

Appraisal Framework Module 13. Cost and Commercial Viability: Cost and Revenue Identification Heathrow Airport Extended Northern Runway

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Executive Summary

This report sets out the assessment of the capital cost to deliver the Heathrow Airport Extended Northern Runway scheme, which includes an additional runway, taxiways and terminal infrastructure. The assessment has been undertaken in general accordance with the HM Treasury's The Green Book - Appraisal and Evaluation in Central Government, which advises the adjustment of base cost estimates to include risk and optimism bias. The scheme is estimated to cost £13.5 billion with mitigated optimism bias applied and £15.6 billion with unmitigated optimism bias, compared to Heathrow Hub's estimate of £10.1 billion (excluding surface access costs. HH's estimate does not include optimism bias).

In order to enable the Cost and Commercial Viability study to consider the viability of the scheme investment, the report also summarises the wider cost and revenue context of that investment. Therefore, assessments were made of the underlying investment in airport infrastructure that would be required irrespective of the extended runway investment, the ongoing maintenance and replacement of the existing and developed asset, the ongoing operational expenditure relating to the existing and developed asset, the non-aeronautical revenue the existing and developed asset would generate; and, beyond the airport boundary, the surface access works required to facilitate the scheme (along with the operational and maintenance costs of those surface access improvements).

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1 Introduction

This report sets out the determination of the capital cost estimate to develop the Heathrow Airport Extended Northern Runway scheme (hereafter “the scheme”). Section 2 sets out an overview of the methodology adopted, with the analysis presented in Section 3.

Recognising that it is not possible to determine with accuracy a single cost estimate, the primary aim of the study was to establish an estimate upon which it would be reasonable for the assessments within Appraisal Framework Module 13: Cost and Commercial Viability to be conducted.

Details of the scheme costs and supporting detail are presented in Appendices B and C.

In order to enable the Cost and Commercial Viability study to consider the viability of the investment in the scheme, it was necessary to understand the wider cost and revenue contexts of that investment. Therefore, assessments were made of the following:

- *the underlying investment in airport infrastructure that would be required irrespective of the extended runway investment, referred to as Core works in this report, as discussed in Appendix D;*
- *the ongoing replacement of the existing and developed asset, as also discussed in Appendix D;*
- *ongoing operational expenditure relating to the existing and developed asset, as also discussed in Appendix F;*
- *non-aeronautical revenue the existing and developed asset would generate as discussed in Appendix G; and*
- *beyond the airport boundary, the surface access works required by the scheme along with the operational and maintenance costs of those surface access improvements as discussed in Appendix H.*

Throughout this report a consistent colour scheme has been adopted to present the cost and revenue estimates developed for each demand scenario. With reference to the demand scenarios presented in Section 2.3, the scenarios and their respective colours are as given in Table 1-1:

Scenario
Assessment of Need Carbon Capped
Assessment of Need Carbon Traded
Global Growth Carbon Traded
Global Fragmentation Carbon Capped
Heathrow Hub

Table 1-1 Demand Scenario Reference Colours

2.1 Approach

Throughout this report consistent nomenclature has been adopted. Estimates were developed for “Core” and “Scheme” costs, where the “Core” works relate to the investment in the airport irrespective of investment in the additional runway works, the additional cost of which is reported as the “Scheme” cost. The Scheme works were established from the promoter’s submission to the Airports Commission. Details of the approach to the Core works and to asset replacement are presented in Appendix D.

2.2 Scheme Capital Cost

The over-arching approach was to assess the reasonableness of the estimate provided by Heathrow Hub (HH) in order to reach a view as to an appropriate estimate to be used with the Cost and Commercial Viability assessment. This was undertaken by comparison of the provided costs, or any costs independently determined, against industry expectation. All costs were re-based as necessary to be consistently presented in 2014 values.

The following tasks were undertaken:

- *the scope of work was determined and disaggregated into the greatest level of detail reasonably possible from material provided and appropriate to this stage of analysis;*
- *for each element of the disaggregated works the effective unit rate was determined;*
- *the unit rate was assessed for whether it was in accordance with expectation of a reasonable market rate taking into account the nature, site and location of the works;*
- *unit rates were aligned between HH and Heathrow Airport Ltd (HAL)¹;*
- *amendments were made as appropriate;*
- *the base cost was established and risk and optimism bias were applied as discussed below.*

A 15% project on-cost was added to the base construction cost to allow for design and project management services. This cost was included within the base cost and was therefore adjusted for risk and optimism bias. Optimism bias was applied to the risk adjusted base cost.

Noting the inherent nature of capital expenditure projects to exhibit risk and uncertainty the processes and guidance of HM Treasury’s The Green Book - Appraisal and Evaluation in Central Government (hereafter referred to as “The Green Book”)², and supplementary guidance with respect to optimism bias³ were adopted. The guidance recommends making such adjustments on the basis that there is a demonstrated, systematic tendency for project appraisers to be overly

¹ In certain instances, the rates proposed or implicit in HH’s analysis differed significantly from those determined for HAL for the same element of the scheme. The rates and costs for these elements were aligned between the two schemes.

² https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf

³ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/191507/Optimism_bias.pdf

optimistic. A risk premium was applied to address the unknown engineering detail of the identified works which would be expected to lead to an under estimate of the cost despite the scope being reasonably defined. For example, geological surveys may find that the tunnels (such as for baggage or transit systems) need to be bored through much harder rock than previously expected. Risk premiums of 20% on Scheme costs were adopted to take account of the risk of the costs to deliver the identified scope of works increasing. These allowances are in line with our expectation of typical allowances at this stage of project development.

Scheme costs were assessed in as much detail as possible based upon the extent of information presented by the promoter and as appropriate to this stage of analysis. Engineering judgement and experience were used to assess whether the detailed item rate, or a higher aggregate planning rate, was appropriate for the element of the works, its engineering context and the operational environment within which the works would be constructed. This judgement was based upon Jacobs's experience of similar airport projects within London and within the UK.

The environmental and community impact and mitigation costs are the costs as presented by the promoters. The parallel studies being undertaken on behalf of the Airports Commission have indicated that the scale of the costs proposed are reasonable assumptions, although noting that developing a detailed budget for such costs is difficult at this stage as particular aspects of design can have significant knock on effects and the costs may increase by up to circa 50%. This falls within the range of sensitivities treated within the Commission's financial modelling, further detail of which can be found in 13. Cost and Commercial Viability: Funding and Financing Assessment.

2.2.1 Risk and Optimism Bias

(a) Risk

Based upon our expectation of a reasonable allowance at this stage of project development, a 20% risk premium was applied. We would note that this allowance could be seen as being optimistic and that a higher allowance would not be considered inappropriate. We note however that the individual items of work base costs (the risk and optimism bias unadjusted costs) make due allowance for the environments in which they will be delivered and/or the complexity of the items of work. Therefore, whilst we would observe 20% to be at the lower end of an expected range for projects at this relatively early stage of development, we consider it to be a reasonable base upon which to establish a reasonable cost estimate.

(b) Optimism Bias

HM Treasury's Supplementary Green Book Guidance sets out a detailed calculation method to establish the appropriate level of optimism bias to be applied taking into account a number of factors. Noting that these calculations require judgement across a range of factors, most of which are difficult to establish with accuracy from an external assessment to the organisation reasonable for project delivery, and noting that those assessments are subjective in nature rather than demonstrably objective, the approach to optimism bias was to establish a reasonable allowance, rounded to the nearest 5%, applied consistently to each scheme.

The works were assessed, at a high level, to determine the types of project(s) applicable and the weighting that should be applied based on their percentage of the

total budget. The works were assessed to comprise a mixture of Standard Building and Standard Civil Engineering. It could be argued that the T6 works, essentially within the confines of an operational airfield and with restricted site access given the location of the M25, could be considered as non-standard building works. The base cost for these works were noted to include a greater allowance to reflect the impact of the works location and greater cost of construction. However, we note that this mixture is open to interpretation and may change as the nature of the scheme develops.

The upper bounds, the starting points for determining the appropriate level of adjustment for optimism bias, are 24% for Standard Buildings and 44% for Standard Civil Engineering. The upper bound figures relate to average historic optimism bias at the outline business case stage for traditionally procured projects. The Green Book approach does not require each component of the scheme to be analysed separately, other than by project type as described above. Based upon a representative distribution between these two construction types, an upper bound of 38% was determined. This rate was adopted as the upper bound/unmitigated estimate of optimism bias.

The upper bound optimism bias can be reduced according to the extent to which various contributory factors have been managed as listed in Appendix B.

The works were assessed to be largely undertaken beyond the current airport boundary, within areas of less well known site conditions, in part out-with extant procurement processes and, given the long time frame and uncertainty of the investment, with a developing business case. The calculations in line with The Green Book are presented in Appendix B. Appendix B also sets out comments and notes of the processes and strategies that the airport would be expected to adopt in support of reducing the optimism bias from the upper bound value. Following this analysis a 20% mitigated optimism bias was adopted.

We note that HH has commented on the applicability of, and methodology for, the adoption of optimism bias. We note HH's comments and also that The Green Book methodology is in part subjective and open to differing interpretation or assumption on each mitigating factor. We consider the adopted rates (mitigated: 20% and unmitigated: 38%) to be appropriate allowances at this stage of project development within the context of the analyses in which these cost estimates are to be used. It would be expected, however, that as the scheme is developed and reaches more advanced stages of design, the estimates for optimism bias are likely to decrease significantly and ultimately reach next to zero as construction begins and risks either materialise or are no longer relevant.

(c) Summary of Adjustments

In summary, the following adjustments for risk and optimism bias were made:

		Scheme
Risk		20
Optimism Bias	Mitigated	20
	Unmitigated	38

Table 2-1 Summary of Risk and Optimism Bias Adjustments to the Base Costs (%)

2.3 Phasing

The Scheme cost estimate was determined in total and by build phase. Reference should be made to the Jacobs’s Heathrow Airport Extended Northern Runway Appraisal Module 14: Operational Efficiency Ground Infrastructure report for detail of the individual phases. For the purposes of informing the Cost and Commercial Viability assessments, the capital costs of each build phase were triggered by demand against the requirements of four principal demand scenarios and as shown in Figure 2-1:

- *Assessment of Need Carbon Capped*
- *Assessment of Need Carbon Traded*
- *Global Growth Carbon Traded*
- *Global Fragmentation Carbon Capped*

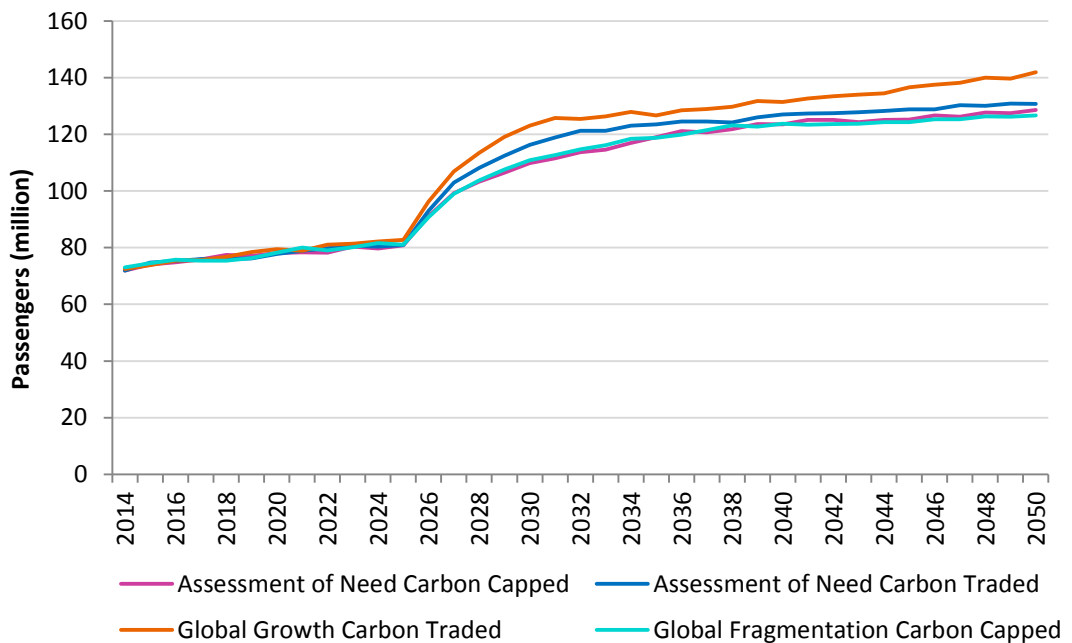


Figure 2-1 Airports Commission Demand Scenarios

Opening of the extended runway was driven by air transport movement (ATM) demand exceeding the current capacity irrespective of passenger demand. Although certain demand scenarios exceeded the current 480,000 ATM per annum cap of the existing runways before 2026, the earliest the extended runway was assumed to be opened was 2026, based upon the Airports Commission’s view of the likely timescale required for regulatory and planning processes.

Each phase was assumed to open at the end of the year before demand was forecast to exceed capacity. With reference to the Operational Efficiency Ground Infrastructure report, the following phase capacities were adopted.

Phase	Capacity (mppa)
Existing	80
With T6 Phase 1	85
With T6 Phase 2	100
With T2 Phase 2	110
With T2D	120
With T2 Phase 3	130

Table 2-2 Capacity Provision by Phase

In the years prior to opening of the phase, the estimated cost of the phase was incurred over a period of three to six years depending upon the value of expenditure, following a simplified, but typical sigmoidal curve (S-curve) profile.

3 Scheme Capital Expenditure

Following the approach set out in Section 2.2, the elements of the scheme were disaggregated based upon the data provided by HH within its submissions. This enabled a statement of quantity and rate by item. The quantities were confirmed against the scheme master plan and the rates compared to our expectation of a reasonable market rate taking into account the nature, site and location of the works. Risk and optimism bias adjustments were applied to the base case. Appendix C presents the resulting build-up of the Scheme works (including mitigated optimism bias) for all phases. The cost was estimated to be £13.5 billion with mitigated optimism bias applied and £15.6 billion with unmitigated optimism bias, compared to HH's estimate of £10.1 billion (excluding surface access costs and optimism bias).⁴

With reference to Section 2.3 and from a comparison of Figure 2-1 and Table 2-2, it can be observed that all demand scenarios require the completion of all phases of the scheme.

Section 3.1 summarises the forecast Scheme capital expenditure, by year, against each of the Airports Commission's demand scenarios. Given that all scenarios require the full build-out of all phases, the difference between the scenarios is the profile of expenditure required to deliver capacity in line with the differing demand requirements. In all scenarios the total expenditure is £13.5 billion and £15.6 billion with mitigated and full optimism bias respectively. Section 3.2 presents HH's Scheme capital expenditure forecast.

In summary, for each scenario, Scheme capital expenditure is as shown in Table 3-1 with mitigated and unmitigated optimism bias. For reference, H's estimate is also stated unadjusted for optimism bias.

Scenario	Optimism Bias	
	Mitigated	Unmitigated
Assessment of Need Carbon Capped	13,539	15,570
Assessment of Need Carbon Traded	13,539	15,570
Global Growth Carbon Traded	13,539	15,570
Global Fragmentation Carbon Capped	13,539	15,570
HH	10,121	

Table 3-1 Total Scheme Capital Expenditure by Demand Scenario (2014 prices, £'million)

⁴ Note: the Airports Commission scheme includes the works described in the corresponding Appraisal Module 14. Operational Efficiency Ground Infrastructure report, which, with reference to Appendix B of that report, varies from the proposal set out by HH. For example, the Scheme includes the dual western extension of the parallel taxiway serving the additional runway, which is estimated to increase the Scheme capital cost by around £200 million, representing circa 1.5% of the cost with mitigated optimism bias.

