

ARCADIS GUIDANCE TO THE CIVIL AVIATION AUTHORITY  
REGARDING SECRETARY OF STATE SECTION 16 REPORT

# **HEATHROW EXPANSION PROGRAMME: COST EFFICIENCY REVIEW**

INTEGRATED BASELINE PURPLE BOOK (0.61) REVIEW:  
FINAL REPORT



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# Heathrow Expansion Programme: Cost Efficiency Review Integrated Baseline Purple Book (0.61) Review: Final Report

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# Glossary

Abbreviation	Description
ABS	Asset Breakdown Structure
APM	Automated People Movers
CAA	Civil Aviation Authority
CAPEX	Capital Expenditure
DfT	Department for Transport
GWBS	Group Work Breakdown Structure
HAL	Heathrow Airport Limited
HEM	Heathrow Expansion Surface Access
HEP	Heathrow Expansion Programme
IFS	Independent Fund Surveyor
L & L	Leadership and Logistics
MSCP	Multi Storey Car Park
OHP	Overhead and Profit
2R	Development of Heathrow Airport with two runways
3R	Development of Heathrow Airport with three runways

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# 1 Introduction

Arcadis has been appointed by the Civil Aviation Authority (CAA) to provide technical advice in support of their work on capacity expansion at Heathrow Airport.

This report builds upon and supersedes the findings of the 'CAA Interim Report' issued by Arcadis on 16 August 2017 and finalises the summary of the cost efficiency review of Heathrow Airport Limited (HAL) Integrated Baseline Purple Book 0.61 (Purple Book) (see section 1.1 below) and any associated data made available as per the agreed and scoped Project Charter titled 'Cost Efficiency Review (part 1)' and 'Cost Efficiency Review (part 2)'.

This report forms part of Arcadis' wider holistic review of efficiency of the Heathrow Expansion Programme as Technical Advisor to the CAA and our current scope and phase of work related to the Section 16 report. This current phase of work included the HAL Key Component Green Reviews which have been identified and our Westerly Option Review. These reviews have been detailed in our reports 'Key Component Green Review Report (Runway | M25 Alignment & Junctions | Local Roads | Rivers & Flood Storage | Terminals, Satellites & Aprons)' and 'Westerly Option Review Report' also dated and issued in April 2018 respectively.

This report, however, aligns with the agreed project charters between Arcadis and the CAA. The originally outlined deliverables were as follows:

Provide a report capturing a summary of cost efficiency review of HAL's 'Purple Book' version 0.61 and any associated data made available. This report is to include:

- Specific cost efficiency observations with the inclusion of additional benchmarks.
- 'Pound in the Ground' elements.
- Summarisation / extension of The Independent Fund Surveyor (IFS) report on HAL.
- Holistic view of efficiency based on inclusion of further information and data available to date.
- Emerging thoughts for other areas of investigation.

Our work then sought to build upon the 'Interim report' and provide final baseline position of 'Purple Book' 0.61 review including further benchmarking.

Our scope of work has sought to capture and provide the above information, for the benefit of the CAA, in line with the project charters and scope of work described therein. This has been monitored through ongoing conversations between the CAA and Arcadis and via flash reports with updates regarding progress.

Finally, the following report has been provided to the CAA in two formats; unredacted and redacted. The unredacted version is provided to the CAA for full disclosure of the work completed by Arcadis and all details of the analysis, assessments and recommendations. The redacted version of this report has been provided to protect information that is deemed commercially sensitive at the time of the reports publication (April 2018).

## 1.1 Overview of Purple Book

Our review was based on 'HAL Integrated Baseline Purple Book' – Baseline 0.61 (identified above as the 'Purple Book'). The Purple Book, which a first version was produced in December 2015, is updated iteratively and version 0.61 represents its 5<sup>th</sup> version. The Purple Book is HAL's Capital Expenditure (CAPEX) plan for the Third Runway (3R) programme of works. The CAPEX values contained within the Purple Book are based upon the scope of works as defined in the Airports Commission Submission May 2014 and the Airports Commission recommendations in July 2015 and the subsequent government announcement on 25 October 2016. It includes third runway 3R scope derived from the Baseline 0.5 with scope adjusted for a faster delivery and reduced capital expenditure. It also includes scope for the main airport (2R) consistent with the business case development from Autumn 2015. The base date for all the costs is 2014 which aligns with the submission date. It is also based on HAL's programme which details a start on site in 2020 and completion of the runway by 2026, with other expansion-related investment continuing beyond this date.

## 2 Executive Summary

### 2.1 Key Observations in completing our Report

- The Purple Book presents a significant amount of cost information spread across six different programmes to provide the required additional capacity at Heathrow Airport. For future iterations of the Purple Book, it is recommended that HAL include two additional sections, covering 'Estimating' and 'Benchmarking' procedures. The Estimating procedures section should cover 'Basis of Estimate', assumptions, inclusions and exclusions whereas the Benchmarking procedures should clarify where all the benchmarks are derived from and how these have been normalised.
- HAL has produced several documents as listed in Appendix A of this report, where they formalise their approach to the development of the Purple Book and its expansion programme. However, we consider that the structure of the Purple Book and its associated documents could be improved upon to aid understanding and review of the information by others and recommend that this structure is developed by HAL in the forthcoming months.
- Additional measures to increase the cost certainty and hence 'efficiency' of the Purple Book are required. This can be achieved by additional benchmark input and further breaking down and quantification of not-measured items, such as allowances. HAL should look to incorporate benchmark from other aviation projects both in the UK and internationally and incorporate benchmarks from other infrastructure sectors. HAL should also look to market test key elements.
- Based on the analysis we have undertaken, we observe that HAL used best practice estimating processes and a certain level of benchmarking to define the baseline for the Expansion Programme. However, we note that only 30% of direct costs have been benchmarked to date and we recommend that further benchmarking is undertaken by HAL to increase accuracy of costs and allow for a more in-depth cost efficiency assessment (see Table 5 for breakdown).
- Given the level of maturity of the masterplan, Arcadis would expect the level of benchmarks applied to direct costs to be higher than 30%. We also note that this has been highlighted in the Independent Fund Surveyor's (IFS) report referenced in section 8 of our report.
- Regarding terminals, HAL has benchmarked against T2 and T5 only. We have undertaken a wider benchmarking exercise finding that HAL's benchmarks sit in the middle of industry benchmark figures. Two different benchmarks which are used for piers and satellites each compare at the highest and lowest end of the industry benchmarks; this requires attention by HAL. Multi-storey car park benchmarks show that HAL is the most expensive both among airports and other commercial projects' benchmarks. This requires attention and Arcadis suggest that HAL widen the benchmark data that they are using.
- We recommend HAL to utilise a scoring system to rate maturity, which rates the four elements of Purple Book estimates (Scope; Cost; Risk, and Programme) 1 to 5 against descriptive criteria to assess the level of maturity.
- HAL scores relatively well regarding indirect cost efficiency. However, in all benchmarking comparisons there were instances where other airports scored higher than HAL which suggests that opportunities for improvement exist. The benchmarking also suggests that there are opportunities to improve efficiency by adopting best practice from non-aviation organisations.
- We encourage HAL to look for best practice and lessons learned from comparable programmes at other airports and organisations within the transport sector to identify opportunities to increase the indirect cost efficiency of the Expansion Programme.
- The level of project specifics seems low based on the current level of maturity of the masterplan. Further information is required to ascertain as how the factors such as the facility type have been considered when determining project specifics.

## 2.2 Recommendations

For the benefit of the CAA, Arcadis has provided recommendations that they may wish to be shared with HAL with the aim of collaboration and assisting HAL achieve their objectives. These recommendations are provided with good intention and include, but are not limited to, the following:

Ref	Recommendation
1	Formalise the approach to the development of the Purple Book within the expansion programme. It is recommended that the structure of the Purple Book is further developed by HAL to assist with the inclusion of new information and review and understanding by others.
2	Arcadis encourages HAL to look for best practice and lessons learned from comparable programmes at other airports and organisations within the transport sector, to identify opportunities to increase the indirect cost efficiency of the Expansion Programme.
3	Review the 'Basis of Estimate' and undertake a maturity assessment for future iterations of the Purple Book.
4	For future iterations of the Purple Book, include two additional sections covering 'Estimating' and 'Benchmarking' procedures.
4a	- The Estimating procedures section should cover the 'Basis of Estimate', i.e. Assumptions, Inclusions and Exclusions.
4b	- The Benchmarking procedures section should clarify where all benchmarks are derived from and how these have been normalised, and review the approach to benchmarking, considering the depth, breadth and maturity of data available.
4c	- Additional measures to increase the cost certainty of the Purple Book can be achieved by additional benchmark input and further break down and quantification of not measured items (such as allowances).
4d	- HAL to set a roadmap with fixed timeframes for providing quantification and benchmarking studies for the not benchmarked and not measured items.
5	Provide further clarification on the application of project specifics in future iterations of the Purple Book. It is recommended that these are broken down by facility level and that unique facility and programme characteristics are taken into consideration.
6	Review the application and benchmarking of preliminaries, overhead & profit and leadership & logistics.
7	Incorporate structured and robust check mechanisms to avoid arithmetical errors in the process of updating versions of the Purple Book.
8	Undertake further analysis of CAPEX associated with scheme enablers such as property purchase and noise insulation scheme as the masterplan design develops.

## 3 Scope of Work, Approach and Methodology

### 3.1 Introduction

Our scope of work in relation to this report is to capture, analyse and provide assurance that the expansion plans of HAL are 'cost efficient'. The purpose of the cost efficiency review is to enable the CAA to advise the DfT on the cost efficiency of the HAL Expansion Programme by providing high quality, evidence-based advice using benchmarking and data analysis techniques.

This report builds upon and supersedes an interim report provided by Arcadis and finalises the summary of the cost efficiency review of Heathrow Airport Limited (HAL) Integrated Baseline Purple Book 0.61 (Purple Book).

Arcadis are aware and appreciate the developing nature of the programme and in accordance the iterative approach to the Purple Book. Notwithstanding the recommendations contained in sections 2.2 and 2.3, Arcadis do not propose any further detailed review of the Purple Book 0.61. We propose a future review of revised and updated versions of the Purple Book and that this report and supporting analysis will act and provide a point of reference for that future review.

Given the scope of the cost efficiency review, Arcadis submitted formal information requests to HAL to gather data and supporting evidence necessary to inform our analysis and advice to the CAA. Arcadis notes that whilst information has been provided, some documents remain outstanding as listed in Appendix A (section 10.1) and have not formed part of our analysis and assessment. Arcadis feels that while the majority of the outstanding information would not materially impact our conclusions, we would welcome the opportunity to review the assessment of the property costs and the HEP risk registers in particular. Arcadis also consulted publicly available information related to the expansion programme. In addition to the review of documentation, Arcadis has enjoyed ongoing engagement and meetings with HAL and that interaction to date has been of a productive nature.

### 3.2 Summary of our approach

Arcadis has analysed both the information contained in this version of the Purple Book as well as HAL's approach to collating that information. To do this we initially reviewed the Purple Book in its totality and subsequently undertook a further study whereby we interrogated the indirect costs in more detail.

For the overall review we looked at HAL's approach to the following key elements of the CAPEX plan:

- **Scope capture** – To ensure all relevant elements are considered.
- **Quantification** – Assessing the amount measured, the basis of the measurements and the extent of work where quantification has not yet been undertaken.
- **Pricing** – Where this is based on benchmark data and where it is benchmarked.
- **Benchmarking** – Analysing the depth and relevance of sample base analysed.
- **Project specifics** - Costs associated with working on this programme specifically. E.g. constrained working, airside working, phased delivery and logistics.
- **Application of on-costs** – For design and HAL costs.
- **Risk** – Percentages applied and/or analysis of the risk management process.

Following the above analysis, we have then looked at the indirect costs, undertaking a study referred to as 'Pound in the Ground' which analyses net construction costs compared to final costs to a client. This looks to understand how efficiently the works are being delivered.

This has then been benchmarked against both other aviation programmes and infrastructure sectors to understand how efficiently HAL will be delivering this programme of works.

In this report we refer to some of HALs activities as being ‘best practice’. In this context we use this term to describe ‘commercial or professional procedures that are accepted or prescribed as being correct or most effective’. This is Arcadis’ view, given our deep aviation sector experience and drawing from lessons learnt across other capital-intensive industries (e.g. rail, highways, energy, utilities, etc.). In this report we differentiate the design of best practice methodologies, from the implementation and operation of commercial or professional procedures.

- Further clarification is required on the application of project specifics. It is recommended that these are broken down by facility level that unique facility and programme characteristics are taken into consideration.
- However, we understand given the application of these project specifics HAL has considered the considerable challenges of working in a live operational airport environment.
- Clarification has been provided by HAL as to why there is a difference of £[redacted]m between the hard copy and electronic versions of the Purple Book. We understand this was an arithmetic error and that HAL has addressed this issue in the later versions of the Purple Book. Our recommendation is that HAL should have structured and robust check mechanisms in place to avoid such errors in the future
- Back-up calculations should be included in the appendices of the IFS report to assist the audience in its understanding of the basis of the recommendations for cost variances in the Purple Book.

### 3.3 Information Requested and Reviewed

Given the scope of the cost efficiency review, Arcadis submitted formal information requests to HAL to gather data and supporting evidence necessary to inform our analysis and advice to the CAA.

A summary of the information requested is summarised as follows:

- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>• Masterplan layouts and Scheme Development Process.</li> <li>• Detailed designs for specific sprint studies.</li> <li>• CAPEX plans for sprint studies.</li> <li>• Supporting measurements.</li> <li>• Benchmarking data and details of methods of application.</li> <li>• Programme and Phasing strategy.</li> <li>• Delivery Report.</li> </ul> | <ul style="list-style-type: none"> <li>• Risk Register.</li> <li>• Reports from IFS.</li> <li>• Work Breakdown Structure.</li> <li>• Purple Book and associated supporting documents.</li> <li>• Governance process documents.</li> <li>• Integrated Design Team Procedures.</li> <li>• Evaluation Criteria.</li> <li>• Presentations to Airlines.</li> </ul> |
|---|---|

Further details of documentation requested has been included in Appendix A of this report.

Arcadis notes that whilst information has been provided, some documents remain outstanding as listed in Appendix A and have not formed part of our analysis and assessment. Arcadis feels that while the majority of the outstanding information would not materially impact our conclusions, we would welcome the opportunity to review the assessment of the property costs and the HEP risk registers. Nonetheless, we feel this report provides an appropriate review and analysis of the information that was made available and we reference those documents reviewed throughout and as such has not materially affected our conclusions.

