small proportion of those who use the route. The AC concluded that additional demand associated with expansion might be the factor that triggers the need for measures to increase capacity on the M4. These measures could include managing demand or providing additional capacity, including as widening sections of the M4. The AC included the full cost of M4 widening in its assessment, whilst acknowledging that there were alternatives to widening which might be less expensive.

2.5 Alternately, airport expansion may only have a limited impact, or could be viewed as simply bringing forward the need to undertake surface access improvements by a few years, implying that the full cost of the works should not be ascribed to airport expansion. The department has concluded that the M4 should be considered holistically as part of the normal roads investment process. It is not possible at this stage to say with confidence what the cost of any eventual solution to increased congestion on the M4 might be, or what proportion should fall to the airport. As such, surface access costs for the two Heathrow schemes are now presented as a range, with and without the AC's cost estimates for M4 widening, reflecting this uncertainty.

2.6 Road and rail investment programmes have continued since the AC carried out their work and so the timing and nature of other schemes assumed to occur in the AC's baselines may change, reflecting different circumstances and priorities.

2.7 The AC's costs also included initial estimates for community compensation such as noise insulation and land acquisition. Between its autumn 2014 consultation process and its final report, the AC undertook further work with the scheme promoters to update and clarify these costs. This included a sensitivity test to examine the impact of updated compensation offers on the affordability and financeability of the schemes. Where compensation is offered to mitigate disbenefits that are monetised elsewhere in the AC's appraisal, including the cost of the compensation may not be appropriate. The currently unquantified reduction in disbenefits that mitigation would deliver could plausibly be expected to offset the cost incurred. As it is the net effect that is of interest for appraisal purposes, the noise compensation costs have been removed from the central present value of costs for each scheme.

2.8 The AC used material provided by promoters to determine the schemes' scopes and associated capital costs, but adjusted these where necessary. In addition to the AC's central case, a sensitivity was undertaken by the AC that explored costs under plausibly reduced scheme scopes.

2.9 Actual scheme designs and costs will be dependent on the outcome of planning and economic regulatory processes involving airports, airlines and local communities. Given the uncertainty around this, rather than including a point estimate of scheme costs in the central case a range is used within the NPVs from the AC's reduced scope estimates to the AC's full scope central case.

2.10 Table 2.1 shows the AC's central estimates of costs as well as the AC's 'cost reduction' estimates. Also shown are the AC's central and reduced estimates revised to be more consistent with WebTAG and to exclude noise compensation. Finally, the table shows the revised AC central case with M4 costs excluded, and the range of the department's central case - the upper end of which is equal to the AC's adjusted central case, the lower end of which uses the AC's reduced scheme costs and excludes the cost of widening the M4[11]. The numbers shown are negative because they represent costs.

2.11 As with the other quantified impacts in the economic appraisal, the costs in Table 2.1 have been discounted to give their present values. They have also been uplifted by an indirect tax factor to ensure consistency. While they therefore differ from the headline scheme and surface access costs quoted in other documents, they reflect the same underlying costs.

Table 2.1 Scheme and surface access costs, alternate assessments (present value, £bn, 2014 prices)

	AC estimates		Revised estimates				
	Central case	Reduced scheme cost	AC central case	AC reduced scheme cost	AC central case with M4 cost excluded	AC reduced scheme cost with M4 cost excluded	DfT central case
LGW Second Runway	-6.0	-5.8	-7.0	-6.9	-7.0	-6.9	**-6.9 – -7.0**
LHR Extended Northern Runway	-14.1	-13.1	-15.9	-14.6	-13.9	-12.6	**-12.6 – -15.9**
LHR Northwest Runway	-16.1	-14.4	-18.4	-16.3	-16.3	-14.3	**-14.3 – -18.4**

2.12 The costs of the expansion options naturally carry a high degree of uncertainty. They will become clearer once the selected scheme moves closer to being finalised and progresses further through the planning process.

2.13 The financing costs of the options have not been included in the assessment of scheme costs. Financing costs are uncertain and will be dependent on the capital structures that are used. The ultimate pricing will only be known when there is better clarity on risk allocation and will be determined by financial market conditions at the time of financing.

2.14 The detail of the regulatory settlement for airport expansion will be a matter for the Civil Aviation Authority (CAA) to conclude. This will have an impact on how scheme costs, including surface access costs, will be allocated – ie whether they will fall to users of the new capacity (eg airlines and passengers), or the airport (shareholders).

[11] As M4 widening is only associated with the two Heathrow schemes, this aspect of variation does not affect the costs of the LGW Second Runway scheme.

3. Direct economic benefits

3.1 Airport expansion has a direct impact on passengers, airlines and airports, and government revenue. This chapter briefly summarises the AC's assessment of these direct impacts, which was deemed to be robust in the department's review.

3.2 The AC presented its estimates of these direct economic impacts in both chapter 7 of its final report and further supplementary reports in the economy impacts module of the appraisal framework. The AC report *Economy: updated transport economic efficiency impacts* sets out the AC estimates of passenger benefits from lower fares and improved frequencies, airline impacts from lower fares, and government revenue impacts from people diverting their spending behaviour towards air travel.[12] The report *Economy: updated final delay impacts assessment* presents the AC's estimates of benefits to passengers and airlines from reduced delays due to greater resilience in schedules.[13]

3.3 The department has found the AC's analysis of these impacts to be robust and generally consistent with WebTAG guidance. The estimates of these impacts in the department's central case are therefore those calculated by the AC.

3.4 Figure 3.1 shows the AC's estimates of passenger benefits, and Figure 3.2 presents the AC's estimates of airline and government revenue impacts.

3.5 The AC's analysis of the impacts of airport expansion differs from WebTAG and the Treasury's Green Book with regards to its treatment of UK residents and international to international transfer passengers. Costs and benefits to all passengers and airlines (regardless of their residency or whether they are a transfer passenger) are assessed in the AC's central case, and feed into the calculation of the schemes' NPVs. The department considers this approach to be appropriate given the challenges faced in attributing costs on the basis of nationality. Although it is possible to attribute benefits to specific groups (as shown in Figure 3.1), without a reliable method of apportioning costs to these groups any estimate of UK-only NPV would be subject to a high degree of uncertainty. A UK-only NPV has been estimated by the department in a sensitivity test (discussed in chapter 9), which suggests that a UK-only approach would deliver greater net present values for all schemes.

3.6 The AC's estimates of **reduced fares** are dependent on strict assumptions around the evolution of "aero-charges". The department has considered the impact of this further and concluded that the AC's approach is reasonable. Sensitivity testing, explored in more detail in chapter 9, suggests that relaxing these assumptions still results in positive direct economic benefits, although they are lower than in the central case for all schemes.

[12] Airports Commission (2015), 'Economy: Updated Transport Economic Efficiency Impacts', Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/439169/economy-updated-transport-economic-efficiency-impacts.pdf

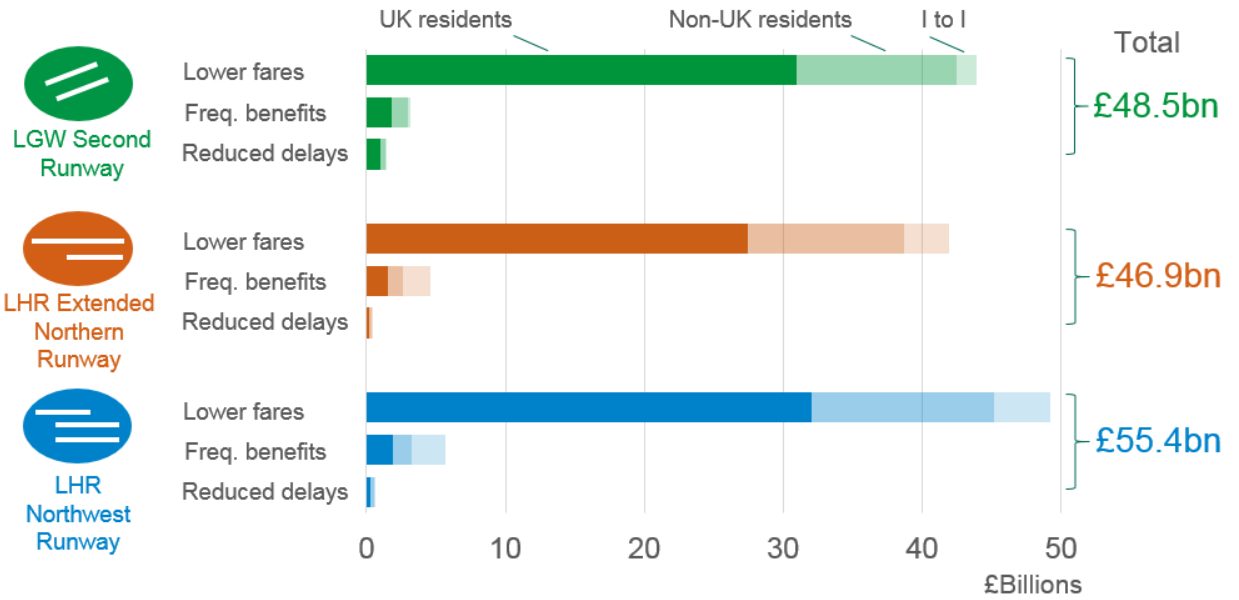
[13] Airports Commission (2015), 'Economy: Updated Final Delay Impacts', Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/439680/economy-updated-final-delay-impacts-assessment.pdf

3.7 WebTAG does not include guidance on estimating **delay** or **frequency** impacts of air transport schemes, so the AC devised an appropriate new approach. There were however a number of delay impacts that the AC could not quantify. These included:

- the benefits of reduced delays to new passengers generated by each option
- the demand response from reduced delays
- unscheduled delay time saving benefits.

3.8 These impacts would potentially increase the benefits from expansion but are not expected to substantially alter the overall assessment of the options.

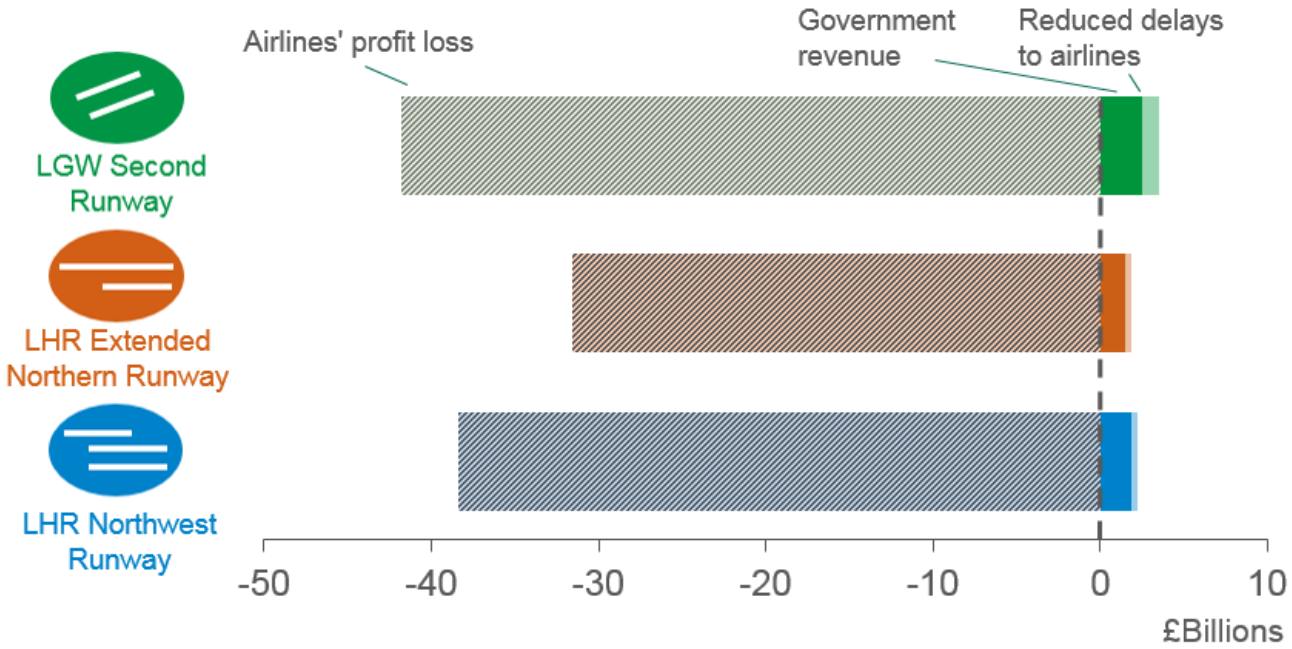
Figure 3.1 Passenger benefits (present value, £bn, 2014 prices)[14]



	Lower fares			Frequency benefits			Reduced delays			Total		
	UK residents	Non-UK residents	I to I	UK residents	Non-UK residents	I to I	UK residents	Non-UK residents	I to I	**UK residents**	**Non-UK residents (including I to I)**	**Total**
LGW Second Runway	31.0	11.5	1.4	1.8	1.1	0.2	1.0	0.4	0.0	**33.9**	**14.6**	**48.5**
LHR Extended Northern Runway	27.5	11.2	3.2	1.5	1.1	1.9	0.2	0.2	0.0	**29.2**	**17.7**	**46.9**
LHR Northwest Runway	32.0	13.1	4.0	1.9	1.3	2.4	0.3	0.2	0.1	**34.2**	**21.2**	**55.4**

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

Figure 3.2 Airline and government impacts (present value, £bn, 2014 prices)



	Airlines' profit loss	Reduced delays to airlines	Total airline impact	Government Revenue
LGW Second Runway	-41.8	1.0	**-40.8**	**2.5**
LHR Extended Northern Runway	-31.6	0.3	**-31.2**	**1.5**
LHR Northwest Runway	-38.4	0.4	**-38.0**	**1.8**

4. Environmental impacts

Overview

4.1 Airport expansion has substantial implications for the environment and these were considered by the AC. This chapter briefly summarises the AC's assessment of the monetised impacts on air quality, biodiversity, carbon, and noise impacts. The department's review concluded that the AC's assessments were robust.

4.2 It is important to note that aspects of the scheme designs, notably surface access under the Heathrow Extended Northern Runway scheme, have been revised since the AC's final report, and will continue to evolve over time. The quantified impacts shown in this chapter reflect the scheme designs as considered by the AC.

4.3 Any expansion scheme will be accompanied by a package of measures to manage and mitigate impacts on local communities and the environment. The quantified assessments in this chapter broadly consider outcomes before such mitigations have been implemented. Some of the mitigations considered by the AC are briefly discussed in Box 4.1.

Box 4.1 Mitigation measures

The AC proposed a comprehensive package of measures to manage and mitigate the impacts of the LHR Northwest Runway scheme on local communities and the environment, should that scheme be taken forward. Among the recommendations were measures to limit the impact of aircraft noise, including a ban on all scheduled night flights between 11:30pm and 6:00am, a legally enforceable 'noise envelope' and periods of predicable respite; a community compensation package; and a recommendation that expansion should be contingent on acceptable performance on air quality.

Since the AC final report, the department has explored the potential impacts of some of the noise mitigations proposed by the AC, including a night flight ban and measures to provide more respite. This analysis can be found in chapter 9. The analysis of noise mitigations has a low level of analytical assurance and is at best viewed as indicative of some of the potential impacts of mitigation measures on the appraisal.

The department has also commissioned further work to test the AC's work on air quality against the Government's new National Air Quality Plan, which was released in December 2015.

As the preferred scheme develops and the full package of measures is established, further analysis will assess the costs and benefits of these mitigations.

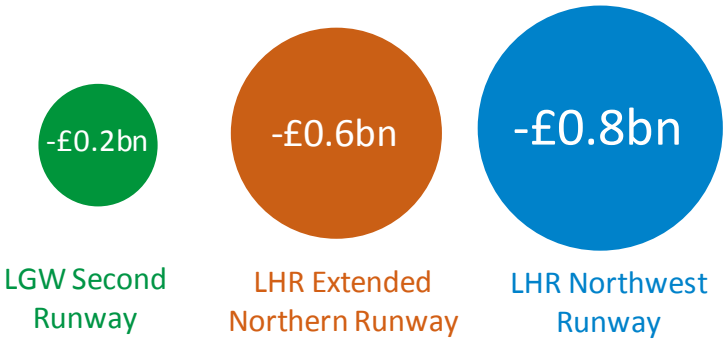
Air quality

4.4 Emissions of air pollutants are created by aircraft, airport operations and surface access, and these 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 of air pollutants are also of concern nationally and as such are subject to legal limits.

4.5 The AC presented its estimates of the monetised impact of expansion on air quality in chapter 7 of its final report, as well as in the air quality module of its appraisal framework. The supplementary reports underpinning the AC's monetised air quality impacts are available on the AC's website in the air quality section of its November 2014 consultation announcement.[15] This assessment of air quality impacts does not include potential emissions from induced road traffic that may be generated as a consequence of surface access improvements. The department views the AC's estimates as robust and consistent with the current cross-departmental guidance. The present value of air quality impacts for each of the AC's capacity options are shown in Figure 4.1. The numbers shown are negative because they represent disbenefits to society. These are subtracted from the benefits when considering the impact of the scheme overall.

4.6 The AC estimates of emissions of air pollutants refer specifically to the expanded airport and related surface access. The AC did not publish analysis that considered the possibility of lower emissions of air pollutants at other airports, so these are not included from the estimates presented. Therefore the figures presented here potentially over-estimate the impact of expansion on air quality emissions at a national level, although accounting for this omission would have a very small impact as the share of emissions coming from surface access is small.

Figure 4.1 Air quality impacts (present value, £bn, 2014 prices)



4.7 After the AC's final report was published, the Government released a new Air Quality Plan for Nitrogen Dioxide (NO_2) in December 2015.[16] The department commissioned further analysis to test the AC's work on air quality against the Government's new National Air Quality Plan. The results of this work can be found in the *AIR QUALITY REANALYSIS Impact of New Pollution Climate Mapping Projections and National Air Quality Plan* Report.[17]

4.8 Since the AC's assessment, the Department for Environment, Food and Rural Affairs (Defra) has also considered updated advice from the Committee on the Medical Effects of Air Pollutants (COMEAP), and has published interim guidance

[15] https://www.gov.uk/government/publications/additional-airport-capacity-air-quality-analysis
[16] https://www.gov.uk/government/collections/air-quality-plan-for-nitrogen-dioxide-no2-in-uk-2015
[17] This report is yet to be published at time of drafting, but is expected to be released alongside this document

on using new concentration-response functions for estimating the health impacts, and valuation, of NOx. The department has therefore completed a sensitivity test on the impact of taking account of the new interim Defra guidance. This can be found in chapter 9. As this guidance is developed, the department will consider how any revised values will affect the monetised air quality impacts.