3.1 Airports Commission Demand Scenarios

3.1.1 Assessment of Need Carbon Capped

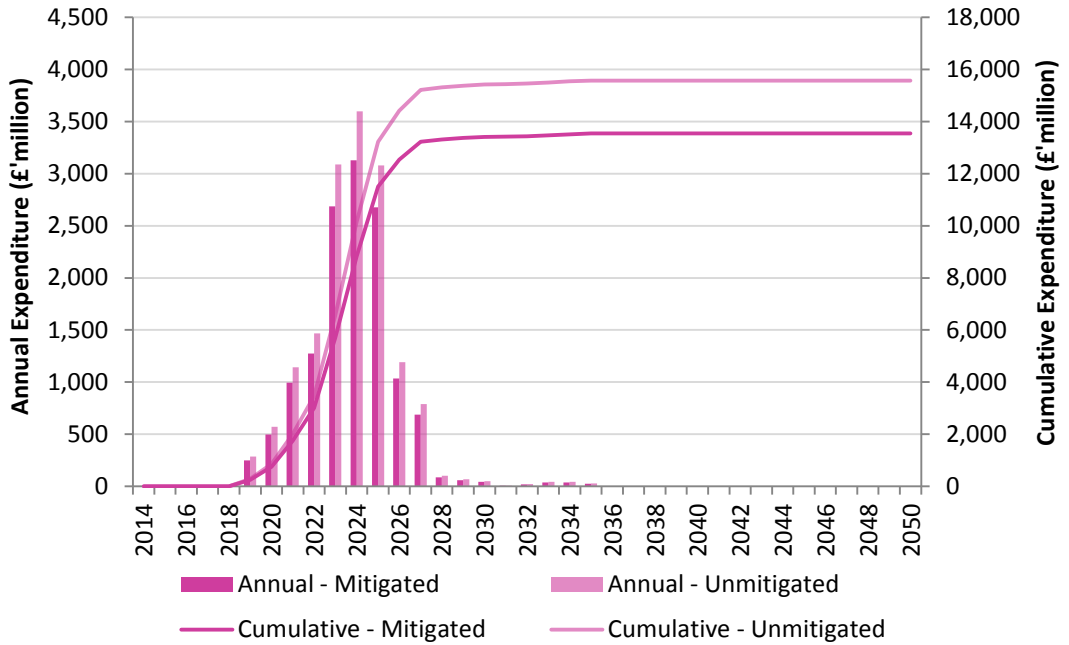


Figure 3-1 Assessment of Need Carbon Capped

3.1.2 Assessment of Need Carbon Traded

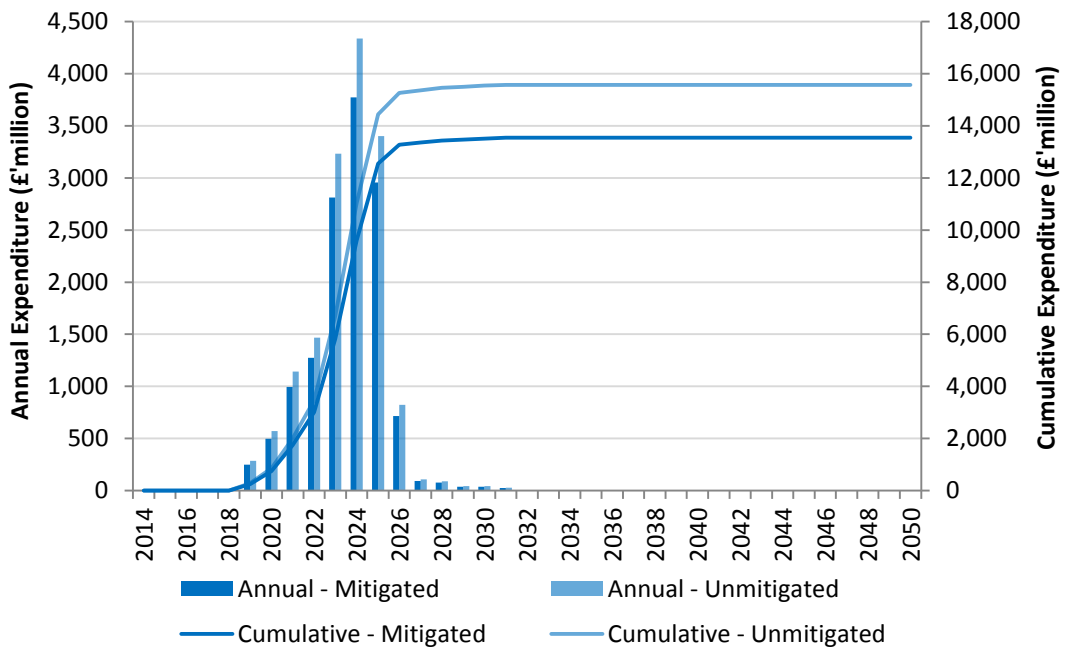


Figure 3-2 Assessment of Need Carbon Traded

3.1.3 Global Growth Carbon Traded

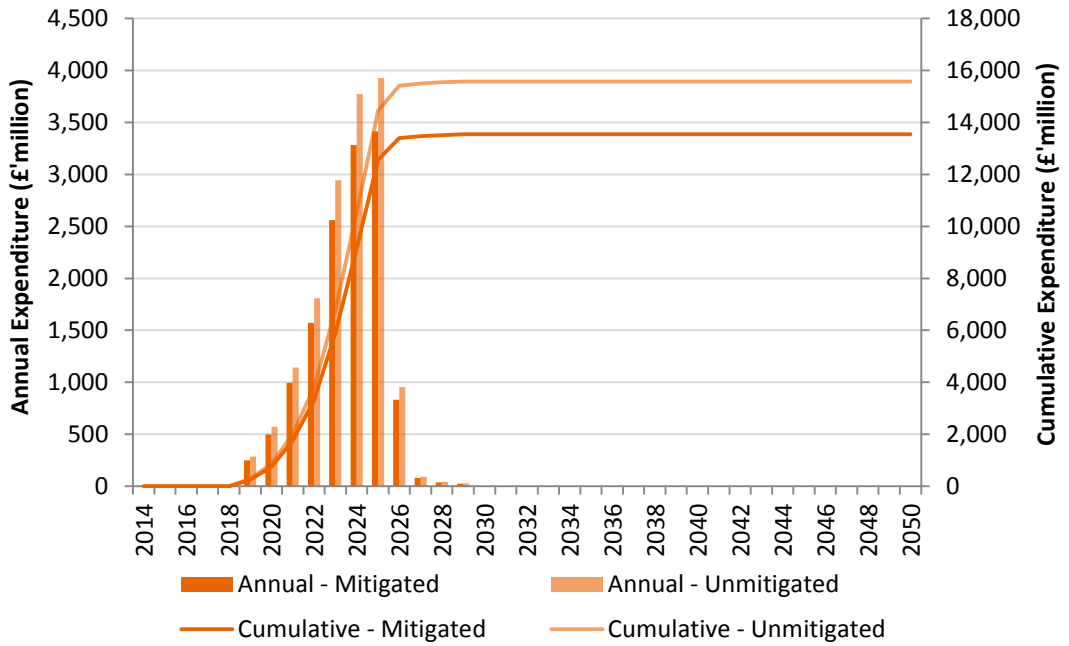


Figure 3-3 Global Growth Carbon Traded

3.1.4 Global Fragmentation Carbon Capped

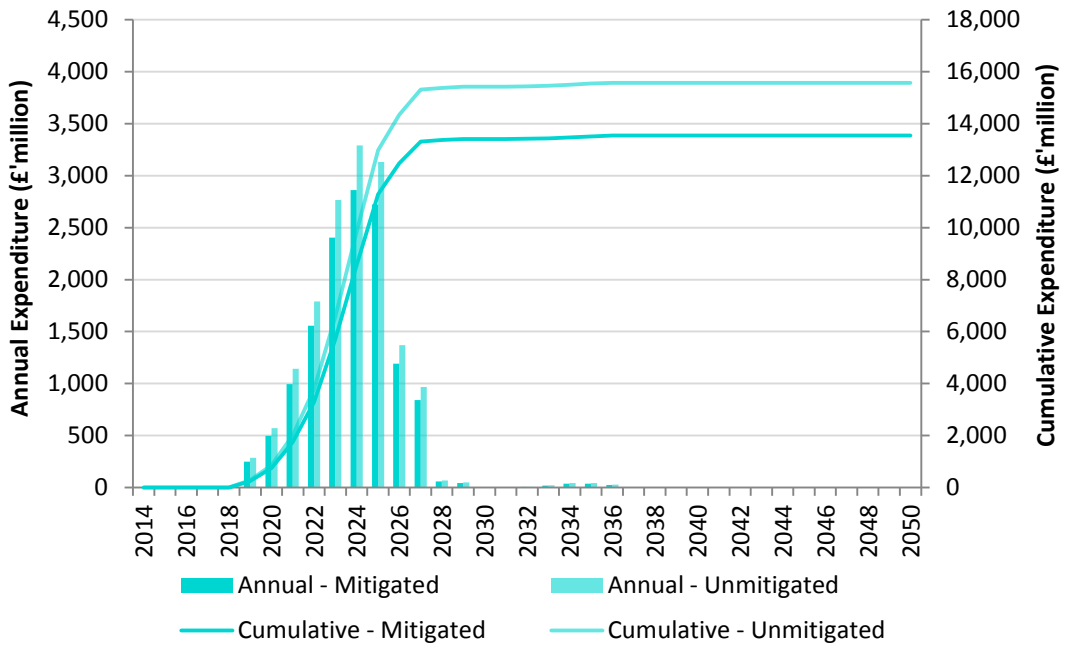


Figure 3-4 Global Fragmentation Carbon Capped

3.2 Heathrow Hub Scheme Capital Expenditure

HH estimates a total Scheme expenditure of £10.1 billion, with a profile of expenditure as presented in Figure 3-5. No adjustments have been made to this presentation which therefore is unadjusted for optimism bias and includes risk following the methodology adopted by HH.

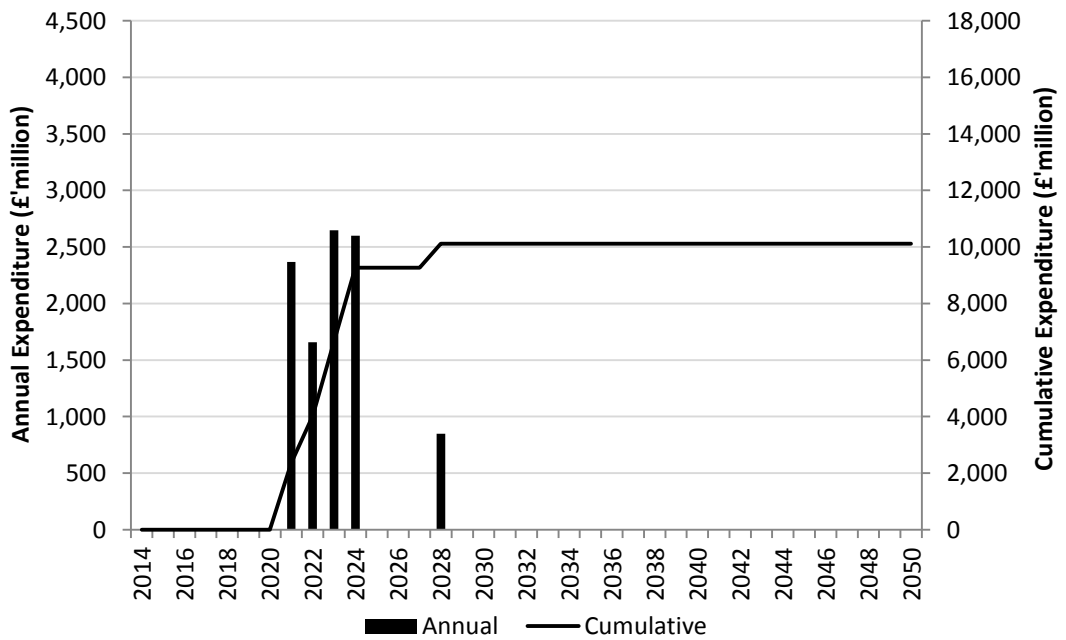


Figure 3-5 HH Scheme Capital Expenditure

3.3 Annual Scheme Capital Expenditure Summaries

The tables on the following pages present the data underlying the previous figures with mitigated optimism bias. These tables are based upon the detailed breakdown presented in Appendix C, but, for the purpose of enabling the assessment of depreciation, summarises the total expenditure into the following headings. General costs itemised separately with the breakdown presented in Appendix C (enabling works, project management on-cost, etc), are distributed across the below headings in the following tables in proportion to the underlying cost of each cost heading to the total cost.

- *Terminal buildings: passenger terminal buildings including piers and satellites*
- *Plant: building plant (e.g. air conditioning, etc) including utilities and power generation*
- *Transit systems: passenger transit systems above or below ground*
- *Runways: runway and associated instrument landing systems*
- *Taxiways and aprons: taxiways, aprons and their associated systems*
- *Equipment: mobile equipment and baggage handling installations*
- *Land: acquisition of land including commercial businesses and residential properties*
- *Airfield ancillary: other infrastructure elements for example control tower, rescue and fire fighting facilities, fencing, airside roads, etc*
- *Car parks: all car parks whether multi-storey or surface*
- *Third party land users: provision of serviced plots for third party development*
- *Environment: river diversions and environmental compensation and mitigation*
- *Community: community impact compensation*

2014, real prices in £'million - Mitigated optimism bias

Scheme	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	
<i>Terminal buildings</i>	3,515	-	-	-	-	-	-	-	-	269	673	984	972	370	247	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Plant</i>	391	-	-	-	-	-	-	-	-	30	75	109	108	41	27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Transit systems</i>	300	-	-	-	-	-	-	-	-	23	56	83	82	33	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Runways</i>	279	-	-	-	-	-	14	28	56	56	56	42	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Taxiways and aprons</i>	804	-	-	-	-	-	32	64	127	136	150	131	106	35	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Equipment</i>	1,001	-	-	-	-	-	-	-	-	47	117	190	247	240	160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Land</i>	1,281	-	-	-	-	-	64	128	256	256	256	192	128	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Airfield Ancillary</i>	622	-	-	-	-	-	31	62	124	124	124	93	62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Car Parks</i>	580	-	-	-	-	-	-	-	-	15	36	68	93	107	105	40	30	-	-	4	13	26	26	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Third Party Land Users</i>	77	-	-	-	-	-	4	8	15	15	15	12	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Environment</i>	246	-	-	-	-	-	12	25	49	49	49	37	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Community</i>	306	-	-	-	-	-	15	31	61	61	61	46	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Risk</i>	1,880	-	-	-	-	-	34	69	138	216	334	397	378	165	117	8	6	-	-	1	3	5	5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Optimism Bias</i>	2,257	-	-	-	-	-	41	83	166	260	401	477	454	198	140	10	7	-	-	1	3	6	6	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	13,539	-	-	-	-	-	248	497	993	1,558	2,404	2,861	2,722	1,190	841	58	43	-	-	6	19	37	37	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Table 3-5 Global Fragmentation Carbon Capped

Appendix A Glossary

ATM	Air transport movement
CAA	UK Civil Aviation Authority
CAGR	Compound annual growth rate
COPI	Construction price output index
Core	Investment in the airport irrespective of investment in the additional runway works
CPI	Consumer prices index
CUTE	Common user terminal equipment
DfT	Department for Transport
EAC	Electrification access charge
EASA	European Aviation Safety Agency
EC4T	Electric current for traction
HAL	Heathrow Airport Limited
HH	Heathrow Hub
IMF	International Monetary Fund
IPP	Income per passenger
mppa	million passengers per annum
RPI	Retail prices index
Q6	Quinquennium 6 (2014 to 2018)
Q7	Quinquennium 7 (2019 to 2023)
PRM	Passengers with reduced mobility
Scheme	Investment in the additional runway works
tph	Trains per hour
VTA	Variable track access
WebTAG	Web-based Transport Analysis Guidance

Appendix B Optimism Bias

Upper bound values for combined projects

Project Type	CAPEX (%)	Upper bound OB (%)	OB contribution (%)	Resultant OB (%)
Standard Building	30%	24	7.2	
Standard Civil Engineering	70%	44	30.8	
Combined				38.0