This Final Report addresses the outstanding areas in the Interim Report where the level and depth of the Arcadis review was constrained due to the date and timing of information becoming accessible.

## 4 Engagement Overview

To become familiar with HAL's proposals and for the benefit of context regarding capacity expansion, reviews of publicly available information such as those on HAL's website, the Airports Commission materials and relevant CAA documents have been performed.

In addition to the review of documentation, Arcadis has enjoyed ongoing engagement, meetings and workshops with HAL (and the CAA) to obtain relevant information and data on the HAL Expansion Programme.

HAL has also produced a variety of documents where it formalises its approach to the development of its expansion programme. However, we have not seen any evidence to date that these documents have been included in a structure which lends itself to being easily understood by the internal HAL team and external stakeholders. Arcadis would recommend that such a structure is adopted in the subsequent months to aid the review of information by the various stakeholders likely to be engaged and interested in the future.

Arcadis believes it is worth noting that the meetings to date with HAL have been of a productive nature and the exchange of information and response to queries has been direct and forthcoming in general. In the future, Arcadis believes that further meetings between the CAA, Arcadis and HAL will be more topic and query specific and that a structured and planned approach to engagement, in line with an agreed scope of review, will continue to enable an effective and detailed assessment of matters.

## 5 Cost Efficiency

### 5.1 Introduction

The purpose of the Cost Efficiency Review is to enable the CAA to assess the cost efficiency of the HAL Expansion Programme by providing high quality, evidence-based advice using benchmarking and data analysis techniques.

As described in detail in section 1.1 our review was based on HAL Integrated Baseline Purple Book – Baseline 0.61. The Purple Book categorises the overall cost into the following two main categories:

- Direct costs.
- Cost adjustments.

The direct costs have been built up by the abstraction of quantities, where possible from the design, or as advised by the design team and relevant rates applied to these. Some rates are benchmarked against previous projects and others are assessed using professional judgement. The drawings and associated design information is reviewed to ensure full capture of all scope.

The cost adjustments are further split into subcategories as follows:

- Project specifics.
- Leadership and Logistics (L&L).
- Preliminaries.
- Design.
- Overhead and Profit (OHP).

/Risk is shown at Level 2 summary as P50 risk at project level and P80 risk at the programme level. This is consistent with similar programmes. For information, this is included in section 6.8.

Based on how the Purple Book is structured, our review was divided between Direct Costs Efficiency Review and Indirect Costs Efficiency Review. Direct costs and Project specifics were reviewed as part of the Direct Cost Efficiency review, whereas the remaining components of the cost adjustments are reviewed in the Indirect Cost Efficiency Review. Details of these reviews are included in sections 6 and 7 below.

The IFS has also performed a review of the Purple Book, the results of which are documented in their report named 'Baseline Cost Estimate (Purple Book) Review', from July 2017. We have reviewed their report and our comments are included in section 8 of this report.

A combined section with recommendations and next steps from both reviews is included in section 9.

### 5.2 The Purple Book

The first step in the cost efficiency assessment is to understand the structure of the Purple Book and how information flows into the document.

The Purple Book contains HAL's planned investment relating to the 2R and 3R development masterplans as well as overlap costs required to enable distinctions to be made between 2R and 3R separate totals, costs associated with surface access and 2R commercial opportunities. This is also where HAL maintains its Integrated Baseline Costs for the Expansion Programme.

The Purple Book uses an Asset Breakdown Structure (ABS) to breakdown costs into six programmes and capture costs at facility level, as shown in the table below:

ABS	Description	Direct Costs (£M)	Cost Adjustments (£M)	Total Costs (£M)
H2R	Heathrow 2R Programme			
H2X	Heathrow 2R_3R Overlap			
H2Y	2R Commercial Opportunities			
H2Z	2R Q6 Overlap			
HEM	Heathrow Expansion Surface Access			
HEP	Heathrow Expansion Programme			
	Total			

Table 1: Purple Book Asset Breakdown Structure

Arcadis was provided with both a hard copy and an electronic copy of the Purple Book and performed a reconciliation between the two documents. The reconciliation identified a difference of [REDACTED]m in cost adjustments; as shown in the table below:

Item	Description	Direct Costs (£m)	Adjustment Costs (£m)	Total Costs (£m)
1	Purple Book 0.61 Hardcopy			
2	Baseline 0.61 Extracted to Excel			
	Difference			

Table 2: Purple Book Electronic/Hard Copy Comparison

This difference has also been identified by the IFS in its review of the Purple Book. It is important that we review this difference with HAL to ensure the accuracy of our review of the costs.

There are also unit rate errors in the electronic version of the Purple Book such as for the H2R and H2X car parks, where false unit rates are shown against multiple items. This is not observed at the hardcopy version.

We understand that HAL has addressed this issue in the later versions of the Purple Book.



## 6 Direct Cost Efficiency Review

### 6.1 Context and Approach

The Direct Cost Efficiency Review focused on providing assurance over Direct Costs and Project Specifics for the facilities within the Purple Book by reviewing the cost estimating and benchmarking processes in line with best practice.

The following procedures have been performed:

- Review of HAL estimating procedures available to date.
- Review of HAL estimating benchmarking procedures.
- Direct Cost review including the Purple Book build-up, quantification, base pricing, and project specifics.
- Benchmark analysis.
- High-level overview of procurement strategy, delivery strategy and risk; and assessment of their impact on cost efficiency.

The estimates within the Purple Book inform the budget and affordability of the HAL Expansion Programme and they also serve as baseline for the different masterplan options currently under analysis by HAL. This section and the following sub-sections in detail aims at providing the CAA with the assurance over the cost estimates included within the document.

### 6.2 Estimating Procedures

#### 6.2.1 Process

A cost estimate is built upon three pillars; the base cost, associated risks, and programme impact. These factors must be considered in parallel to truly and accurately estimate the cost of a project, rather than independently. This is called integrated estimating process.

The process can be expressed in a linear representation of best practice for delivery of a project. This should provide the commercial advice upon which business decisions can be made.

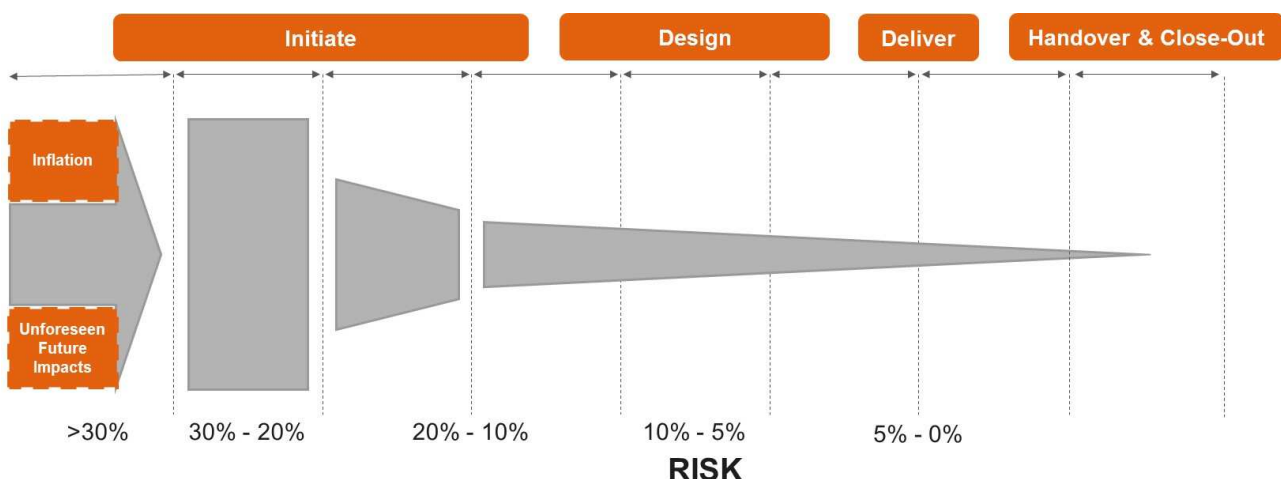


Diagram 1: Project Risk Process Map

As with any process of estimating and information management, the accuracy of the outputs will only be as good as the brief, the detail available and the professional application of appropriate techniques. If there is little base information, the quality and maturity of the outputs will reflect this. The conceptual stages of a project are particularly sensitive to this challenge. HAL are currently still in the initiate stage, hence the P50/80 risk converted to a percentage remains high which is reflected in their allowances within the Purple Book. This is reviewed in detail in section 7.8 of this report.

Therefore, it is critically important to be clear on the 'Basis of Estimate' that will support the cost estimates at each point through the programme / project stages. In our review of the Purple Book, we have observed that, although some items are accompanied with more detailed description and notes, these remain to be captured in a structured manner in a 'Basis of Estimate' section for clarity.

Guidance notes, such as a 'Basis of Estimate', are a framework for expressions of professional advice. In an environment as diverse as an international airport there will, on occasions, be alternative solutions. As HAL is looking at various masterplan assembly options with variable cost impact, it is crucial to locate these within the cost estimate document. Whilst the outputs and data requirements are fixed, how they are established may use alternative techniques to those noted.

Although the structure of the Asset Breakdown Structure (ABS), fairly detailed requirement summary and where applicable a reference to the schedule and change log as shown in Figure 1 all suggest that best practice estimating procedures have been used by HAL in the build-up of costs for the Purple Book, Arcadis has not had visibility of these procedures and is unable to provide a comprehensive assessment at this stage.

Requirement Summary:			
<b>Taxiways</b>			
A & B Taxiways Relocated To East of T2C : A & B taxiways are reconfigured at the Eastern end in order to create the site for T2C.			
New Rapid Exit Taxiways: 4 No. existing Northern Runway to Alpha Taxiway.			
Northern Alpha taxiway and remainder of Bravo: Upgraded to Code F of raining areas of Alpha and bravo not previously alter to Code F.			
Northern Holds: Northern holds is altered to eliminate dependencies on Taxiway Alpha 123 improving resilience and facilitating the Taxiway E & F: Taxiways altered in two phases to facilitate the construction of T2D and T2E.			
<b>Change Log:</b>			
B'line	Group	Description	Decision
0.6	H2R - New RET's (No.4) to existing northern runway to Alpha Taxiway (Step 1)	Now included in H2R having been previously excluded from scenario 7/business case pack.	Agreed
0.61	H2R - New RET's (No.4) to existing northern runway to Alpha Taxiway (Step 1)	Now included in H2R having been previously excluded from scenario 7/business case pack.	Agreed
<b>Schedule Dates:</b>			
<b>Activities:</b>			
P6 Activity ID	Activity Name	Start	Finish
	Northern Alpha taxiway and remainder of Bravo upgraded to Code F (T2 A)	10/01/2020	19/09/2022
	Northern Runway RETS reconfiguration	19/09/2022	28/08/2024
	EMB WS 5 - Alpha & Bravo Taxiway Reconfigurations	16/05/2023	23/12/2027
<b>Estimate:</b>		<b>Direct Cost</b>	<b>Cost Adjustments</b>
<b>Taxiways Total:</b>			<b>Total</b>

Figure 1: An example page from the Purple Book

Whilst analysing the individual rates, we identified for example a Control Tower rate that is significantly different than the associated benchmark in the Purple Book. HAL confirmed that the difference in rates is due to a newer assumption of a remote tower, whereas the Purple Book still indicates as a virtual tower. The 'Basis of Estimate' section would capture these and hence prevent any misalignments moving forward.

We are aware that HAL is working on the next version of the baseline and we recommend that a 'Basis of Estimate' section is included to enable a more detailed review in the future.

## 6.2.2 Maturity

An integral part of the estimating process is undertaking a maturity assessment. The maturity of the information is key to understanding the detail and method by which way the estimate is developed. As it matures, a superior scope definition of a project emerges, and the risks of the project also become more evident and clearly defined. Greater risk certainty permits the risk allowance to be reduced. Mitigation actions can be undertaken to reduce impact of risks inherent in a project unless they are engineered out by design.

To assess the reliability of the information and consider next steps, it is regarded as best practice to view the maturity of the information in the first instance. Although acknowledged as a subjective matter, a scoring system which rates the four elements of an estimate (Scope; Cost; Risk, and Programme) 1 to 5 against descriptive criteria is recommended to provide a common basis. We cannot confirm whether HAL used this or a similar scoring system to rate the maturity of the estimates within the Purple Book and further discussions with HAL are proposed.

We understand that the different sections of HAL's Purple Book estimate have variable levels of maturity because of ongoing sprint studies and in-depth reviews. We recommend that HAL put a structure in place to capture and incorporate these into the baseline and that this forms an integral part of the Purple Book.

Arcadis' view is that the risk level of the Expansion Programme depends on the robustness of the estimating procedures and the maturity of the estimate and therefore recommend that HAL include this explicitly and it is as an area of focus in a future review of the Purple Book.

## 6.3 Estimating Benchmarking Procedures

### 6.3.1 Process

Projects or programmes can become overly design-led and focused on preferential features and aesthetics at the expense of optimising functionality, commerciality, benefits and return on investment. This can lead to a lack of focus on the key cost and value drivers and a lack of clarity on how to optimise the business and benefits case leading investment decisions to become misaligned with the value to be derived from them.

Adopting a *Should-cost* Modelling approach using key cost and asset specific spatial and performance benchmarks to inform the design and delivery approach is essential. This provides clarity on the impact of site / project specific issues, optimises the design solution and has the potential to maximise the returns on investment. In the future, we would recommend and expect HAL to adopt a *Should-cost* Modelling approach.

Cost benchmarks, by definition, are the analysis of historical data adjusted for known variances to provide an indication, at high level, of the likely cost of a similar product if replicated at a given time and location.

Most benchmark rates can be built up from individual components and the total divided by the measurement unit (e.g. m<sup>2</sup> or m<sup>3</sup>). Once the total costs of all components are established, a whole asset can be broken down into units and multiplied by the benchmark rate to yield total costs. For example, the total cost of a car park divided by the total number of car parking spaces would give a cost per car parking space. This unit cost is then compared with other similar examples and industry standards to assess cost efficiency.