Biodiversity

4.9 The building of new airport infrastructure and its associated surface access links has implications for biodiversity.

4.10 The AC presented its estimates of the monetised impact of expansion on biodiversity in chapter 7 of its final report, as well as in the biodiversity module of its appraisal framework. The supplementary reports underpinning the AC monetised biodiversity impacts are available on the AC's website in the biodiversity analysis section of its November 2014 consultation announcement.[18]

4.11 The AC monetised biodiversity impacts using two separate methodologies – the compensatory habitat approach and the replacement value of lost ecosystem services approach. Both approaches resulted in a range of estimates, shown in Figure 4.2 and Figure 4.3.

Figure 4.2 Biodiversity impacts - Range of outline cost estimates for provision of compensatory mitigation habitat approach (present value, £m, 2014 prices)

Figure 4.3 Biodiversity impacts - Range of replacement value of lost ecosystem services approach (present value, £m, 2014 prices)

4.12 The AC's estimates of biodiversity impacts are consistent with Green Book and cross-departmental guidance and are therefore viewed by the department as robust. As can be seen, the costs of mitigating the impacts on biodiversity are generally lower than the replacement value of lost ecosystem services. It is therefore rational to expect that the mitigations would be adopted, and as a result,

[18] https://www.gov.uk/government/publications/additional-airport-capacity-biodiversity-analysis

it is the mid-point of the compensatory mitigation figures that are included in the central case. But it should be noted that the biodiversity impacts are much smaller in magnitude than the other monetised impacts so adopting the replacement value approach would not have a material impact on the economic appraisal.

Carbon

4.13 Airport expansion falls within the context of global climate change policy and has an impact on carbon emissions from air transport movements, airport ground operations (including buildings and energy use), surface access and construction.

4.14 The AC presented its estimates of the monetised impact of expansion on carbon emissions in chapter 7 of its final report, as well as in the carbon module of its appraisal framework. The supplementary reports underpinning the AC's monetised carbon impacts are available on the AC's website in the carbon impacts sections of its November 2014 consultation announcement and also in its final report.[19] The AC's estimates are slightly different in its final report compared to the supplementary report. This report presents the AC's estimates of monetised impacts taken directly from the technical report *Carbon: further assessment.*[20]

4.15 The AC's carbon-traded assessment is consistent with cross-government guidance and is therefore viewed by the department as robust. Updated carbon appraisal values have been published by DECC since the AC published its final report. These prices do not materially differ from those used by the AC[21]. A sensitivity test has subsequently been undertaken by the department in which the carbon prices used in the demand forecasts and direct economic benefits are updated to the latest values as part of a wider update of the economic input data. For further information, see chapter 9.

4.16 The AC's carbon-traded scenario incorporates measures to ensure that an increase in CO_2 emissions from flights departing UK airports as a result of airport expansion does not lead to an increase in CO_2 emissions at the international level. The scenario uses the central carbon traded values for appraisal published by DECC in 2012.[22] Up to 2020, these values are based on the current price of the European Union Emissions Trading Scheme (EU ETS) carbon credits and the price of futures contracts on these credits. Beyond 2030 the price is based on the assumption that there will be a fully functioning global carbon market, where the values represent the cost of buying credits in this market. Between 2020 and 2030 the price is an assumed extrapolation between the 2020 and 2030 values as the world transitions towards the global carbon market. Increases in aircraft CO_2 emissions from expansion were therefore not treated as additional (as they would be offset by emissions reductions in other sectors, paid for by the aviation sector) and were not included in the monetised assessment of costs and benefits.

4.17 Since the AC published its final report a number of events have occurred that could have an impact on the carbon values underlying the AC's carbon-traded scenario. These include the UK's decision to leave the EU, and the recent agreement at the International Civil Aviation Authority (ICAO) assembly to introduce a global carbon offsetting scheme for aviation from 2021. The

[19] https://www.gov.uk/government/publications/additional-airport-capacity-carbon-analysis and https://www.gov.uk/government/publications/airports-commission-final-report-carbon
[20] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/437260/carbon-further-assessment.pdf
[21] The AC used the DECC 2013 carbon prices for appraisal
[22] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/245385/6667-update-short-term-traded-carbon-values-for-uk-publ.pdf

Government will also publish its Emissions Reduction Plan in due course. As the government continues to update its climate change policy, the carbon values used by the AC are still the most suitable to use given the current outlook relating to aviation emissions.

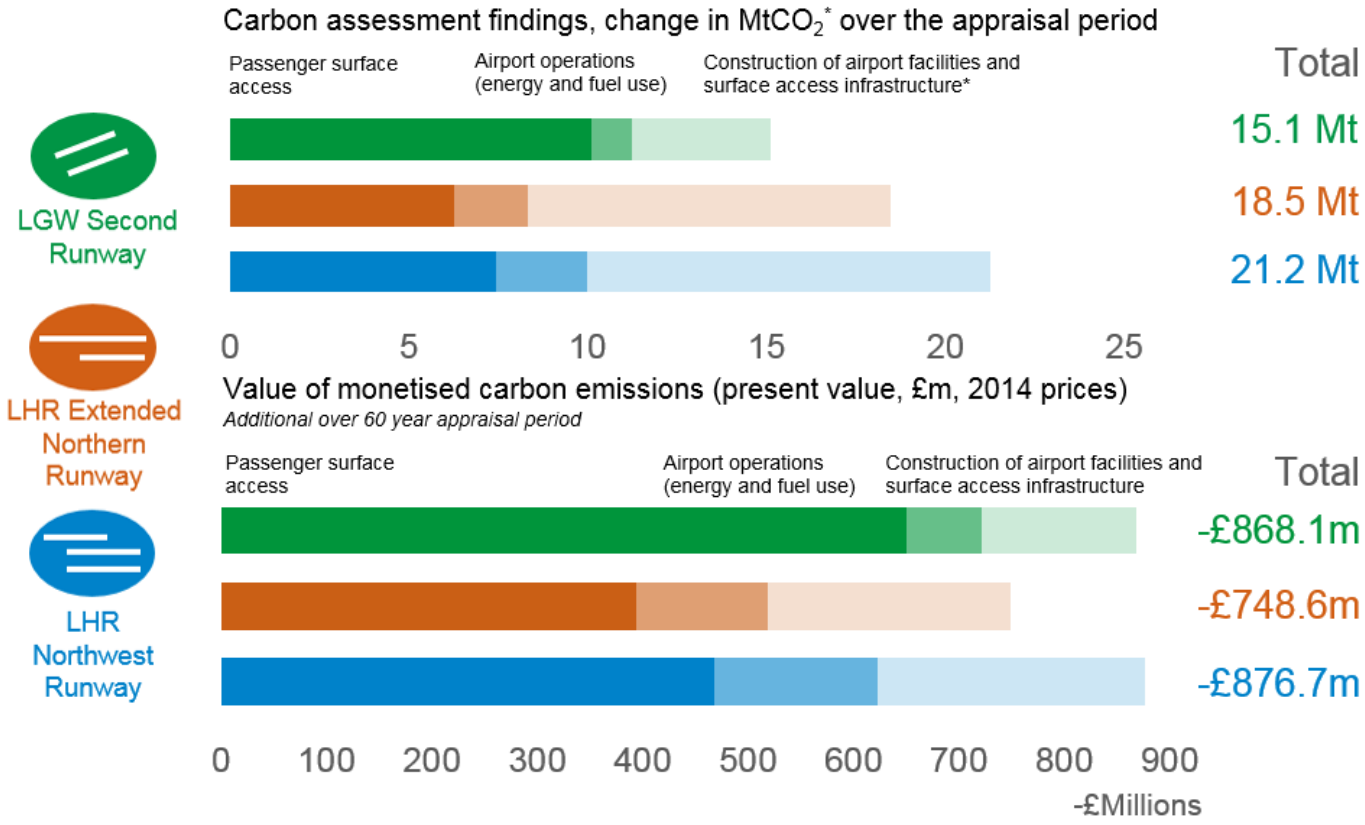
4.18 Airport expansion would lead to further emissions from other sources such as passenger journeys to or from the airport and the construction of the airport itself. These were assumed by the AC to not be part of a trading system and therefore to be additional. To the extent that this is not the case (such as if construction materials are bought from a sector covered by the EU ETS), this will result in an over-estimate of the associated emissions.

4.19 The AC estimates of emissions from surface access journeys refer specifically to the expansion at the airport and do not include the potential for reduced surface access emissions from other airports as a consequence of expansion. The AC's carbon assessment suggests that expansion could lead to reduced emissions at the national level as the emissions at the expanded airport are more than offset by reduced emissions at other UK airports. The AC did not publish the national impact for the full 60 year appraisal period, as a result the impact is only presented for the expanded airport. This is therefore an over-estimate of the net impact of expansion on surface access emissions at the national level, and should be treated with caution. Conversely, the AC did not calculate the impact of increased CO_2 emissions from additional staff and freight surface access journeys, although these would again be partially offset by a reduction in journeys to other UK airports.

4.20 The AC also considered alternative carbon policy cases, including a carbon-capped case in which the CO_2 emissions from flights departing UK airports are limited to the Committee on Climate Change (CCC) planning assumption of 37.5 $MtCO_2$ in 2050. The impact on the appraisal of alternative cases is explored further in chapter 8.

4.21 Figure 4.4 shows the AC's estimates of the increase in carbon emissions arising from expansion, and their monetised impacts.

Figure 4.4 Carbon impacts (present value and change in $MtCO_2$)



	Carbon assessment findings, change in $MtCO_2$* over the appraisal period				Value of monetised carbon emissions (present value, £m, 2014 prices)			
	Passenger surface access	Airport operations (energy and fuel use)	Construction of airport facilities and surface access infrastructure*	Total	Passenger surface access	Airport operations (energy and fuel use)	Construction of airport facilities and surface access infrastructure	Total
LGW Second Runway	10.1	1.1	3.9	**15.1**	-650.5	-71.0	-146.6	**-868.1**
LHR Extended Northern Runway	6.3	2.1	10.1	**18.5**	-393.8	-125.2	-229.6	**-748.6**
LHR Northwest Runway	7.4	2.6	11.3	**21.2**	-467.7	-155.9	-253.0	**-876.7**

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

Noise

4.22 The impact of expansion on noise from aircraft remains a significant concern for affected communities. Exposure to noise is an annoyance, can disturb sleep, and can also affect cardiovascular health. Sensitivity to noise is subjective and varies between individuals. The AC presented its estimates of the monetised impact of expansion on noise in chapter 7 of its final report, as well as in the noise module of its appraisal framework. The supplementary reports underpinning the AC's monetised noise impacts are available on the AC's website in the noise section of the consultation announcement.[23]

4.23 The AC's approach is viewed by the department as robust. It is consistent with the December 2015 update to departmental guidance which is an improvement on previous guidance because it is mode specific and addresses night noise. The AC's estimates of noise impacts without the effect of the proposed night flight ban are shown in Table 4.1.

[23] https://www.gov.uk/government/publications/additional-airport-capacity-noise-analysis

Table 4.1 Noise impacts (present value, £bn, 2014 prices)

	Low	Central	High
LGW Second Runway	-0.2	**-0.4**	-1.6
LHR Extended Northern Runway	-1.0	**-1.4**	-8.7
LHR Northwest Runway	-0.6	**-1.0**	-7.9

Summary of environmental impacts

4.24 The combined impact of environmental and health disbenefits is shown in Table 4.2.

Table 4.2 Summary of environmental impacts (present value, £bn, 2014 prices)

	Air Quality	Biodiversity	Carbon	Noise	Total
LGW Second Runway	-0.2	0.0	-0.9	-0.4	**-1.5**
LHR Extended Northern Runway	-0.6	0.0	-0.7	-1.4	**-2.8**
LHR Northwest Runway	-0.8	0.0	-0.9	-1.0	**-2.7**

5. Wider economic impacts

5.1 The economic impacts of airport expansion go beyond the immediate effects on passengers, airports, airlines and the government. They ripple out into the economy more widely, bringing businesses and people closer together and in turn potentially increasing productivity. This chapter considers the two approaches undertaken by the AC to estimate these effects:

i. conventional appraisal

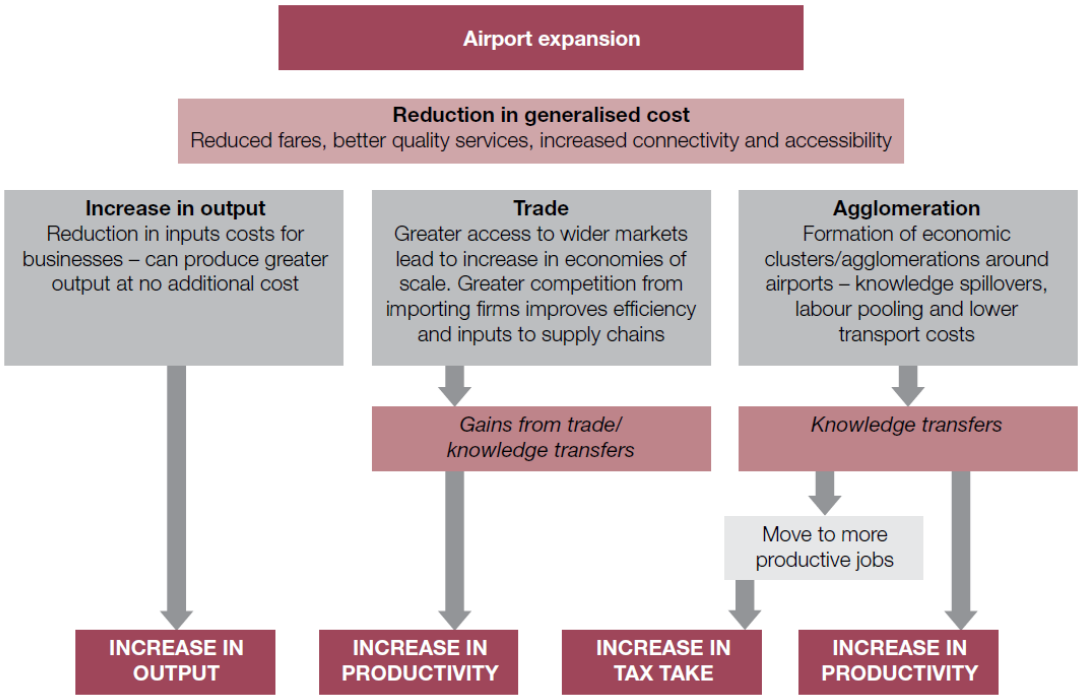
ii. S-CGE modelling of Gross Domestic Product (GDP).

5.2 It then summarises the department's assessment of these approaches.

Conventional appraisal

5.3 This section presents the wider economic impacts of expansion using a cost-benefit approach. The AC's framework for assessing these impacts is summarised in Figure 5.1.

Figure 5.1 Wider economic impacts of airport expansion



5.4 Using this framework, the AC estimated the impacts on the wider economy through four channels:

- agglomeration
- increase in business output in imperfectly competitive markets

- increase in tax-take resulting from labour market impacts ("tax wedge")
- increased productivity arising from more trade (which was separated into impacts on imports and exports).

5.5 Three further channels were considered by the AC (migration, tourism and foreign direct investment), but not monetised, either because of a lack of significance or issues with quantification being deemed insurmountable. They are discussed fully in the AC's *Economy: Wider Economic Impacts Assessment.*[24]

5.6 While the department fully recognises the existence of wider economic benefits, and supports the framework of impacts set out by the AC in Figure 5.1, the exact magnitude of these benefits is inherently uncertain. In the department's review of the AC's evidence base, some potential issues were found with the approaches taken.

5.7 The rarity of airport expansion appraisals limits the extent to which relevant best practice can be established. Departmental guidance does provide a robust starting point, but it has been generated largely for surface modes of transport, so careful consideration must be given to its application in the case of airport development.

5.8 The impacts from increased output and tax take made use of the department's appraisal guidance, while the agglomeration impacts were based on a similar but not identical method. There is currently no guidance on appraising the trade impacts of expansion - although the department agrees that such benefits might exist - and as a result the AC developed its own approach.

5.9 The department's review of the calculated agglomeration benefits found issues relating to the underlying evidence and implementation of the chosen methodology. Revised estimates of agglomeration benefits are presented in Figure 5.2.

5.10 The department has not identified any issues with the AC's application of guidance to estimate business output benefits (the AC's estimate of an 'increase in output in imperfectly competitive markets'). As per WebTAG guidance, these are simply estimated to be a proportion of the direct benefits experienced by UK business passengers. These direct business passenger benefits are considered to be robust (see chapter 3), and as such so are the estimates of wider impacts. These unchanged estimates are presented in Figure 5.2.

5.11 The tax wedge, as defined by departmental guidance, arises when a scheme causes the generalised cost of transport to fall. A reduction in travel costs facilitates longer distance commuting providing access to potentially more productive jobs. The higher wage associated with more productive jobs in turn leads to an increase in the tax take.

5.12 The generation of this increase in tax take is driven by the extent to which a scheme reduces the cost of commuting. While this is clearly important for road and rail projects, the numbers of people commuting by air, even on a weekly basis, is negligible. The department has therefore not deemed it appropriate to include this impact.[25]

5.13 The AC presented estimates for wider economic impacts that included productivity benefits arising from additional trade. Some of these benefits may however

[24] Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/439681/economy-wider-economic-impacts-assessment.pdf

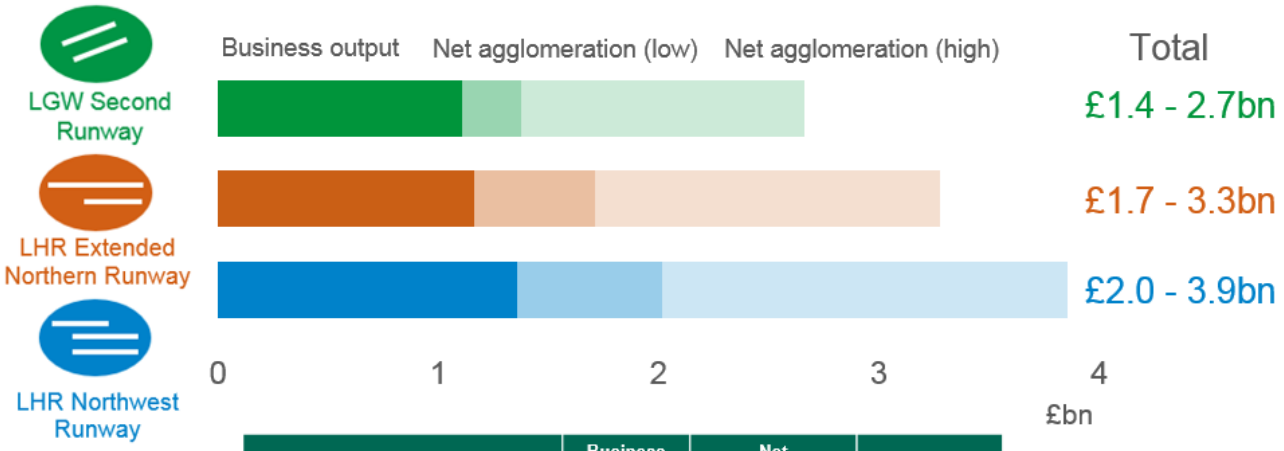
[25] A tax wedge impact may still arise from the higher concentration of jobs in the South East that airport expansion would cause - average wages are relatively high in the South East. The department was however unable to robustly quantify this impact.

already be captured in the estimates of other economic impacts. This is discussed in more detail in Box 5.1. To avoid counting these benefits twice, trade benefits have not been included in the total reported wider economic impacts, but are reported separately.