Contributory Factors		Standard Building optimism bias (%)	Mitigation Factor (0<x<1)	Reduction in optimism bias	Mitigated optimism bias (%)	Standard Civil Engineering optimism bias (%)	Mitigation Factor (0<x<1)	Reduction in optimism bias	Mitigated optimism bias (%)
Procurement	Late Contractor Involvement in Design	2	0.95	1.9	0.1	3	0.95	2.9	0.2
	Poor contractor Capabilities	9	0.95	8.6	0.5				
	Dispute and Claims Occurred	29	0.70	20.3	8.7	21	0.70	14.7	6.3
Project Specific	Design Complexity	1	0.90	0.9	0.1				
	Degree of Innovation	4	0.80	3.2	0.8				
	Environmental Impact					22	0.50	11.0	11.0
	Other					18	0.50	9.0	9.0
Client Specific	Inadequacy of the Business Case	34	0.80	27.2	6.8	10	0.80	8.0	2.0
	Project Management Team	1	0.90	0.9	0.1				
	Poor Project Intelligence	2	0.80	1.6	0.4	7	0.80	5.6	1.4
	Other - omitted (<1)								
Environment	Public Relations	2	0.50	1.0	1.0	9	0.50	4.5	4.5
	Site Characteristics	2	0.80	1.6	0.4	3	0.80	2.4	0.6
	Permits/Consents/Approvals								
External Influences	Economic	11	0.20	2.2	8.8	7	0.20	1.4	5.6
	Legislation/Regulations	3	0.70	2.1	0.9				
Weighted Total		100			28.6	100			40.6

Adjusted Capital Expenditure Optimism Bias

Project Type	Percentage of CAPEX (%)	Mitigated OB (%)	OB contribution (%)	Resultant OB (%)
Standard Building	30%	6.9	2.1	
Standard Civil Engineering	70%	17.8	12.5	
Combined				14.5

Figure B-1 Core Works

Upper bound values for combined projects

Project Type	CAPEX (%)	Upper bound OB (%)	OB contribution (%)	Resultant OB (%)
Standard Building	30%	24	7.2	
Standard Civil Engineering	70%	44	30.8	
Combined				38.0

Contributory Factors		Standard Building optimism bias (%)	Mitigation Factor (0<x<1)	Reduction in optimism bias	Mitigated optimism bias (%)	Standard Civil Engineering optimism bias (%)	Mitigation Factor (0<x<1)	Reduction in optimism bias	Mitigated optimism bias (%)
Procurement	Late Contractor Involvement in Design	2	0.95	1.9	0.1	3	0.95	2.9	0.2
	Poor contractor Capabilities	9	0.95	8.6	0.5				
	Dispute and Claims Occurred	29	0.70	20.3	8.7	21	0.70	14.7	6.3
Project Specific	Design Complexity	1	0.80	0.8	0.2				
	Degree of Innovation	4	0.90	3.6	0.4				
	Environmental Impact					22	0.30	6.6	15.4
	Other					18	0.10	1.8	16.2
Client Specific	Inadequacy of the Business Case	34	0.70	23.8	10.2	10	0.70	7.0	3.0
	Project Management Team	1	0.90	0.9	0.1				
	Poor Project Intelligence	2	0.70	1.4	0.6	7	0.60	4.2	2.8
	Other - omitted (<1)								
Environment	Public Relations	2	0.20	0.4	1.6	9	0.20	1.8	7.2
	Site Characteristics	2	0.50	1.0	1.0	3	0.50	1.5	1.5
	Permits/Consents/Approvals								
External Influences	Economic	11	0.20	2.2	8.8	7	0.20	1.4	5.6
	Legislation/Regulations	3	0.70	2.1	0.9				
Weighted Total		100			33.1	100			58.2

Adjusted Capital Expenditure Optimism Bias

Project Type	Percentage of CAPEX (%)	Mitigated OB (%)	OB contribution (%)	Resultant OB (%)
Standard Building	30%	7.9	2.4	
Standard Civil Engineering	70%	25.6	17.9	
Combined				20.3

Figure B-2 Scheme Works

Assuming that the works would be delivered through the HAL management team and processes, the following are non-exhaustive notes and actions/processes likely to be adopted by HH/HAL to enable the mitigated optimism bias:

- *HAL supply chain in place and contractors will be selected that are familiar with procurement procedures, existing facilities and with details of different phases of the scheme.*

- *Contractors to have a proven track record working at airports, excellent health and safety standards and an exceptional record following HAL procedures, reflected by good key performance indicator scores.*
- *Contractors are selected from existing frameworks and a list of preferred contractors that will have extensive knowledge of working on the airport.*
- *HAL has detailed processes to manage the different phases of a project and associated risks.*
- *New staff with relevant expertise expected to be recruited to accommodate project scope.*
- *Construction within live airfield and above an extensive tunnel network, however extensive records available.*
- *No innovative architectural, structural or civils designs proposed and there are no unusual site conditions expected that would call for an innovative solution.*
- *Significant investment made by HAL into environmental mitigation schemes.*
- *Experienced and proven PM team to be appointed.*
- *Extensive surveys are to be carried out in areas of proposed construction and extensive record information for the airport is available electronically to the designers and contractors.*
- *Dispensations from EASA may be required.*
- *The process of gaining international approval to operate the new runway scheme is likely to take time, and may be slow to realise.*

Appendix C Scheme Capital Cost Estimate Breakdown

The table on the following pages sets out the breakdown of the total Scheme cost, for all phases. The breakdown includes mitigated optimism bias.

Ref No	Description	Quantity	Unit	Unit Rate	Total (£)
HHL	Heathrow Hub (Jacobs Estimate)				13,539,360,462
01.	Investment Costs				9,402,333,654
01.01.	Airport Infrastructure Construction				7,044,415,320
01.01.01.	Enabling Works				1,064,784,817
01.01.01.0001.	Advanced Enabling Works, Clearing Site and Preparation				1,064,784,817
01.01.01.0001.0010	Site clearance	358.16	ha	156,327	55,990,201
01.01.01.0001.0020	Demolition / Enabling works	0.91		170,612,245	154,456,920
01.01.01.0001.0030	Remediation works	193	ha	454,974	87,714,495
01.01.01.0001.0050	Earthworks, cut, fill, grading of imported fill	21,903,520	m3	35.00	766,623,200
01.01.02.	Airfield				557,642,572
01.01.02.0001.	Runway				81,630,792
01.01.02.0001.0010	Runway including shoulders	221,600	m2	368	81,630,792
01.01.02.0002.	Taxiways & Aprons				210,766,948
01.01.02.0002.0030	Parallel Taxiway Links, Rapid Exit Taxiway (RETs), Taxiway Hold incl. fillets to support new runways.	185,576	m2	368	68,360,631
01.01.02.0002.0040	Taxiway shoulders	386,585	m2	368	142,406,316
01.01.02.0003.	Stands				220,724,112
01.01.02.0003.0050	Stands	460,831	m2	479	220,724,112
01.01.02.0004.	Airfield Instrumentation				44,520,720
01.01.02.0004.0120	Navigational Equipment / Lighting	1,463,054	m2	30	44,520,720
01.01.03.	Airfield Ancillary Facilities				203,787,733
01.01.03.0001.	Air Traffic Control				
01.01.03.0002.	Security				18,579,184
01.01.03.0002.0090	Fencing and CCTV to Terminal Area	7,700	m	600	4,620,000
01.01.03.0002.0100	Police Facilities	0	item	15,300,000	0
01.01.03.0002.0110	Control posts	1	item	13,959,184	13,959,184
01.01.03.0003.	Rescue and Fire Fighting				3,060,000
01.01.03.0003.0030	Fire Station	1	Nr	3,060,000	3,060,000
01.01.03.0004.	Fuel Systems				49,219,049
01.01.03.0004.0060	Fuel Farm	7	Nr	7,031,293	49,219,049
01.01.03.0004.0070	Diversion of existing fuel line	0	m	2,040	0
01.01.03.0005.	De-icing & Snow Clearance				20,000,000
01.01.03.0005.0050	De-icing pads	1	item	20,000,000	20,000,000
01.01.03.0006.	Serviced areas for ancillary facilities e.g. Hotels, Offices, Cargo Buildings, Hangars, etc				34,969,500
01.01.03.0006.0010	Serviced areas for ancillary facilities e.g. Hotels, Offices, Cargo Buildings, Hangars, etc	349,695	m2	100	34,969,500
01.01.03.0007.	Surface Water Drainage				29,160,000
01.01.03.0007.0030	Balancing Ponds incl. equipment, pumping, controls * instrumentation, oil interceptors, pipework, etc	97	ha	300,000	29,160,000
01.01.03.0008.	Noise Control Measures				48,800,000
01.01.03.0008.0080	Noise walls	4,800	m	6,000	28,800,000
01.01.03.0008.0090	Boundary Treatment - Environmental bund	4,000	m	5,000	20,000,000
01.01.04.	Terminal Buildings				3,350,360,417
01.01.04.0001.	Terminals				1,559,368,141
01.01.04.0001.0010	T6 Terminal building, Substructure	67,605	m2	3,573	241,529,003
01.01.04.0001.0020	T6 Terminal building, Superstructure	67,605	m2	6,732	455,130,381
01.01.04.0001.0030	T6 Terminal building, Fit Out	67,605	m2	12,761	862,708,757
01.01.04.0002.	Piers & Satellites				1,600,083,184
01.01.04.0002.0010	Satellite Substructure	53,081	m2	2,684	142,477,897
01.01.04.0002.0020	Satellite Superstructure	53,081	m2	8,129	431,490,141
01.01.04.0002.0030	Satellite Fit Out	53,081	m2	5,612	297,910,212
01.01.04.0002.0040	T2E Satellite	21,780	m2	33,435	728,204,935
01.01.04.0003.	Fixed Links, VCC, Rotunda/Nodes, PCA and Airbridges				190,909,091
01.01.04.0003.0030	VCC, Airbridge, PCA, nodes and fixed links to new stands	60	Nr	3,181,818	190,909,091

Ref No	Description	Quantity	Unit	Unit Rate	Total (£)
01.01.05.	Airside Infrastructure				495,186,720
01.01.05.0001.	Access Roads				112,697,250
01.01.05.0001.0010	Service / Circulatory roads within airport	5,000	m	4,080	20,400,000
01.01.05.0001.0070	Airside roads, perimeter track (actually access road)	103,250	m2	153	15,797,250
01.01.05.0001.0080	Airside Road - C&C Tunnel	1,000	m	76,500	76,500,000
01.01.05.0002.	Baggage Tunnels				125,409,972
01.01.05.0002.0040	Baggage Tunnels Civils	1,200	m	30,864	37,036,968
01.01.05.0002.0050	Baggage Tunnels Fit Out	1,200	m	73,644	88,373,004
01.01.05.0003.	TTS Tunnels				100,095,552
01.01.05.0003.0010	TTS - Tunnel Civils	1,200	m	57,856	69,426,624
01.01.05.0003.0020	TTS - System and Fit-out	1,200	m	22,157	26,588,928
01.01.05.0003.0070	Additional TTS Cars	2	Nr	2,040,000	4,080,000
01.01.05.0004.	TTS Station / Depot			317,700,681	156,983,946
01.01.05.0004.0030	TTS Station	1	Nr	74,190,476	74,190,476
01.01.05.0004.0060	TTS Station Fit Out	0.34	sum	107,795,918	36,650,612
01.01.05.0004.0070	TTS Maintenance Base Substructure	0.34	sum	103,142,857	35,068,571
01.01.05.0004.0080	TTS Maintenance Base Fit Out	0.34	sum	32,571,429	11,074,286
01.01.05.0005.	Facilities				0
01.01.05.0005.0070	Coaching Facility - Terminal		item	3,876,000	0
01.01.06.	Landside Infrastructure				500,204,082
01.01.06.0002.	Car Parks				500,204,082
01.01.06.0002.0020	Car Park - Surface & Multi Storey Parking	1	sum	500,204,082	500,204,082
01.01.07.	Equipment				729,755,102
01.01.07.0001.	De-Icing & Snow Clearance Equipment				
01.01.07.0002.	Rescue & Fire Fighting				
01.01.07.0003.	Baggage Handling Systems				729,755,102
01.01.07.0003.0010	Baggage Equipment Terminal	1	sum	299,346,939	299,346,939
01.01.07.0003.0050	Baggage Equipment Satellite	1	sum	430,408,163	430,408,163
01.01.08.	Operational Commissioning				139,591,837
01.01.08.0001.	Operational Commissioning				139,591,837
01.01.08.0001.0010	Operational Commissioning	0.80	sum	155,102,041	124,081,633
01.01.08.0001.0020	Operational Readiness	0.80	sum	19,387,755	15,510,204
01.01.09.	Operational Handover				3,102,041
01.01.09.0001.	Operational Handover				3,102,041
01.01.09.0001.0010	Operational Handover	0.80	sum	3,877,551	3,102,041
01.02.	Purchase of Land & Existing Infrastructure				579,326,988
01.02.01.	Purchase of Land & Existing Infrastructure				579,326,988
01.02.01.0001.	Purchase of Land & Existing Infrastructure				579,326,988
01.02.01.0001.0030	Land Purchase		sum	579,326,988	579,326,988
01.03.	Surface Transport Infrastructure & Services				
01.04.	Environmental Compensation & Mitigation				246,200,000
01.04.01.	Airport Infrastructure Construction				185,000,000
01.04.01.0001.	Airport - Ecology / Environmental / Archaeological				159,500,000
01.04.01.0001.0010	Ecology - allowance for mitigation and monitoring of ecological impact	1	sum	51,000,000	51,000,000
01.04.01.0001.0050	Noise mitigation measures to nearby houses	4,000	Nr	8,000	32,000,000
01.04.01.0001.0060	Flood water mitigation	1	sum	76,500,000	76,500,000
01.04.01.0002.	M25 Diversion / Other Road Works - Ecology / Environmental / Archaeological				25,500,000
01.04.01.0002.0010	Ecology - Allowance for mitigation and monitoring of ecological impact	1	item	25,500,000	25,500,000
01.04.02.	Associated Road Works				25,500,000
01.04.02.0001.	Airport - Ecology / Environmental / Archaeological				25,500,000
01.04.02.0001.0010	Ecology - allowance for mitigation and monitoring of ecological impact	1	sum	25,500,000	25,500,000
01.04.03.	Southern Rail Access - T5 to Staines				14,280,000
01.04.03.0001.	Airport - Ecology / Environmental / Archaeological				14,280,000
01.04.03.0001.0010	Ecology - allowance for mitigation and monitoring of ecological impact	1	sum	14,280,000	14,280,000
01.04.04.	Southern Rail Access - M25 Junction 13 to Ruxbury Road Junction				21,420,000
01.04.04.0001.	Airport - Ecology / Environmental / Archaeological				21,420,000
01.04.04.0001.0010	Ecology - allowance for mitigation and monitoring of ecological impact	1	sum	21,420,000	21,420,000

Ref No	Description	Quantity	Unit	Unit Rate	Total (£)
01.05.	Community Impacts				306,000,000
01.05.01.	Community Impacts				306,000,000
01.05.01.0001.	Community Impacts				306,000,000
01.05.01.0001.0010	Residential - noise	1	sum	255,000,000	255,000,000
01.05.01.0001.0020	Community Infrastructure Levy	1	sum	51,000,000	51,000,000
01.06.	Project / Design Team Fees				1,226,391,346
01.06.01.	Project / Design Team Fees				1,226,391,346
01.06.01.0001.	Project / Design Team Fees			15%	1,226,391,346
01.06.01.0001.0010	Project / Design Team Fees on 01.01			%	1,056,662,298
01.06.01.0001.0020	Project / Design Team Fees on 01.02			%	86,899,048
01.06.01.0001.0030	Project / Design Team Fees on 01.03			%	0
01.06.01.0001.0040	Project / Design Team Fees on 01.04			%	36,930,000
01.06.01.0001.0050	Project / Design Team Fees on 01.05			%	45,900,000
02.	Operating Costs				
02.01.	Operating Costs				
02.01.01.	Operating Costs				
02.01.01.0001.	Operating Costs				
03.	Risks & Optimism Bias				4,137,026,808
03.01.	Risks (Design, Construction & Employer Risk)				1,880,466,731
03.01.01.	Risks (Design, Construction & Employer Risk)				1,880,466,731
03.01.01.0001.	Risks (Design, Construction & Employer Risk)			20%	1,880,466,731
03.01.01.0001.0010	Risk Contingency on 01.01			%	1,408,883,064
03.01.01.0001.0020	Risk Contingency on 01.02			%	115,865,398
03.01.01.0001.0030	Risk Contingency on 01.03			%	0
03.01.01.0001.0040	Risk Contingency on 01.04			%	49,240,000
03.01.01.0001.0050	Risk Contingency on 01.05			%	61,200,000
03.01.01.0001.0060	Risk Contingency on 01.06			%	245,278,269
03.02.	Optimism Bias				2,256,560,077
03.02.01.	Optimism Bias				2,256,560,077
03.02.01.0001.	Optimism Bias			20%	2,256,560,077
03.02.01.0001.0010	Optimism Bias on 01.01			%	1,408,883,064
03.02.01.0001.0020	Optimism Bias on 01.02			%	115,865,398
03.02.01.0001.0030	Optimism Bias on 01.03			%	0
03.02.01.0001.0040	Optimism Bias on 01.04			%	49,240,000
03.02.01.0001.0050	Optimism Bias on 01.05			%	61,200,000
03.02.01.0001.0060	Optimism Bias on 01.06			%	245,278,269
03.02.01.0001.0070	Optimism Bias on 03.01			%	376,093,346

Appendix D Approach to Core and Asset Replacement Capital Expenditure

The approach to the Core works and Asset Replacement estimates was based upon the estimates provided by HH and HAL. This approach recognised that HAL has greater knowledge relating to the condition of the current assets and the detail of its plans in the absence of the extended runway Scheme works. However, recognising the Green Book guidance to correct for the systematic tendency for project appraisers to be overly optimistic, HAL and HH's estimates post Q6 were adjusted for optimism bias.