### 6.3.2 Review of Heathrow's Benchmarking Approach

HAL provided Arcadis with two benchmarking reports. A review of these procedure documents and the backup spreadsheet which are listed below form part of the scope of this final report:

- Heathrow Baseline History – For Discussion with CAA, 5 July 2017
- Heathrow Turner & Townsend Expansion Benchmarking, Draft version 1.1, April 2016
- Agreed Benchmarks April 2016 – Excel spreadsheet

The Heathrow Baseline History report details the context around the evolution of the Purple Book and covers the following key points:

- What scope is contained within the HAL submission to the Airports Commission, expansion and core CAPEX (2R masterplan).
- Evolution of the Purple Book from version Baseline 0 to Baseline 0.63, albeit that this review is on version 0.61, providing commentary of movement.
- Details benchmarking supporting information, and analyses extent of benchmarking within the Purple Book and how this has increased from Baseline 0 to version 0.61.
- Defines the process of benchmarking, collecting data, analysing and adjusting.
- Demonstrates how the data from T5 and T2 has been normalised. Provides terminology definitions for base costs, project specifics, leadership & logistics and net construction costs.
- How the programme development, baseline strategy, schedule and estimate maturity will be linked.

The Heathrow Turner & Townsend Expansion Benchmarking report details specific benchmarking approach, covering in detail:

- Objectives and methodology of benchmarking.
- How the costs are analysed and how they are stripped back to a net construction cost plus preliminaries and overheads and profit (OH&P) to generate a Base Cost. The Base Costs exclude project specifics and leadership & logistics.
- How the benchmarks are uplifted to the current cost base date.
- Data around the percentage of the CAPEX which has been benchmarked and the number of projects which have been analysed for each facility.
- Benchmarks are also included for OH&P, preliminaries and leadership & logistics.
- Detailed commentary around the results of the terminals, satellites, multi storey car parks, baggage, taxiways, bored tunnels, cut & cover tunnels, highways, stands, runway, control tower, surface parking, decked parking and control posts data analysis.

These documents show that HAL have designed best practice principles through normalising relevant benchmark data, in the development of the Purple Book, although as noted below they have not always implemented these principles correctly.

The reports demonstrate that they have taken final out turn costs from similar projects, stripped out any elements which were specific to the project being analysed, stripped out any elements which aren't determined on a £/m<sup>2</sup> basis, i.e. baggage, vertical circulation cores for the nodes to form a 'typical base cost' for similar projects. They then detail how they have uplifted the costs from the date of the specific project to the base date for the 3R CAPEX plan and what indices have been applied to undertake this.

As these are published in different timescales, the earlier draft refers to Baseline 0, whereas the Baseline History document compares the baseline with the Purple Book 0.61.

In addition to these, Arcadis has also requested the backups to the stated benchmarks in the Purple Book as how these are normalised. These additional documents are listed in Appendix A.

Whilst we believe that this backup information is valuable and forms a good basis of discussion, we have proposed the following actions:

- The inclusion of how all the benchmarks rates are normalised within the Purple Book. Currently, there is no structure to these, as this information is spread across various reports and spreadsheets.
- A series of normalisation techniques have been applied to the data for the Terminals and Satellites analysing T2 and T5 costs. The normalised numbers, however do not match with those in the Purple Book. We recommend HAL to fully align their rates and assumptions across a range of documents to ensure consistency.
- HAL to look at external benchmarks in addition to the T2 and T5 for the Terminal and Satellites and identify potential areas for improving cost efficiency.

- The normalisation of all benchmarks. In some instances, the benchmarks have not been cleared of project specifics, such as working in a live operational environment, this should not be used to justify the differences in rates, all benchmarked rates should be normalised. (i.e. Reinforced Concrete MSCP – Per Space: “BL0 is an extension of an existing facility in live operational T5 MSCP which helps to explain the higher rate” as mentioned in Expansion Benchmarking document draft v1.1 issued in April 2016).
- Consolidating the supporting documents into the Purple Book for a streamlined change control. We identified that the unit rate for the runways in Purple Book is in line with the Expansion Benchmarking draft v1.1 April 2016, however the rate in the Agreed Benchmarks April 2016 spreadsheet is different than others.
- Review of runway and/or shoulders rates. The unit rate used for both the runway and the shoulders is the same. Runway shoulders typically have a lower load bearing capacity and hence a lower CAPEX, therefore an opportunity to reduce this rate exists subject to further analysis.
- Address additional concerns such as extra allowance for the roof design of the satellites need to be justified. The cost impact of this 5% minor adjustment to the benchmarks is a ■■■m direct cost in the Purple Book.

## 6.4 Direct Cost Analysis

This section provides an overview of the direct costs and the project specifics covered in the Purple Book with regards to quantification, benchmarking and consistency of their application across facilities and programmes.

### 6.4.1 Benchmarking Approach and Analysis

In developing our approach, we have divided direct cost into two main categories:

- Net Construction Costs.
- Scheme Enablers.

Net construction costs are directly related to the provision of airport capacity and associated construction activities not necessarily specific to Heathrow. These are typically found in infrastructure and airport projects and as such can be benchmarked against various examples both in the UK and internationally. Location factor indices can then be applied to adjust the agreed benchmark rate to take account of local cost influences in the London region.

Scheme enablers are related to pre-construction, environment and community; and are typically project specific costs, unique to the location and project characteristics, such as the requirement of property purchase, levies, environmental mitigation measures outside project boundaries and re-provision or enhancement of community assets.

Each of these categories are broken down further into sub-categories across six different programmes encompassed in the Purple Book. We have then consolidated similar facilities across these programmes to have a holistic view within this final report. Detailed analysis on the programme basis can be found in the appendices of this report, including HEP which has already been covered in the interim report.

The complete facility level breakdown of these categories is detailed in the table below:

Category	Sub-Categories
Net Construction Costs: (Base Construction Costs less; Contractors Preliminaries, less Overhead and Profit)	<ul style="list-style-type: none"> <li>• Enabling Works (Site Preparation, Demolition)</li> <li>• Airfield (Runways, Taxiways, Aprons, Stands, Airfield Instrumentation, Earthworks and Landscaping)</li> <li>• Airside Facilities (Airside Roads and Tunnels, Automated passenger mover (APM), Baggage Tunnels, Noise Control, Security, Surface Water)</li> <li>• Terminals and Satellites (Terminals, Piers, Satellites, Baggage Handling System, Energy Centre)</li> </ul>

Category	Sub-Categories
	<ul style="list-style-type: none"> <li>• Roads and Car Parks (Multi-Storey and Surface Car Parks, Airport Roads, Local Roads, Highways, Rail)</li> <li>• Utilities</li> <li>• Operational Readiness</li> <li>• Water Course Diversions</li> <li>• Archaeology and Ecology</li> </ul>
Scheme Enablers: Pre-Construction, Environment and Community	<ul style="list-style-type: none"> <li>• Land Purchase</li> <li>• Compensation / Blight</li> <li>• Levies &amp; 106 Agreements</li> <li>• Equipment</li> <li>• Obstacle Clearances</li> <li>• Environmental Mitigation</li> <li>• Temporary Facilities</li> </ul>

Table 3: List of Cost Sub-Categories

Due to their nature, a benchmark analysis is not envisaged for the scheme enablers, consisting of pre-construction, environment and community costs. However, given the significance of these costs, we recommend that additional reviews of these costs are undertaken due to their potential impact in the level of accuracy of costs within the Purple Book.

The cost breakdown between the Net Construction Costs and Scheme Enablers is shown in the below table:

Purple Book (Direct Cost)	Value (£m)	%
Net Construction Costs	£ [REDACTED]	71 %
Scheme Enablers	£ [REDACTED]	29%
<b>TOTAL (£m)</b>	£ [REDACTED]	<b>100%</b>

Table 4: Purple Book Direct Cost Breakdown

## 6.4.2 Benchmarking Levels

The level of benchmarked costs has a direct impact on the level of accuracy of costs contained within the Purple Book. Where benchmark rates cannot be obtained, it is important to understand the process for deriving the estimate and the assumptions applied in the estimation.

HAL has adopted several benchmark references and rates to increase cost certainty of specific elements within the Purple Book. In total, 24 benchmark references have been used to substantiate 136 items in the ABS across five of six different ABS Level 1 Categories. This equates to 30% of the direct costs by value ( [REDACTED] bn of £ [REDACTED] bn) leaving circa £ [REDACTED] bn 70% that has not been benchmarked in the Purple Book.

Based on experience we believe this percentage to be low and it is therefore recommended that further benchmarking is performed by HAL. We also note that this has been highlighted by the IFS in the report on the review of the Purple Book. Arcadis expects HAL to set a roadmap shortly with fixed timeframes for providing quantification and benchmarking studies for the not benchmarked and not measured items.



Diagram 2: Breakdown of item number

In the Purple Book the direct cost equals £ [redacted] m and 2,483 individual rows in total. 1,861 of these have costs greater than 0, excluding risk.

A total of 136 out of 1,861 non-zero items are benchmarked, whereas the remaining 1,725 are not.

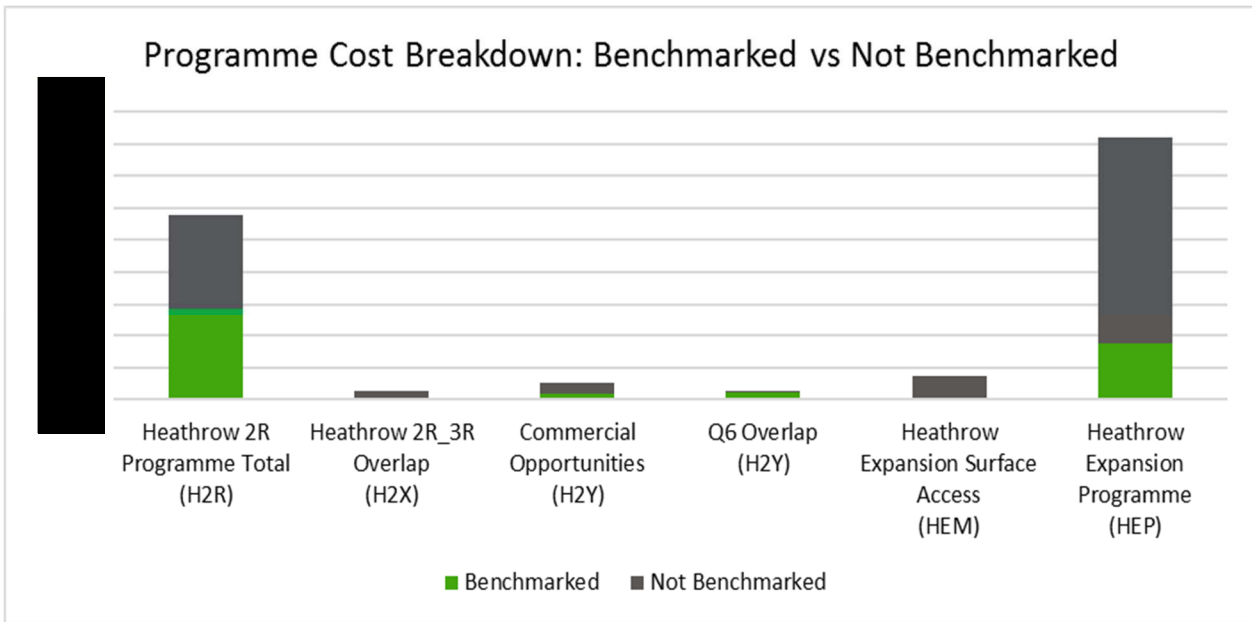
A further review of not benchmarked items shows that 472 of these items are not measured but based on allowances, sums, item(s) or percentages. These are mostly related to the scheme enablers such as the property purchase, noise insulation scheme, utility diversions, demolitions and disposal of contaminated material, planning approvals and operational readiness. These items add up to [redacted] on. Therefore, 34% of the Purple Book is not benchmarked or measured at this stage. The question is whether there are enough industry benchmarks to compare these allowances against, given the unique characteristics and of some high-value workstreams such as the property purchase. We recommend that these to be broken down into measured packages comparable to other examples for increased cost assurance.

The table below shows the benchmarked / not benchmarked breakdown:

Programme Description	Net Construction Cost (£m)	%	Scheme Enablers (£m)	%	Purple Book Total (£m)	%
Measured and Benchmarked		39%		0%		30%
Measured, NOT Benchmarked		43%		90%		36%
NOT Measured		18%		66%		34%
<b>TOTAL (£m)</b>		<b>100%</b>		<b>100%</b>		<b>100%</b>

Table 5: Purple Book Direct Cost Breakdown: Benchmarked vs Not Benchmarked

H2R, H2Y and HEP are the programmes with the highest utilisation of benchmarks, whereas no benchmarking is used for HEM as the graph below illustrates:



Graph 1: Programme Cost Breakdown: Benchmarked vs Not Benchmarked

Based on our procedures to date, we conclude that HAL followed best practice in providing an appropriate level of benchmarks. However, the percentage of benchmarked items within the Purple Book does not appear to be sufficient to provide reasonable assurance over the accuracy of costs. It is recommended that this is treated as an area of focus by HAL for the next baseline review.

We envisage further discussions with HAL around the non-benchmarked items in any next phase of the cost efficiency review.

### 6.4.3 Analysis of Project Specifics

Project Specifics are identified factors that characterise a base build project with details of a unique project. These are typically represented by logistic, location, extended time, phasing, and inflation factors.

The Purple Book has 297 individual estimates by group with direct cost values greater than zero. Each of these can be treated as an individual project with their unique considerations of design, construction and delivery strategy. Out of these 297 individual estimates by group, project specifics have been applied to 82 estimates, whereas 215 of these have zero project specifics in the Purple Book.