5.14 Given the uncertainty associated with estimating wider economic impacts, various calculation approaches have been proposed over time. Ongoing engagement with external experts means that the preferred methodology continues to evolve, and is likely to continue doing so after the publication of this report.

5.15 Because of this, and in an approach consistent with the AC and best practice, the overall impact of the capacity options has been presented both including and excluding estimates of wider economic impacts. Wider economic impacts, where appropriate, are presented as a range to reflect the inherent uncertainty underlying their calculation. Estimates of wider economic impacts included within the NPV are shown in Figure 5.2.

Figure 5.2 Wider economic impacts (present value, £bn, 2014 prices)



	Business Output	Net agglomeration	Total
LGW Second Runway	1.1	0.3 – 1.6	**1.4 – 2.7**
LHR Extended Northern Runway	1.2	0.5 – 2.1	**1.7 – 3.3**
LHR Northwest Runway	1.4	0.7 – 2.5	**2.0 – 3.9**

Box 5.1 Trade

While trade impacts have not been included in the estimates of NPVs, this is not to suggest that the department no longer considers them likely. Rather, an assessment of the approach taken by the AC found that the inclusion of trade impacts risked the double-counting of benefits.

This double-counting is thought to largely occur in two ways. Firstly, where trade induced productivity benefits accrue to a business passenger's firm, these impacts can be expected to be incorporated into purchasing decisions and thus be reflected in direct business passenger impacts. Secondly, because trade studies do not separate out the two effects, the estimated trade impacts will include some impacts already attributed to agglomeration effects.

Some of the wider economic impacts delivered by trade could be additional. It has been noted that FDI impacts were not assessed by the AC, partially due to the concern that these benefits would double-count the quantified impacts of trade. Further additional benefits may accrue to firms who, while not undertaking additional flights themselves, benefit from the knowledge spillovers from those firms who do.

The trade benefits estimated by the AC considered how increases in business passenger numbers might be expected to drive additional trade. The mechanism through which this would operate is outlined in the AC's Wider Economic Impacts assessment.[24] The department has reviewed this approach, and also considered an alternative method whereby trade benefits are related to total passenger numbers (and not just numbers of business passengers[26]), given that the observed relationship used to estimate the trade impacts relates to total passenger numbers.

Trade is limited by a variety of factors – from the existence of language barriers to the cost of transporting goods. In assessing the latter, we can consider how increasing the supply of freight capacity, by reducing the cost of transport, can result in additional trade. The supply of freight is dependent on the physical volume and weight carrying capacity of the bellyhold of passenger aircraft, in addition to the number of dedicated freighter aircraft. Over time this capacity will become increasingly constrained at London airports. The department has therefore considered a further approach to assessing trade benefits, drawing on the relationship between seat numbers (as a proxy for bellyhold capacity) and trade that was first recommended in the AC's *Econometric analysis to develop evidence on the links between aviation and the economy* report.[27]

Mirroring the passenger-based approach, by assessing the historic relationship between seat numbers and trade, an estimate for future trade, and the resulting economic benefits, can be derived.

The trade impacts estimated under both approaches are reported in Table 5.1. Neither approach should be considered more appropriate than the other given the difficulties involved in their estimation – they reflect two attempts to quantify a highly uncertain outcome. It is not the case that the review has identified evidence to suggest that the passenger based estimates should not be used – a seat based

[26] Neither the AC approach nor the alternate approach include transfer passengers as drivers of trade
[27] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/372332/economic-analysis-consultants-reports.zip

approach is merely seen as providing a different way to consider the issue. The passenger based estimates might be considered to be more applicable to trade in services, with the seat based estimates more applicable to trade in goods. On the one hand, while trade in goods is far larger than the trade in services, the goods sector makes up a much smaller share of the UK economy, so greater productivity improvements here may have a more muted impact on the UK economy as a whole. By contrast, the predominance of the service sector in the UK economy would suggest productivity improvements in this sector could be more important to the UK economy overall. Without more robust evidence on the underlying determinants, it is difficult to be certain about the relationship between trade and productivity growth. These approaches are therefore of low analytical assurance, and their results should be treated accordingly. Both the absolute and relative magnitude of the impacts are illustrative and should not be compared with other impact estimates that contribute to the NPVs.

Table 5.1 Trade impacts (present value, £bn, 2014 prices)

	Passenger based		Seat based
	Business passengers	All passengers	All seats
LGW Second Runway	6.9	13.1	43.0
LHR Extended Northern Runway	5.5	10.0	85.8
LHR Northwest Runway	6.6	11.9	108.3

The range in the results reflects the uncertainty surrounding these estimates. Passenger-based analysis suggests that over the long-term, expanding Gatwick may deliver slightly higher trade benefits than expanding Heathrow, whereas the seat-based analysis suggests the Heathrow schemes could deliver substantially higher benefits. Both approaches suggest that Heathrow expansion delivers greater trade benefits than Gatwick in the early years after expansion. In the case of the passenger-based approach, additional benefits delivered by Gatwick expansion in the later years would offset these earlier years. This is mainly due to Gatwick expansion generating far less international transfer traffic than Heathrow expansion and, hence, less displacement of local demand.[28]

The trade benefits assessed here represent just one benefit to business passengers. Other benefits to business travellers are captured elsewhere in the appraisal (eg through direct frequency benefits).

[28] A secondary reason relates to the slightly higher capacity that a second runway at Gatwick would provide compared to an additional or extended runway at Heathrow.

An alternative approach - calculating impacts on GDP

S-CGE modelling

5.16 In addition to conventional cost-benefit analysis, the AC undertook Spatial Computable General Equilibrium (S-CGE) modelling of the GDP impacts of airport expansion.

5.17 Computable General Equilibrium (CGE) models are large-scale numerical models that provide a stylised representation of core economic interactions within the economy. CGE models, based on economic theory and observed relationships, have been used by numerous governments and institutions to analyse the effects of major policies.

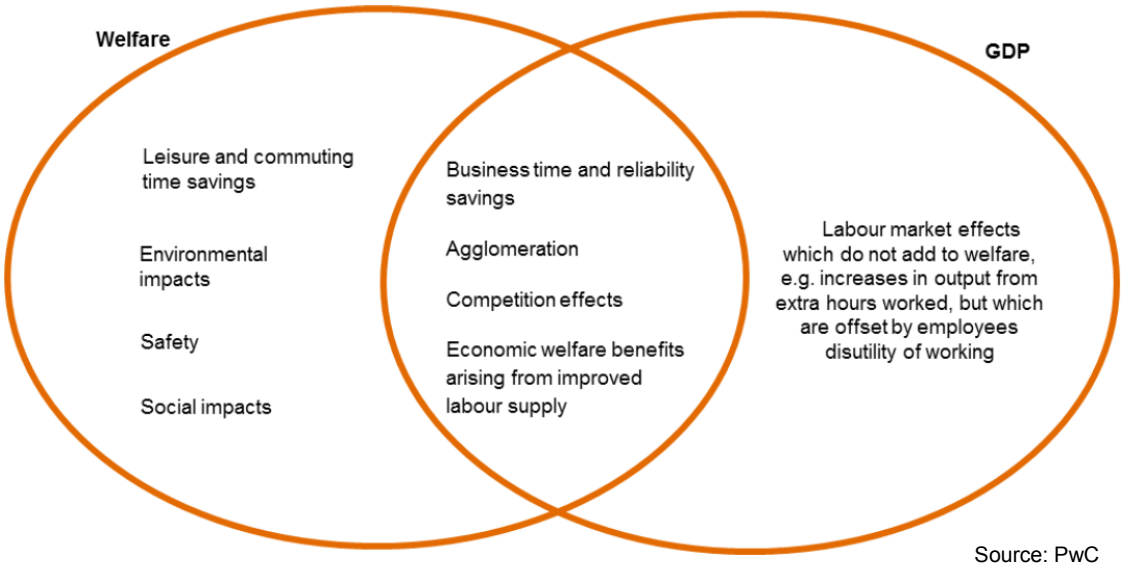
5.18 General equilibrium models inherently operate at a higher level of aggregation than the partial equilibrium approach used in conventional appraisal. While partial equilibrium models may allow more detailed modelling of local impacts (eg noise), such models do not necessarily provide full information on second and third round effects.

5.19 It is these subsequent effects that are central to the generation of wider economic impacts. They provide many of the impacts on third parties not always taken into consideration by decisions makers – and not captured in assessments of direct scheme costs and benefits.

5.20 S-CGE models add an additional dimension to the CGE framework, explicitly considering the relationship between different regions within the economy. This allows a more nuanced, sub-national, picture to be developed. This is important when considering a localised increase in infrastructure investment, which will naturally have distributional effects.

5.21 The national level GDP approach of S-CGE modelling provides a complementary, but fundamentally different approach to typical welfare analysis. The differences and similarities in effects measured are displayed in Figure 5.3.

Figure 5.3 Relationship between economic welfare and GDP



Source: PwC

AC methodology

5.22 The S-CGE model created for the AC by PwC modelled four distinct effects of airport expansion:

- changes in passenger flows
- productivity effects (captured through international trade)
- frequency benefits to airport users
- transport economic efficiency effects.

5.23 These were used to generate estimates of changes in GDP, household consumption, investment, government expenditure, net trade, employment and wages, and welfare. The methodology behind these estimates is discussed in the AC report *Strategic Fit: GDP/GVA Impacts*.[29]

Assessment of GDP estimates

5.24 The use of S-CGE modelling, while increasingly common in the appraisal of improvements to surface modes of transport, is highly innovative when applied to a project of this scope. The addition of international relationships inherently complicates attempts to model changes in the UK economy. And, as in conventional appraisal, the transmission mechanisms for air travel may be significantly different to those observed in other modes of transport.

5.25 Due to this complexity, and in response to concerns raised both by the expert panellists and during the department's review, the department commissioned PwC to refine the approach taken by the AC. But while changes could be made to some aspects of the implementation, there remains a lack of consensus around the specification of some key relationships within the model (eg the increase in trade and productivity that would result from an increase in airport capacity).

5.26 At present, it is the view of both the expert panellists and the department that given this lack of consensus, it is highly challenging to produce a single central estimate of the GDP impact of airport expansion using the S-CGE approach with the evidence currently available. The existence of the relationships within the modelling, however, is accepted (such as an increase in airport capacity leading to greater levels of productivity).

5.27 The GDP impacts estimated by the AC using S-CGE modelling did not form part of the AC's economic case. The exclusion of these impacts does not therefore affect the NPVs presented in chapter 7.

[29] Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/439176/strategic-fit-updated-gdpgva-impacts.pdf

6. Local economy impacts

6.1 Airport expansion has an impact on the local economy. The construction of the new capacity and resulting increase in airport operations directly creates new local jobs. New employees purchase goods and services in the local economy, in turn further increasing the number of jobs in the local area. These employees in turn purchase goods and services, and so it continues. The increased number of jobs has the potential to place pressure on local housing and infrastructure. While these impacts are not included in the schemes' net present values, they should be considered in their own right. This section summarises the department's assessment of the AC's local jobs estimates, and provides further adjusted estimates of local employment effects.

6.2 The AC presented its estimates of local economic impacts in chapter 7 of its final report, and further supplementary reports in the local economy impacts module of the appraisal framework. The AC did not monetise the impacts on the local economy, but undertook a literature review of the local economic impacts of expansion and estimated the impact on the number of local jobs. This local impact is not necessarily additional at the national level, as the local jobs may be displaced from elsewhere in the country due to passengers switching from other airports, or displaced from other employment sectors altogether.

6.3 The supplementary reports underpinning the AC's assessment are available on the AC's website in the local economy impacts section of its November 2014 consultation announcement and in its final report.[30]

6.4 The department agrees with the AC's overall framework for analysing local jobs impacts, but identified a number of uncertainties with the approach taken. These uncertainties mean that varying the assumptions in the analysis could lead to significantly different results. The department has therefore undertaken work to further review the evidence and generate a range of estimates for the number of local jobs created. In addition, inconsistencies were identified between the AC's stated method and the actual calculation of these impacts, so some further revisions were made to the estimates for LGW Second Runway scheme.

6.5 The department's alternative approach uses the same data as the AC (on-airport employee surveys) for the projections of the number of direct jobs. For the estimates of indirect and induced jobs the AC relied on multipliers provided by the scheme promoters. The department has considered an alternative approach which uses data on current employment at Gatwick[31] and Heathrow[32] from Berkeley Hanover Consulting Ltd (BHC) and Optimal Economics Ltd respectively in order to re-estimate these impacts. These studies use survey data rather than assumptions to generate estimates of the indirect job multipliers, providing additional assurance

[30] https://www.gov.uk/government/publications/airports-commission-final-report-local-economy-impacts and https://www.gov.uk/government/publications/additional-airport-capacity-local-economy-impact-analysis

[31] 'Gatwick Airport Employment Generation to 2020 in the Context of the Local Labour Market', Report to West Sussex County Council, Berkeley Hanover Consulting, 2011

[32] http://www.heathrow.com/file_source/Company/Static/PDF/Communityandenvironment/Heathrow-Related-Employment-Report.pdf

around their robustness. Estimates of the number of induced jobs supported are however calculated using multipliers assumed by BHC and Optimal. A further difference arises as the size of the Heathrow local catchment area used in the department's approach is smaller than that used by the AC. Indicative analysis suggests this only accounts for a small proportion of the difference between the two figures.

6.6 The number of local jobs supported by the presence of an airport depends on many factors including the type of airport, size of the airport passenger and employment catchment areas, and even the size of these areas compared to the size of the country as a whole. Reflecting these uncertainties, Table 6.1 displays a range based on the revised AC estimates and the alternative approach considered by the department. It should be noted that the local jobs created by 2050 are the cumulative total, and cannot be added to the number of jobs created by 2030.

Table 6.1 Cumulative additional local employment (at expanded airport), by forecast year

	AC Final report	Alternative approach
LGW Second Runway		
2030	12,500*	5,290
2050	44,190*	18,700
LHR Extended Northern Runway		
2030	76,650	38,720
2050	65,610	32,750
LHR Northwest Runway		
2030	76,650	37,740
2050	78,360	39,100

*Figures revised for consistency with the AC's stated method

7. Combined impact of costs and benefits

7.1 By combining the monetised costs and benefits estimated by the AC and supplemented by further analysis by the department, a Net Present Value (NPV) can be produced for each option. The NPV should be considered alongside other quantified impacts that are not included, for example the local jobs created and trade benefits, as well as non-monetised impacts, such as passenger experience, and alternative metrics, such as Net Public Value.

7.2 The NPV provides the overall picture when the costs and benefits to different groups of society are added together. These may also be of interest in their own right. For example, airport expansion is primarily a private sector investment, and so the majority of the costs of all three schemes will initially fall to private businesses, whilst the benefits will include wider benefits to society.

7.3 After the department's changes, the revised central case suggests that, in line with the AC, the LHR Northwest Runway scheme delivers the greatest benefits to passengers, government and the wider economy, net of environmental disbenefits. It would also lead to the most jobs created locally. The revised net benefits, disbenefits to private business from reduced profits (due to lower fares), and the costs of construction are shown in Table 7.1.

Table 7.1 The department's analysis of monetised impacts (present value, £bn, 2014 prices, assessment of need carbon-traded scenario)[33]

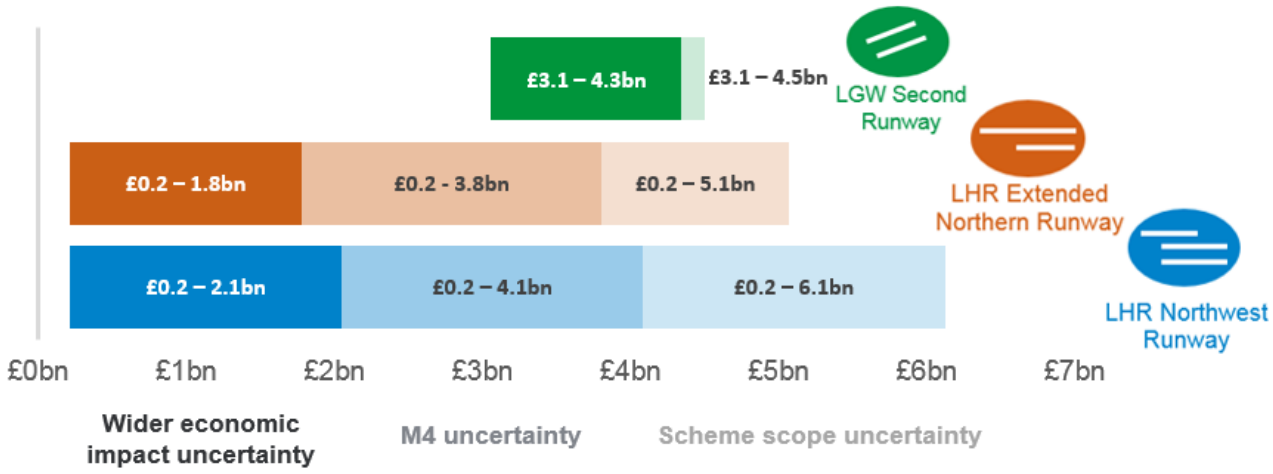
	Gatwick Second Runway	Heathrow Extended Northern Runway	Heathrow Northwest Runway
Passenger benefits (lower fares, reduced delays and higher frequency of flights)	48.5	46.9	55.4
Government revenue	2.5	1.5	1.8
Wider economic impacts	1.4 – 2.7	1.7 – 3.3	2.0 – 3.9
Total benefits	**52.4 – 53.7**	**50.1 – 51.7**	**59.2 – 61.1**
Environmental costs (noise, air quality, carbon, biodiversity)	-1.5	-2.8	-2.7
Airline profit loss (net of reduced delays)	-40.8	-31.2	-38.0
Net social benefit (AC definition)	**10.1 – 11.4**	**16.1 – 17.7**	**18.6 – 20.4**
Scheme cost	-6.4 – -6.3	-12.0 – -10.7	-14.9 – -12.9
Surface access cost	-0.6	-3.9 – -1.9	-3.4 – -1.4
Net Present Value	**3.1 – 4.5**	**0.2 – 5.1**	**0.2 – 6.1**
Net Public Value	**50.3 – 52.2**	**43.5 – 48.9**	**53.1 – 58.4**

[33] The Net Present Value, Net Social Benefit and Net Public Value presented for all three options include costs and benefits to non-UK residents. A sensitivity test has been undertaken which attempts to estimate UK-only variants of these metrics. Further information can be found in Annex 1.