Following the approach to optimism bias set out in Section 2.2.1, the Core works were assessed to be undertaken in a more known environment comprising established procurement methodologies and supply chains, and within the footprint of the current site, therefore, with reference to Appendix B, it was considered that optimism bias could be reasonably mitigated to a greater extent than that applied to the Scheme works, and a consistent 15% allowance was determined. As per Section 2.2.1, we note HH's comments, but consider 15% to be an appropriate allowance at this stage of project development within the context of the analyses in which these cost estimates are to be used.

In summary, therefore, adjustments were made as follows:

		Core		Asset Replacement
		Part Q6	Post Q6	(Post Q6)
Risk		0	0	20
Optimism Bias	Mitigated	0	15	20
	Unmitigated	0	15	38

Table D-1 Summary of Risk and Optimism Bias Adjustments to the Base Costs (%)

D.1 Core Works

The approach to the Core works for the Heathrow Airport Extended Northern Runway scheme adopted the same input drivers as developed from HAL's submissions.

HAL provided estimates of its Core works, primarily commencing in financial year 2019. Therefore, in order for the capital cost estimate to commence in 2014, the whole of the Q6⁵ capital expenditure requirement were adopted. HAL's cost estimate was adopted as presented without adjustment for risk, as this was assumed to be already included, but it was adjusted to include optimism bias at the reduced Core rate of 15% as discussed above. In the absence of confirmation to the contrary, HAL's values were assumed to be in 2014 values⁶.

⁵ Q6 is the current five year regulatory period adopted by the Civil Aviation Authority (CAA). The Q6 settlement or 'notice granting the licence' is a binding commitment between the airport and the CAA covering the period April 2014 to December 2018 inclusive.

⁶ Other financial values in HAL's submission were indicated as being based in other year's, however, capital expenditure was unstated and therefore assumed to be in current values.

D.1.1 Q6

The CAA set out in CAP 1151 the minimum capital expenditure required as a condition of HAL’s licence. These costs are presented in Table D-2 below:

£ million	9 mo. 2014	2015	2016	2017	2018	Total
Capex	439.1	669.0	645.6	528.8	533.9	2,816.4

Table D-2 Q6 Capital Expenditure (Source: CAP 1151, CAA)

The 2014 calendar year for HAL was inflated pro-rata for the 9 months of 2014. The costs within CAP1151 are presented in 2011/12 prices. These were inflated into 2014 prices using the Construction Output Price Index (COPI), which represented a 4.9% increase to the above values. The costs were adopted, unadjusted for risk and optimism bias as they had gone through the airport’s capital cost development, constructive engagement and the CAA’s regulatory processes.

As instructed by the Airports Commission, the HAL’s Q6 cost was modelled as asset replacement with the exception of an element of work identified by HAL during Q6 which was considered to be expansion.⁷

D.1.2 Core Works Cost Estimate

The key elements of Core work were identified as being:

- completion of the “toast rack” including satellites and corresponding ramp areas, with the exception of T2E which is included within the Core works;
- Phases 2 and 3 of T2;
- completion of the tracked transit and baggage systems to connect T5 to T2; and
- accommodating works to enable the above.

The total cost of the works was £13.1 billion including adjustment for optimism bias at 15%.

D.2 Asset Replacement

The allowance for asset replacement sought to cover expenditure relating to:

- routinely maintain the assets condition and capacity;
- periodic major investment to restore the assets deteriorated condition and capacity; and
- invest in improvements to condition and capacity of the existing infrastructure.

It is recognised that the asset replacement category of cost is difficult to estimate with accuracy. Most notably the final allowance, to improve the condition or capacity of the existing asset within the confines of the existing asset, is the most ill-defined as it seeks to ensure a number of unknown, but likely to be incurred, costs are adequately included. For example, it represents investment in existing infrastructure to increase efficiency, improve passenger experience, respond to changing regulatory requirements, or to support an enhanced business case (for example, a

⁷ HAL included a c £55 million investment in the Q6 period within its Core works estimate. This was included as Core works (as presented by HAL) and therefore the Q6 (and therefore asset replacement) expenditure within the relevant years was reduced to ensure the Q6 annual and total expenditure remained as the licence condition.

new CIP lounge for a new entrant airline), which by their nature are unknown across the planning horizon. Whilst such investments would be subject to their own business case at the time, it is not clear to what extent it can be assumed that traffic would continue to grow without investment in improved services within the extant infrastructure, or that non-aeronautical revenues would not deteriorate without such investment. Such improvements are often undertaken in conjunction with more clearly expansionary works, further clouding the uncertainty of this cost element, but noting that the Scheme works do not allow for any such contemporaneous investments it is necessary to ensure that the cost is separately identified. Even in the absence of purely expansionary works, it is reasonable to assume that HAL would seek to improve the condition and capacity of its existing infrastructure, either driven by regulation or to remain competitive within its national and international markets.

D.2.1 Approach

The asset replacement costs were assessed on a per passenger basis. This considered the total asset replacement estimate against the corresponding traffic forecast. The resulting average per passenger rate, adjusted for risk and optimism bias, was used in the differing Airports Commission’s demand scenarios.

D.2.2 Asset Replacement Cost Estimate

Based upon information from the current asset owner and with reference to material submitted by the promoter, it was established that investment of £9,440 million from 2019 to 2050 (i.e. for the period beyond Q6) had been forecast. With reference to the above methodology, this investment can be interpreted into a per passenger rate as follows:

Total investment (£’million)	9,440
Total passengers (millions, 2019-2050)	3,541
Average investment per passenger (£)	2.67
Plus 20% risk allowance (£)	3.20
With mitigated optimism bias (20%)	3.84
With unmitigated optimism bias (38%)	4.42

Table D-3 Determination of HH Asset Replacement Cost per Passenger

This asset replacement rate per passenger was assessed in the context of market expectation and considered to lie towards the lower end of, but within an expected range. As such, as discussed above, the resulting expenditure may provide an adequate budget to cover the first two identified elements of asset replacement (routine and major intervention maintenance expenditure), but may constrain the potential for investment in the third element (investment in improvements to the condition and capacity of the infrastructure that would exist at that time, for example, response to changing regulatory requirements or new business opportunities requiring investment within the existing infrastructure as discussed above). Nonetheless, the rate was considered to be reasonable for the purposes of this assessment.

In addition to the adoption of the above per passenger rates from 2019 onwards, the Q6 capital expenditure requirement was included as asset replacement as directed by the Airports Commission. Consequently, across the assessed demand scenarios, driven by the differing passenger flows, total asset replacement over the

forecast period varied from £16.5 to £17.5 billion with mitigated optimism bias and from £18.6 to £19.7 billion with unmitigated optimism bias.

Appendix E Core and Asset Replacement Capital Expenditure Summary

The tables on the following pages summarise the annual capital expenditure relating to the Core and asset replacement works under each of the demand scenarios set out in Figure 2-1. The summaries are presented with mitigated optimism bias applied.

2014, real prices in £'million - Mitigated optimism bias

Core Works	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	
Terminal buildings	6,858	-	-	-	-	-	-	-	24	51	100	398	636	723	818	716	325	104	77	462	795	815	590	220	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Transit systems	943	-	-	-	-	-	-	-	-	-	54	113	146	178	185	147	70	44	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Runways	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Taxiways and aprons	1,295	-	-	9	20	25	-	31	105	123	135	129	105	62	-	-	232	258	-	26	22	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Equipment	620	-	-	-	-	-	-	-	3	6	9	11	12	26	133	148	39	25	21	35	44	46	38	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Land	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Airfield Ancillary	1,406	-	-	-	-	-	-	-	91	223	311	331	283	167	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Car Parks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Third Party Land Users	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Environment	250	-	-	-	-	-	-	-	16	33	44	49	47	38	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Community	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Risk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Optimism Bias	1,697	-	-	-	-	-	-	5	36	66	98	155	184	179	174	152	100	65	16	78	129	131	94	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Core Works Total	13,069	-	-	9	20	25	-	36	275	503	751	1,185	1,413	1,374	1,332	1,163	766	497	120	601	991	1,005	722	279	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Asset Replacement	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Asset Replacement	12,415	614	702	668	535	535	206	208	209	209	214	213	216	243	276	284	293	297	303	306	312	317	323	322	325	330	329	333	334	331	334	334	338	337	340	340	343	
Risk	1,872	-	-	-	-	-	41	42	42	42	43	43	43	49	53	55	57	59	59	61	61	62	63	65	64	65	66	66	67	67	66	67	68	67	68	68	69	
Optimism Bias	2,247	-	-	-	-	-	49	50	50	50	51	51	52	58	64	66	68	70	71	73	73	75	76	78	77	78	79	79	80	80	80	80	80	81	81	82	82	82
Asset Replacement Total	16,535	614	702	668	535	535	296	300	301	301	308	306	310	350	381	397	409	422	428	436	440	449	457	465	463	468	475	474	480	480	477	480	481	486	485	490	490	494

Table E-1 Assessment of Need Carbon Capped

2014, real prices in £'million - Mitigated optimism bias

Core Works	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Terminal buildings	6,858	-	-	-	-	-	-	24	60	82	355	699	986	1,034	702	496	795	815	590	220	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transit systems	943	-	-	-	-	-	-	-	4	58	116	174	207	195	139	44	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Runways	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Taxiways and aprons	1,295	-	-	9	20	25	-	31	105	123	135	129	105	62	232	285	22	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equipment	620	-	-	-	-	-	-	3	6	9	11	25	40	138	161	62	52	51	38	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Land	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Airfield Ancillary	1,406	-	-	-	-	-	-	91	191	277	318	291	196	42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Car Parks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Third Party Land Users	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Environment	250	-	-	-	-	-	-	-	16	33	44	49	47	38	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Community	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Risk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Optimism Bias	1,697	-	-	-	-	-	-	22	57	87	147	205	237	226	189	133	131	132	94	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Core Works Total	13,069	-	-	9	20	25	-	172	439	670	1,126	1,572	1,816	1,735	1,445	1,020	1,007	1,011	722	279	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Asset Replacement	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Asset Replacement	12,687	614	702	668	535	535	203	207	210	213	215	214	216	248	275	288	300	310	317	323	323	328	330	332	332	331	336	339	340	340	341	342	344	343	347	347	349	349
Risk	1,927	-	-	-	-	-	41	41	42	43	43	43	43	50	55	58	60	62	63	65	65	66	66	66	66	66	67	68	68	68	68	68	69	69	69	69	70	70
Optimism Bias	2,312	-	-	-	-	-	49	50	51	51	52	51	52	59	66	69	72	74	76	78	78	79	79	80	80	79	81	81	81	82	82	82	82	82	83	83	84	84
Asset Replacement Total	16,926	614	702	668	535	535	293	299	303	307	310	309	311	357	395	415	432	446	456	466	466	473	475	478	477	484	488	489	490	491	492	495	495	500	500	502	502	

Table E-2 Assessment of Need Carbon Traded

2014, real prices in £'million - Mitigated optimism bias

Core Works	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050		
Terminal buildings	6,858	-	-	-	-	-	8	41	75	107	416	931	1,148	1,319	1,187	815	590	220	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transit systems	943	-	-	-	-	-	-	4	8	61	145	203	217	187	113	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Runways	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Taxiways and aprons	1,295	-	-	9	20	25	31	105	123	135	129	105	62	258	280	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equipment	620	-	-	-	-	-	3	6	9	11	25	40	62	169	176	54	43	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Land	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Airfield Ancillary	1,406	-	-	-	-	-	-	91	191	277	318	291	196	42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Car Parks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Third Party Land Users	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Environment	250	-	-	-	-	-	-	-	16	33	44	49	47	38	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Community	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Risk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Optimism Bias	1,697	-	-	-	-	-	6	37	63	94	161	243	260	302	267	133	95	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Core Works Total	13,069	-	-	9	20	25	49	284	485	718	1,238	1,861	1,992	2,314	2,046	1,021	728	279	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Asset Replacement	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Asset Replacement	13,117	614	702	668	535	535	209	212	210	216	217	219	221	257	285	303	318	328	335	334	337	341	338	342	344	346	351	350	354	356	357	359	364	367	369	373	373	378
Risk	2,013	-	-	-	-	-	42	42	42	43	43	44	44	51	57	61	64	66	67	67	67	68	68	68	69	69	70	70	71	71	71	72	73	73	74	75	75	76
Optimism Bias	2,415	-	-	-	-	-	50	51	51	52	52	53	53	62	68	73	76	79	80	80	81	82	81	82	83	83	84	84	85	85	86	86	87	88	88	90	89	91
Asset Replacement Total	17,545	614	702	668	535	535	301	305	303	311	312	316	318	370	411	436	457	473	483	481	485	491	486	493	495	498	506	505	509	512	515	516	525	528	531	538	536	545

Table E-3 Global Growth Carbon Traded

2014, real prices in £'million - Mitigated optimism bias

Core Works	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050		
Terminal buildings	6,858	-	-	-	-	-	-	-	24	51	100	406	670	933	980	628	104	77	462	795	815	590	220	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Plant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Transit systems	943	-	-	-	-	-	-	-	-	4	58	116	174	207	195	139	44	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Runways	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Taxiways and aprons	1,295	-	-	9	20	25	-	31	105	123	135	129	105	62	-	232	258	-	26	22	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Equipment	620	-	-	-	-	-	-	3	6	9	11	12	26	40	137	143	25	21	35	44	46	38	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Land	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Airfield Ancillary	1,406	-	-	-	-	-	-	-	91	223	311	331	283	167	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Car Parks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Third Party Land Users	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Environment	250	-	-	-	-	-	-	-	16	33	44	49	47	38	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Community	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Risk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Optimism Bias	1,697	-	-	-	-	-	-	5	36	67	99	156	196	217	200	171	65	16	78	129	131	94	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Core Works Total	13,069	-	-	9	20	25	-	39	279	510	758	1,200	1,500	1,664	1,535	1,313	497	120	601	991	1,005	722	279	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Asset Replacement	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	
Asset Replacement	12,412	614	702	668	535	535	204	209	213	211	214	218	216	242	264	277	287	296	301	306	310	316	317	320	324	328	327	330	329	330	330	331	332	334	334	337	337	338	
Risk	1,872	-	-	-	-	-	41	42	43	42	43	44	43	48	53	55	57	59	60	61	62	63	63	64	65	66	65	66	66	66	66	66	66	66	67	67	67	67	68
Optimism Bias	2,246	-	-	-	-	-	49	50	51	51	51	52	52	58	63	66	69	71	72	73	74	76	76	77	78	79	79	79	79	79	79	80	80	80	80	81	81	81	
Asset Replacement Total	16,530	614	702	668	535	535	293	301	307	303	308	313	311	349	380	398	413	426	433	441	446	455	456	460	466	473	471	475	474	475	475	477	477	481	481	485	485	487	

Table E-4 Global Fragmentation Carbon Capped

Appendix F Operational Expenditure

F.1 Introduction

This appendix sets out the approach used to develop an independent forecast of operating costs for the period 2014 to 2050 for the Heathrow Airport Northern Runway Extension scheme.

This appendix contains the following sections:

- *Section F-2 describes the methodology adopted in developing operating cost forecasts for the period, including the modelling assumptions used for all schemes and the approach towards the treatment of risk and optimism bias.*
- *Section F-3 describes the inputs received from the scheme promoter and any specific assumptions used to develop the independent operating cost forecasts.*
- *Section F-4 sets out the operating cost modelling outputs in comparison to the costs submitted by the scheme promoter.*

F.2 Methodology

The approach took as its starting point the CAA's notice granting the licence to Heathrow Airport Limited (Heathrow: CAP 1151) for the Q6 period (2014-2019), adjusted to 2014 prices and revised to reflect differences in traffic forecasts.