In our opinion, the allocation of these projects to one of the six Purple Book programmes has a considerable impact on the levels of project specifics. The following analysis by programme also support this view:

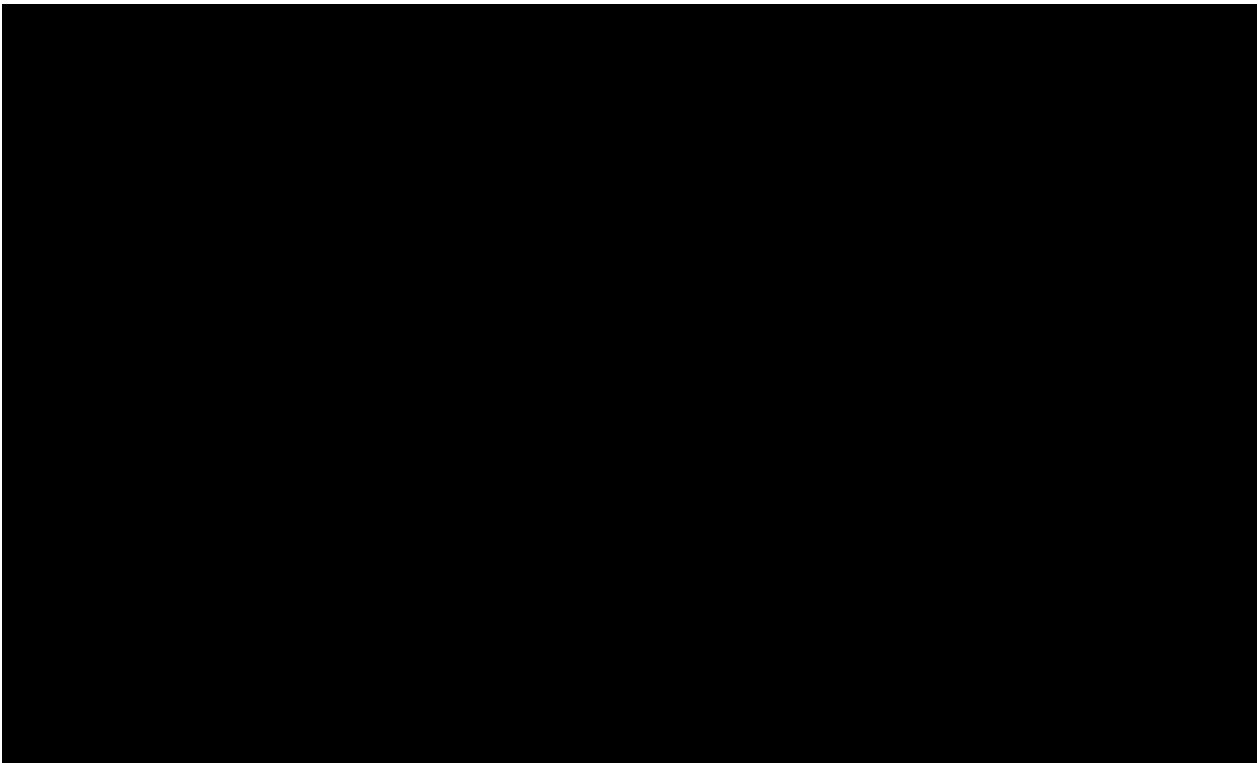
- H2R – 66 records
- HEP – 9 records
- H2X, H2Y, H2Z and HEM – 7 records in total

The above split clearly shows that there is a definite pattern of the application of project specifics to the H2R programme, which is mainly related to the existing airport and operating under live operational airport environment. Therefore, we understand HAL has considered the challenges of working in a live operational airport environment but recommend that a structured breakdown of project specifics is provided in the future.

Another important observation is that out of the 82 estimates by group, 73 records use the same 6.3% fixed rate regardless of the type of different facilities in the Purple Book. In our opinion, project specifics need to be applied based on the facility type such as the airfield, terminal or piers, APM, or baggage systems and the specific factors to which that particular facility is subject to, rather than simply using a 'blanket approach'.



The following graph illustrates the different levels of project specifics applications and compares these with the parent facility of the individual project:



*Graph 2: Variations of Project Specifics Percentages*

All in all, ████m project specifics equate to 3.2% of Net Construction Costs excluding the Scheme Enablers. This level of project specifics seems low given the live operational airport environment and logistical constraints. Furthermore, we have not been able to identify a structure showing how distinctly the project specifics are applied. These percentages also vary across similar facility types. For example, 25% for project specifics is applied to T2B and T2D TTS Station fit-out whereas 8% is applied to T2C. As the above graph shows, two of the outliers here are the HEP – MSCP Forecourts & Basement Car Parks with a project specifics rate of 49% and Baggage Tunnels Fit-Out with 164% of the direct cost. These merit attention.

In summary, the level of project specifics applied within the Purple Book seems low and we would like to understand the rationale underlying this. We recommend a further review is taken considering the following factors:

- Application of project specifics at facility level (i.e. terminals, taxiways, car parks).
- Considering the location and access requirements (within operational boundaries or unrestricted access).
- New build, extension of an existing facility or refurbishment / reconfiguration.
- Consolidation of direct cost phasing allowances in project specifics.
- Considerations of other schedules of activities with regards to phasing and delivery constraints (i.e. availability of material and equipment simultaneously for multiple projects in parallel).

## 6.5 Facility Level Benchmarks

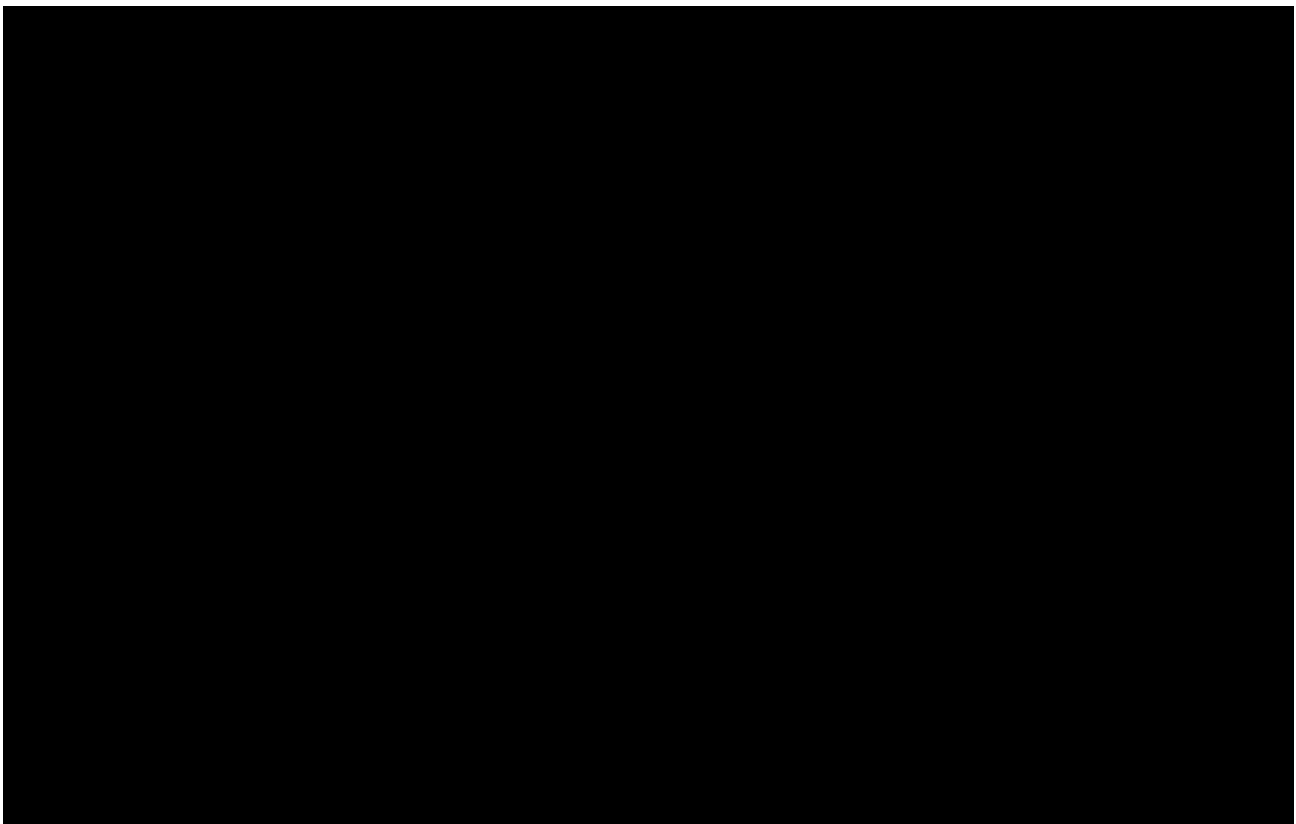
A key aspect of assessing the cost efficiency is how the implemented direct cost rates compare to those in other similar programmes of works.

Cost benchmarks, by definition, are the analysis of historical data adjusted for known variances to provide an indication, at high level, of the likely cost of a similar product if replicated at a given time and location.

Arcadis proposes the following facility level benchmarks to compare against Heathrow’s programme of works:

- Terminals.
- Piers and Satellites.
- Taxiways.
- Stands.
- Car Parking MSCP.

The following graph shows Base Construction costs broken down further by facility:



*Graph 3: All Purple Book Programme Benchmarking Breakdown per Facility (excluding scheme enablers)*

The above analysis shows that:

- Benchmarks are mainly concentrated in airfield, terminals and satellites, roads and car park facilities across the Purple Book.
- One-third of the Purple Book costs that are quantified are yet to be benchmarked.
- Sum/allowance/item(s)/% account 34% of the facilities and are not measured.

This analysis provides further evidence that additional benchmarking is required to provide reasonable assurance over the robustness of the costs within the Purple Book.

Further insight around quantification can be also be obtained from marked-up drawings, measurements and any associated back-up data from HAL and as such should be included in a more detailed review of cost efficiency of the Purple Book.

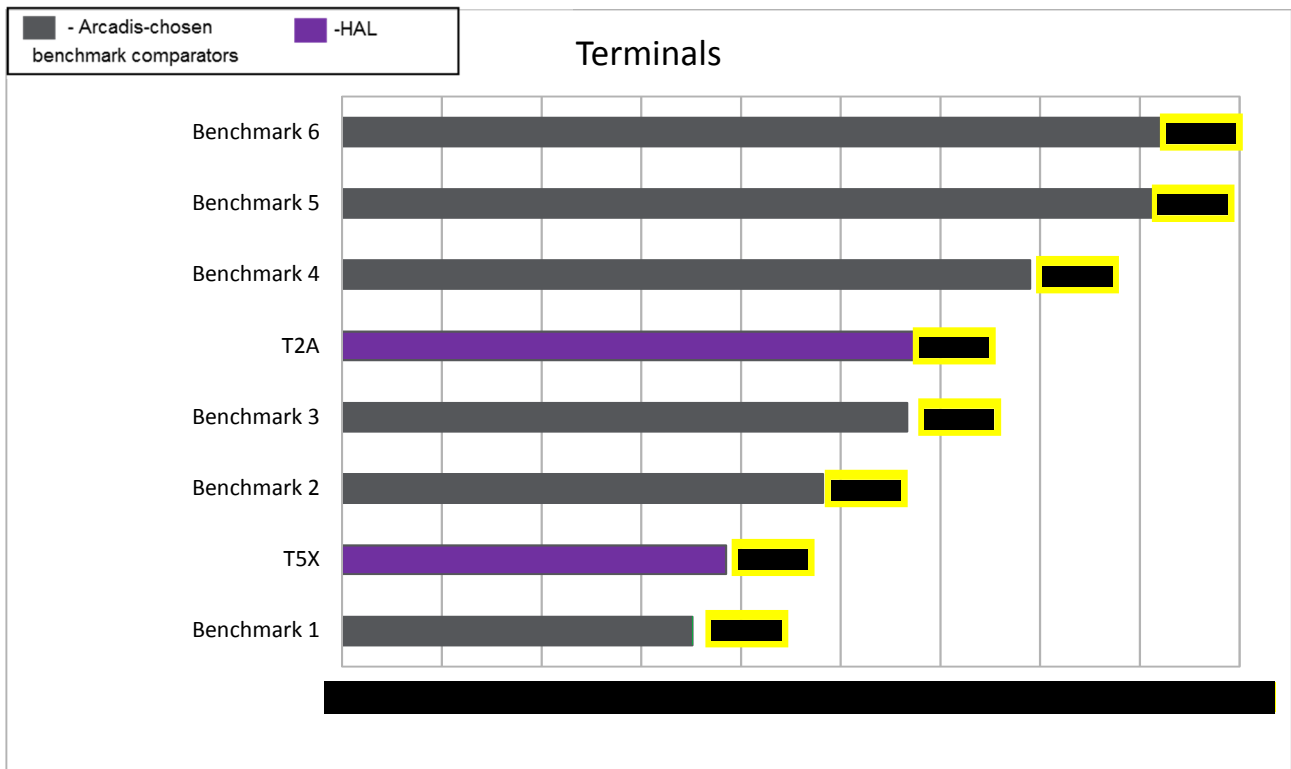
In the following sections Arcadis have compared the Heathrow benchmarks with the Arcadis benchmarks which include data from aviation organisations across the UK. The organisations were selected due to their capital programme objectives and characteristics being relevant to Heathrow. This is summarised in the table below:

Sector	Capital Programme Objectives and Characteristics	Relevance to Heathrow
Airports	<ul style="list-style-type: none"> <li>• Similar nature of projects</li> <li>• Projects are carried out in a complex live environment</li> <li>• Supply chain includes a number of specialised contractors</li> <li>• Projects tend to support strategic objectives around capacity and passenger experience</li> </ul>	<p>Airports included in the benchmark share one or more of the following characteristics with Heathrow</p> <ul style="list-style-type: none"> <li>• Operate in the same geographic environment</li> <li>• Shared controlling interest</li> <li>• Similar nature of facilities</li> </ul>

Table 6: Capital Programme Objectives

### 6.5.1 Terminals

Arcadis have compared the Heathrow benchmarking to the Arcadis benchmark data set. The source of Arcadis data is other UK airports whilst Heathrow have used benchmark data from the terminal developments related to the T2 and T5. The comparison shows that both terminals sit within the middle to mid-lower range of the benchmarks.