7.4 While Table 7.1 shows that the Heathrow Northwest Runway scheme delivers the greatest direct and wider economic benefits, the Heathrow schemes are also more expensive. The NPVs for the three schemes are shown in Figure 7.1, with the key areas of uncertainty in the central estimates. The accompanying table shows the NPVs both with and without the estimates of wider economic impacts (WEIs).[34] Impacts are presented separately for UK and non-UK residents.

7.5 The scale of these impacts remains uncertain and is subject to change in line with revisions to the scheme designs. There is little difference in the NPVs of the schemes when considered over a 60 year appraisal period. The revised analysis suggests that the NPVs of the Heathrow schemes are subject to more uncertainty than the LGW Second Runway scheme, with the LHR Northwest Runway delivering the highest NPV at the upper end of the central range, and the LGW Second Runway delivering a higher NPV at the lower end.

Figure 7.1 Scheme Net Present Values, with key areas of uncertainty (£bn, 2014 prices)



	Costs	Disbenefits		Benefits				Net Present Value	
	Scheme and surface access costs No UK/Non-UK split	Airlines' profit loss (net of reduced delays) No UK/Non-UK Split	Air pollution, noise, carbon & biodiversity UK	Government UK	Direct passenger UK	Direct passenger Non-UK	WEIs UK	NPV	(Excluding WEIs)
LGW Second Runway	-6.9 – -7.0	-40.8	-1.5	2.5	33.9	14.6	1.4 – 2.7	**3.1 – 4.5**	**1.7 – 1.8**
LHR Extended Northern Runway	-12.6 – -15.9	-31.2	-2.8	1.5	29.2	17.7	1.7 – 3.3	**0.2 – 5.1**	**-1.5 – 1.8**
LHR Northwest Runway	-14.3 – -18.4	-38.0	-2.7	1.8	34.2	21.2	2.0 – 3.9	**0.2 – 6.1**	**-1.8 – 2.3**

7.6 Including the monetised wider economic impacts, each option delivers positive net economic benefits and is 'economically positive' in value-for-money terms. If wider economic impacts are excluded, the LGW Second Runway continues to deliver a positive NPV across the entire central case range, but the LHR Extended Northern Runway and LHR Northwest Runway options both deliver negative NPVs at the lower end of the range, given the impacts that the department has been able to monetise. It should be noted that although there is uncertainty around the magnitude of the wider economic impacts, the department considers that all three shortlisted schemes would generate wider benefits.

7.7 Consistent with the AC, it was found that the NPVs were closely grouped and reflect the dichotomy of the higher benefit, higher cost nature of the Heathrow

[34] As recommended by departmental guidance

schemes contrasting with the lower benefit, lower cost nature of LGW Second Runway.

7.8 NPVs reflect one way to aggregate the costs and benefits of a project. The AC also assessed the schemes by their net social benefits – a measure of costs and benefits excluding the costs of construction. A further metric, net public value, is proposed by the Treasury. The components of each of these metrics, and their values for each of the three schemes, are presented in Table 7.2 below.

7.9 The NPV, net social benefit and net public values presented for all three schemes include the costs and benefits to non-UK residents. A sensitivity test has been undertaken which attempts to estimate UK-only variants of these metrics. Further information can be found in Annex 1.

Table 7.2 Project appraisal metrics – components and values (present value, £bn, 2014 prices)

	Total benefits (AC definition)	Net Social Benefit (AC definition)	Net Present Value	Total benefits (DfT definition)	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			✓		
Airline profit loss**					
Airline delay benefit**	✓				
LGW Second Runway	53.4 – 54.7	10.1 – 11.4	3.1 – 4.5	52.4 – 53.7	50.3 – 52.2
LHR Extended Northern Runway	50.4 – 52.0	16.1 – 17.7	0.2 – 5.1	50.1 – 51.7	43.5 – 48.9
LHR Northwest Runway	59.7 – 61.5	18.6 – 20.4	0.2 – 6.1	59.2 – 61.1	53.1 – 58.4

Airline profit impacts can either be treated in an aggregated manner (*) or in terms of their sub-components (**)
+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

7.10 Out of the three schemes under consideration, the LHR Northwest Runway scheme is estimated to deliver the highest net social benefit. The LHR Northwest Runway scheme is also found to deliver the highest net public value.

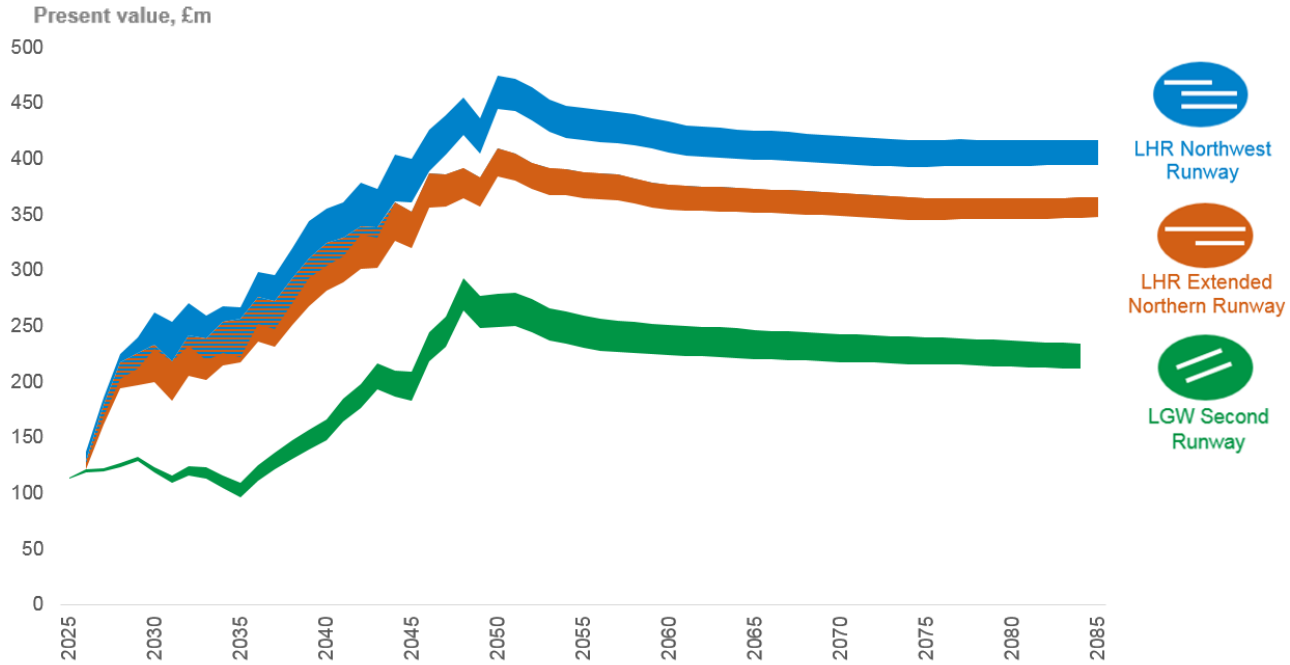
7.11 It should be noted that these results only represent one possible future scenario. The direct passenger benefits are particularly sensitive to the different global demand scenarios. Although not all monetised impacts have been calculated for the five scenarios, the NPV ranking of the schemes could change depending on the demand scenario considered. The NPVs for some of the options could potentially be negative under some demand scenarios, although it should be noted that these do not represent the central case.

7.12 The following two sections explore first, how the economic benefits and costs vary through time, and second, the resilience of the NPVs to changes in the estimated costs and benefits.

Economic benefits and costs over time

7.13 Figure 7.2 shows the annual discounted benefits over the appraisal period. The benefits are comprised of passenger benefits net of airline impacts, government revenue impacts and wider economic impacts. The Heathrow schemes would deliver greater passenger benefits over the period to around 2050. After this date, the passenger benefits delivered by the Gatwick second runway scheme would be higher. Once airline, government and wider economic impacts, are factored in, the Heathrow schemes have greater net benefits throughout the time period. The costs are comprised of the scheme and surface access costs. The environmental impacts are excluded because of the absence of appraisal outputs in each year. Nonetheless they would be expected to move in line with the benefits profile, albeit at a lower order of magnitude.

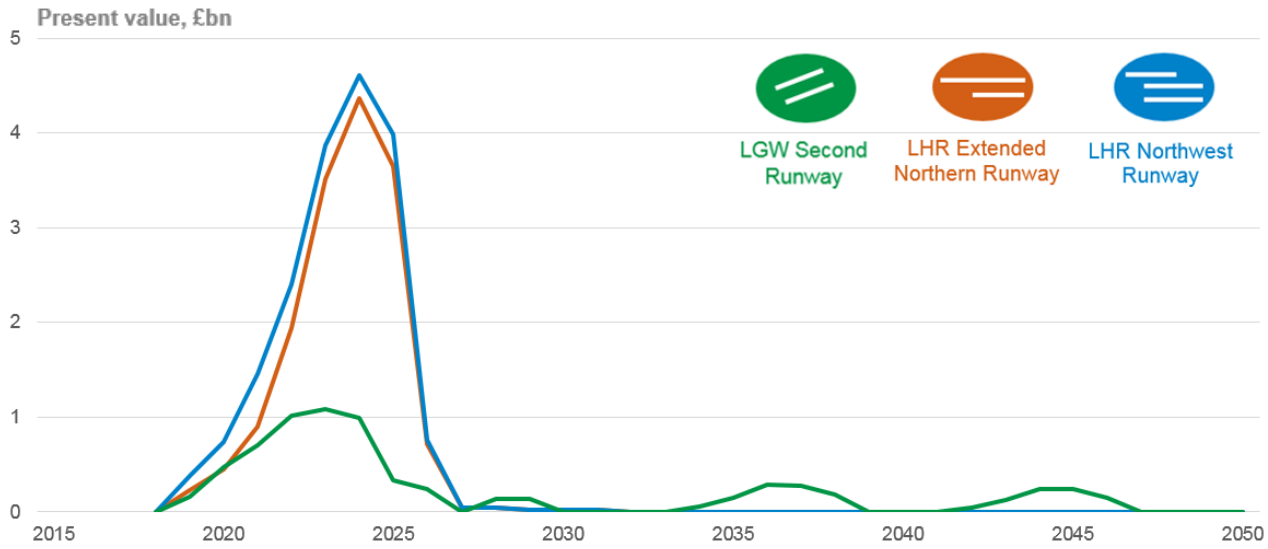
Figure 7.2 Annual discounted benefits (present value, £m, 2014 prices)



7.14 For all three shortlisted options, the benefits only start accruing in the year of the scheme opening (assumed to be 2025 for LGW Second Runway and 2026 for both Heathrow options). For the LGW Second Runway, the increase in benefits through time is a relatively smooth progression from the year of scheme opening. The Heathrow options display a sharper increase in benefits from the year of the scheme opening, followed by smoother increases in subsequent years. In all the shortlisted options, the benefits follow an upward trend to 2050 (the final modelled year), after which they continue to increase in real terms, but at a slower rate because of the relatively cautious extrapolation method from 2050 onwards, the post-model period.

7.15 Figure 7.3 presents the annual discounted financial costs (under the AC's full scheme scopes) over the appraisal period.

Figure 7.3 Annual discounted financial costs (full AC scheme scopes, present value, £bn, 2014 prices)



7.16 Consistent with GAL's current proposal, the LGW Second Runway scheme capital costs have been spread between 2018 and 2047, and split into three phases. This results in a 'lumpy' profile of costs. Both Heathrow schemes see a sharp spike in scheme capital costs between 2018 and 2027, after which they fall to zero.

Sensitivity of NPV to changes in costs and benefits

7.17 Government appraisal guidance and forthcoming WebTAG guidance recommends assessing the robustness of positive NPVs to changes in costs and benefits. Table 7.3 shows the percentage change in monetised benefits and costs required to change the classification of each scheme from economically positive to economically negative (ie, from NPV>0 to NPV<0). This assessment of robustness relates only to the monetised impacts discussed in this report. A full assessment of value-for-money requires additional consideration of the non-monetised impacts of the schemes.

7.18 In Table 7.3, the costs only include surface access and construction costs. All other components of the economic case are classified as benefits, with loss of profits and environmental costs being recorded as negative benefits. This tests the risks around the social impacts and capital costs, as it is reasonable to assume that the risks relating to these two groups of impacts are independent of each other.

7.19 The upper end of the ranges presented in Table 7.3 reflect the use of reduced scheme costs and the exclusion of M4 costs from the Heathrow schemes, with benefits using the high estimates of wider economic impacts. The lower end of the ranges reflects the use of full scheme costs, including the cost of widening the M4, with benefits using the low estimates of wider economic impacts.

Table 7.3 Percentage changes required for economic costs of expansion to exceed benefits

	Change in benefits	Change in costs
LGW Second Runway	-30% to -40%	+44% to +66%
LHR Extended Northern Runway	-1% to -29%	+1% to +40%
LHR Northwest Runway	-1% to -30%	+1% to +43%

7.20 Table 7.3 shows that the monetised benefits have to be 30% to 40% lower than estimated, or monetised costs would have to be 44% to 66% higher than estimated for the economic costs of Gatwick expansion to exceed its benefits (ie for the NPV to be negative).

7.21 For Heathrow Extended Northern Runway, either monetised benefits have to be 1% to 29% lower than estimated or monetised costs need to be 1% to 40% higher than estimated for the economic costs of Heathrow expansion to exceed its monetised benefits. For Heathrow Northwest Runway these ranges are 1% to 30% and 1% to 43% respectively.

7.22 These results reflect the greater degree of uncertainty around the precise NPVs for the Heathrow schemes, but suggest all schemes are to some degree resilient to changes in costs and benefits.

8. Scenario analysis

Overview

8.1 The preceding chapters of this report explored the impacts of expansion in one view of the future, referred to by the AC as the assessment of need, carbon-traded case. This is a central case to provide a coherent story of how airport expansion has an impact on people, businesses, the environment and society. But there are many possible alternative ways that aviation and the global economy may develop, and it is important to understand potential ranges and outcomes under alternative future scenarios in order to judge the resilience of the proposals in the face of uncertainty.

8.2 The AC took uncertainty into account through two types of analysis: scenario analysis and sensitivity analysis.

i. Scenario analysis considers the impact of alternative states of the world on the economic impacts of the options, and involves simultaneously changing multiple inputs to define a coherent but alternative view of the future.

ii. Sensitivity analysis involves changing just one input or assumption at a time in order to better understand the effect of an individual variable on the end result.

8.3 This chapter reports the results of the department's scenario analysis, while the next chapter reports the results of the sensitivity analysis.

8.4 The AC described its demand scenarios in chapter 6 of its final report, and in the supporting reports in the strategic fit module of its appraisal framework. The supplementary reports underpinning the AC demand forecasts are available on the AC's website in the strategic fit section of its 2014 consultation and in its final report.[35]

8.5 The AC's demand forecasts were an input to the monetised assessment of the costs of construction, direct economic benefits, environmental impacts[36] and wider economic impacts reported in the previous chapters. The AC presented its testing of the monetised impacts using alternative demand scenarios in the supplementary information for the individual modules published alongside the consultation and final report.

8.6 The department has reviewed the approach to scenario analysis used by the AC and concluded that it is reasonable. As explained in previous chapters, the department has revised the AC's estimates of the costs and wider economic impacts of expansion since the AC published its final report. The department has also revised the AC's estimates of wider economic impacts using the AC's five

[35] https://www.gov.uk/government/publications/additional-airport-capacity-strategic-fit-analysis and https://www.gov.uk/government/publications/airports-commission-final-report-strategic-fit

[36] Excluding biodiversity

future scenarios of how demand for aviation might evolve. The revised uncertainty ranges are presented in this chapter.