Airport operating costs typically increase in relation to growth in airport activity, assessed using passenger numbers. In addition, because a certain proportion of airports' operating cost are fixed, relating to the infrastructure rather than directly to passenger numbers, the addition of new infrastructure brings with it a step-change in fixed costs. Efficient airports take steps to make as much of their operating cost base as possible variable rather than fixed, for example by designing staff rosters to match passenger demand as closely as possible and by switching off lighting in unoccupied areas of the terminal building. Operating cost forecasts for efficient airports therefore tend to adopt higher elasticities to airport activity (i.e., passenger numbers) rather than infrastructure size, since a greater proportion of the total cost is variable. Because airport operating costs can never be fully variable, a relationship with infrastructure size (i.e., terminal gross floor space and airfield area) is appropriate to take account of the step-change in fixed costs.

The independent forecasts developed for each scheme following the Q6 period (i.e. from 2019 to 2050) used a combination of drivers based on passenger growth and infrastructure expansion (see Section 2.3) to derive annual costs for each category, taking into account the opportunity to implement efficiencies in certain categories over time.

These forecasts were then treated according to The Green Book guidelines to take account of the risk that costs, individually or collectively, could prove higher than forecast, and to adjust for optimism bias, which takes account of unforeseen factors that could cause outturn costs to be higher than forecasted.

F.2.1 Elasticities

Elasticities, where supplied by scheme promoters, were reviewed against comparable benchmarks, and adjusted according to various aspects of each

airport’s operation (e.g. its complexity, existing cost base, current efficiency, level of fixed cost) to reflect the nature of each airport. The resulting elasticities, based on industry experience, were considered to be similar for each scheme.

Elasticities to passenger growth, terminal floor space and airfield area were applied, and adjustments for efficiency improvements were also provided for.

The following table presents the elasticities used from 2019 onwards for all schemes.

Elasticities	Staff	Routine Maintenance	Utilities	Rent & Rates	Rail	Other
Passenger increase	40%	40%	5%	0%	40%	40%
Gross floor area increase	40%	40%	70%	80%	0%	30%
Airfield increase	5%	5%	5%	20%	0%	5%

Table F-1 Elasticities Used for all Schemes

The model assumed that cost increases for Routine Maintenance should be deferred for two years after terminal or airfield expansion to take account of warranty periods and the likelihood that less routine maintenance will be required on these assets in the first two years.

F.2.2 Efficiencies

Like other businesses, airports continually seek to improve the efficiency of their operations. Efficiency is embedded within the elasticity based approach described above. Over and above this, further efficiencies were assumed across all cost categories, with the exception of Rent & Rates against which the airport has little or no capacity to achieve efficiencies.

Efficiencies of 1% per annum were assumed from 2019, after the Q6 period. These efficiencies were phased out over time reflecting a number of airport-specific factors, including the overall level of efficiency of the airport assumed at the end of Q6 and the scope for further efficiencies thereafter, and the impact that opening substantial new infrastructure would have in terms of transforming the operation of the airport.

F.2.3 Treatment of Risk and Optimism Bias

The Green Book guidance on appraisal and evaluation in Central Government has been adopted for the purposes of determining appropriate adjustments for risk and optimism bias. The guidance recommends making such adjustments on the basis that there is a demonstrated, systematic tendency for project appraisers to be overly optimistic.

Allocations have been made within the Airports Commission’s independent cost estimates for each scheme, seeking to address two unknown factors:

- *Risk: the unknown detail of the identified airport operation which would be expected to lead to an under-estimate of the operating costs although the scope may be reasonably defined. For example, wage rates increasing above inflation; and*

- *Optimism Bias: the unknown scope of all necessary operating activities which could extend significantly to deliver the fully operational scheme. For example, the design of the new terminal requiring a greater number of operational staff than foreseen.*

The allocation for optimism bias is calculated on the risk-adjusted price.

F.2.3.1 Risk

In order to address the risk that operating costs escalate at a greater rate than forecast, a compound real growth increase of 0.5% per annum was applied from 2019 onwards (i.e. after Q6). Risk is already taken into consideration within the Q6 regulatory settlement.

The risk value is applied as a 0.5% real increase in the cost base, calculated using an index with base year 2018 (the final year of the Q6 period). Therefore 2019 is the first year in which risk-adjusted costs are 0.5% higher than the base case forecast. At the end of the forecasting period (2050), this adjustment is equivalent to $(1.005)^{32}$, a 17.3% increase, and is applicable to the operating costs associated with the whole airport (i.e., both the core airport and the scheme).

	2018	2019	2020	2021	2022	2023	2024	2025	2030	2040	2050
Risk Index (0.5% per annum)	1.000	1.005	1.010	1.015	1.020	1.025	1.030	1.036	1.062	1.116	1.173

Table F-2 Risk Index

This approach to applying risk takes account of the greater certainty of cost estimates at the beginning of the forecasting period in comparison to a much greater level of uncertainty in 2050.

F.2.3.2 Optimism Bias

HM Treasury’s Supplementary Green Book Guidance recommends an upper bound of 41% on ‘Outsourcing projects’, which, in the absence of other data, has been applied to appraisal of operating costs.

Applicable mitigation factors were assessed to determine where a reduction in the adjustment could be justifiable. These included the experience and capabilities of the project management team, the early involvement of the operator in the design phase, the level of innovation and complexity of the proposed operation, and external influences including economic and regulations/legislation.

HM Treasury’s Supplementary Green Book Guidance does not set out a calculation method to establish the appropriate level of optimism bias to be applied to operational expenditure. Noting that the setting of an appropriate rate requires judgement across a range of factors, most of which are difficult to establish with accuracy from an external assessment of the organisation responsible for operational delivery, and noting that those assessments would be subjective in nature rather than demonstrably objective, the approach to optimism bias was to establish a reasonable allowance that was applied consistently to all schemes.

Table F-3, below, sets out the calculation used to derive an appropriate level of mitigated optimism bias used consistently for all schemes.

Operating Expenditure Contributory Factors	The Green Book Descriptions	Outsourcing Optimism Bias (%)	Mitigation Factor (0<X<1)	Reduction in Optimism Bias
Procurement	Late Contractor Involvement in Design	5	0.8	4
	Poor contractor capabilities	15	0.8	12
Project Specific	Design Complexity	5	0.5	2.5
	Degree of Innovation	5	0.5	2.5
Client Specific	Project Management Team	20	0.7	14
	Poor Project Intelligence	10	0.5	5
Environment	Site Characteristics	5	0.4	2
External Influences	Economic	20	0.25	5
	Legislation/Regulations	15	0.25	3.75
Weighted Total		100		50.75
Adjusted Optimism Bias	= 50.75 * Upper Bound (41%)			20%

Table F-3 Optimism Bias Mitigations

The purpose of optimism bias is to address the unknown scope of all necessary costs required to deliver a fully operational scheme and acceptable service standards. Given that the scope of costs is much better understood for the existing core airport operation, it was determined that optimism bias should apply only to the incremental operating expenditure associated with the additional runway and new facilities, and not to the core airport. This also follows the Department for Transport’s Web-based Transport Analysis Guidance (WebTAG) which recommends that for rail schemes, optimism bias should only be applied to the operating costs associated with the incremental scheme and not to any existing operation. Based on the mitigation calculation set out in Table F-3, a mitigated adjustment of 20% is proposed at this stage of the appraisal process.

Costs have also been modelled with the upper bound optimism bias of 41% applied.

F.2.4 Inflation

The Retail Prices Index (RPI) was adopted as a basis for modelling operating costs. The financial model inputs incorporate real increases or decreases in relation to RPI as appropriate. For instance, staff costs (which reflect a combination of staff numbers, wage rates and other employment costs) are modelled on the basis of RPI, with real efficiency improvements reflected in the forecasts over the long term as appropriate. Contract costs, such as with cleaning providers, suppliers and outsourced maintenance providers, are typically linked to RPI. RPI is more reflective of wage rate increases than the Consumer Prices Index (CPI) and is, therefore, considered appropriate for modelling staff costs. Materials and other non-staff costs are also assumed to increase with RPI.

F.3 Modelling Inputs

HH provided operating expenditure forecasts for the period 2017 to 2041, in 2011/12 prices. These were inflated to 2014 prices using a multiplier of 7.453% (Source: UK inflation, average consumer prices. IMF World Economic Outlook Database, April

2014). HH's forecasts for 2017 and 2018 were based on Q6, with an adjustment made for a higher passenger forecast compared with the CAA's Q6 forecast.

The CAA's Q6 settlement for Heathrow, inflated to 2014 prices, was used to populate HH's forecast for years 2014-2018. HH supplied only total annual operating costs for the period 2018-2041. A cost breakdown for HH's costs was developed based upon Q6 and historic data. The elasticity to passenger growth (0.3x) and efficiency (0.5%/year) drivers proposed by HH were adopted to populate a forecast from 2042 to 2050.

F.3.1 Elasticities

HH proposed an overall elasticity of 0.3x passenger growth and a 10% stepped increase in costs in 2023, assumed to reflect the operation of new infrastructure.

F.3.2 Efficiencies

Our forecasting approach assumes efficiencies of 1% per annum were assumed across all cost categories (with the exception of Rent & Rates). For this scheme, the efficiency factor was reduced to 0.5% per annum after 2030.

HH forecasts assume an efficiency factor of 0.5% throughout the forecasting period. Table F-4 below illustrates the efficiency factors that have been applied for each category, for each scheme. Sample years 2025 and 2035 have been shown to illustrate how efficiencies have been phased out. Efficiencies are shown as negative values in the table below since they reduce operating expenditure.

Year	Staff	Routine Maintenance	Utilities	Rent & Rates	Rail	Other
2019-34	-1.0%	-1.0%	-1.0%	0%	-1.0%	-1.0%
2035-50	-0.5%	-0.5%	-0.5%	0%	-0.5%	-0.5%

Table F-4 Real Efficiency Factors by Category

F.4 Independent Operational Expenditure Forecast

This section presents graphical outputs of the independent operating cost model, compared with the costs presented by, or inferred from, the scheme promoter's submission.

Figure F-1 below shows HH's forecast total operating costs against our independent forecasts for each of the demand scenarios. The independent forecasts include Risk applied to total costs and optimism bias at the mitigated level of 20% applied to scheme operating costs.

The stepped increases in cost in our forecasts are in line with increases in terminal floor space and airfield area. The phasing of terminal development differs between scenarios, accounting for the stepped increases occurring at different times.

HH's forecast includes a 10% stepped increase in total costs in 2023, which is assumed to correspond with the opening of new infrastructure.

Our independent forecasts include a stepped increase occurring in 2026 in line with the opening of the extended runway and new terminal infrastructure, with smaller

stepped increases in the years between 2025 and 2036 (at different times depending on demand scenario) during which more terminal buildings are opened.

HH's forecast illustrates the impact of the -0.5% efficiency factor stated by the scheme promoter. While our forecasts apply a similar efficiency factor at this time, this is offset by a corresponding Risk premium.

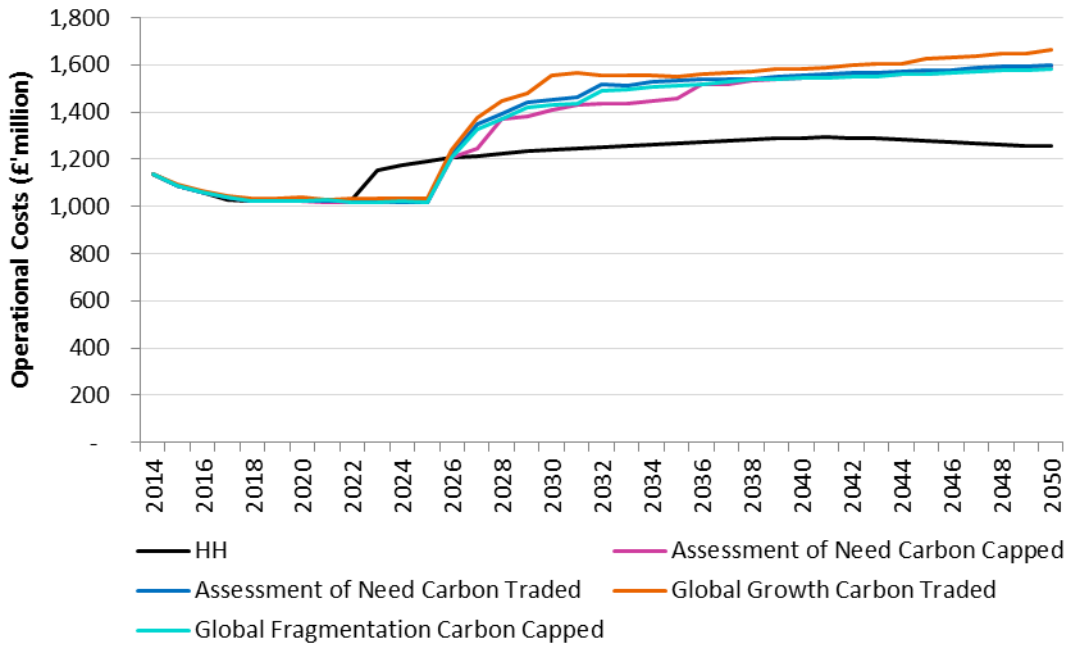


Figure F-1 Heathrow Airport Northern Runway Extension Scheme Forecast Operating Expenditure (Risk Adjusted and Mitigated Optimism Bias)

On a per passenger basis, forecasts provided by HH and our independent forecasts show a downward trend through the forecasting period, as shown in Figure F-2.

Temporary increases occur during the period following the opening of new infrastructure. When new terminal buildings open, there is a marked increase in fixed costs. Over time, as passenger numbers increase to fill the terminal buildings, costs become more efficient on a per passenger basis.