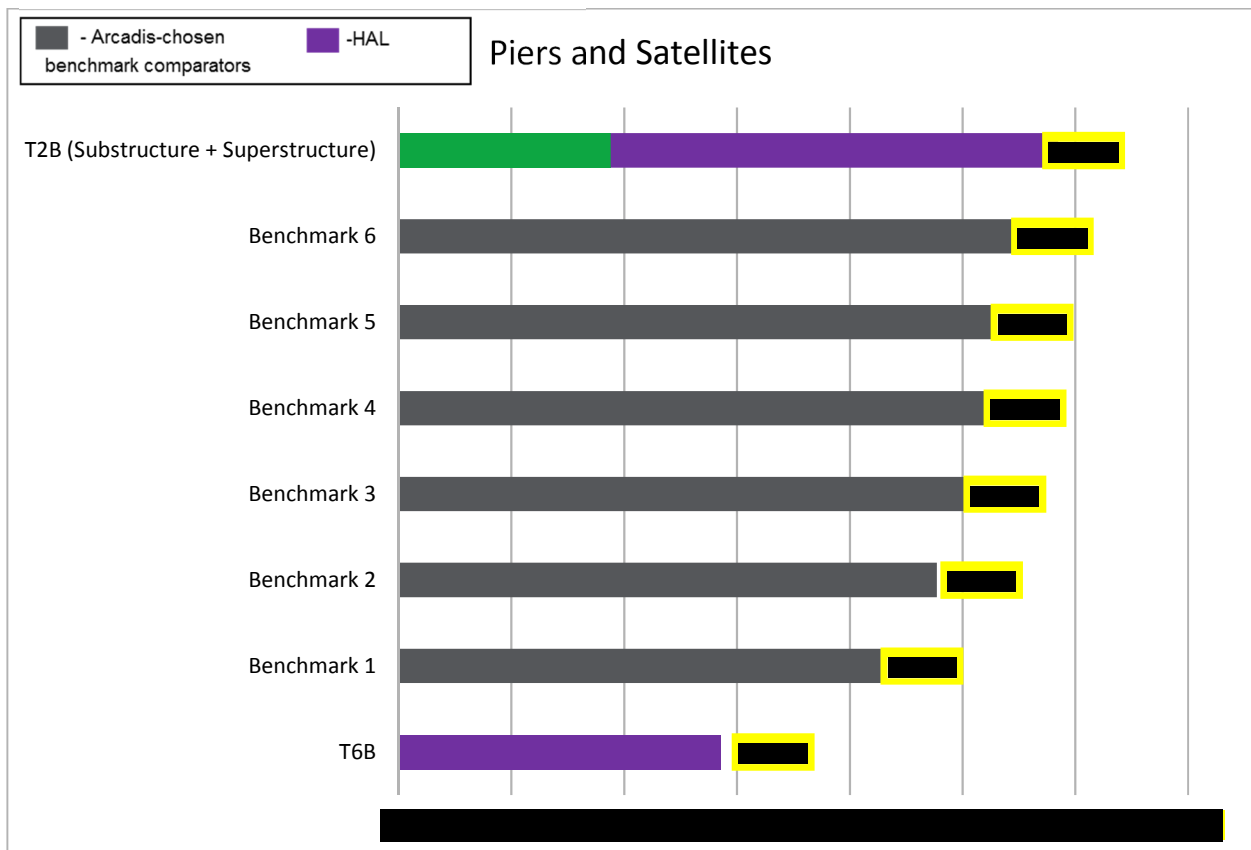


Graph 4: Terminal Benchmarks

The above benchmarks generally include the facility as a whole being constructed without abnormal restrictions or constraints. Benchmarks used by HAL as the basis of the direct cost assessment indicate that the proposals are likely to be cost efficient when compared to the wider data set compiled by Arcadis.

### 6.5.2 Piers and Satellites

Similar to the terminals, two different benchmark levels are used by Heathrow for the satellites. These are for T2B substructure and superstructure, and for T6B. Whilst T6B compares relatively lower to the other benchmark, T2B including the substructure as at the higher end of the spectrum. We recommend HAL to capture what drives these differences in rates in their assumptions.

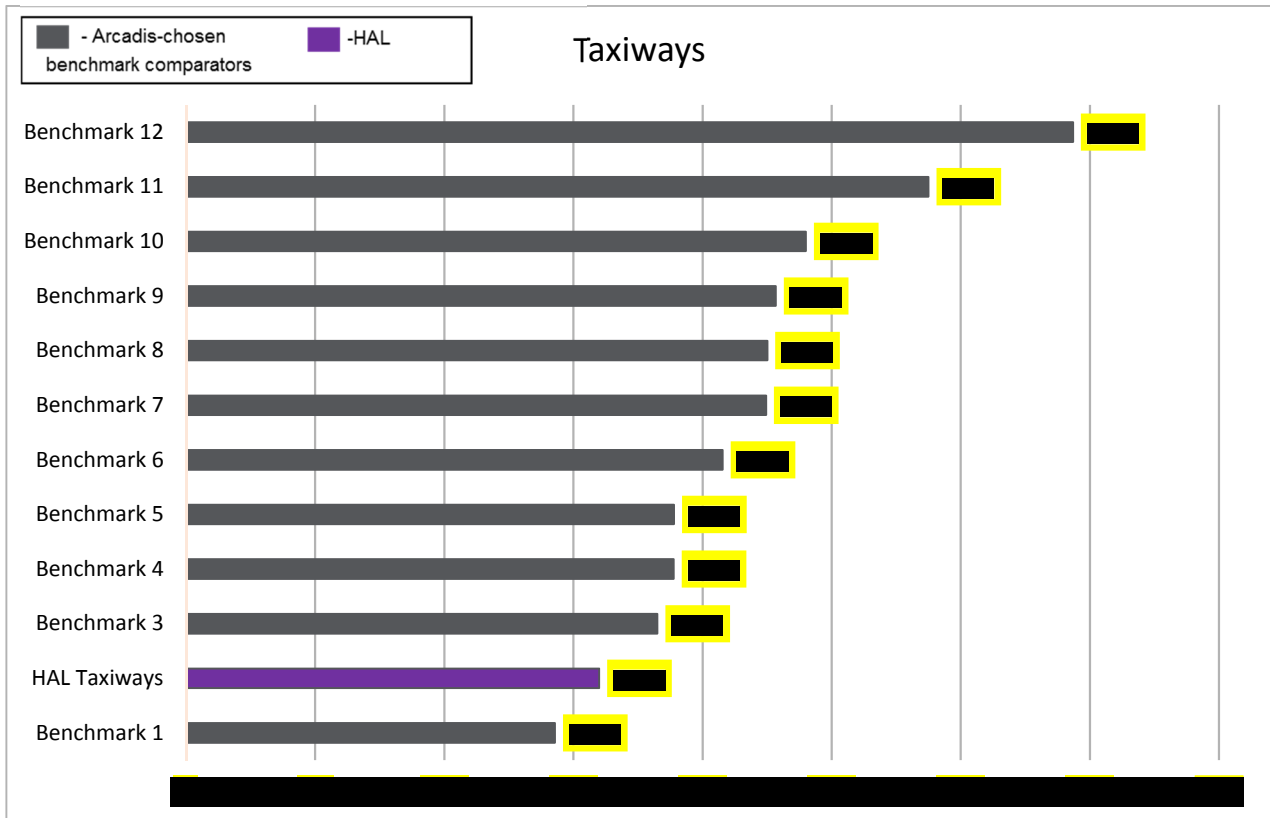


Graph 5: Piers and Satellites Benchmarks

### 6.5.3 Taxiways

As with other airfield works the costs of taxiways can vary considerably depending on the code of aircraft they are required to accommodate; extent of ground controls and lighting; in addition to the normal ground condition variances; locations and working restrictions.

The rate that HAL used sits relatively close to the lower end of the spectrum.



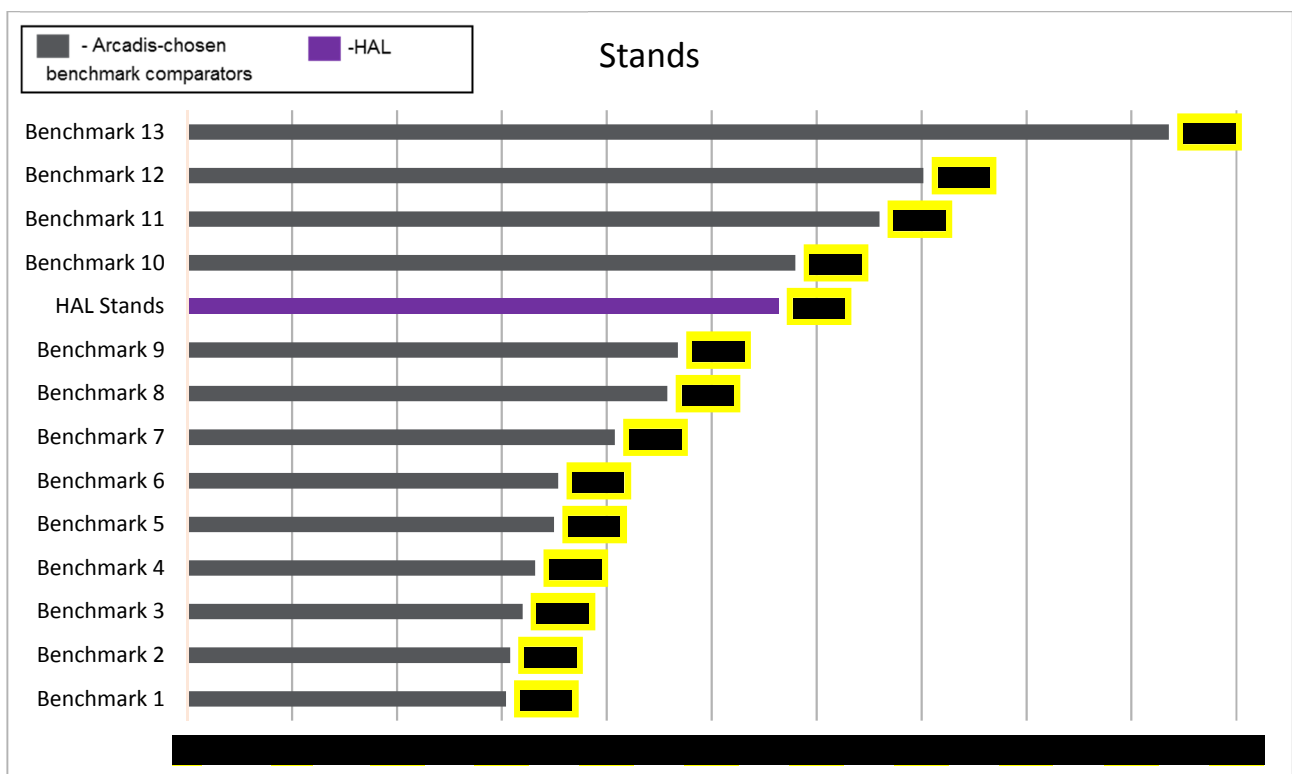
Graph 6: Taxiway Benchmarks

## 6.5.4 Stands

The construction of stands and the benchmarking thereof have a number of variables which affect the unit cost in benchmarking terms. These include:

- The extent to which the stands are serviced, the drainage requirements.
- The stand construction can vary depending on the aircraft size and loadings.
- Location can add a complexity and construction constraints.

In our analysis, we observe that Heathrow's selected rate is within the middle to upper-middle range of the benchmarks.