8.7 This chapter also presents the AC's estimates of the monetised impacts of expansion in the carbon-capped case.

The AC's five global economic scenarios

8.8 Table 8.1 shows the range in the AC's forecasts of passenger demand in 2030 and 2050 across the demand scenarios in the carbon-traded case. A full definition of the scenarios was provided in the AC report *Strategic fit: updated forecasts*.[37]

Table 8.1 The AC's forecasts of demand under global demand scenarios (million passengers per annum)

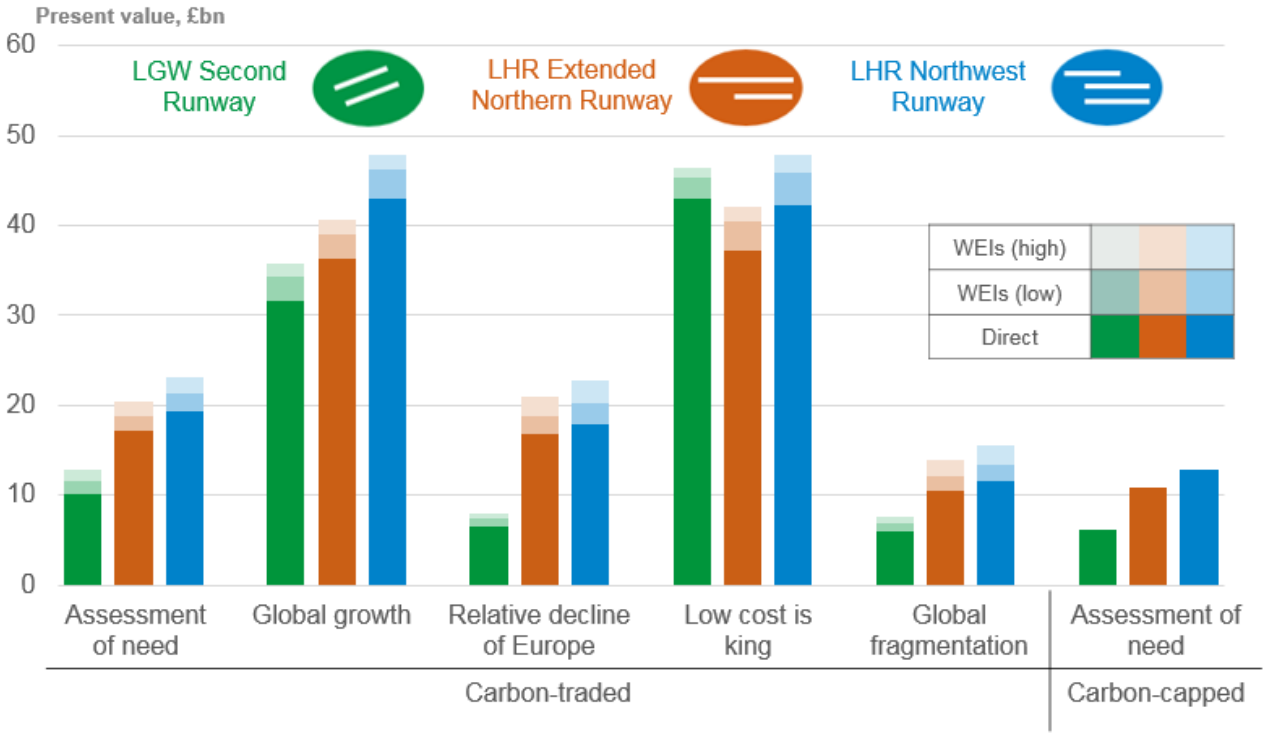
	Assessment of need		Global growth		Relative decline of Europe		Low cost is king		Global fragmentation	
	2030	2050	2030	2050	2030	2050	2030	2050	2030	2050
No expansion	314	411	332	457	313	418	332	458	302	397
LGW Second Runway	316	426	339	488	315	431	350	499	303	406
LHR Extended Northern Runway	331	430	354	491	326	432	347	489	312	415
LHR Northwest Runway	331	435	355	496	329	435	353	494	312	420

8.9 The AC produced an estimate of the direct benefits and wider economic impacts of the different capacity options in each of these demand scenarios. The direct benefits are presented in Figure 8.1, alongside the department's revised estimates of wider economic impacts.[38] The AC did not publish estimates for the environmental impacts in all of the scenarios, and therefore they are not reported. The environmental impacts are of a lower order of magnitude when monetised than the economic impacts and vary less under different demand forecasts.

8.10 Figure 8.1 shows that, while always positive, the economic benefits of the schemes are highly sensitive to changes in the global demand scenario chosen. The range suggests that while the scale of benefits is sensitive to the demand scenario, the relative magnitude of these benefits across the three shortlisted schemes is relatively stable.

[37] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/439687/strategic-fit-updated-forecasts.pdf
[38] Wider economic impacts have not been re-estimated for the assessment of need, carbon-capped scenario

Figure 8.1 Direct and wider economic impacts in the AC demand scenarios[39] (PV, £bn, 2014 prices)



The impact of alternative carbon policy scenarios

8.11 The UK has a legally binding climate change target for 2050 and a mechanism of carbon budgets to reduce greenhouse gas emissions (measured in carbon dioxide equivalent, or CO_2e) to achieve that goal. International aviation emissions are not currently included in the UK's carbon budgets or the 2050 target. However, the Climate Change Act 2008 states that these emissions must be taken into account when setting the carbon budgets.

8.12 The AC considered two carbon cases, carbon-traded and carbon-capped, each of which represented a different approach for managing the CO_2 emissions from aviation in the future. The carbon-traded case is consistent with government policy and is the department's central case. The carbon-capped case considered the impacts if the CO_2 emissions from flights departing UK airports in 2050 are kept within the planning assumption suggested by the Committee on Climate Change of 37.5MtCO_2. This case included consideration of indicative policies to keep emissions within this planning assumption. The AC set out its analysis in the report *Economy: carbon policy sensitivity test*.[40]

8.13 The benefits of all three shortlisted options are lower in the carbon-capped cases, but the relative scale of the monetised impacts of all the schemes remains relatively stable. The LGW Second Runway has lower costs across all three carbon-capped / policy scenarios, while the Heathrow options have greater estimated benefits.

[39] Wider economic impacts have not been re-estimated for the assessment of need, carbon-capped scenario, and so are not included in the chart.
[40] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/439679/economy-carbon-policy-sensitivity-test.pdf

9. Sensitivity analysis

Overview

9.1 The AC took uncertainty into account through two types of analysis: scenario analysis (presented in chapter 8) and sensitivity analysis (presented in this chapter). Sensitivity analysis involves changing just one input or assumption at a time in order to better understand the effect of an individual variable on the end result. This chapter presents the further sensitivity analysis undertaken by the department and supplements the sensitivity tests reported by the AC.

9.2 The AC undertook a number of sensitivity tests which were reported in its 2013 Interim Report,[41] its 2014 consultation documents[42], and its final report with supporting documents.[43] These are discussed briefly in Box 9.1. In most cases the AC presented the subset of impacts that can be estimated using the department's aviation modelling suite. This includes the AC demand forecasts reported in *Strategic fit: updated forecasts*, and the subset of direct economic benefits reported in *Economy: updated transport economic efficiency impacts*.[44] The direct economic benefits in the central case are outlined in chapter 3. The subset considered here is comprised of:

- benefits to passengers from reduced fares and increased frequencies;
- impacts on airlines of reduced profits; and
- government revenue impacts.

9.3 These represent the vast majority of direct economic impacts, excluding only benefits arising due to reduced delays, which account for only a small proportion of the total impact.

Box 9.1 Airports Commission sensitivity tests

In its final report, the AC undertook sensitivity testing to understand the passenger, airline and government revenue impacts of:

- varying the carbon price assumptions ("high carbon price" and "no carbon price");

[41] https://www.gov.uk/government/news/airports-commission-publishes-interim-report
[42] https://www.gov.uk/government/news/airports-commission-publishes-consultation-on-shortlisted-options-for-a-new-runway
[43] https://www.gov.uk/government/news/airports-commission-releases-final-report
[44] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/439687/strategic-fit-updated-forecasts.pdf and https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/439169/economy-updated-transport-economic-efficiency-impacts.pdf

- varying passenger demand growth ("high demand", "low demand", and "no passenger demand growth beyond 2050");
- phasing capacity increases (LHR Northwest Runway only);
- lowering capacity to 200,000 additional ATMs (LHR Extended Northern Runway only); and
- applying 'assessment of need' macroeconomic growth rates to 'low-cost is king' airport specifications.

The department has since revisited the issue of varying carbon prices, the results of which are discussed later in this chapter.

As is to be expected, the benefits to passengers, airlines and governments are reduced for all schemes under the low demand sensitivity, and increased under the high demand sensitivity. There are relative differences across the schemes, however, with the benefits of the Gatwick scheme increasing proportionately more under the high demand sensitivity than for the Heathrow schemes. For the low demand sensitivity, the relative decrease in benefits under the Gatwick scheme is far greater. This suggests that the benefits delivered by Gatwick are much more sensitive to demand uncertainty.

The Heathrow-specific phased capacity and lower capacity sensitivities also give unsurprising results, with benefits being reduced, but not substantially so.

The low-cost is king airport specification test sees slight increases in passenger, airline and government revenue benefits for the Heathrow schemes when compared to the assessment of need scenario, but a substantial increase for the LGW Second Runway scheme. The benefits delivered by all schemes in this sensitivity, including the Gatwick Second Runway, are, however, substantially lower than in the original low-cost is king scenario.

9.4 The department has reviewed the AC's sensitivity tests and concluded that they are robust. The review did, however, identify areas where further sensitivity testing would be helpful to better understand the impact of key assumptions and uncertainties. In addition it is helpful to consider new information which has become available since the AC published its final report.

9.5 The department has therefore undertaken further sensitivity testing to understand the direct economic impacts of:

- aero-charges being fully passed onto passengers rather than being absorbed by airlines ("aero-charge pass through");
- delaying the scheme start date by two years ("two year scheme delay");
- limiting capacity as part of two potential noise mitigations:
  - providing more respite; or
  - a night flight ban;

- varying technical modelling assumptions relating to the capacity of overseas hubs ("unconstrained overseas hub capacity");
- varying the carbon price assumptions ("low carbon prices" and "high carbon prices"); and
- updating the model base year to 2014 and using more up to date economic input data ("updated model base year").

9.6 For these sensitivity tests, the department has estimated the direct economic benefits discussed in para 9.2, but has not attempted to produce NPVs or other summary metrics. These direct economic benefits represent the largest impacts of expansion and are directly affected by changes to the underlying assumptions. As such, they provide sufficient indication as to what the likely overall impact on the schemes would be. Where appropriate, other monetised impacts under these sensitivity tests are discussed qualitatively.

9.7 In addition, a sensitivity test has been undertaken for which it is possible to produce an NPV and other project appraisal metrics:

- calculating an NPV for UK-residents only ("UK-only NPV").

9.8 Further sensitivity tests, for which direct economic benefits have not been re-estimated, were undertaken to examine other aspects of the appraisal:

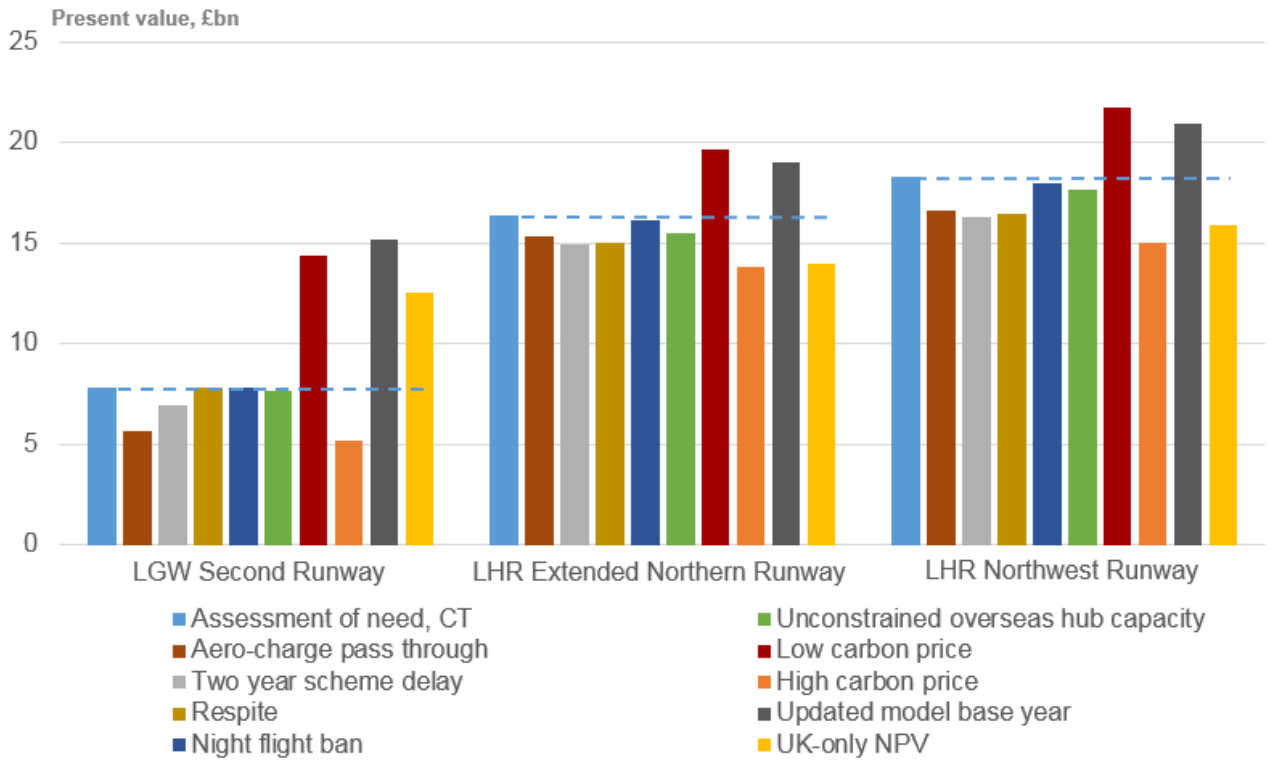
- updating the air quality values in line with Defra's proposed interim guidance; and
- varying the technical model assumptions relating to commercial route viability thresholds.

Conclusions of sensitivity analysis

9.9 Detailed results of the sensitivity analyses are presented in Annex 1. The direct economic benefits estimated under the eight relevant sensitivities undertaken by the department are summarised in Figure 9.1, alongside the estimate of monetised benefits under the central (assessment of need, carbon-traded) scenario for comparison.[45] Under all of the sensitivities, these benefits are estimated to remain positive for all three of the shortlisted options. The results of the sensitivities, including those for which direct economic benefits have not been estimated, are summarised below.

[45] Values for the two year scheme delay sensitivity relate to the 'fixed-appraisal end date' approach described in Annex 1.

Figure 9.1 Direct economic benefits quantified through the central case (assessment of need, CT) and DfT further sensitivities, PV, £bn, 2014 prices



9.10 The AC assumed that on average the increased **aero-charges** required to pay for expansion would be absorbed by airlines and not passed on to passengers. There is evidence to support the AC's assumption, but some uncertainty remains. The department has therefore tested the impact in a case where aero-charges are passed on to passengers, thereby reducing demand at the expanded airport. As expected, the test results in lower direct economic benefits. This test is of low analytical assurance.

9.11 The department has considered the **impact of a delay** to the opening of all the shortlisted schemes by two years. The impact of such a delay on the direct economic impacts of the options is small. This test is of medium analytical assurance.

9.12 The department has undertaken some further analysis of two potential noise mitigation measures, as these were not fully examined by the AC.:

i. The level of **respite** will be agreed as part of the planning process. For indicative analysis, a sensitivity test has been developed where all schemes provide respite through reducing and alternating the use of runways on similar lines to the system currently used by Heathrow Airport Ltd. This test potentially underestimates benefits as it does not quantify noise benefits to communities.

ii. A high level indicative analysis of a potential **night flight ban** has been undertaken. This did not however take account of the potential wider economic impacts of losing high value flights from the Far East that might be affected by such a ban.

9.13 Both of these tests are of low analytical assurance, and appear to show that the impacts on the direct economic benefits would be relatively small.

9.14 The department has run a sensitivity to establish whether assumptions in the model relating to the **capacity of overseas hubs** have a significant impact on the appraisal outcome. This test is of high analytical assurance, and has a relatively small impact on the direct economic benefits.

9.15 Given the uncertainty around the form of future carbon markets, two sensitivities have been undertaken to test the impact of varying **carbon prices** on the appraisal outcomes, based primarily on the high and low variants published by DECC**.** As expected, the higher carbon price test results in higher air fares, leading to reduced demand and lower direct economic benefits, while the reverse is true for the low carbon price test. These tests are of low/medium analytical assurance.

9.16 The AC used a version of the department's aviation model with a base year of 2008, but calibrated to 2011 data. The department has undertaken further analysis to **update the base year of the model** to 2014 to incorporate recent patterns of passenger growth. This test has the largest effect on the direct economic benefits of all the sensitivities, with the greatest increase in benefits for the Gatwick Second Runway Scheme, and has a medium/high level of analytical assurance. The direct economic benefits in this test are greater than the central case shown in chapter 3 for all three schemes. This reflects a higher level of passenger growth than was forecast in the earlier model version, which has been most evident at Gatwick Airport.

9.17 Costs and benefits to all passengers and airlines (regardless of their residency or whether they are a transfer passenger), are assessed in the AC's central case, and feed into the calculation of the schemes' NPVs. This is not fully consistent with Treasury or departmental guidance. As such, the department has estimated an indicative **UK-only NPV**. This sensitivity test results in higher NPVs for all schemes, but is of low analytical assurance.

9.18 The department has assessed the impact of using updated **air quality values** on the monetised disbenefits arising from reductions in air quality. This test finds substantially lower air quality disbenefits for all schemes.

9.19 The department has undertaken a sensitivity test to examine the impact of lower **route viability thresholds** on passenger traffic in response to stakeholder concerns. This has limited impact on passenger demand under either of the Heathrow schemes, but causes modest increases in demand under Gatwick expansion in the longer term. This test is of medium analytical assurance, and is expected to have a limited effect on the direct economic benefits.

9.20 Further information on the methodology and results of each of these sensitivity tests are reported in Annex 1.

Annex 1: Sensitivity analysis results

A.1 Sensitivity analysis has been undertaken to assess how robust the results in the central case are to changes in key assumptions. This annex provides additional information on these sensitivity tests. All sensitivities are based on the AC's assessment of need, carbon-traded scenario - the results of which are presented throughout this section for comparison. As outlined in chapter 9, the department has completed the following sensitivity tests:

- aero-charges being fully passed onto passengers rather than being absorbed by airlines ("aero-charge pass through");
- delaying the scheme start date by two years ("two year scheme delay");
- limiting capacity as part of two potential noise mitigations:
  - a night flight ban; or
  - providing more respite;
- varying technical modelling assumptions relating to the capacity of overseas hubs ("unconstrained overseas hub capacity");
- varying the carbon price assumptions ("low carbon prices" and "high carbon prices");
- updating the model base year to 2014 and using more up to date economic input data ("updated model base year");
- calculating an NPV for UK-residents only ("UK-only NPV");
- updating the air quality values in line with Defra's proposed interim guidance; and
- varying the technical model assumptions relating to commercial route viability thresholds.

A.2 A number of these tests involved generating alternative demand forecasts. Although the forecasts were estimated for the years 2030, 2040 and 2050, for brevity this annex presents the year 2040 only, as the midpoint. An expanded Heathrow is expected to reach capacity more rapidly than an expanded Gatwick, so comparisons using 2030 data typically show a relatively higher level of growth under the Heathrow schemes. By 2050, however, the differences between the schemes are less substantial. All of the present values outlined in this annex relate to a 60 year appraisal period from the year of the scheme opening (2025 for the LGW Second Runway, 2026 for the LHR Northwest Runway and LHR Extended Northern Runway).[46]

A.3 These sensitivity tests have been run independently of each other and thus the results are not additive. Complex interactions between the variables considered

[46] For the 'two year scheme delay' sensitivity, results are presented for both a 60 year appraisal period and a 58 year appraisal period (with the latter keeping the appraisal end-date fixed).

mean that it is not a trivial process to combine these results into distinct 'high' or 'low' scenarios. The results of each sensitivity test should therefore be considered in isolation.

Impact of changing the treatment of aero-charges

A.4 An implicit assumption in the AC's appraisal is that any increases in aero-charges to pay for the additional airport capacity are absorbed by airlines and not passed on to passengers as higher fares. To inform this assumption, the AC drew on previous research and submissions made during their consultation.[47] Since the AC published its Final report, the department has examined the evidence to further consider whether this is the most appropriate assumption to use. The findings of both the AC's and the department's reviews of the evidence are set out in Box A 1.