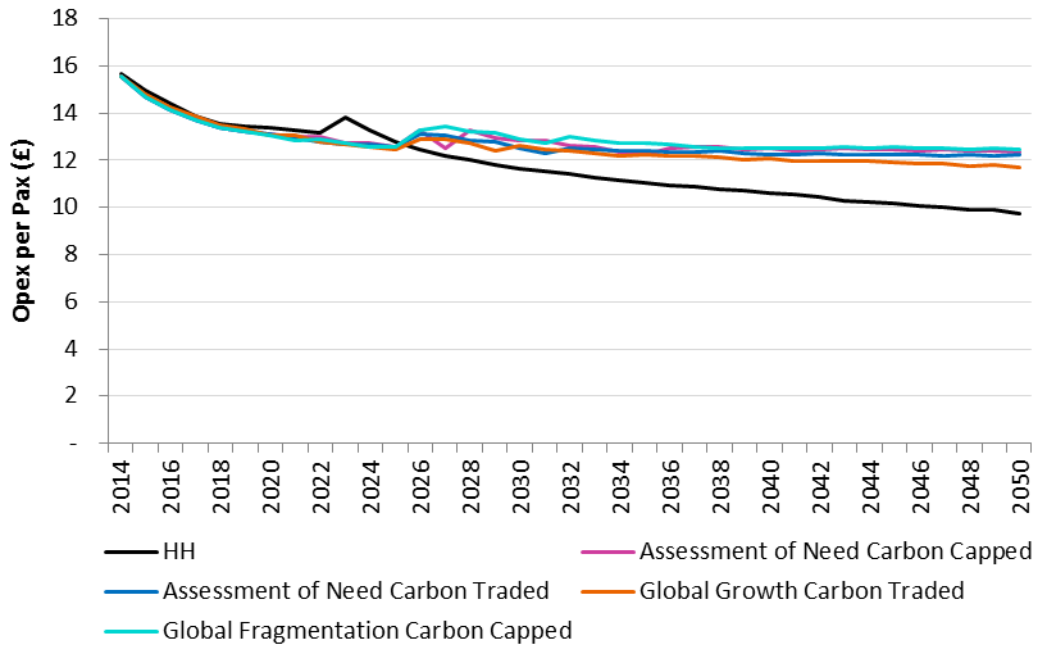


Figure F-2 Heathrow Airport Northern Runway Extension Scheme Forecast Operating Expenditure per Passenger (Risk Adjusted and Mitigated Optimism Bias)

2014, real prices in £'million

HH	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	
Staff	17,159	451	431	420	408	407	407	407	407	406	456	463	469	469	474	477	481	480	482	484	485	487	488	487	489	490	490	491	491	488	486	483	479	477	472	469	465	463	
Routine maintenance	6,593	173	166	161	157	156	156	156	156	156	175	178	180	180	182	183	185	184	185	186	186	187	188	187	188	188	188	189	189	188	187	186	184	183	181	180	179	178	
Utilities	3,540	94	89	87	84	84	83	83	83	82	91	92	93	100	99	98	97	102	102	101	102	101	101	104	103	102	102	101	101	101	100	99	98	98	97	96	95	94	
Rent and rates	6,004	129	125	122	120	120	121	122	122	122	137	140	143	161	161	161	161	171	171	172	174	175	176	182	183	183	184	185	186	187	187	188	188	189	188	189	189	189	190
Rail	2,487	61	58	56	55	54	55	56	57	58	66	68	70	63	65	66	68	64	65	66	67	68	69	68	69	70	71	72	73	74	75	76	76	77	77	78	78	79	
Other	8,742	229	218	211	204	203	203	203	203	202	227	232	236	232	235	238	241	238	240	242	243	245	247	246	248	249	251	253	254	254	254	252	253	252	251	250	250		
Opex	44,525	1,137	1,087	1,058	1,028	1,025	1,025	1,027	1,027	1,027	1,152	1,172	1,191	1,206	1,216	1,224	1,232	1,239	1,246	1,252	1,257	1,263	1,268	1,273	1,278	1,283	1,287	1,291	1,294	1,291	1,289	1,285	1,277	1,275	1,267	1,264	1,257	1,255	
Opex/pax (£)	-	15.66	14.94	14.42	13.89	13.52	13.43	13.36	13.27	13.18	13.79	13.25	12.78	12.43	12.20	12.01	11.82	11.66	11.53	11.40	11.28	11.16	11.06	10.95	10.85	10.77	10.69	10.61	10.56	10.44	10.30	10.20	10.19	10.05	10.03	9.92	9.88	9.76	

Assessment of Need Carbon Capped	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	
Staff	16,900	449	425	410	399	393	391	389	385	381	381	376	375	436	447	483	484	485	489	488	485	484	485	504	500	500	500	497	497	495	491	490	488	488	485	484	482	481	
Routine maintenance	6,300	168	160	154	150	148	147	146	145	144	144	142	141	147	151	170	170	183	183	182	183	183	183	184	182	189	189	188	188	187	186	185	184	184	183	183	182	182	
Utilities	3,842	94	94	93	92	91	90	89	88	87	87	86	85	101	101	113	112	111	113	112	110	109	109	115	115	114	114	113	113	112	112	111	111	110	110	109	108	108	
Rent and rates	6,312	129	128	127	125	124	124	124	124	124	124	124	124	159	159	183	183	183	187	187	187	187	187	201	201	201	201	201	201	201	201	201	201	201	201	201	201	201	201
Rail	2,087	69	58	57	57	56	56	55	55	54	54	54	53	56	57	57	58	58	57	57	57	57	57	57	57	57	57	56	56	56	56	56	55	55	55	55	55	55	
Other	9,263	228	222	218	215	211	210	209	207	205	205	204	204	233	240	256	258	259	262	263	262	263	265	274	274	275	277	276	278	278	277	278	278	279	279	280	280	281	
Opex	44,704	1,137	1,086	1,059	1,039	1,024	1,018	1,013	1,005	996	995	985	982	1,131	1,154	1,261	1,264	1,279	1,291	1,289	1,285	1,283	1,286	1,335	1,329	1,335	1,337	1,332	1,333	1,329	1,322	1,321	1,317	1,317	1,312	1,312	1,307	1,307	
Opex (incl. risk and 20%OB)	49,631	1,137	1,086	1,059	1,039	1,024	1,023	1,023	1,020	1,016	1,020	1,015	1,017	1,208	1,244	1,369	1,381	1,408	1,429	1,435	1,438	1,445	1,455	1,516	1,516	1,532	1,542	1,545	1,554	1,556	1,555	1,560	1,563	1,572	1,572	1,582	1,584	1,591	
Opex/pax (£)	-	15.57	14.67	14.15	13.73	13.39	13.24	13.09	13.02	12.98	12.70	12.73	12.58	13.26	12.53	13.25	12.96	12.82	12.81	12.63	12.55	12.35	12.23	12.50	12.56	12.57	12.47	12.50	12.42	12.44	12.51	12.47	12.48	12.41	12.45	12.39	12.42	12.37	

Assessment of Need Carbon Traded	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	
Staff	17,172	449	425	410	399	393	391	388	386	384	382	378	375	439	486	491	500	502	501	518	513	511	509	508	506	503	503	502	500	498	496	494	493	490	490	487	486	483	
Routine maintenance	6,411	168	160	154	150	148	147	146	145	145	144	142	141	148	153	173	187	188	190	189	187	194	193	193	192	190	191	190	189	189	188	187	187	186	186	185	184	183	
Utilities	3,893	94	94	93	92	91	90	89	88	87	87	86	85	101	114	113	115	114	113	119	118	117	116	116	115	114	114	113	113	112	112	111	111	110	110	109	109	108	
Rent and rates	6,399	129	128	127	125	124	124	124	124	124	124	124	124	159	183	183	187	187	187	201	201	201	201	201	201	201	201	201	201	201	201	201	201	201	201	201	201	201	201
Rail	2,108	69	58	57	57	56	56	55	55	55	54	54	53	56	58	59	59	59	59	59	58	58	58	58	58	57	57	57	57	56	56	56	56	55	55	55	55	55	
Other	9,398	228	222	218	215	211	210	209	208	207	206	204	204	234	256	260	265	268	269	277	276	276	276	277	277	277	278	279	280	280	280	281	281	282	282	282	283	283	
Opex	45,381	1,137	1,086	1,059	1,039	1,024	1,018	1,011	1,007	1,002	997	988	983	1,138	1,250	1,278	1,313	1,317	1,319	1,363	1,353	1,356	1,353	1,352	1,348	1,342	1,344	1,343	1,340	1,336	1,333	1,330	1,328	1,323	1,324	1,319	1,317	1,313	
Opex (incl. risk and 20%OB)	50,414	1,137	1,086	1,059	1,039	1,024	1,023	1,022	1,022	1,022	1,022	1,018	1,018	1,216	1,346	1,391	1,439	1,452	1,463	1,518	1,514	1,527	1,531	1,538	1,540	1,541	1,551	1,558	1,561	1,565	1,568	1,573	1,577	1,579	1,589	1,591	1,596	1,599	
Opex/pax (£)	-	15.57	14.67	14.15	13.73	13.39	13.24	13.13	12.95	12.80	12.66	12.66	12.56	13.08	13.08	12.86	12.79	12.49	12.31	12.52	12.48	12.41	12.39	12.34	12.36	12.40	12.31	12.26	12.26	12.27	12.26	12.26	12.24	12.26	12.19	12.23	12.20	12.22	

Global Growth Carbon Traded	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
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Appendix G Non-Aeronautical Revenue

G.1 Introduction

This appendix sets out the approach used to develop an independent forecast of non-aeronautical revenues for the period 2014 to 2050 for the Heathrow Airport Northern Runway Extension scheme (hereafter “the scheme”).

This appendix contains the following sections:

- *Section G-2 describes the data inputs received from scheme promoters, including their own non-aeronautical revenue forecasts for the period, and the passenger traffic forecasts against which these were developed.*
- *Section G-3 describes the independent non-aeronautical revenue forecasting methodology.*
- *Section G-4 provides commentary on the non-aeronautical revenue model outputs.*

G.2 Non-Aeronautical Revenue Forecast Data Inputs

HH provided non-aeronautical revenue forecasts for the period 2018 to 2041 in 2011/12 prices. These were inflated to 2014 prices using a multiplier of 7.453% (Source: UK inflation, average consumer prices. IMF World Economic Outlook Database, April 2014).

HH supplied a high-level non-aeronautical revenue breakdown: Car Parking, Retail, Property Rental, Other Regulated Revenue, and Other Revenue. The Retail revenue breakdown was developed in the form of yearly category shares applied to the total.

HH’s non-aeronautical revenue forecasting methodology adopted a flat real yield per passenger per category, based on Heathrow Airport Limited’s (HAL) Q6 2018 yield per passenger, per category. Detailed scheme non-aeronautical revenues were estimated for the period 2018-2050 using the mentioned yields by major category. Prior to 2018, the Heathrow Airport forecast values were adopted.

Terminal gross floor space was derived from the capacity analysis work presented in Section 2.3. The timing of the phases of expansion of terminal buildings, which differs under each passenger traffic scenario, formed a key input to the non-aeronautical revenue modelling work.

G.3 Independent Non-Aeronautical Revenue Forecasts

G.3.1 General Forecast Commentary

All non-aeronautical revenues are presented in real 2014 prices.

Forecasts have been developed for the following non-aeronautical revenue categories:

- *Retail (Duty and Tax Free, Food and Beverage, Other Retail)*
- *Car Parking*
- *Property Rental*

- *Other Revenue*

The 'Other Retail' sub-category includes:

- *Specialist Retail*
- *Bureaux de Change*
- *Other Retail*

The 'Other Revenue' category includes:

- *Passengers with Reduced Mobility (PRM)*
- *Staff Car Parking*
- *Operational facilities and utilities income' (common user terminal equipment (CUTE), baggage systems, utility cost recovery)*

The forecast base year is 2014, which reflects the most recent available data on non-aeronautical revenue performance. Additionally, 2014 should reflect the revenue performance in the absence of one-off events such as the Olympics, a terminal opening, or a terminal commercial space reconfiguration.

The independent non-aeronautical revenue forecasts have taken into consideration the attributes of each airport scheme, in terms of:

- *Passenger mix: high share of transfer traffic, impacting terminal concessions spend*
- *Surface access options (i.e., Crossrail), as well as price disincentives to discourage driving to the airport, impacting car parking revenues*
- *Terminal commercial space design: Heathrow's non-aero revenue historic performance reflects the opening of commercially optimised terminals (i.e., T5).*

G.3.2 Impact of Overcapacity

Under the Global Growth Carbon Traded scenario, there are periods towards the end of the forecasting period in which the provided terminal capacity is exceeded by forecast passenger demand. A modelling approach has been introduced to take account of the impact that passenger congestion would be likely to have upon retail revenues. This retail impact may manifest itself through retail space being sacrificed to be used for passenger processing, by congestion in the terminal deterring or preventing passengers from making purchases they would otherwise have made, or a combination of the two.

According to the modelling approach adopted, terminals are assumed to operate at up to 105% of intended capacity without any detrimental impact on retail revenues. When capacity is assessed to have exceeded 105%, a proportionate decrease in passenger airside dwell time occurs, based on an assumed average of 45 minutes departure lounge dwell time. A benchmark value of £0.10 per passenger per minute of dwell time lost was applied.

The resulting decrease in retail revenue is split between Duty Free, Other Retail, and Food & Beverage according to their original proportions.

Under the Global Growth Carbon Traded case, overcapacity above the 105% threshold occurs from 2045.

G.3.3 Risk and Optimism Bias

The Green Book guidance suggests that revenue forecasts should be adjusted for both risk and optimism bias.

Adjustments for risk are intended to take account of the potential for foreseeable negative impacts on revenues to occur. Adjustments for optimism bias are intended to take account of inherent optimism when forecasting revenues and for the potential for unforeseeable negative impacts to occur.

Whereas the approach adopted for applying optimism bias to operating costs considers only the incremental operating costs of the scheme, to be incurred when operating the expanded facilities as a result of a new runway being built at the airport, this approach would be less robust for non-aeronautical revenues since any risk factors would be likely to apply to the whole airport rather than just the new facilities. For example, if retail revenues at a new terminal were to fall short of forecast levels as a result of an aspect of design, it can be expected that airport management would take the necessary steps to reconfigure the space to address the shortfall. If, however, retail revenues fell short of forecast levels as a result of a general trend away from airport shopping, then this could be expected to impact revenues at the existing terminal as well as the new terminal.

Setting appropriate levels for risk and optimism bias is a matter of professional judgement rather than robust evidence available from benchmarks or best practices. Although peaks and troughs in revenues can be expected through the forecasting period, a sustained period of underperforming non-aero revenues would likely be met with remedial action by management. It was proposed that a compound 0.25% per annum reduction in non-aeronautical revenues would be appropriate to take account of risk across the portfolio of non-aeronautical revenues. For optimism bias, a further 0.25% per annum reduction would apply to the risk-adjusted non-aeronautical revenue value. Both adjustments have been implemented from 2019, the first year after the Q6 regulatory period has ended. The same adjustments are applicable to each airport scheme.

By 2050, the risk adjustment of 0.25% per annum with a further 0.25% per annum for OB applied to the risk-adjusted value results in a 15% reduction in annual non-aeronautical revenues. The risk-adjusted reduction is 7.7% by 2050.

G.3.4 Historical Trends

As shown in Figure G-1, net non-aeronautical revenue per passenger has increased at a compound annual growth rate (CAGR) of 1.1% over the FY07 – FY13 period. Net non-aeronautical revenues have grown at a 2.2% CAGR over the same period, in the context of 1.1% passenger growth.

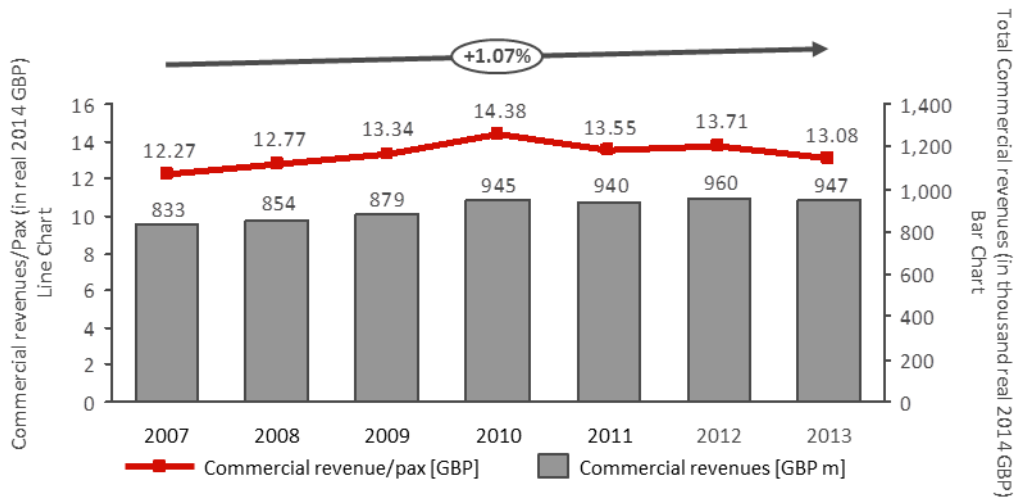


Figure G-1 Heathrow Airport historical non-aeronautical revenue in Real 2014 GBP

Net retail revenue (including Duty Free, Catering, and Other Retail) has increased at a 4.2% CAGR over the same 7-year period, while revenue per passenger has increased at a CAGR of 3.1%.

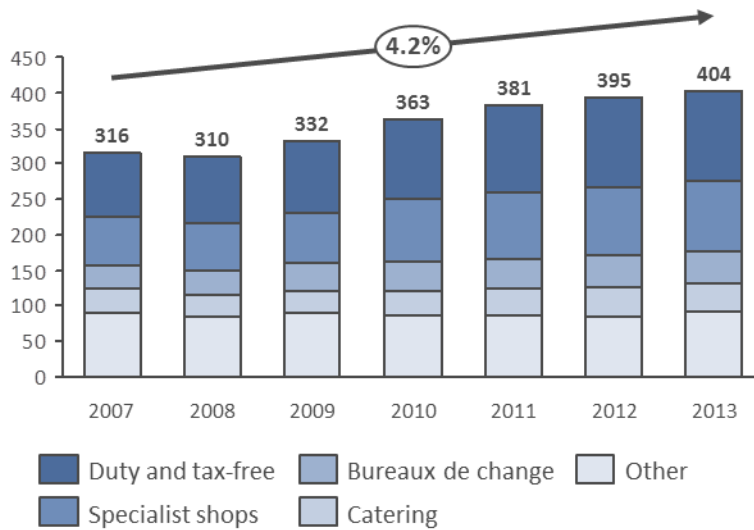


Figure G-2 Heathrow Airport historical retail revenue Split in Real 2014 GBP

G.3.5 Non-Aeronautical Revenue Forecast Assumptions Provided by HH

HH’s non-aeronautical revenue forecasting methodology adopted a flat real yield per passenger per category, based on HAL’s Q6 2018 yield per passenger, per category. No further information was provided. The assumed yields for the period 2018 to 2041 are shown on the following page.