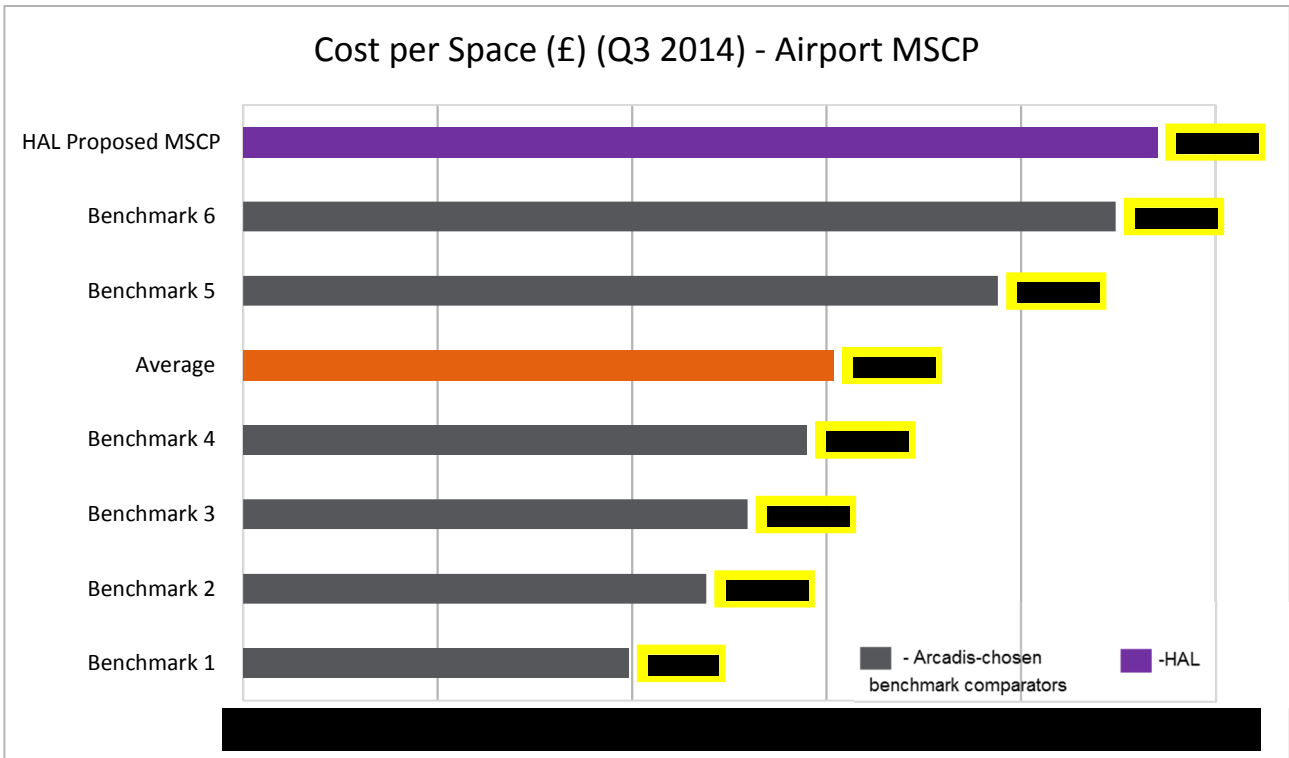
Graph 7: Taxiway Benchmarks

## 6.5.5 Multi-Storey Car Parks

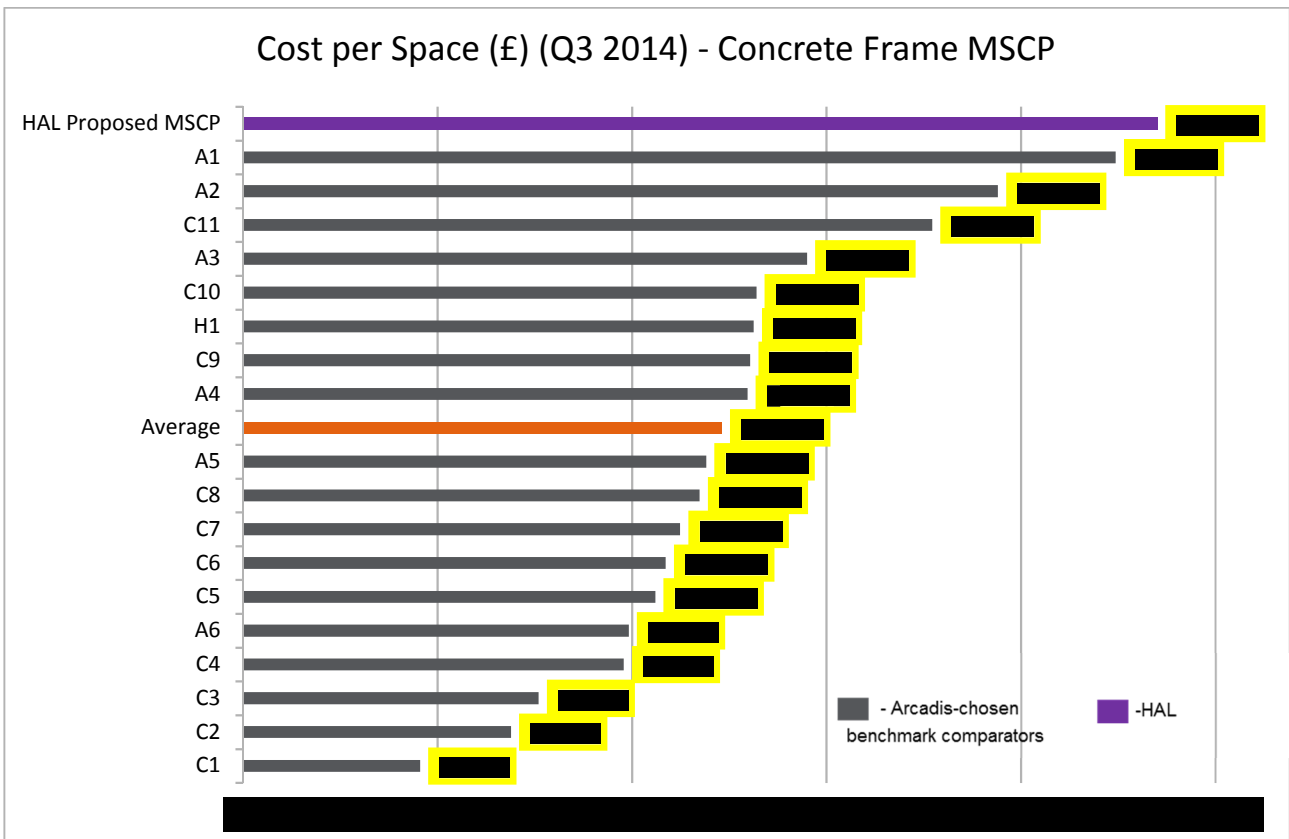
HAL has used a benchmark figure of [redacted] space for the reinforced frame MSCP (Base Date: 3Q14). We have compared this figure with other airport car parks and with other commercial car parks.

The direct comparison shows that the proposed MSCP is both the highest across airports and other facilities (see Appendix B4 for further details). It is understood that Heathrow's car parking specifications are one of the highest in the industry and this could help explain why HAL scores the highest in our benchmarking comparison. Another general cost driver could be the ratio of ramps and passenger lobbies to the parking bays.

Further analysis and discussion with HAL is advised to understand the basis of the used benchmark and to assess the reasonableness of the figure used, as on first inspection it appears inflated.



Graph 8: Cost per Space (£) (Q3 2014) - Airport MSCP



Graph 9: Cost per Space (£) (Q3 2014) – Concrete Frame MSCP

## 6.5.6 Conclusions of Benchmarks

The above analysis shows that HAL's benchmarks for the terminals, taxiways and stands compare relatively in the middle range to the industry benchmarks. This is not insignificant as these facilities constitute a majority of the expansion programme from a cost perspective. Efforts should be made therefore to understand the reasons why Heathrow are able to deliver these facilities at a comparable rate to other major aviation of capital development programmes and what lessons can be learned from that.

Two different benchmarks that are used for piers and satellites each comparing at the highest and lowest end of the industry benchmarks which require attention. We recommend HAL to put these benchmarks in context and also make use of external benchmarking data to ensure cost efficiency.

Multi-storey car park benchmarks show that HAL figure is the most expensive one both among airports and other commercial projects' benchmarks. At almost double the average benchmarked cost we feel this requires attention. Arcadis recommend that HAL substantiate the level of carpark design for these components to understand what is driving the high cost.

## 6.6 Procurement Strategy

Creating a procurement strategy with aligned objectives, incentives and outcomes has utmost importance, especially for a programme of this magnitude. It is the opinion of Arcadis that a detailed review of the Procurement Strategy and Supply Chain Management should be completed. This would also provide an opportunity to provide HAL with insight on best practice and to qualify a level of assurance regarding their plans for engagement and implementation.

From a cost efficiency point of view, the procurement strategy in place has direct impacts on cost and schedule.

The following elements are expected to be included in HAL Procurement Strategy and would enable an assessment on a cost efficiency basis:

- The method of procurement at facility level (i.e. competitive tender versus single sourcing): as well as increasing cost certainty this will allow rates to be flagged and adjusted in the event of a different procurement route being selected than that applying in the benchmark itself.
- Contracting strategy: this will provide assurance that the original strategic intent and risk management strategy is not diluted during the execution of the procurement plan, negotiations and execution of contracts.
- Tiering of the contractors and how Tier 1 contractors will be engaged with HAL around the Expansion Programme.

We are yet to receive substantial documentation with regards to the procurement strategy and the methodology of packaging of different contracts.

Therefore, this cost efficiency study cannot be included as part of our report and we would strongly advice that Procurement is identified for further investigation and assessment.

## 6.7 Delivery Strategy

The sequencing and grouping of various workstreams is one of the crucial cost efficiency drivers. It is therefore important to understand the phasing, logistics and schedule assumptions to assess various options. The robustness of these components at early stages will provide increased cost certainty around the programme of works.

These are covered to a certain extent in the Construction Delivery Review by MACE issued in February 2015 as part of HAL's submission to the Airports Commission which is in the public domain and the updated version issued in November 2015 which was made available to Arcadis subsequently.

As a high-level review, we have observed that the delivery report is focused on phasing, sequencing, and site logistics. There is also some initial information about packaging of the works. The appropriate selection of these will have a significant impact on the costs of the scheme.



Logistical constraints due to Heathrow’s geographical location and the scale of the development put additional stress on the programme. These are directly correlated with the project specifics, which can be quite significant for large-scale infrastructure projects.

Furthermore, we recommend that a comprehensive review be performed based on the latest delivery strategy and available report, as a further step. This will prevent the duplication of effort with regards to different versions of the same report.

## 6.8 Risk

We understand that the risk component of the Purple Book is based on the outputs of a Quantitative Risk Analysis (QRA). This analysis often uses simulation techniques known as “Monte Carlo Analysis (MCA)”. In this technique, risks captured in the “risk register” documents are assigned to the relevant activities with the likelihood of occurrence, time and cost impacts. A simulation model is run, and the key milestones are measured for confidence levels (P50 and P80).

We understand that HAL’s approach to risk is based on a combination of P80 at programme level and P50 at project level to account for risk and uncertainty. The difference between the P80 and P50 is held at the programme level, whereas P50 values are assigned to individual projects in line with best practice however, we await receipt of the documents before we are able to verify this.

It is important to understand the build-up of the risk register. However, at the time of this draft, the risk register was not made available to Arcadis by HAL. Therefore, a detailed analysis can only be undertaken after it is submitted.

In the meantime, we have performed a high-level assessment of the risk based on the maturity of the estimate and what it may be expected to resemble at this stage.

HAL signalled in various meetings that the Purple Book should be considered as a “capital investment plan” rather than a detailed cost plan, based on the detail and maturity of the estimates. Therefore, a sufficient risk allowance needs to be provided.

ABS	Programme	P50 (£m)	P50 – P80 (£m)	Total (£m)	% of Total
H2R	Heathrow 2R Programme				15%
H2X	Heathrow 2R_3R Overlap				N/A
H2Y	2R Commercial Opportunities				N/A
H2Z	2R Q6 Overlap				N/A
HEM	Heathrow Expansion Surface Access				19%
HEP	Heathrow Expansion Programme				18%
	<b>TOTAL (£m)</b>				<b>16%</b>

Table 7: Programme Risk Breakdown

The combined P50 and P80 risk and uncertainty equals to [redacted] bn, which is 16% of the overall [redacted] bn cost. The risk is only applied to the H2R, HEM, and HEP. Further information is needed for other programmes. The risk allowances being slightly higher for HEM and HEP programmes may be due to the typically higher risk allowances applied to the land acquisition and surface access schemes.

Most similar “mega” projects at this stage have a higher percentage allowance of risk, in line with HM Treasury’s Green Book Guidance advice on risk and optimism bias. In our view, we would encourage HAL to demonstrate how this guidance and industry best practice is taken on board to define the risk.

Given the limited amount of information available at this stage, a robust assessment of the existing risk allowance and HAL’s process for calculation has not been possible. But from the information we have reviewed our opinion is that HAL appears to be following best practice for risk allowances.

When more description about the criteria and application is received, we suggest a further detailed analysis based on individual facilities rather than advising an overall percentage for the entire set of the programmes.

## 7 Indirect Cost Efficiency Review

### 7.1 Context

To assess indirect cost efficiency, we have used an approach centred on 'Pound in the Ground' benchmarking assessment. Pound in the Ground provides an overview of the overheads and indirect costs associated with delivering capital assets – that is, how much it costs to deliver £1 of capital expenditure. This section of the report did not require an update between in the interim and final report. This was due to all additional information provided after the interim report’s completion was benchmark information on direct costs.

### 7.2 Benefits of Pound in the Ground

- Cross sector benchmarks: the size and scale of HAL Expansion Programme is unique. This means comparisons with projects and programmes in the aviation sector are limited. Pound in the Ground allows us to bring in benchmarks from other sectors, in and outside the UK, and as such we can compare the capacity programme with other major infrastructure programmes of a similar scale, size and complexity.
- Pound in the Ground can be tracked: using this initial study as a baseline, the Pound in the Ground score can be monitored as the masterplan progresses and throughout the lifecycle of the programme. As the capacity programme develops, more detail can be added to the Pound in the Ground calculations providing an updated and more accurate view of cost efficiency performance.

### 7.3 Pound in the Ground application at HAL

Direct costs are mostly influenced by market forces outside Employer’s (in this case, HAL) control whereas indirect costs are within the Employer’s control. Therefore, as well as providing a different perspective on cost efficiency, Pound in the Ground enables the identification of elements influencing cost efficiency and insight into how (if) or where improvements can be made in the future.

It also enables HAL to draw recommendations from top performers in the benchmark study.

### 7.4 Approach

The calculation requires all cost data to be grouped into four cost components:

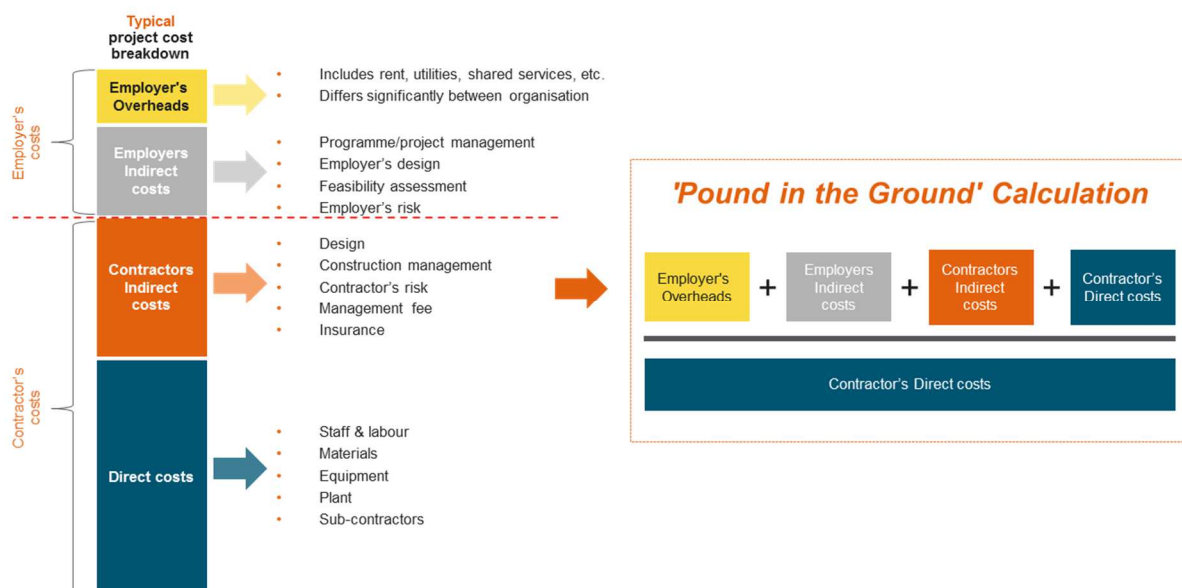


Diagram 3: Project Cost Breakdown

As a result of how HAL distributes the costs for the facilities within the Purple Book, Arcadis has classified each facility costs as follows:

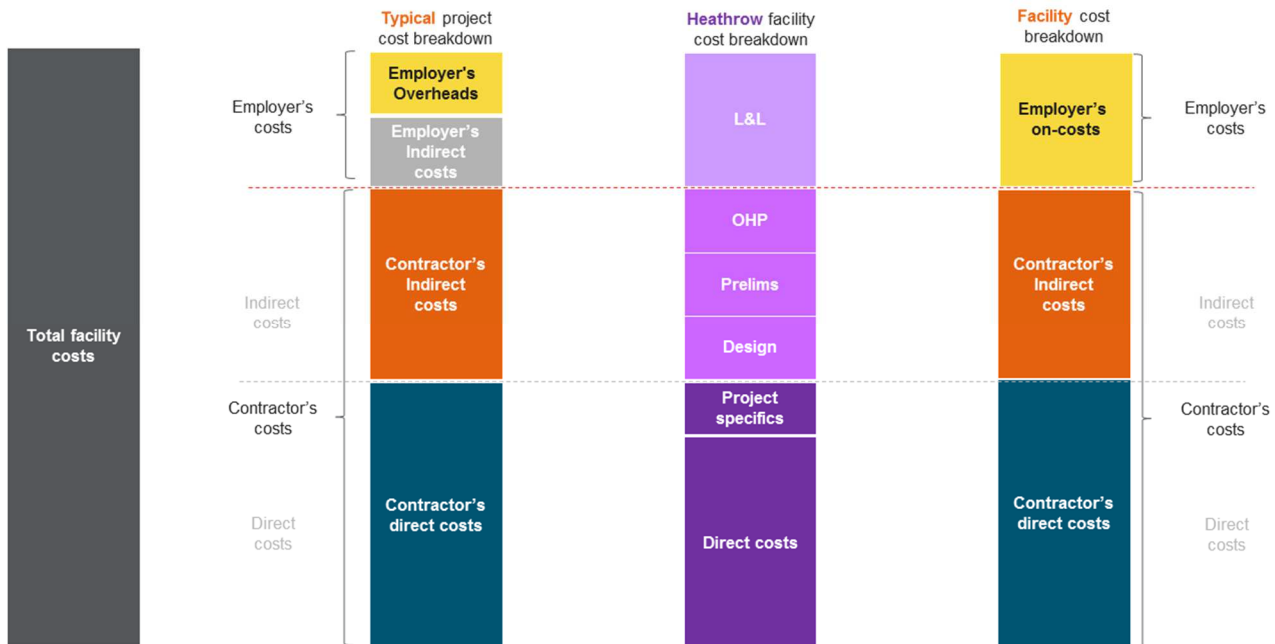


Diagram 4: Project Cost Breakdown by Facility

This is a high-level classification and further understanding as to how Purple Book costs relate to the Group Work Breakdown Structure (GWBS) are required to derive a more accurate split for Pound in the Ground calculation purpose. It is understood, based on the findings from IFS' Baseline Cost Estimate (Purple Book) Review and discussions with HAL that this correlation is yet to be completed.