A.5 The department has concluded that the literature and evidence on slot trades does suggest that there is scope for airlines to absorb increases to aero-charges and therefore limit the pass-through to passengers, particularly at Heathrow (see Box A 1). This confirms the reasonableness of the AC's assumption that aero-charges can be absorbed by airlines. The central case therefore remains the most appropriate assessment of scheme impacts.

Box A 1 Review of the literature on whether airlines could absorb increases to aero-charges

The theory of scarcity rents

Gatwick and Heathrow airports are operating at or near capacity, particularly during peak periods. If the airports were able to price in a profit maximising way, then higher prices (aero-charges) would be used to balance the relatively high level of demand with the relatively low level of capacity available, which would lead to higher costs to the airlines and, in turn, in higher fares charged to passengers.

The regulatory regime prevents airports from doing this. Instead, when there is excess demand (that is, more people wanting to fly than there are aircraft seats available), airlines can set fares at a higher level. Higher fares allow those airlines with landing slots to gain higher profits than would be possible in the absence of the capacity constraints. Excess profits of this type are known as scarcity rents, and if these exist, airlines could absorb an increase in aero-charges through a reduction in their scarcity rent.

AC literature review

The literature reviewed by the AC suggested that evidence on scarcity rents is mixed. An ITF/SEO study argues that airlines at Gatwick and in particular at Heathrow benefit from scarcity rents due to the excess demand and the caps

[47] SEO (2015). Scarcity rents and airport charges
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/439688/strategic-fit-scarcity-rents-and-airport-charges.pdf

placed on the charges that can be levied by the airports.[48] On the other hand, BA argue that if scarcity rents exist, they would be reflected in excess profits and return on capital, which BA, it argues, does not experience. According to Starkie[49] "*it is difficult to accept, in the light of the CAA evidence[50] and more particularly in view of BA's willingness to pay other airlines operating at Heathrow considerable sums for an exchange of their slots, that there is no Heathrow premium*", although he does accept that BA may face greater competition at other airports and use rents from Heathrow to sustain a larger network and a greater service frequency.[51]

This argument is further supported by a subsequent report commissioned by the CAA.[52] It concluded that the fall in airline costs and fares in real terms over the last 10 years coinciding with strong GDP growth, suggests that any potential scarcity rents associated with growing constraints at specific airports are used by airlines to address competitive pressures across the sector. Therefore, at the sector level excess profits are not seen. The report further theorises that competitive pressures have led to cost reductions being passed through to consumers as lower fares.

Evidence from slot trading

The existence of a market for take-off and landing slots lends weight to the view that airlines experience scarcity rents. The fact that airlines are prepared to pay a price, in excess of normal airport charges to use a constrained airport, suggests that excess profits can be made.

Although there is no official register of slot prices, the department has examined the evidence from sales reported in the press. This evidence is at best indicative as many of the slot deals may have included benefits more complex than simple monetary payments and so these transaction prices may give an incomplete picture of the full slot value. Moreover, as many other slot trades may have gone unreported, the figures presented below may not be fully representative of all trades.

The limited evidence suggests that the value airlines place on slots is quite large at Heathrow, especially for morning slots, and that the value has been rising over time. Press reports of sales over the last 3 years by Scandinavian Airlines, Air France and Alitalia, suggests that the average price of a morning daily slot pair[53] was around £30m (2016 prices). For slot bundles that are more spread out over the day, data from the same time drawn from three separate deals, suggests the average price paid was around £15m per daily slot pair. At Gatwick, there are few available examples of slot trading and hence less evidence of the existence of scarcity rents.

[48] ITF (2014). Impacts of expanding airport capacity on competition and connectivity: the case of Gatwick and Heathrow. Report prepared for the Airports Commission, December 2014. http://www.internationaltransportforum.org/Pub/pdf/14Impacts-Airport-Capacity.pdf

[49] Institute of Economic Affairs. Member of the CAA's expert panel for NATS price cap review 2006 and airport competition framework assessments 2010-11.

[50] This refers to research undertaken during the 2002 CAA review of price caps – "Heathrow, Gatwick and Stansted Airports' Price Caps, 2003–2008: CAA Recommendations to the Competition Commission, London."

[51] Starkie, D. (2004). Testing the regulatory model: the expansion of Stansted Airport. Fiscal Studies 25(4), 389-413.

[52] SLG (2013). Q6 review of the distribution of economic rent between airport, airlines and passengers and cargo users at Heathrow and Gatwick. A report prepared for the CAA by SLG Economics Ltd.

[53] Slots are traded in pairs as aircraft require two uses of an airport's runway – one for landing and one for take-off.

A.6 Although the approach taken in the central case has been further assured, the department has also undertaken a sensitivity test of the impact of incorporating aero-charges into the demand forecasts (so assuming that higher aero-charges are passed through to passengers in higher fares) and the associated estimates of impacts on passengers, airlines and government revenue.

Method

A.7 The expansion-related aero-charge impact at Heathrow was calculated from information in the AC report *Cost and Commercial Viability: Additional Sensitivities*.[54] The AC did not publish comparable information for the Gatwick option. For modelling purposes, it was assumed that the expansion-related aero-charge increase was the same for LGW Second Runway as for LHR Extended Northern Runway. This sensitivity is therefore of low analytical assurance and is provided to give only an indication of the potential demand response associated with an expansion-related increase in aero-charges.

A.8 The modelling assumes that passengers treat the additional cost of aero-charges in the same way as they would treat an increase in surface access or shadow costs. In practice this implies that passengers are highly price sensitive, substantially more so than the (albeit non-London specific) literature would suggest. Therefore the effect in reducing demand is potentially exaggerated and the appraisal results should be considered a worst case.

Impact on demand

A.9 In the sensitivity test aero-charges are assumed to be passed on in full to passengers until an airport reaches capacity. This dampens demand and consequently passenger benefits during the earlier years of appraisal. This effect is most noticeable for an expanded Gatwick, where the additional capacity takes longer to fill. The effects on demand in 2040 are shown in Table A 1.

Table A 1 The impact on demand of aero-charge pass through

Terminal passengers, millions, 2040	Assessment of need, carbon traded					Aero-charge pass through				
	Gatwick	Heathrow	London	Non-London	**Total UK**	Gatwick	Heathrow	London	Non-London	**Total UK**
No expansion	46	90	196	163	**360**	46	90	196	163	**360**
LGW Second Runway	62	91	213	156	**368**	49	90	199	163	**362**
LHR Extended Northern Runway	44	127	229	154	**383**	45	121	225	156	**381**
LHR Northwest Runway	43	134	234	153	**387**	46	117	222	156	**379**

Quantified impact on the appraisal

A.10 The reduction in passenger demand leads to lower monetised benefits for all the options. The effects on these passenger, airline and government revenue impacts[55] are displayed in Table A 2, alongside the AC's central estimates for comparison.

[54] Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/440104/cost-and-commercial-viability-additional-sensitivities.pdf

[55] These impacts are the (majority) subset of passenger, airline and government revenue effects that are defined as transport economic efficiency impacts in chapter 9. These direct impacts, and those presented throughout this annex, do not include benefits arising from reduced delays.

Table A 2 The impact on passengers, airlines and government revenue of aero-charge pass through (present value, £bn, 2014 prices)[56]

	Aero-charge pass through					AoN, CT
	Passenger frequency benefits	Passenger fare benefits	Airline profits	Government revenue	PV	PV
LGW Second Runway	1.2	29.3	-25.6	0.8	**5.6**	**7.8**
LHR Extended Northern Runway	4.5	37.2	-27.5	1.2	**15.4**	**16.4**
LHR Northwest Runway	4.6	42.4	-31.9	1.5	**16.6**	**18.3**

Potential impact on other areas of the appraisal

A.11 There would also be large impacts on other areas of the business case. As demand builds more slowly in the LGW Second Runway expansion option, the scheme costs could also be delayed, reducing their present value. There may also be lower wider economic impacts for the same reason. Both Heathrow schemes would experience similar impacts to one another, but it would be a less pronounced effect than the Gatwick scheme given the relatively smaller impact aero-charges have on demand.

Conclusion

A.12 The department's review of the existing evidence base has determined that the approach taken toward aero-charges in the central case is the most appropriate one. This sensitivity test, of low analytical assurance, produces lower estimates of net benefits to passengers, airlines and government revenue than found in the central case shown in chapter 3. The ordering of schemes in terms of direct economic benefits remains unchanged.

Impact of delays to scheme opening

A.13 As with any large infrastructure project there is a risk of delays in the planning and construction of the additional airport capacity or in delivering the necessary surface access improvements. To better understand the impact this would have on the appraisal, the department has undertaken a sensitivity test where the opening of capacity is delayed by two years (from 2025 for the Gatwick scheme and 2026 for both of the Heathrow schemes).

Method

A.14 The impact on passengers, airlines and government revenue has been considered under two sets of appraisal assumptions: one where the last year of the appraisal is the same as in the central case, giving an appraisal period of 58 years, and one where the appraisal period is set at 60 years from scheme opening, in line with standard transport appraisal guidance.

A.15 Delaying the start date of the introduction of new capacity may decrease the economic benefits for two reasons. First, even once the new capacity is fully used, the benefit associated with it is slightly lower as some routes become available at alternative airports during the delay. Second, if a fixed appraisal end-point is

[56] Airline profit loss is net of additional revenue gained from aero-charges

assumed, there are fewer years (58 compared to 60) over which to experience benefits.

A.16 Assuming a fixed appraisal period of 60 years pushes the end point back by two years allowing a further two years of benefits, although these additional benefits are greatly reduced by discounting.

Impact on demand

A.17 Delaying the start date means that the capacity constraints on the London system become more acute before the scheme opening. In the LGW Second Runway option, this means that the benefits to passengers are greater in the years immediately following the scheme opening.

A.18 In the LHR Extended Northern Runway and Northwest Runway options, the impact on demand is muted. This is because the underlying constraints built up over many more years result in more demand being reallocated to alternative airports, which in turn take the opportunity to become more competitive by developing more frequent services. The demand impact is shown in Table A 3.

Table A 3 The impact on demand of a two year delay to scheme opening

Terminal passengers, millions, 2040	Assessment of need, carbon traded					Two year scheme delay				
	Gatwick	Heathrow	London	Non-London	**Total UK**	Gatwick	Heathrow	London	Non-London	**Total UK**
No expansion	46	90	196	163	**360**	46	90	196	163	**360**
LGW Second Runway	62	91	213	156	**368**	61	91	211	156	**367**
LHR Extended Northern Runway	44	127	229	154	**383**	44	126	229	153	**382**
LHR Northwest Runway	43	134	234	153	**387**	45	134	235	152	**387**

Quantified impact on the appraisal

A.19 Table A 4 shows the passenger, airline and government revenue impacts for each of the options under both the fixed appraisal end point and fixed appraisal period approaches, alongside the results from the AC's central case for comparison.

Table A 4 The impact on passengers, airlines and government revenue of a two year delay to scheme opening (present value, £bn, 2014 prices)

	Two year scheme delay (fixed appraisal length)					AoN, CT
	Passenger frequency benefits	Passenger fare benefits	Airline profits	Government revenue	**PV**	**PV**
LGW Second Runway	2.7	45.7	-43.8	2.6	**7.3**	**7.8**
LHR Extended Northern Runway	3.9	44.0	-33.9	1.5	**15.6**	**16.4**
LHR Northwest Runway	4.7	51.4	-41.0	1.9	**17.0**	**18.3**

	Two year scheme delay (fixed appraisal end)					AoN, CT
	Passenger frequency benefits	Passenger fare benefits	Airline profits	Government revenue	PV	PV
LGW Second Runway	2.6	43.7	-41.9	2.5	**7.0**	**7.8**
LHR Extended Northern Runway	3.8	42.3	-32.7	1.4	**14.9**	**16.4**
LHR Northwest Runway	4.6	49.5	-39.5	1.8	**16.3**	**18.3**

Potential impact on other areas of the appraisal

A.20 This analysis has not considered the impact on the other monetised impacts in the appraisal. Some of these could be affected significantly. The present value of airport capacity construction costs would be materially lower (by 7%) if they are discounted for 2 more years. On the other hand, the financial and disruption related surface access costs could be higher depending on the reason for the delay in construction.

A.21 Wider economic impacts could be slightly lower than those estimated by the AC as the demand would be lower until the expanded airport fills. The delay benefits would drop (but from a small base), as the new capacity would be utilised more quickly, reducing the years when there is scope for extra capacity to inject extra resilience into airline schedules. The environmental disbenefits would be expected to slightly reduce as they would occur a little later.

Conclusion

A.22 This sensitivity test, of medium analytical assurance, produces lower estimates of net benefits to passengers, airlines and government revenue than found in the central case shown in chapter 3. The ordering of schemes in terms of direct economic benefits remains unchanged.

Potential impact of noise mitigation measures

A.23 It is expected that a noise mitigation package will be put in place regardless of which of the three shortlisted options is selected. The impact of expansion on noise from aircraft remains a concern for affected communities. High exposure to noise is an annoyance, can disturb sleep, and can also affect cardiovascular health. An important economic consideration is therefore the extent to which such impacts can be mitigated and the cost of that mitigation.

A.24 The department has undertaken further work on the impacts of two potential measures to mitigate the noise impacts on communities: increased respite and a night flight ban. The analysis at this stage has a low level of analytical assurance and should be viewed as only indicative of some of the potential impacts of mitigation measures on the appraisal.

Noise respite

A.25 One potential option to mitigate noise impacts is to adapt the use of the runways in order to provide communities with assurances of respite for set and predictable periods of time.

Method

A.26 A likely outcome of adapting runway operations in this way is that the maximum number of air transport movements (ATMs) possible under the expansion options would be reduced. This sensitivity therefore tests the impact of a reduction in expanded runway capacity as a proxy for respite measures.

A.27 The analysis is purely indicative and does not consider any specific respite measures, or the flight paths or noise impacts that would be associated with them. The flight paths and air traffic control (ATC) arrangements for each of the schemes are at an early stage of development, so it would not be appropriate to undertake detailed analysis yet. It is recognised that a limitation of this simplified analysis is that the impacts of reduced capacity are only estimated for the years in which the new capacity is forecast to be fully utilised.

A.28 As neither section of LHR Extended Northern Runway scheme could be used in mixed-mode while the other section is operating, the scope to deliver respite through runway alternation is limited in this option.

Impact on demand

A.29 Reducing the available capacity of the schemes results in slightly lower forecasts of demand in the years following expansion. The resulting demand is shown in Table A 5. Total UK demand with the LGW Second Runway option is unaffected in 2040 as the additional capacity is not forecast to fill up by this time, so a reduction in capacity is assumed to have no impact on demand at this point.

Table A 5 The impact on demand of an illustrative respite regime

Terminal passengers, millions, 2040	Assessment of need, carbon traded					Respite				
	Gatwick	Heathrow	London	Non-London	**Total UK**	Gatwick	Heathrow	London	Non-London	**Total UK**
No expansion	46	90	196	163	**360**	46	90	196	163	**360**
LGW Second Runway	62	91	213	156	**368**	62	91	213	156	**368**
LHR Extended Northern Runway	44	127	229	154	**383**	44	121	224	155	**379**
LHR Northwest Runway	43	134	234	153	**387**	44	127	229	154	**383**

Quantified impact on the appraisal

A.30 Table A 6 shows the impact of the reduced capacities of each of the schemes on the passengers, airlines and government revenue.[57]

[57] Results for LGW Second Runway are based on the assessment of need, carbon-traded appraisal results, as modelled appraisal impacts of a revised respite regime were found to be immaterial.

Table A 6 The impact on passengers, airlines and government revenue of an illustrative respite regime (present value, £bn, 2014 prices)

	Respite					AoN, CT
	Passenger frequency benefits	Passenger fare benefits	Airline profits	Government revenue	PV	PV
LGW Second Runway	3.2	43.9	-41.8	2.5	**7.8**	**7.8**
LHR Extended Northern Runway	3.9	37.7	-28.0	1.3	**15.0**	**16.4**
LHR Northwest Runway	4.8	43.7	-33.5	1.4	**16.5**	**18.3**

Potential impact on other areas of the appraisal

A.31 This sensitivity test assumes that respite measures reduce the extra ATMs that become possible through expansion, which in turn would be expected to result in a slight decrease in wider economic impacts, and a slight fall in the carbon and air quality impacts. The purpose of the increased respite would be to mitigate some of the noise impacts of the schemes, but the effect on noise has not been quantified. The benefits from fewer delays would also be expected to fall as the additional capacity would fill up more quickly than in the central case, reducing the window of time between the new runway opening and the airport filling up (during which time there is excess capacity and thus fewer delays due to congestion). The change in biodiversity impacts would probably be negligible. The impact on costs is uncertain. The costs associated with construction are unlikely to change, but a new noise regime could involve additional costs to the promoters or airlines if operational adjustments are required.

Conclusion

A.32 The AC recommended that approaches to mitigate noise must incorporated into airport expansion, with some possible approaches likely to reduce scheme capacity. This sensitivity test, of low analytical assurance, suggests that reducing the available capacity in order to provide respite does not have a material impact on the quantified benefits for each of the options. At this stage, the test is too uncertain to estimate what the impact of such a regime might be on the overall NPVs for each of the options.

A.33 As the chosen option becomes further developed, and new flight paths are defined, a range of options for how to mitigate the adverse noise impacts for local residents will also be further developed.

A.34 This analysis assumes that respite measures are possible, but it should be recognised that there is uncertainty in the assumptions on the reduction in ATMs.

Night flight ban

Introduction

A.35 A second option for reducing the adverse impacts of noise is to ban night flights during core night hours. Given the link between sleep disturbance and health, this may help to mitigate the effects of increased noise from aircraft.

Method

A.36 As with measures to improve respite, a likely outcome of such a regime would be that there would be a reduction in the capacity associated with the options. This

sensitivity therefore tests the impact of a reduction in capacity as a proxy for a night flight ban.

A.37 The sensitivity assumes that ATMs are restricted in a manner consistent with the annual night movement limit regulated by the government's current night flight regime.[58] This limit is not assumed to increase with airport expansion.

Impact on demand

A.38 Reducing the available capacity of the scheme results in slightly lower forecasts of demand in the years following expansion. The resulting demand is shown in Table A 7.