Category	GBP/Passenger Real 2011/12
Car Parking	1.03
Retail	5.77
Property	1.42
Other Regulated Revenue	2.75
Other Revenue	1.94

G.3.6 Independent Non-Aeronautical Revenue Forecast Approach and Assumptions

The table below summarises the independent non-aeronautical revenue assumptions.

Revenue Category	Driver	Assumptions
Car Parking	<ul style="list-style-type: none"> ▪ Originating passengers 	A decreasing elasticity to originating passenger traffic growth has been assumed to reflect the impact of Crossrail starting operations in 2019, as well as various proposed initiatives to encourage the increased usage of public transport
Retail	Drivers per sub-category	Assumptions per sub-category
<i>Duty Free</i>	<ul style="list-style-type: none"> ▪ Total passengers ▪ Elasticity to GDP by region 	Elasticities to GDP in the range of 20% to 30% have been assumed per world regions (UK, LDCs, NICs, OECDs, West Europe) and correlated to the corresponding passenger traffic categories, in order to capture the changes in passenger mix over time, as well as the different spending patterns by region. A 50% elasticity to passenger traffic growth has been assumed. The long term forecasts, in particular the last 10 year period leading to 2050, reflect a more conservative view, to account for unknown changes in the economy
<i>Other Retail</i>	<ul style="list-style-type: none"> ▪ Total passengers ▪ Elasticity to GDP by region for the Specialist Retail category 	The same assumptions applied to Duty Free revenues have been reflected in the Specialist Retail revenue sub-category forecast. Bureaux de Change and Other Retail revenues have not been linked to GDP growth
<i>Catering</i>	<ul style="list-style-type: none"> ▪ Total passengers 	An elasticity of 70% to passenger traffic has been assumed, accounting for the share of transfer traffic (i.e., limited stop-over times)
Property Rental	<ul style="list-style-type: none"> ▪ Terminal size 	A 10% elasticity to terminal size growth has been assumed, reflecting the stepped increases in terminal space, which would allow for more revenue from spaces such as airline lounges and offices to be accrued

Revenue Category	Driver	Assumptions
Rail	<ul style="list-style-type: none"> O&D passengers 	The category represents revenues accrued as a result of the Heathrow Express operation. The near term forecast assumes a 100% elasticity to O&D passenger traffic growth, as does HAL, however the elasticity is assumed to decrease following 2019, reflecting the introduction of Crossrail as a surface access option
Other Revenues	<ul style="list-style-type: none"> Total passengers Terminal size Utilities category linked to OpEx by applying the same drivers 	<ul style="list-style-type: none"> Category includes 'Operational Facilities and Utilities Income sub-category' and 'Other Revenues' (PRM, Staff Car Parking) The Utilities Income represents the recovery of utility costs from airport tenants. The independent forecast estimates a 40% cost recovery share, and the actual GBP amount is obtained by applying this share to the FY 2013/14 utility costs. This amount, which represents the base of the Utility Income forecast, represents 13% of the Operational Facilities and Utilities Income. Utility cost (e.g., OpEx) drivers have been applied to the Utility Income forecast in order to maintain the 40% cost recovery share over the forecast period A 10% elasticity to terminal size has been assumed for the operational facilities revenues (87% share of the sub-category) to account for the additional CUTE systems to be employed as terminal size increases. The low elasticity also reflects the large share of scheduled airlines (BA, VS), which have their designated check-in areas, as opposed to making extensive use of the CUTE systems In the absence of a detailed split of the 'Other revenues' category, a low elasticity to passenger traffic has been applied to the whole category to reflect PRM revenue increases Heathrow Airport proposes to significantly reduce staff accessing the airport by car, and encourages the use of shared car usage, as well as the use of public transport (see paragraph 2.2.4). In this context, only a low elasticity to terminal size and passenger traffic, both drivers capturing the increase in staff numbers, has been assumed

Table G-1 Independent Non-Aeronautical Revenue Assumptions

G.4 Non-Aeronautical Revenue Modelling Outputs

This section presents graphical outputs of the independent non-aeronautical revenue model, compared with the revenues presented by, or inferred from, the scheme promoter's submission.

The independent forecasts for non-aeronautical revenues under all demand scenarios commence at a lower revenue base than HH's forecast for FY 2019 and remain lower throughout the forecast period, in both the risk and OB adjusted and unadjusted cases. This is principally due to HH's assumption that yield per passenger would remain flat in real terms throughout the forecast period. Various

categories (e.g. Property Rental, which is not expected to grow with a relationship to passenger numbers) do not support such an assumption.

The risk and optimism bias adjusted independent forecast for the 2019 to 2050 period shows non-aeronautical revenues increasing at between 0.7% and 0.9% Compound Average Growth Rate (CAGR) compared with HH's non-aeronautical revenue forecast which sees performance increasing at 1.7% CAGR.

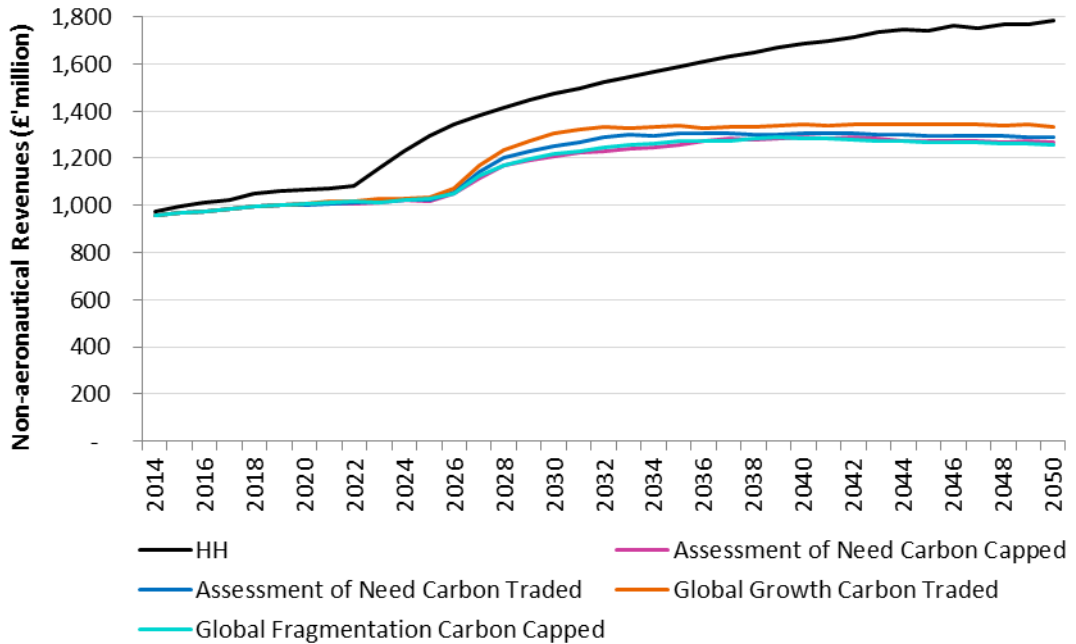


Figure G-3 Heathrow Airport Northern Runway Extension Scheme Forecast Non-Aeronautical Revenue (Risk Adjusted and Optimism Bias)

Non-aeronautical revenue per passenger is forecast to decrease at between 0.8% and 1.0% CAGR in real terms over the 2019-2050 period, depending on demand scenario, when risk and OB adjustments are included. Revenue per passenger is forecast to reduce as a result of the change in the mix of passengers, a trend towards increased use of public transport to access the airport, resulting in lower car parking revenues per passenger, and the relatively flat relationship between passenger growth and certain revenue streams such as Property and Other. HH assumes flat revenue per passenger performance over the same period.

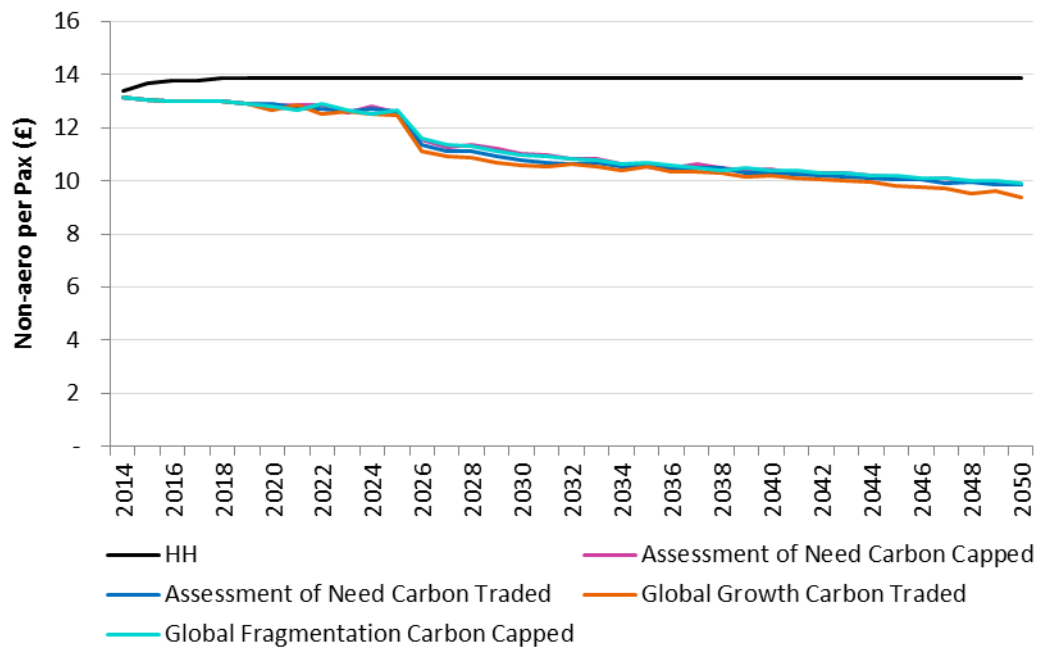


Figure G-4 Heathrow Airport Northern Runway Extension Scheme Forecast Non-Aeronautical Revenue per Passenger (Risk Adjusted and Optimism Bias)

Table G-2, on the following page, sets out the independent forecast.

2014, real prices in £million

HH	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	
Car parking	4,249	69	74	76	79	84	84	85	86	86	92	98	103	107	110	113	115	118	120	121	123	125	127	129	130	132	133	135	136	137	139	139	139	139	140	140	141	141	142
Total retail	23,861	398	428	447	454	470	473	476	480	483	518	549	578	601	618	632	646	659	670	681	691	701	711	721	730	738	746	754	759	767	776	781	777	787	784	790	789	798	
Duty and tax-free	8,829	127	137	144	147	154	155	157	159	161	173	185	196	206	213	221	228	235	241	247	253	258	264	269	274	280	286	291	296	301	307	312	314	321	322	328	330	336	
Other retail	12,826	232	248	259	262	271	273	274	275	276	294	311	326	337	344	349	355	359	363	367	371	375	379	382	386	388	390	393	394	397	400	401	398	401	398	400	398	401	
Food and beverage	2,207	39	42	44	44	45	46	46	46	47	50	53	56	58	61	62	64	65	66	67	67	68	69	70	70	70	70	69	69	69	68	66	65	63	63	61	60		
Property rental	5,900	111	114	113	114	116	116	117	118	119	127	135	142	148	152	156	159	162	165	167	170	173	175	177	180	182	184	186	187	189	191	192	191	194	193	194	194	196	
Rail	8,295	128	121	124	133	138	139	140	141	142	152	161	170	177	181	186	190	193	197	200	203	206	209	212	214	217	219	221	223	365	370	372	370	375	373	377	376	380	
Other revenue	11,203	266	258	250	242	243	245	247	249	250	268	284	299	312	320	327	335	341	347	353	358	363	369	374	378	382	387	391	393	258	261	263	261	265	263	266	265	268	
Non-aero	53,506	972	995	1,011	1,022	1,051	1,058	1,065	1,073	1,080	1,158	1,227	1,292	1,345	1,382	1,413	1,445	1,473	1,498	1,522	1,545	1,569	1,591	1,612	1,633	1,651	1,668	1,686	1,698	1,716	1,737	1,748	1,739	1,761	1,753	1,768	1,765	1,784	
Non-aero/pax (£)	-	13.39	13.67	13.77	13.80	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.86	13.87	13.87	13.87	13.87	13.87	13.87	13.87	13.87	13.87	13.87	

Assessment of Need Carbon Capped	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	
Car parking	3,529	66	66	66	68	70	72	73	75	76	77	80	80	83	91	98	100	101	103	104	105	105	107	108	110	109	110	111	110	112	112	111	111	111	112	112	113	112	
Total retail	21,462	406	410	416	422	427	432	437	442	444	448	455	456	478	524	557	576	593	607	618	628	637	650	662	672	674	684	690	692	697	696	695	698	701	706	707	712	713	
Duty and tax-free	7,662	129	131	134	137	139	142	144	146	147	149	153	153	161	181	196	204	212	218	223	228	232	238	243	248	249	253	256	257	260	259	259	260	261	264	264	266	266	
Other retail	11,675	236	238	241	244	246	248	251	253	254	255	259	259	269	290	305	314	321	328	333	338	342	348	353	357	358	363	365	366	369	368	368	369	370	373	373	375	376	
Food and beverage	2,125	40	40	41	41	42	42	43	43	43	44	44	44	48	53	56	58	60	61	62	63	64	65	66	66	67	68	68	68	69	68	69	69	69	69	70	70	70	
Property rental	4,239	108	111	111	111	111	111	111	111	111	111	111	111	114	114	116	116	116	116	116	116	116	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	
Rail	7,421	126	126	126	130	133	137	140	144	146	147	153	154	157	176	190	196	201	206	210	215	218	223	228	234	235	239	244	245	250	252	253	257	259	264	265	270	272	
Other revenue	9,881	253	253	253	253	253	253	253	253	252	252	252	252	263	264	272	272	272	274	273	273	273	273	277	277	277	277	276	276	276	276	275	275	275	275	275	275	275	274
Non-aero	46,532	960	967	973	983	994	1,004	1,014	1,024	1,029	1,036	1,051	1,053	1,095	1,168	1,232	1,260	1,283	1,305	1,321	1,338	1,350	1,370	1,393	1,409	1,412	1,426	1,438	1,441	1,452	1,453	1,451	1,459	1,463	1,474	1,476	1,486	1,489	
Non-aero (incl. risk and OB)	43,049	960	967	973	983	994	999	1,004	1,009	1,009	1,010	1,020	1,017	1,052	1,117	1,172	1,193	1,208	1,223	1,232	1,241	1,246	1,258	1,273	1,282	1,278	1,283	1,288	1,284	1,288	1,282	1,274	1,274	1,272	1,275	1,270	1,273	1,268	
Non-aero/pax (£)	-	13.15	13.06	13.00	13.00	13.00	12.93	12.85	12.88	12.88	12.57	12.80	12.57	11.54	11.25	11.34	11.20	11.00	10.96	10.83	10.83	10.65	10.57	10.50	10.62	10.48	10.38	10.42	10.26	10.29	10.31	10.18	10.18	10.04	10.09	9.94	9.98	9.86	

Assessment of Need Carbon Traded	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	
Car parking	3,622	66	66	66	68	70	72	73	75	77	79	81	81	83	93	101	104	107	109	111	112	112	113	112	113	113	112	113	114	114	114	114	114	114	114	114	115	115	115
Total retail	21,943	406	410	416	422	427	432	437	442	448	454	457	459	481	535	576	600	621	638	653	663	668	677	683	689	691	695	703	707	708	710	712	714	716	719	724	725	727	
Duty and tax-free	7,867	129	131	134	137	139	142	144	146	149	151	154	154	162	185	203	214	224	231	238	243	245	249	252	255	256	262	264	264	265	266	267	268	269	271	272	273		
Other retail	11,895	236	238	241	244	246	248	250	253	255	258	260	260	270	295	314	325	334	349	353	356	360	362	365	366	368	371	373	374	374	375	377	378	379	381	381	383		
Food and beverage	2,181	40	40	41	41	42	42	43	43	44	44	44	44	49	55	59	61	63	65	66	67	67	68	68	68	69	70	70	70	70	71	71	71	71	71	72	72		
Property rental	4,247	108	111	111	111	111	111	111	111	111	111	111	111	114	116	116	116	116	116	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	
Rail	7,617	126	126	126	130	133	137	140	143	147	150	154	155	158	179	197	205	212	218	224	230	231	235	237	241	242	243	248	252	255	257	260	263	267	269	274	276	279	
Other revenue	9,911	253	253	253	253	253	253	253	253	252	252	252	252	264	273	273	274	274	278	278	278	278	278	278	277	277	277	277	277	276	276	276	276	276	275	275	275	275	275
Non-aero	47,349	960	967	973	983	994	1,004	1,014	1,023	1,035	1,046	1,055	1,057	1,099	1,195	1,262	1,301	1,331	1,355	1,383	1,400	1,405	1,420	1,427	1,437	1,440	1,444	1,458	1,466	1,470	1,474	1,479	1,484	1,490	1,494	1,505	1,507	1,514	
Non-aero (incl. risk and OB)	43,795	960	967	973	983	994	999	1,004	1,008	1,014	1,020	1,024	1,021	1,056	1,143	1,201	1,231	1,253	1,270	1,289	1,298	1,297	1,304	1,304	1,306	1,302	1,300	1,306	1,301	1,298	1,297	1,295	1,292	1,295	1,290	1,290	1		

Appendix H Surface Access Capital Expenditure, Operational Expenditure and Maintenance Cost

H.1 Introduction

This appendix briefly sets out the approach used to develop an independent forecast of surface access costs for the Heathrow Airport Northern Runway Extension scheme.