Cost adjustments were calculated by applying a fixed percentage and compounded according to a set of application levels to direct costs. Arcadis at this stage has not undertaken a review to ascertain if the percentages applied are appropriate based on the nature of the facilities within the Expansion Programme. This may want to be considered should a future 'Pound in the Ground' benchmarking is completed.

The HAL facility costs were used to calculate a mean 'Pound in the Ground' for Heathrow Expansion Programme. It is important to note that, the below were excluded from the 'Pound in the Ground' calculation to normalise the costs for comparison.

- Risk and uncertainty.
- Allowances for costs payable to local community to minimise impact of Expansion Programme.
- Site clearance and demolitions.
- Costs associated with site logistics, airspace changes and planning applications.
- Costs not relating to an individual asset/facility.

These costs are in scope for the Direct Cost Review only.

Our sample contained a total 201 items, representing 58% of total Purple Book costs, as shown on the table below:

ABS	Description	TOTAL COSTS				
		Purple Book (£m)	Included in review (£m)	%	Excluded from review (£m)	%
HEP	Heathrow 2R Programme			79%		
HEM	Heathrow Expansion Surface Access			100%		
HEP	Heathrow Expansion Programme			45%		21%
H2X	Heathrow 2R_3R overlap			0%		100%
H2Y	Heathrow Commercial Opportunities			0%		55%
H2Z	Heathrow 2R Q6 overlap			0%		100%
	<b>Total</b>			<b>58%</b>		<b>42%</b>

Table 8: Programme Cost Breakdown by Review

Given the nature of the exclusions, it is our view that the 'Pound in the Ground' calculations were based on a representative sample of the costs from the Purple Book.

Heathrow's mean 'Pound in the Ground' was benchmarked against several organisations within the Transport, Utilities and Commercial sectors. The Transport sector was further divided into Airports and all other types of Transport, including Railways and Highways.

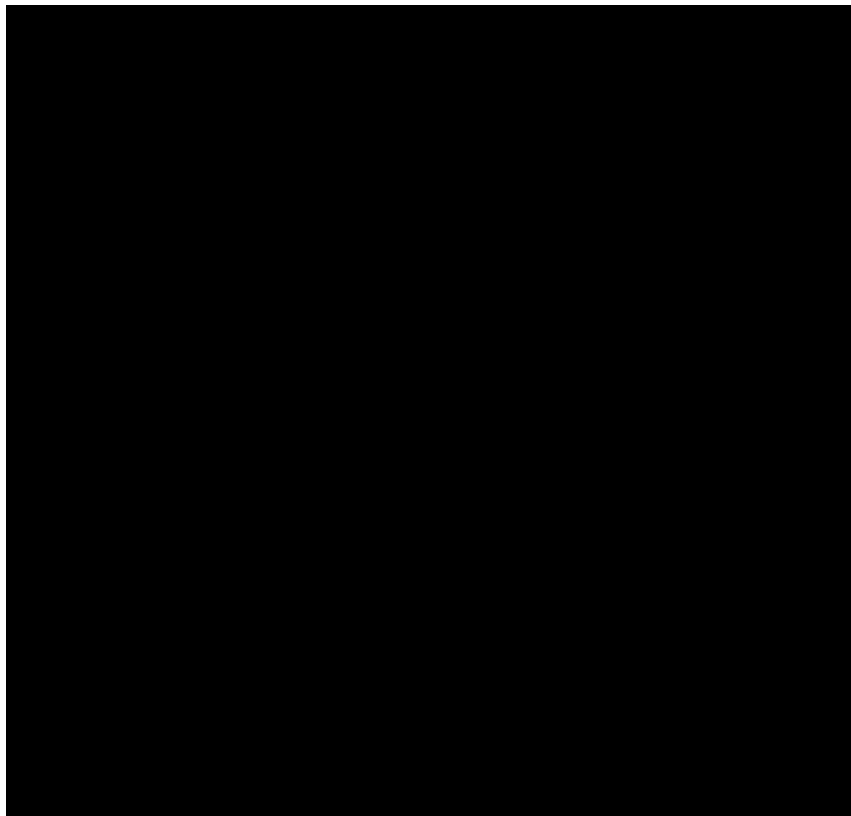
The organisations and sectors were selected due to their capital programme objectives and characteristics being relevant to Heathrow. This is summarised in the table below:

Sector	Capital Programme Objectives and Characteristics	Relevance to Heathrow
Airports	<ul style="list-style-type: none"> <li>Similar nature of projects</li> <li>Projects are carried out in a complex live operational environment</li> <li>Supply chain include a number of specialist contractors</li> <li>Projects tend to support strategic objectives around capacity and passenger experience</li> </ul>	Airports included in the benchmark share one or more of the following characteristics with Heathrow: <ul style="list-style-type: none"> <li>Operate in the same geographic location (e.g. UK, Europe)</li> <li>Shared controlling interest</li> <li>Serves the capital city of the country they are located</li> <li>Comparable capacity</li> </ul>
Utilities Sector	<ul style="list-style-type: none"> <li>Capital programme usually involves a mix of large capacity related programmes and smaller asset replacement programmes</li> <li>Utilities clients will have more than one delivery organisation in the business to deliver programmes with different work content</li> </ul>	<ul style="list-style-type: none"> <li>Heathrow Expansion Programme's objective is to deliver the outcomes for customers and stakeholders as determined by the regulators</li> <li>Cost reduction pressures are high due to regulatory scrutiny</li> <li>Projects generally require close collaboration with stakeholders (e.g. regulator, airlines)</li> </ul>

Sector	Capital Programme Objectives and Characteristics	Relevance to Heathrow
	<ul style="list-style-type: none"> <li>The scope of the programme is defined in collaboration with the organisation and the supply chain</li> </ul>	<ul style="list-style-type: none"> <li>Certainty of project outcome has the ability to impact public perception of the organisation</li> </ul>
Commercial Sector	<ul style="list-style-type: none"> <li>The primary driver for projects in this sector is strong emphasis on quality, faultless delivery and programme certainty</li> <li>Some programmes are delivered to a fixed budget which is often reduced year-on-year as part of wider performance challenge</li> <li>Supply chain is engaged under framework or alliance agreements, leading to sophisticated programme management</li> </ul>	<ul style="list-style-type: none"> <li>For large corporate occupiers, programmes often comprise a large number of low value projects (£0 - £10m)</li> <li>The scope is not complex but there is a focus on certainty of delivery</li> <li>Physical scope of work tend to be aligned to certain Heathrow commercial projects (i.e. Commercial &amp; Government facilities), though governance arrangements may differ (internal governance rather than regulatory)</li> </ul>
Transport Sector	<ul style="list-style-type: none"> <li>Unlike the utilities sector, there is less of a networkwide / systematic focus on the achievement of broadly defined customer focused programme outcomes</li> <li>Wide range of scheme types, both in terms of costs and complexities</li> <li>Programmes are typically focussed on delivering a series of defined projects</li> </ul>	<ul style="list-style-type: none"> <li>Focus on cost reduction driven by reduced budget allocations and Cabinet Office and Infrastructure UK performance improvement initiatives</li> <li>Projects generally require close collaboration with stakeholders (e.g. regulator, airlines)</li> <li>Certainty of project outcome has the ability to impact public perception of the organisation</li> </ul>

Table 9: Capital Programme Objectives

The sample of 20 organisations benchmarked against HAL are listed below. These have been coded as ‘A’ for Airports, ‘T’ for other Transport organisations, ‘U’ for Utilities and ‘C’ for Commercial organisations when presented as results.



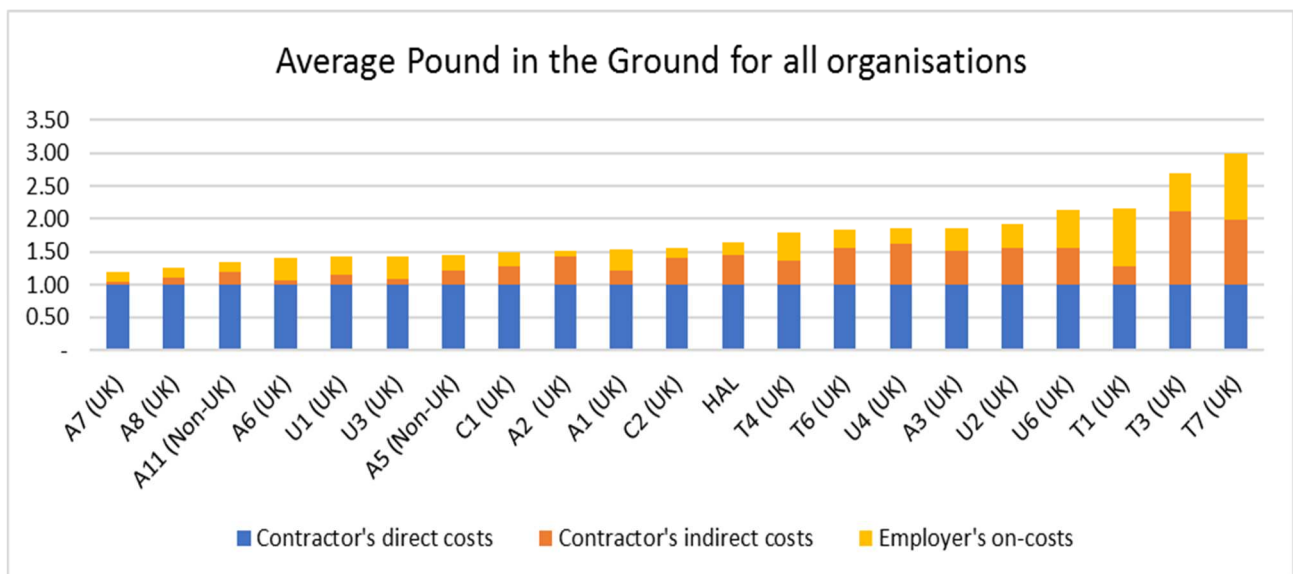
## 7.5 Benchmarking Results

### 7.5.1 Main Benchmarking Analysis

Heathrow's 'Pound in the Ground' is £1.64 based on the facilities reviewed.

### 7.5.2 Heathrow's Pound in the Ground compared to 20 organisations

The following graph shows how Heathrow's Pound in the Ground compares to the 20 organisations included within the sample:



Graph 10: Average Pound in the Ground for all Organisations

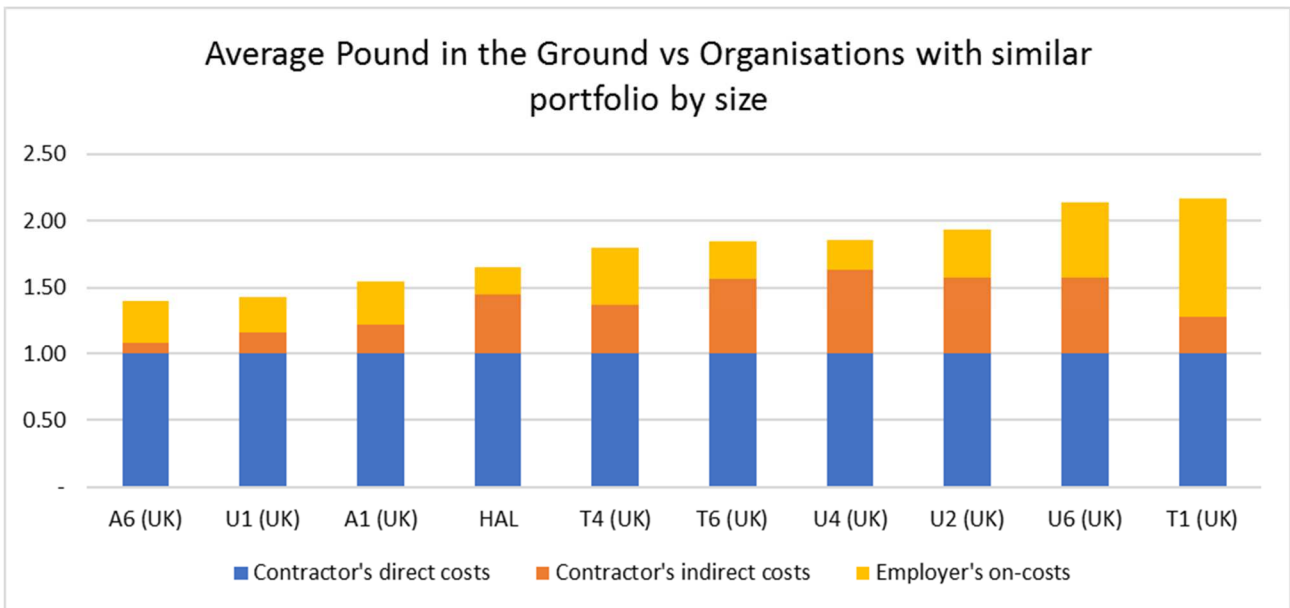
HAL scores 12<sup>th</sup> out of 21 in terms of Pound in the Ground and very close to the mean of the group. HAL score is 37% behind the leading organisation in this sample.