Table A 7 The impact on demand of the night flight sensitivity

Terminal passengers, millions, 2040	Assessment of need, carbon traded					Night flight ban				
	Gatwick	Heathrow	London	Non-London	**Total UK**	Gatwick	Heathrow	London	Non-London	**Total UK**
No expansion	46	90	196	163	**360**	46	90	196	163	**360**
LGW Second Runway	62	91	213	156	**368**	62	91	213	156	**368**
LHR Extended Northern Runway	44	127	229	154	**383**	44	125	227	154	**381**
LHR Northwest Runway	43	134	234	153	**387**	44	132	233	153	**385**

Quantified impact on the appraisal

A.39 Table A 8 shows the impact on passengers, airlines and government revenue of the reduced capacities of the schemes.[59]

Table A 8 The impact on passengers, airlines and government revenue of the night flight sensitivity test (present value, £bn, 2014 prices)

	Night flight ban					AoN, CT
	Passenger frequency benefits	Passenger fare benefits	Airline profits	Government revenue	**PV**	**PV**
LGW Second Runway	3.2	43.9	-41.8	2.5	**7.8**	**7.8**
LHR Extended Northern Runway	4.4	41.1	-30.9	1.5	**16.1**	**16.4**
LHR Northwest Runway	5.5	48.3	-37.6	1.8	**18.0**	**18.3**

A.40 The AC monetised the impact of sleep disturbance with and without a ban on core night flights (23:30-06:00) at the shortlisted airports. Table A 9 shows a summary of the AC's results, as published in an ERCD modelling report.[60] The department understands that this modelling was based on the AC's assessment of need, carbon-capped forecasts, as outlined in the Jacobs report for the AC *Noise: Local Assessment* (2014).[61] The carbon-capped demand forecasts are generally lower than the central, carbon-traded forecasts presented in this report, and as a result the impacts would be expected to be smaller.

[58] Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/330354/night-noise-decision.pdf
[59] These impacts have been interpolated from the results of the respite sensitivity test and the assessment of need, carbon-traded scenario
[60] ERCD (2015) "Noise modelling for the Airports Commission: Compendium of Results"
[61] Jacobs (2014), 5. Noise: Local Assessment, Annex A1 available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/372488/noise--local-assessment.pdf

Table A 9 Monetised noise benefits of a night flight ban (present value, £bn, 2014 prices)

	Noise benefits - No core night flights
LGW Second Runway	0.1
LHR Extended Northern Runway	2.1
LHR Northwest Runway	1.4

Potential impact on other areas of the appraisal

A.41 The reduced number of ATMs would probably result in a slight decrease in wider economic impacts, and a slight fall in delay, carbon and air quality impacts. The costs associated with construction are unlikely to change, but a new night noise regime may involve additional costs to the promoters or airlines if operational adjustments are required.

A.42 The sensitivity test assumes that Heathrow night flights are rescheduled to arrive in the early morning period after 06:00. Rescheduled night flights would require approximately the first 30 minutes of new capacity from 06:00. This may have further impacts on the growth potential of Heathrow, limit the opportunities to enter into emerging long-haul markets and increase the opportunity cost associated with establishing potentially less competitive domestic connections.

A.43 The AC concluded that a night flight ban or significant reduction in night flights would be difficult to impose at Gatwick because of the high proportion of low cost carriers currently operating at the airport. Low cost carriers depend on a high number of route rotations, which depend on early morning starts and late evening finishes, to keep costs down. The impacts presented in Table A 8 do not include these potential additional costs to airlines and passengers.

Conclusion

A.44 The two sensitivities above present purely illustrative examples of mitigation measures that could reduce residents' exposure to noise. This does not mean that these are the only mitigations available, nor that they should necessarily be implemented. Noise mitigations are subject to ICAO's Balanced Approach to Aircraft Noise Management.

A.45 As the chosen option becomes further developed, and the flight paths have been defined, a range of options for how to mitigate the adverse noise impacts for local residents will be considered. This sensitivity test, of low analytical assurance, suggests that reducing the available capacity to a level consistent with a night flight ban does not have a material impact on the benefits that it has been possible to quantify. At this stage, the test is too uncertain to estimate what the impact of such a regime might be on the overall NPVs for each of the options.

A.46 The analysis can only be treated as indicative as it does not consider the effects of re-scheduled flights or changes to flight paths. Additionally, it does not take into account early morning slots or night flights having a higher commercial value than flights at other times of the day. As the costs of the reduced capacities are estimated on an annual basis, this analysis does not capture the disbenefits of reduced slot choice in the years before the schemes reach capacity.

Impact of increased capacity overseas

A.47 The aviation model produces forecasts for all of the major UK airports and four foreign hubs (Amsterdam, Paris Charles de Gaulle, Frankfurt and Dubai). The capacity available at each modelled airport is an input to the model.

A.48 A consideration is whether the benefits of the expansion options would still be realised if overseas hub airports were expanded beyond the planned increases incorporated into the AC's forecasts. To understand the extent to which the benefits are sensitive to this variable, the department has undertaken a sensitivity test where overseas hubs are assumed to be entirely capacity unconstrained.

A.49 This represents a substantially less realistic scenario than that considered in the central case, which remains the most appropriate assessment of scheme impacts.

Method

A.50 The AC's runway capacity limits for the overseas hubs within the model were based on discussions with operators and examination of airport masterplans. In practice, the capacity constraints at the overseas hubs were not reached at Dubai or Amsterdam in the assessment of need, carbon-traded scenario.

A.51 In this sensitivity test it is assumed that no overseas hubs are subject to a runway capacity constraint. And, as with the AC's analysis, there is no assumed constraint to terminal capacity. As overseas hubs are subject to their own planning restrictions, this set of assumptions is improbable; rather, the test serves to stress-test the maximum potential impact on results of changing these assumptions in the AC's central case.

Impact on demand

A.52 Increasing overseas hub capacities slightly reduces the demand for use of Heathrow from international-to-international transfer passengers. The impact is small as overseas hubs are, in the AC's modelling, much less capacity constrained than Heathrow. The impact on Gatwick is small, because it concentrates more on point-to-point than transfer traffic and so is less affected by capacity at overseas hubs. As overseas hub capacity does not become binding until after 2040, there is no difference in passenger forecasts under this sensitivity and the assessment of need, carbon-traded scenario in 2040. Passenger numbers do however differ in the final modelled years of the appraisal.

Quantified impact on the appraisal

A.53 The impacts on passengers, airlines and government revenue under this sensitivity test are shown in Table A 10.

Table A 10 The impact on passengers, airlines and government revenue of unconstrained capacity at overseas hubs (present value, £bn, 2014 prices)

	Unconstrained overseas hub capacity					AoN, CT
	Passenger frequency benefits	Passenger fare benefits	Airline profits	Government revenue	PV	PV
LGW Second Runway	3.2	45.4	-43.6	2.6	**7.7**	**7.8**
LHR Extended Northern Runway	4.4	42.2	-32.7	1.6	**15.5**	**16.4**
LHR Northwest Runway	5.6	48.4	-38.2	1.8	**17.6**	**18.3**

A.54 Allowing unlimited capacity at the overseas hubs reduces the benefits of the options, most materially at Heathrow due to its greater share of the transfer market.

Potential impact on other areas of the appraisal

A.55 The impact on other monetised impacts has not been calculated. Due to the very small change to the demand forecasts these impacts are expected to be minimal, and smaller than the impacts outlined in Table A 10 above.

Conclusion

A.56 Unlimited capacity at overseas hubs is an implausible assumption intended to illustrate the impact of developments overseas on the economic case for expansion. The AC's approach of using capacity limits based on discussions with operators and airport masterplans remains the most appropriate approach. In any case, the impact of this sensitivity test is small, and does not affect the relative scale of the benefit, which remain consistent with those shown in chapter 3. This sensitivity test is of high analytical assurance.

Low carbon prices

A.57 The AC's carbon-traded scenario incorporates measures to ensure that the impact of airport expansion on the CO_2 emissions from flights departing UK airports does not lead to increased CO_2 emissions at the international level. In particular, both with and without expansion, it assumes that the CO_2 emissions from flights departing UK airports are traded at the international level. This sensitivity considers a case where carbon prices are lower than assumed by the AC. The AC also presented a high carbon price sensitivity test, which is considered in the next section. Although there remains uncertainty around the form of future carbon markets, the treatment of carbon prices in the central case is considered the most plausible.

Method

A.58 This sensitivity assumes that from 2021 nearly all flights from the UK are part of a global market-based measure (GMBM)[62], and that any increase in CO_2 emissions covered by the GMBM would be offset by reductions in emissions elsewhere. This sensitivity test assesses the impact of carbon prices within the GMBM being

[62] Two exceptions apply: flights entirely within the UK are assumed to be within a European cap and trade scheme similar to the ETS and face the central DECC appraisal carbon price; and flights to less developed countries are assumed to be entirely outside any market based measure until 2035 – because of this the carbon externality for these flights is monetised.

equivalent to the low appraisal carbon price series published by DECC - roughly half the DECC central values that were used in the AC's assessment of need, carbon-traded case.

Impact on demand

A.59 Lower carbon prices lead to lower fares, making air travel more attractive, and leading to higher demand relative to the AC's assessment of need, carbon-traded case.

A.60 Although the resulting higher demand increases UK aviation emissions, these will almost entirely be offset by reductions in emissions elsewhere, as nearly all UK flights are modelled as part of a GMBM. The impact on demand of this sensitivity is shown in Table A 11.

Table A 11 The impact on demand of lower carbon prices

Terminal passengers, millions, 2040	Assessment of need, carbon traded					Low carbon prices				
	Gatwick	Heathrow	London	Non-London	**Total UK**	Gatwick	Heathrow	London	Non-London	**Total UK**
No expansion	46	90	196	163	**360**	46	91	197	176	**373**
LGW Second Runway	62	91	213	156	**368**	68	91	220	164	**385**
LHR Extended Northern Runway	44	127	229	154	**383**	44	126	231	163	**394**
LHR Northwest Runway	43	134	234	153	**387**	43	133	237	163	**399**

Quantified impact on the appraisal

A.61 The impacts on passengers, airlines and government revenue under this sensitivity test are given in Table A 12.

Table A 12 The impact on passengers, airlines and government revenue of lower carbon prices (present value, £bn, 2014 prices)[63]

	Low carbon prices						AoN, CT
	Passenger frequency benefits	Passenger fare benefits	Airline profits	Government revenue	LDC carbon externality	**PV**	**PV**
LGW Second Runway	4.8	64.7	-59.6	4.5	-0.0	14.4	7.8
LHR Extended Northern Runway	5.1	57.2	-45.9	3.4	-0.1	19.7	16.4
LHR Northwest Runway	6.0	63.6	-51.7	3.9	-0.1	21.8	18.3

Potential impact on other areas of the appraisal

A.62 The present value of costs could be materially higher in the LGW Second Runway option if construction needs to be accelerated to match the accelerated demand profile. Other elements are unlikely to be significantly affected.

Conclusion

A.63 This sensitivity test, of low/medium analytical assurance, produces higher estimates of net benefits to passengers, airlines and government revenue than

[63] 'LDC carbon externality' reflects the value of additional CO_2 emissions from flights to less developed countries, as discussed in footnote 62.

found in the central case shown in chapter 3. The ordering of schemes in terms of direct economic benefits remains unchanged.

High carbon prices

A.64 The AC undertook a high carbon price sensitivity which considers a case where carbon prices are higher than assumed in the AC's assessment of need, carbon-traded case. In this sensitivity test the AC's high carbon price sensitivity test is adapted to be consistent with DECC's high carbon price series.

Method

A.65 The AC assumed the high carbon price was delivered through a tax which reduced the level of demand and emissions – so carbon revenue gains to government were included. In contrast, the low carbon price run presented in the previous section assumes that aviation is part of an aviation-specific trading scheme. In this case there is no global increase in emissions.

A.66 This test interprets the AC's high carbon price analysis such that the higher carbon price is assumed to be delivered through a stringent cap and trade scheme, in order to be consistent with the low carbon price sensitivity. It is assumed, for modelling purposes, that prices are equivalent to the high DECC appraisal carbon price series.

Impact on demand

A.67 Higher carbon prices lead to higher fares, which makes air travel less attractive, leading to lower demand relative to the AC's assessment of need, carbon-traded case.

A.68 Although this lower demand decreases UK aviation emissions, these would almost entirely be offset by increases in emissions elsewhere, as nearly all UK flights are assumed to be part of a GMBM. The impact of this sensitivity on demand is shown in Table A 13.

Table A 13 The impact on demand of higher carbon prices

Terminal passengers, millions, 2040	Assessment of need, carbon traded					High carbon prices				
	Gatwick	Heathrow	London	Non-London	**Total UK**	Gatwick	Heathrow	London	Non-London	**Total UK**
No expansion	46	90	196	163	**360**	45	89	194	155	**349**
LGW Second Runway	62	91	213	156	**368**	58	90	207	149	**356**
LHR Extended Northern Runway	44	127	229	154	**383**	43	126	226	146	**372**
LHR Northwest Runway	43	134	234	153	**387**	43	133	231	145	**377**

Quantified impact on the appraisal

A.69 The impacts on passengers, airlines and government revenue under this sensitivity are displayed in Table A 14.

Table A 14 The impact on passengers, airlines and government revenue of higher carbon prices (present value, £bn, 2014 prices)

	High carbon prices					AoN, CT
	Passenger frequency benefits	Passenger fare benefits	Airline profits	Government revenue	PV	PV
LGW Second Runway	2.6	32.8	-31.7	1.5	**5.2**	**7.8**
LHR Extended Northern Runway	4.8	36.7	-28.8	1.0	**13.8**	**16.4**
LHR Northwest Runway	5.0	43.4	-34.8	1.4	**15.0**	**18.3**

Potential impact on other areas of the appraisal

A.70 Intuitively, other elements of the appraisal are likely to be affected in the opposite way to those set out under the low carbon price sensitivity.

Conclusion

A.71 This sensitivity test, of low/medium analytical assurance, produces lower estimates of net benefits to passengers, airlines and government revenue than found in the central case shown in chapter 3 for all three options. The ordering of schemes in terms of direct economic benefits remains unchanged.

Impact of using a partially-updated Aviation Model

A.72 The AC produced demand forecasts in order to assess the connectivity impacts of the schemes and as an input to other areas of the appraisal. The core set of forecasts were produced using an updated version of the department's aviation forecasting model prepared ahead of the AC November 2014 consultation on the shortlisted options.

A.73 As part of the department's ongoing programme of model development, a number of updates to this version of the model have been implemented in order to keep up with recent developments at UK airports and the overseas hubs, as well as reflect the latest published forecasts for the global economy.

A.74 This is not a full update of the model and is yet to be applied to the full range of global demand scenarios. It therefore remains appropriate to use the most recent, fully quality assured published forecasts of demand in the central case.

Method

A.75 The department has undertaken three main developments to the model:

- The model base year has been brought forward from 2008 to 2014 and a detailed validation of the forecasts against actual data for 2014 has been completed.
- Where practical, the macroeconomic inputs, such as OBR GDP projections, have been updated with the latest publically available data.[64]

[64] One exception is oil prices, where further work is underway to reflect the recent developments robustly.

- The appraisal values of time for business and leisure passengers have been updated in line with the latest WebTAG guidance and survey data.[65]

A.76 The updated macroeconomic inputs are taken from a range of publications from December 2014 through to March 2016. This sensitivity test will therefore not reflect the impacts of more recent developments.

A.77 The business appraisal values of time have been updated using 2011-2014 CAA interview income data. The AC values of time have also been updated with new data on average working hours and uprated by 21% for non-wage labour costs and 19% for indirect taxation in order to bring it in line with WebTAG guidance. The Treasury's GDP deflator to adjust nominal income values to real income values is also now used.

A.78 This sensitivity test does not represent a new official forecast. More model updates are planned and further testing and validation will be required before the department can produce new official aviation demand forecasts.

Impact on demand

A.79 The impact of the model updates compared to the AC assessment of need, carbon-traded forecast for 2040 is displayed in Table A 15. The increase in modelled passenger throughput in 2014 and 2015 leads to greater demand in the London system in the do minimum baseline.

Table A 15 The impact on demand of using the partially updated aviation model

Terminal passengers, millions, 2040	Assessment of need, carbon traded					Updated model base year				
	Gatwick	Heathrow	London	Non-London	**Total UK**	Gatwick	Heathrow	London	Non-London	**Total UK**
No expansion	46	90	196	163	**360**	50	87	198	182	**380**
LGW Second Runway	62	91	213	156	**368**	82	86	229	171	**400**
LHR Extended Northern Runway	44	127	229	154	**383**	46	127	233	172	**404**
LHR Northwest Runway	43	134	234	153	**387**	46	133	239	170	**409**

A.80 The numbers of international to international transfer passengers in the UK system are lower in the updated model than in the AC forecasts, probably reflecting better recent performance at the overseas hubs in attracting demand. The new model also has a greater proportion of low cost carriers in the UK airport system and fewer charter carriers. The proportion of scheduled carriers has remained largely unchanged. With no expansion, all of the London airports are forecast to be full by 2030, compared to 2036 in the equivalent AC forecasts. With expansion, the new capacity is forecast to become full again by 2046 for the LGW Second Runway, 2033 for the LHR Extended Northern Runway and 2036 for the LHR Northwest Runway.

A.81 By 2050, forecast throughput in the LGW Second Runway option has increased by 16m from 82m terminal passengers in the AC's forecasts to 98m. Passenger throughputs in the LHR Extended Northern and Northwest Runway options have also increased, but to a much smaller degree, not varying by more than 1m terminal passengers in the years between 2030 and 2050. This is because

[65] Understanding and Valuing Impacts of Transport Investment – Values of travel time savings, Department for Transport, 2015. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/470998/Understanding_and_Valuing_Impacts_of_Transport_Investment.pdf

Heathrow was already expected to become capacity constrained in the 2030s, thus limiting the potential for additional growth.

Quantified impact on the appraisal

A.82 The impact of using the updated forecasts on passengers, airlines and government revenue is shown in Table A 16. All schemes see a significant increase in benefits principally due to higher underlying national demand compared to the AC's assessment of need, carbon-traded case.

Table A 16 The impact on passengers, airlines and government revenue of using the partially-updated aviation model (present value, £bn, 2014 prices)

	Updated model base year					AoN, CT
	Passenger frequency benefits	Passenger fare benefits	Airline profits	Government revenue	PV	PV
LGW Second Runway	5.5	73.8	-68.1	4.1	**15.2**	**7.8**
LHR Extended Northern Runway	5.4	60.5	-49.9	2.9	**19.0**	**16.4**
LHR Northwest Runway	6.0	70.7	-59.4	3.6	**20.9**	**18.3**

Potential impact on other areas of the appraisal

A.83 The monetised impacts on other areas of the appraisal have not been calculated. It would be expected that delay, carbon, noise and potentially scheme costs could increase in line with the proportion of extra passengers accommodated at UK airports by 2050. The greatest impact would most likely be seen with the LGW Second Runway option, because in the new forecast it sees the greatest increase in national passenger numbers and this could impact on the phasing of construction.