This appendix should be read in conjunction with Appraisal Module 4. Surface Access: Heathrow Airport Extended Northern Runway.

This appendix report contains the following sections:

- *Section H-2 describes the road projects required for the scheme*
- *Section H-3 describes the rail projects required for the scheme*
- *Section H-4 summarises the estimates of capital and operational expenditure, and asset replacement costs for both road and rail projects*

H.1.1 Adjustment for Risk and Optimism Bias

In general the guidance of WebTAG has been followed to apply risk and optimism bias to the base cost estimates. Optimism bias was applied to the risk adjusted base cost.

H.1.1.1 Capital Expenditure and Asset Replacement

WebTAG guidance suggests that at this stage of project development, optimism bias should be applied at the level of 44% for road projects and 66% for rail projects.

For rail schemes, WebTAG states that at this stage of early development, no additional allowance for risk is required in addition to adjusting for optimism bias.

The same approach has been followed for road schemes. WebTAG guidance suggests that a quantified risk assessment be undertaken for each non-Highways Agency scheme. Due to the difficulties in understanding the full scope of works required at this stage, in addition to many of these schemes involving Highways Agency works, a separate risk premium is not considered appropriate, given that the upper bound of optimism bias has also been applied for road schemes. However, a 10% risk allocation has been tested as a sensitivity, presented in the output section below.

H.1.1.2 Operational Expenditure

WebTAG guidance suggests that at this stage of project development, optimism bias should be applied at the level of 44% for road projects and 41% for rail projects.

For rail schemes, WebTAG states that at this stage of early development, no additional allowance for risk is required in addition to adjusting for optimism bias.

For road schemes, as per the approach to risk provision for capital expenditure, with agreement of the Airports Commission, no separate allocation for risk has been

applied. However, a 10% risk allocation has been tested as a sensitivity, presented in the output section below.

H.2 Surface Access - Roads

H.2.1 Capital Expenditure

It was determined that the following works would be needed to support the opening of the Heathrow Airport Northern Runway Extension scheme. These are separated below into Highways Agency network projects and local road projects that would be the responsibility of Transport for London and/or relevant local authorities.

Highways Agency network capital costs include the following schemes:

- *M4 J3-J4, hard shoulder running in both directions and additional road widening*
- *M4 airport spur, road widening in both directions*
- *M4 J2-J3, road widening in both directions*
- *M4 J4 and J4B, additional road widening in both directions*
- *M4, large M4 J4b replacement*
- *M4, higher capacity J4a*
- *M25, tunnelling costs (south of J15), including provision of adjacent tunnel to accommodate parallel realigned perimeter road⁸*
- *Capacity improvements to existing main airport tunnel⁹*

M25 tunnelling and large M4 schemes are assumed to be phased over three years, scheduled to commence in 2022. Other Highways Agency and local road schemes are assumed to commence in 2024 and are phased over two years for completion before runway opening in 2026.

Local road capital costs include the following schemes:

- *M25 J13, new dual carriageway link*
- *M25 J13, new spur access*
- *Tunnel from A4 to Terminal 5/Terminal 6 complex*
- *Western tunnel running parallel to M25*
- *A4 access road widening*
- *Airport Way/Southern Perimeter Road Interchange, grade separated junction and flyover/bridge structures*
- *Southern Road Tunnel/Southern Perimeter Road Interchange*

A Southern Road Tunnel project linking the Central Terminal Area with the Southern Perimeter Road is also included, and is scheduled to be constructed over a three year period from 2019-2022.

We note that HAL has included within its Core Capital Expenditure plan £430m of surface access costs associated with a T5 Landside road scheme, which should therefore be included in the Heathrow Airport Northern Runway Extension scheme.

⁸ For the purposes of this analysis, the full costs of the M25 tunnelling works have been categorised as surface access improvements, rather than “scheme capital expenditure” works which ordinarily include engineering projects within the airport boundary. We note that the airport operator has suggested funding 50% of these works, with the remaining 50% borne by the public sector. The Airports Commission has not taken a view as to the split of funding between private and public sources and believes that this would be a matter for negotiation should the scheme be taken forward.

⁹ Not a Highways Agency project, but directly related to the M4 Airport Spur works.

We have not included this scheme within our core capital expenditure forecasts and instead have assumed that the line item refers to the Southern Road Tunnel scheme which is expected to be in the same order of magnitude of costs.

Descriptions of schemes and costs are contained in the Appraisal Module 4. Surface Access: Heathrow Airport Northern Runway Extension.

H.2.2 Asset Replacement Costs

Asset replacement (or Heavy Maintenance) costs were determined using Highways Agency published data (Source: <https://www.gov.uk/government/publications/cost-of-maintaining-the-highways-agency-s-motorway-and-a-road-network-per-lane-mile>). 2011/12 costs were uplifted to 2014 prices using a multiplier of 1.07453 (Source: UK inflation, average consumer prices. IMF World Economic Outlook Database, April 2014).

The Highways Agency (England) figure of £43k per lane mile was used to calculate Highways Agency network maintenance costs while the South East cost of £52k per lane mile was used to calculate local road network maintenance costs.

Road maintenance costs are assumed to begin to be incurred in the year following road scheme completion and to continue thereafter.

H.2.3 Operating Costs

Road operating costs include activities such as lighting, drainage and landscaping. Annual cost estimates have been derived on the basis of DfT Cost and Benefit Analysis guidance (2006). For Highways, Road Type 11 was selected (£45k per km); for local roads, Road Type 6 was selected (£30k per km). Costs were inflated from 2002 to 2014 prices (Source: UK inflation, average consumer prices. IMF World Economic Outlook Database, April 2014).

Road operating costs are assumed to begin to be incurred in the year following road scheme completion and continue thereafter.

H.3 Surface Access – Rail

H.3.1 Capital Expenditure

Rail infrastructure costs comprise the Southern Rail Access scheme to Waterloo, including a train depot. The Southern Rail Access scheme providing a link to Woking has not been included because it is unlikely to deliver sufficient benefits at this stage.

Jacobs's cost estimate was adopted at £487.5m (before risk and optimism bias), phased over three years from 2023-25. The scheme is scheduled for completion in advance of the 3rd runway opening.

Western Rail Access is assumed to be a committed scheme, as it is currently in Network Rail Draft CP5 Enhancements Delivery Plan and the Government has stated it is committed to the project. Therefore it has not been included in this assessment.

H.3.2 Asset Replacement Costs

Asset replacement costs comprise track maintenance and renewals for which an infrastructure fee is payable by the train operator to Network Rail. This fee has been derived according to industry data on per route mile charges paid to Network Rail by existing franchise operators.

H.3.3 Operating Costs

Southern Rail Access operating costs include an additional four trains per hour between Heathrow and Waterloo.

Crossrail costs include an additional two trains per hour (tph).

Operating costs include staff, train leasing, train cleaning and maintenance, variable track access charges, electric current for traction, and other costs.

Operating costs associated with the Heathrow Express are included within the core and scheme airport operating costs rather than surface access costs since the train operation is owned by Heathrow Airport Holdings.

H.3.4 Heathrow Airport North West Runway scheme Rail Operating Cost Assumptions

H.3.4.1 Unit Assumptions

	Heathrow Crossrail +2tph	Heathrow Southern Access
Operating Days p.a.	363	363
Additional train sets required	2	7
Number of vehicles per train	9	10
Additional single journeys	76	152
Mileage per single journey	15	22.75
Traincrew: Additional daily diagrams	3	16

Table H-1 Unit Assumptions

Operating days per annum is assumed to be every day excluding Christmas Day and Boxing Day.

The assumptions for the number of additional trains are based on the indicative timetable drawn up for each option. An additional two Crossrail trains per hour would require an additional two trains based on a journey time between London Paddington and Heathrow T4 of 30 minutes. The Heathrow Southern Access scheme would require an additional seven trains based on a requirement to increase the service to four trains per hour with a journey time of 35 minutes.

The additional traincrew requirements (drivers and hosts) are based on the number of additional daily diagrams. This is calculated from the number of additional trains required, and with additional trains running throughout the day an allowance is made for shift length and breaks. The required additional establishment of drivers and hosts is calculated from the number of additional diagrams with a multiplier of 2.5 to account for days off, annual leave and sickness and training days. It is assumed no train hosts will be required for the Heathrow Crossrail services.

H.3.4.2 Operating Cost Assumptions

The annual costs for drivers and train hosts are based on an assumed salary + NI contributions and benefits of £55k and £40k respectively, in 2014 prices.

The assumptions of costs for electric stock are based on the known costs for a 4 car train as shown below, from which a cost per car has been calculated. The costs per car together with the assumed number of additional cars required is used to calculate the total costs for capital leases, maintenance, cleaning, electric current for traction (EC4T), variable track access (VTA) and electrification access charge (EAC).

	4 car 100mph	£ per car
Capital lease £k p.a.	168	42000
Maintenance £ pvm	0.315	0.315
Cleaning £k pv p.a.	8.2	8200
EC4T £ pvm	0.277	0.277
EAC £ pvm	0.012	0.012
VTA £ pvm	0.0484	0.0484

Table H-2 Cost Assumptions

The Heathrow Southern Access scheme includes an assumption for costs of depot facilities for train maintenance of the additional fleet of trains. It is assumed that they are maintained as part of a larger fleet of trains in existing depots, with one-off investment required to provide additional equipment at an estimated cost of £500k. For the Heathrow Crossrail option which only requires 2 additional trains it is assumed they can be maintained in existing depot facilities.

The infrastructure maintenance cost is calculated from an assumed Long Term Charge for infrastructure of £1.017 per mile, based on a benchmark of the South West Trains' annual charge in CP5 divided by their annual train miles.

H.4 Outputs

Table H-3, below, shows the independently assessed surface access costs and the impact of a sensitivity test in which a 10% risk allowance is added to road capital costs (capital expenditure and asset replacement).

		0% Risk	10% Risk
Roads	Total Asset Replacement	96	105
	Total Opex	76	83
	Total Capex	4,500	4,950
Rail	Total Asset Replacement	76	76
	Total Opex	726	726
	Total Capex	809	809
Total Opex		801	809
Total Capex		5,481	5,940

All costs in 2014, real prices and incl. risk and optimism bias - £'million

Table H-3 Summary Costs and Risk Sensitivity Test

Tables H-4 and H-5, on the following page, set out summaries of the capital, operational and asset replacement costs by road and rail project, including adjustments for risk and optimism bias.

Heathrow Hub Highway/Local Road/Rail	Route	Length (km)	Unit Cost (£'million per km)	Estimated Cost (£'million)	Risk	Optimism Bias	Total (£'million)	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Highway	M4 J3 to J4	3.8	50	190	-	84	274						63	63	63																								
Highway	M4 Airport Spur	2.8	50	140	-	62	202					70	70																										
Highway	M4 J2 to J3	17.6	50	880	-	387	1267					293	293	293																									
Highway	M4 J4 and J4B	4.7	50	235	-	103	338																																
Highway	M4		150	150	-	66	216																																
Highway	M4		40	40	-	18	58																																
Highway	M4		40	40	-	18	58																																
Highway	M25		4	150	600	-	264	864				200	200	200																									
Local Road	Tunnel from A4 to T5	2.1	20	42	-	18	60																																
Local Road	Western Tunnel	3	20	60	-	26	86																																
On-Airport Road	Southern Road Tunnel	5.2	100	520	-	229	749	87	173	173	87																												
Local Road	Airport Way/Southern Perimeter Road Interchange	1	35	35	-	15	50																																
Local Road	Southern Road Tunnel/Southern Perimeter Road Interchange	1	20	20	-	9	29																																
Local Road	M25 J13 (A13) D2	3.9	25	97.5	-	43	140						49	49																									
Local Road	M25 J13 (A13)		35	35	-	15	50																																
Local Road	A4 Access	2.7	15	40.5	-	18	58																																
Rail	SRA to Staines			487.5	-	322	809					163	163	163																									
Total				3,613	-	1,697	5,309	125	250	289	722	1,370	1,705	848	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Highway Maintenance	Source: Highways Agency website inflated from 2011/12	32.9	0.046	1.51																																			
Local Road Maintenance	Source: Highways Agency website inflated from 2011/12	18.9	0.056	1.06																																			
Total Road Maintenance /year				66.47	-	29.25	95.72	-	-	-	-	0.58	0.58	1.97	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70			
Highway Opex	Source: DfT COBA (2006), road type 11, inflated from 2002 to 2014	32.9	0.045	1.48																																			
Local Road Opex	Source: DfT COBA (2006), road type 6, inflated from 2002 to 2014	18.9	0.03	0.57																																			
Total Road Opex /year				52.49	-	23.10	75.59	-	-	-	-	0.31	0.31	1.26	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95			
Rail Maintenance /year	Source: LeighFisher analysis	-	1.75	45.50	-	30.03	75.53	-	-	-	-	-	-	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91			
Rail Opex /year	Source: LeighFisher analysis	-	19.80	514.80	-	211.07	725.87	-	-	-	-	-	-	27.92	27.92	27.92	27.92	27.92	27.92	27.92	27.92	27.92	27.92	27.92	27.92	27.92	27.92	27.92	27.92	27.92	27.92	27.92	27.92	27.92	27.92	27.92			
GRAND TOTAL (£'million)							6,281.96	124.8	249.6	289.2	722.2	1,371.0	1,705.8	882.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5			

Table H-4 Summary Costs

Heathrow Hub	Total 2014-50	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	
Roads																																							
Capex	3,125.0	-	-	-	-	-	86.7	173.3	200.8	314.2	764.2	996.7	589.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Asset Replacement Capex	66.5	-	-	-	-	-	-	-	-	-	0.4	0.4	1.4	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	
Opex	52.5	-	-	-	-	-	-	-	-	-	0.2	0.2	0.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
Rail																																							
Capex	487.5	-	-	-	-	-	-	-	-	162.5	162.5	162.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Asset Replacement Capex	45.5	-	-	-	-	-	-	-	-	-	-	-	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	
Opex	514.8	-	-	-	-	-	-	-	-	-	-	-	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	
Risk on Capex	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Optimism Bias on Capex	1,756.0	-	-	-	-	-	38.1	76.3	88.4	245.5	443.7	546.0	261.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	
Risk on Opex	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Optimism Bias on Opex	234.2	-	-	-	-	-	-	-	-	-	0.1	0.1	0.5	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	
Total Capex (inc. Risk & OB)	5,480.5	-	-	-	-	-	124.8	249.6	289.2	722.2	1,370.7	1,705.5	853.3	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6		
Total Opex (inc. Risk & OB)	801.5	-	-	-	-	-	-	-	-	-	0.3	0.3	29.2	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9		

Table H-5 Summary Outputs