Conclusion

A.84 This sensitivity test, of medium/high analytical assurance, produces higher estimates of net benefits to passengers, airlines and government revenue than found in the central case shown in chapter 3. The differences between the schemes are reduced, but the ordering of schemes in terms of direct economic benefits remains unchanged.

The impact of only including UK residents in the Net Present Value

A.85 The NPV presented by the AC included costs and benefits to both UK and non-UK passengers and airlines due to difficulties in presenting reliably disaggregated UK / non-UK impacts. The department's review noted the advice in the Green Book that all impacts (including costs and benefits, both direct and indirect) on non-UK residents and firms should be identified and quantified separately where it is reasonable to do so, and if such impacts might affect the conclusions of the appraisal. The department's aviation appraisal guidance advises that all foreign

passenger impacts are included apart from international to international interliners.[66]

A.86 The department has therefore undertaken further analysis to explore how a UK-only NPV might differ from the NPV for all passengers and airlines (the AC's approach). Because of the difficulties in implementing this approach, the central case is considered the more reliable assessment of scheme impacts.

Method

A.87 The first step in calculating a UK-only NPV is to identify which appraisal impacts are felt by UK and non-UK residents. This is relatively straightforward for a number of the impacts:

- **Passenger benefits** are calculated using models that naturally disaggregate between UK and non-UK passengers.
- **UK Government revenue** impacts are UK only.
- **Wider economic impacts** only accrue to businesses in the UK.
- **Environmental impacts** are assumed to be UK only.

A.88 Disaggregating both the **costs to airlines** from reduced profits and the **construction costs** of the scheme is more difficult. To separate profit and loss to airlines due to expansion requires a definition of whether an airline is classed as UK or non-UK resident. Where airlines are public companies listed on a stock exchange, a comprehensive determination of the nation of ownership is in most cases unavailable – for example, many airlines are public companies listed on one or more stock exchanges.

A.89 Furthermore, airlines often change ownership. This means that to robustly separate their costs into UK and non-UK requires foresight and a forecast of the long term development of the global airline industry. The separation of costs is also highly sensitive to any assumptions that are made about who receives (or loses) the scarcity rents from airport constraints, which could be experienced by airline owners, employees or the government, and about who ultimately pays for expansion which could be airports, airlines, passengers, and / or the government (in the case of surface access costs). All surface access costs are assumed to be paid by industry.

A.90 Despite these difficulties, the department has attempted to calculate a UK only NPV. This analysis makes the highly simplifying assumption that airline residency can be proxied by the location of the airline's registration or their headquarters, and that this doesn't change over time. The analysis is extremely sensitive to changes in this assumption.

Conclusion

A.91 As shown in Table A 17, the UK-only NPVs are higher than the NPVs estimated under the central case for all of the options. This is because many of the costs of expansion – lower profits and construction costs – ultimately fall to airlines (and/or their passengers), many of whom are defined as being non-UK.[67] These NPVs should be seen as no more than indicative because of the difficulties in robustly apportioning both the costs to airlines and expansion construction costs, and as such are of low analytical assurance. On balance, the department's view is that

[66] The reasons for why this approach is appropriate in the case of aviation appraisal are discussed in https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/487701/TAG_unit_a5.2_aviation_appraisal_dec2015.pdf

[67] For this sensitivity test, costs are assumed to accrue to airlines.

the AC's approach of including impacts to both UK and overseas residents is the most appropriate and internally consistent approach.

Table A 17 The impact of only including UK residents in the Net Present Value (present value, £bn, 2014 prices)

	UK-only NPV		Assessment of need, CT	
	NPV	NPV excluding WEIs	NPV	NPV excluding WEIs
LGW Second Runway	**8.9 - 10.3**	7.5 – 7.6	**3.1 - 4.5**	1.7 – 1.8
LHR Extended Northern Runway	**4.8 – 8.1**	3.1 – 4.8	**0.2 – 5.1**	-1.5 – 1.8
LHR Northwest Runway	**5.8 – 9.9**	3.8 – 6.0	**0.2 – 6.1**	-1.8 – 2.3

A.92 As set out in Chapter 7, NPVs reflect one way to aggregate the costs and benefits of a project. The AC also assessed the net social benefits of the schemes – a measure of costs and benefits excluding the costs of construction. A further metric, net public value, is proposed by Treasury for investment decisions that are privately financed. Table A 18 shows the UK-only net social benefit and net public value for all of the schemes, using the same approach as for the NPV calculations above.

Table A 18 The impact of only including UK residents in the net public value and net social benefit (present value, £bn, 2014 prices)

	Net Public Value			Net Social Benefit (AC definition)	
	(All impacts)	(No I to I impacts)	(UK only impacts)	(All impacts)	(UK only impacts)
LGW Second Runway	50.3 – 52.2	48.7 – 50.5	35.7 – 37.6	10.1 – 11.4	14.2 – 15.5
LHR Extended Northern Runway	43.5 – 48.9	38.3 – 43.7	25.8 – 31.2	16.1 – 17.7	13.4 – 14.9
LHR Northwest Runway	53.1 – 58.4	46.6 – 51.8	31.9 – 37.2	18.6 – 20.4	15.7 – 17.6

Impact of revised air quality values

A.93 Airport expansion results in changes in emissions associated with aircraft, airport, and surface access sources. These changes to emissions alter the quality of the air and this in turn has an impact on health. Where possible these changes in health are monetised as part of the appraisal.

A.94 The AC modelled the changes in emissions and therefore to air quality, as measured by the concentration of nitrogen oxides (NOx) and particulate matter (PM) in the air, for each of the shortlisted capacity options. The AC applied Defra's damage cost estimates for a tonne of NOx to monetise the impact of a change to air quality.

A.95 Since the AC's report, Defra has published interim guidance allowing the direct effect of exposure to NO_2 to be quantified and monetised, as opposed to the

aggregated NOx and PM concentrations. The further guidance recommends the use of impact pathway modelling, which is now Defra's central recommended approach for air quality valuation, and applies concentration-response functions recommended in the interim guidance to Defra from COMEAP (the Committee on the Medical Effects of Air Pollutants).

A.96 The damage costs approach used by the AC to quantify aircraft, airport and surface access emissions is a simplified approach for air quality economic valuation. The transport damage cost values were estimated to reflect the average impact of road traffic emissions, and so are likely to overestimate the impact of the additional emissions from specific airport capacity options. As described by the AC in its air quality module, the majority of additional emissions following airport expansion would be from aircraft departing from and arriving at the airport. Compared to the roadside emissions from road traffic, these aircraft emissions would be dispersed over a wider area and therefore have less impact on concentrations of air pollutants in specific local areas.

A.97 Given this, the AC undertook their own sensitivity test using the impact pathway approach (rather than the damage cost approach) which they reported in Appendix G of the Air Quality Local Assessment report.[68]

A.98 This sensitivity tests the impact of using the latest interim guidance on the estimated air quality impacts of the options. As the guidance becomes further developed it is expected that it will be incorporated into the Green Book and WebTAG guidance and used to form the central case.

Method

A.99 This sensitivity test is based on analysis commissioned by the department and Defra and undertaken by consultants Ricardo – AEA, following Defra's interim impact pathway analysis guidance. Data on the resulting changes in concentrations of NO_2 associated with the airport capacity options are obtained from the analysis published by the AC in Air Quality Local Assessment report.

A.100 The results of the analysis are presented in Table A 19. As these are based on the AC's estimates of emissions, these relate to the scheme and surface access designs considered by the AC. It is noted that subsequent to the AC's work on air quality, further iterations of surface access plans have been proposed by the promoter of the Heathrow Extended Northern Runway scheme. Most elements of their plans have remained unchanged, but there have been some changes to road layout. Although these iterations have not been considered in the *AIR QUALITY REANALYSIS Impact of New Pollution Climate Mapping Projections and National Air Quality Plan* report, it is acknowledged that they were developed with one aim being to reduce air quality impacts associated with the proposal considered by the AC.

[68] Module 6: Air Quality Local Assessment, Detailed Emissions Inventory and Dispersion Modelling, Jacobs (2015) available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/437240/air-quality-local-assessment-detailed-emissions-inventory-and-dispersion-modelling.pdf

Table A 19 The impact on health effects of revised air quality valuation (present value, £bn, 2014 prices)

	Sensitivity test – Revised AQ valuation			AC valuation
	PM_{10}	NO_2	Total	Total
LGW Second Runway	0.03	0.02	**0.05**	**0.2**
LHR Extended Northern Runway	0.06	0.02	**0.08**	**0.6**
LHR Northwest Runway	0.07	0.03	**0.10**	**0.8**

Conclusion

A.101 Table A 20 shows scheme NPVs in this sensitivity test compared to the AC assessment of need, carbon-traded scenario. Since this test relates to the valuation of air quality impacts only, other monetised impacts do not change.

A.102 This sensitivity test, of medium analytical assurance, produces a lower monetised impact of air quality on health than that presented by the AC using the damage cost approach for all three shortlisted options.

Table A 20 The impact on scheme NPVs of revised air quality valuation (present value, £bn, 2014 prices)

	Revised AQ valuation		AC valuation	
	Net Present Value	(Excluding WEIs)	Net Present Value	(Excluding WEIs)
LGW Second Runway	**3.2 – 4.7**	1.8 – 2.0	**3.1 – 4.5**	1.7 – 1.8
LHR Extended Northern Runway	**0.7 – 5.6**	-1.0 – 2.3	**0.2 – 5.1**	-1.5 – 1.8
LHR Northwest Runway	**0.9 – 6.8**	-1.1 – 3.0	**0.2 – 6.1**	-1.8 – 2.3

A.103 The estimates of air quality impacts in this sensitivity test are similar to the AC's estimates that also used the impact pathway modelling methodology.

Impact of using alternative route viability thresholds

Introduction

A.104 The AC's forecasts were produced using the department's aviation model. In order to produce these forecasts at the route level, modelling assumptions were made about the point at which latent demand for a new route is sufficient for it to become viable. This analysis tests the sensitivity of demand to changes in this specific technical modelling input assumption.

A.105 The alternate assumptions used in this sensitivity test are considered to be less accurate than those used in the central case, which remains the most appropriate assessment of impacts.

Method

A.106 The aviation model dynamically models the introduction of new routes by testing in each forecast year whether sufficient demand exists to make new routes viable from each airport. Effectively this assumes that, in line with mainstream economic theory, supply of routes will respond to demand, subject to the availability of airport capacity and clearing a minimum passenger demand threshold. The viability test is two-way: routes can be both opened and withdrawn. The thresholds for new routes becoming available are identified on historic passenger data, are often route specific, and are periodically reviewed as part of model validation.

A.107 In April 2014, the AC published a report by PwC that analysed historical start-up thresholds using Sabre Airport Data Intelligence. The study data source was tickets purchased rather than the time series route level statistical data from the CAA used in the department's analysis. PwC recommended two generic thresholds: one for short-haul routes and another for medium to long-haul routes. This sensitivity tests the impact on total UK demand under each of the schemes if the alternative (and sometimes lower[69]) thresholds proposed by PwC are used.

Impact on demand

A.108 The resulting impact on demand for the three expansion options are shown in Table A 21.

Table A 21 The impact on demand of lower route viability thresholds

Terminal passengers, millions, 2040	Assessment of need, carbon traded					Lower route viability thresholds				
	Gatwick	Heathrow	London	Non-London	**Total UK**	Gatwick	Heathrow	London	Non-London	**Total UK**
No expansion	46	90	196	163	**360**	46	90	196	163	**360**
LGW Second Runway	62	91	213	156	**368**	64	90	213	155	**368**
LHR Extended Northern Runway	44	127	229	154	**383**	44	126	227	153	**381**
LHR Northwest Runway	43	134	234	153	**387**	44	133	232	153	**385**

A.109 In the LGW Second Runway scheme, the alternative thresholds result in a modest increase in traffic levels at Gatwick compared to the AC forecasts. The increased traffic is primarily to long-haul destinations and largely occurs after 2040, when the overall demand in the system is higher. This results in an increase in the number of both short and long-haul destinations served from an expanded Gatwick.

A.110 In both the Heathrow schemes, the alternative thresholds result in relatively minimal changes in passenger demand, with a small rise in short-haul traffic being balanced by a fall in long-haul traffic. This is reflected in the number of destinations available, with slight increase in short-haul destinations and a fall in long-haul. The changes are small, and might reasonably be considered within the bounds of modelling error.

[69] Because the department's viability threshold varied considerably by route using local data it does not follow that they were always higher than the suggested default PwC values.

Conclusion

A.111 The route viability thresholds used in the central case are considered to be based on more accurate data and provide a more disaggregated assessment than those provided by PwC. This sensitivity test, of medium analytical assurance, results in a small increase in demand in the LGW Second Runway option, and minor changes in the Heathrow options. The current approach adopted in the department's aviation model appears more robust and remains most appropriate.

Glossary

Term	Definition
AC	The Airports Commission
AC's final report	The Airports Commission's final report, published 1 July 2015
Aero-charge	Per-passenger charges levied on airlines by airports
Agglomeration	The advantage of business clusters, such as being close to transport links and a dynamic work force
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
Analytical assurance	Conveys the confidence that can be placed on evidence and draws upon the strengths, risks, limitations and uncertainties involved in producing it
AoN	Demand scenario *assessment of need*
AoS	Appraisal of Sustainability
APD	Air Passenger Duty
AQ	Air quality
ATC	Air Traffic Control
ATM	Air Transport Movement. Landings or take offs of aircraft engaged in the transport of passengers or freight on commercial terms
BA	British Airways
Baseline/do minimum	The scenario of adding no new runway capacity as assessed in the AC's interim report
BHC	Berkley Hanover Consulting
CAA	The Civil Aviation Authority
Capacity constrained	Modelling case where passenger and ATM demand must fit 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
Capex	Capital expenditure
Carbon regime	One of the two carbon policy scenarios used by the AC, each of which represents a different approach for managing the CO_2 emissions from aviation in the future
Carbon-capped (CC)	A carbon policy scenario 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 (CT)	A carbon policy scenario 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
Central case	Assessment of Need demand scenario with carbon-traded regime
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COMEAP	Committee on Medical Effects of Air Pollution
Concentration	The level of pollutants in the atmosphere
Concentration response coefficient	Shows the percentage change in an outcome (eg deaths) for a given change in pollution concentration
DECC	Department of Energy and Climate Change
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 suite
DfT (‘the department’)	Department for Transport
Direct effects	Effects which are a direct consequence of changes at the airport (ie not including ‘knock-on’ impacts)
Discounting	Where impacts are adjusted to reflect the fact that society places greater value on the benefits and costs incurred today, than those incurred in the future
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
ERCD	Environment Research and Consultancy Department of the CAA
EU	European Union
EU ETS	EU Emissions Trading System
Excess demand	In an airport context, a situation in which the market demand for flights from a particular airport is greater than the market supply, thus causing higher ticket prices
FDI	Foreign Direct Investment
GAD	Government Actuary Department
GAL	Gatwick Airport Limited, the promoter of the Gatwick Airport Second Runway scheme
GDP	Gross Domestic Product
GF	Demand scenario *global fragmentation*
GG	Demand scenario *global growth*
GMBM	Global market-based measure

Green Book	HM Treasury guidance for public sector bodies on how to appraise proposals before committing funds to a policy, programme or project
GVA	Gross Value Added
HAL	Heathrow Airport Limited, the promoter of the Heathrow Airport Northwest Runway scheme
IMF	International Monetary Fund
Impact-pathway approach	Modelling approach that traces the origins of pollutants through to the locations/ populations that they affect
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
ITF	International Transport Forum
Latent demand	In an airport context, where demand exists for a specific air service but airlines do not provide it
LCK	Demand scenario *low-cost is king*
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 an ATM utilised 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 at the same time
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
Mppa	Millions passengers per annum
Mt	Million tonnes

$MtCO_2e$	Million tonnes of carbon dioxide equivalent
Multiplier	A factor of proportionality that assess how much a variable changes as a reaction to another variable
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
NO_2	Nitrogen dioxide
Noise envelopes	The concept of a 'noise envelope' is one which would create a balance between aviation growth and noise reduction with the objective of incentivising airlines to introduce quieter aircraft whilst giving local communities more certainty about the levels of noise they may expect in the future. A noise envelope can be created through the introduction of a movement cap, a quota count system or setting passenger number limits
Noise Respite	The principle of providing defined periods of noise relief to those living directly under the flight path
NOx	Nitrogen oxides
NPV	Net present value
OBR	Office for Budget Responsibility
OECD	Organisation for Economic Co-operation and Development
Opex	Operating expenditure
Opportunity cost	The benefit lost from the alternatives foregone
Overseas hubs	In the aviation model suite, the overseas hub airports are: Amsterdam Schiphol Airport, Paris Charles de Gaulle Airport, Frankfurt Airport and Dubai International Airport
PM	Particulate matter
Point-to-point	Direct connection between two destinations
Promoter	One of three organisations promoting a scheme
PV	Present value, ie the value today of a stream of future costs or benefits
PwC	Pricewaterhouse Coopers LLP
RDE	Demand scenario *relative decline of Europe*
Real prices	Prices adjusted for inflation
Resilience	In this report, resilience refers to the ability of an airport to be able to anticipate, absorb or recover from unforeseen events, whether they arise from late passengers or aircraft, or from extraneous events such as fog, low visibility, or strong winds
Runway alteration	In this report, runway alteration refers to the practice at Heathrow airport whereby the designated landing runway is changed at 15:00 (so that the designated departure runway becomes the landing one) when the airport is

	operating during westerly operations, providing predictable periods of relief from the noise of landing aircraft for communities under the final approach tracks to the east of the airport
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
Scarcity rents	In cases when demand exceeds the physical capacity of the airport to accommodate it, the scarcity rent is the increase in air ticket prices needed to balance supply and demand.
S-CGE modelling	Spatial-Computable General Equilibrium Modelling
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 short-listed by the AC for runway expansion
Shadow cost	The extra cost of flying required to reduce passenger demand from above an airport's runway or terminal capacity, to a level that is back within capacity
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
Slots	A slot is the right to use a bundle of airport infrastructure at a certain date and time to operate an air service
Surface access	Land-based forms of transport used to access airports
Teeasa model	Transport Economic Efficiency Appraisal Spreadsheet for Aviation, a model within the department's aviation demand modelling suite.
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
WebTAG	Department for Transport appraisal guidance