It is recognised that external and internal factors have a direct impact on the level of efficiency of an organisation. External factors include the economic, political and regulatory environment in which the organisation operates, whereas internal factors include aspects such as operating model, programme management and the size and nature of the capital programme being delivered, among others.

There are a few organisations shown above that either focus on delivering capital projects under £10m or above £10m but not both, as seen in Heathrow's Expansion Programme.

### 7.5.3 Heathrow’s Pound in the Ground compared to organisations with similar portfolio by size

Following the above, the HAL Expansion Programme was benchmarked against organisations that deliver projects both above and below £10m, of which there were 10, including HAL. The results of HAL compare against these organisations are shown below:



Graph 11: Average Pound in the Ground vs Organisations with similar portfolio by size

HAL scores 4<sup>th</sup> out of 10 comparable organisations. It scores just below average and is 17% behind the leading organisation in this sample.

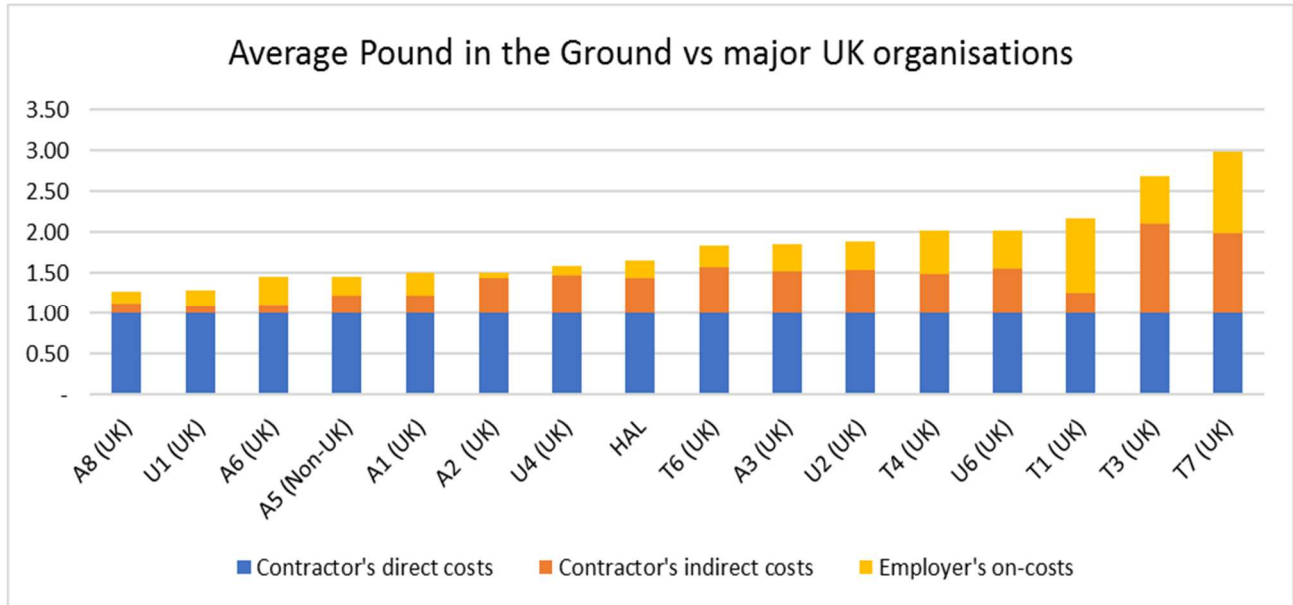
It is worth noting that there are two airports within the comparable organisations, in addition to HAL. Both airports are more efficient than HAL. This suggests that even though HAL is relatively efficient in relation to comparable organisations, there are still lessons that can be learnt and opportunities to further improve indirect cost efficiency.



### 7.5.4 Additional Pound in the Ground benchmarking analysis

Several additional benchmarking analyses were performed, as described below:

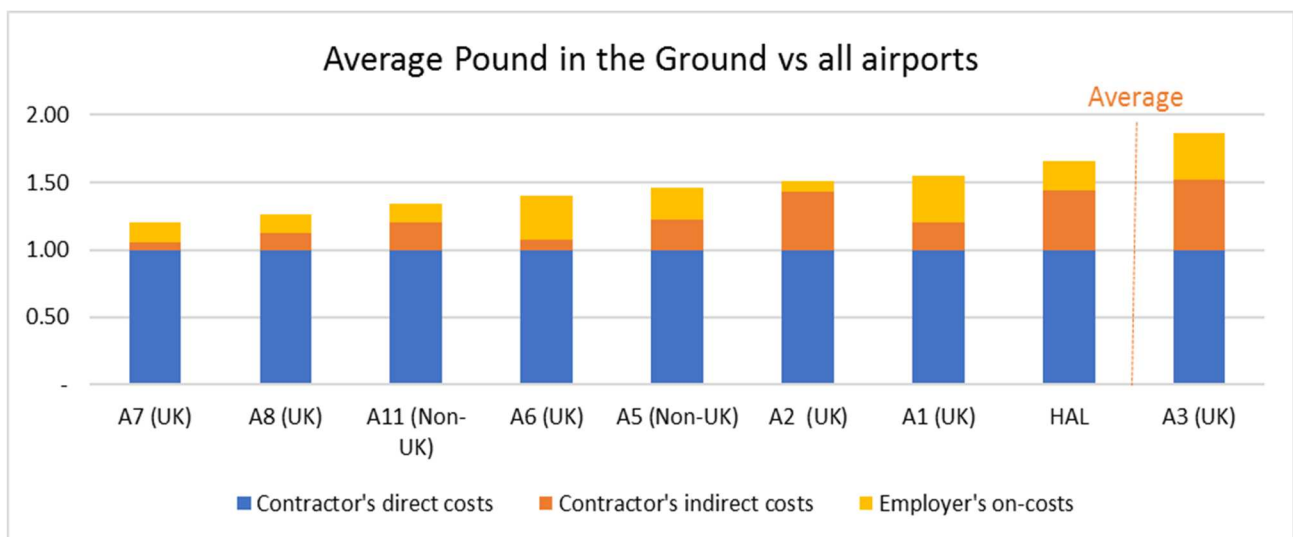
- HAL Expansion Programme vs other major UK organisations.
  - Major UK organisations include organisations with projects greater than £10m that operate in the UK.
  - The £10m threshold was used because it was noted that different operating models were employed for projects above and below £10m, illustrating the importance of considering project value.



Graph 12: Average Pound in the Ground vs major UK organisations

HAL scores 8<sup>th</sup> out of 16 organisations. Organisation A8 is the most efficient, with a Pound in the Ground 30% lower than HAL.

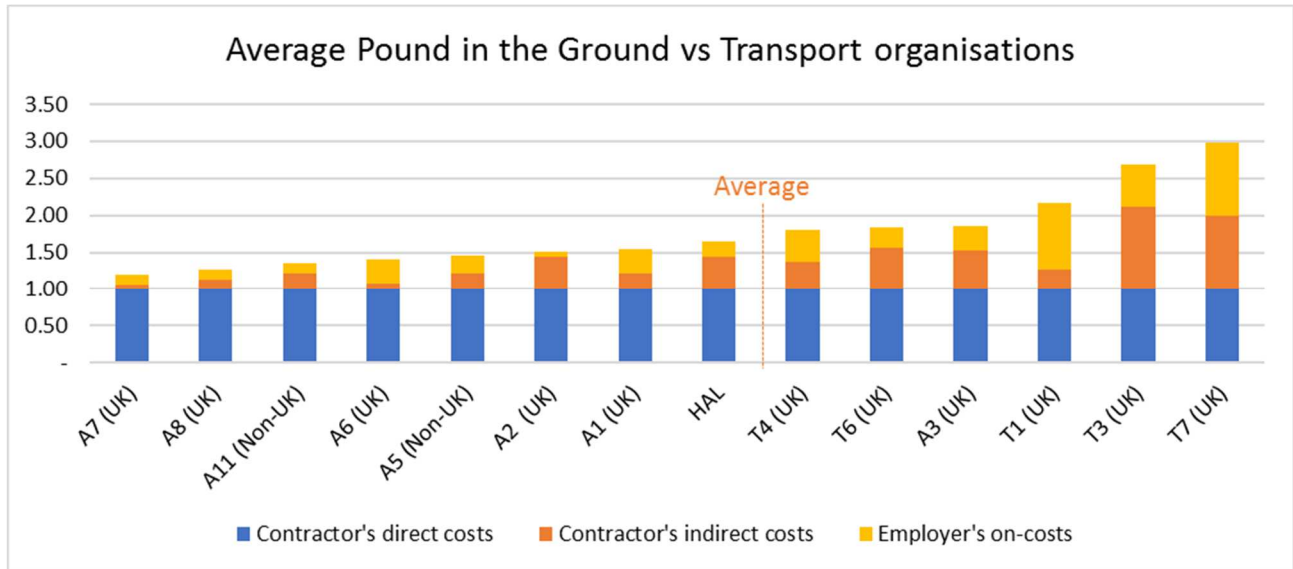
- HAL Expansion Programme vs Airports exclusively.
  - These include major, regulated airports as well as small, regional and/or non-regulated airports.



Graph 13: Average Pound in the Ground vs all airports

HAL scores 8<sup>th</sup> out of 9 airports. Airport A7 is the most efficient, with a Pound in the Ground 37% lower than HAL.

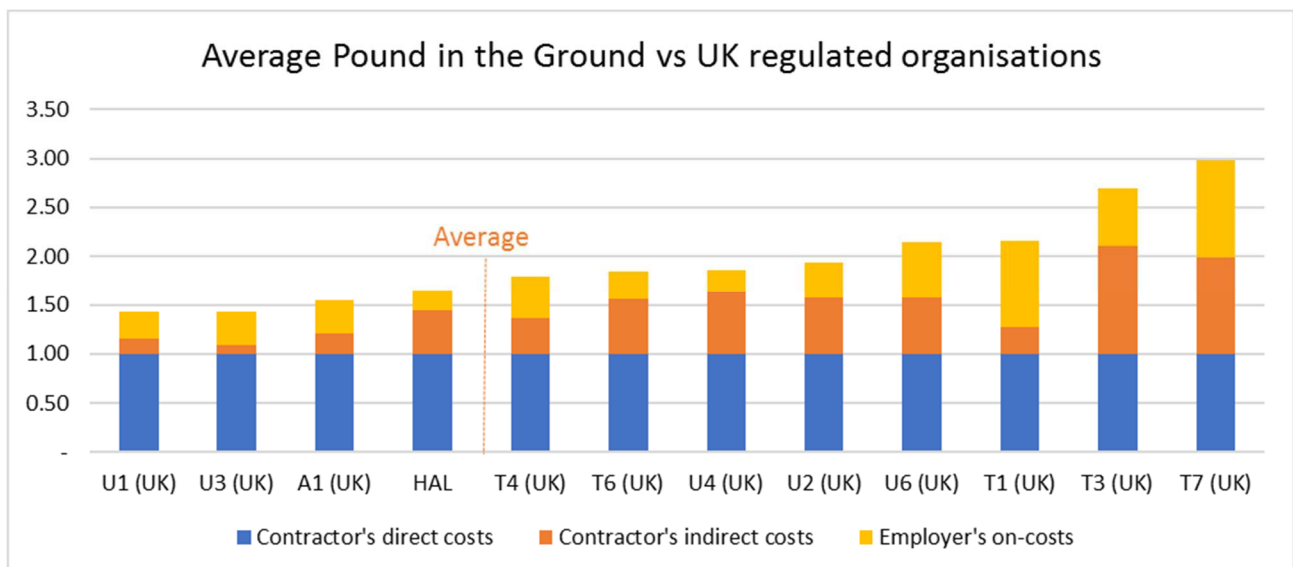
- HAL Expansion Programme vs Transport sector organisations.
  - Transport sector includes airports as well as rail and road organisations.



Graph 14: Average Pound in the Ground vs Transport organisations

HAL scores 8<sup>th</sup> out of 14 organisations. Organisation A7 is the most efficient, with a Pound in the Ground 37% lower than HAL.

- HAL Expansion Programme vs UK regulated organisations.
  - Organisations that are required to report to a regulatory body regarding the delivery of their capital expenditure programme.



Graph 15: Average Pound in the Ground vs UK regulated organisations

HAL scores 4<sup>th</sup> out of 12 organisations. Organisation U1 is the most efficient, with a Pound in the Ground 15% lower than HAL.

### **7.5.5 HAL Pound in the Ground Summary**

Even though HAL has scored relatively well regarding indirect cost efficiency, there were instances where other airports scored higher than HAL, suggesting that opportunities for improvement exist. The Pound in the Ground benchmarking analysis also demonstrates that there are organisations in the Transport and other sectors that are managing indirect costs more efficiently than HAL, which could mean that there are opportunities to improving efficiency by adopting best practices from non-Aviation organisations.

We recognise that HAL are taking serious steps to develop innovative practices and encourage HAL to look for best practices and lessons learned from comparable programmes from other airports and organisations within the Transport sector to identify opportunities to increase the indirect cost efficiency of the Expansion Programme. We encourage HAL to analyse and understand what innovative practices are driving efficiencies across all aspects of capital development. This is not limited to programme delivery but include procurement and supply chain, alternative incentivisation mechanisms with stakeholders, phasing of works and logistics strategies.

## 8 High Level Review of the IFS Report

HAL and the Airlines Community have commissioned Gardiner & Theobald as Independent Fund Surveyor (IFS) to review the baseline cost estimate. Arcadis was invited to conduct an overview of the “Heathrow Expansion Baseline Cost Estimate (Purple Book) Review IFS Report”, which was issued on 27 July 2017, and to incorporate its findings, complement any other points and flag any potential issues within the Direct Cost Efficiency Review.

### 8.1 IFS Contents

The IFS Report comprises seven sections, which are as follows:

1. Executive Summary.
2. Introduction to Purple Book Cost Estimate Content.
3. Cost Estimate Structure & Content.
4. Detailed Analysis of Cost Estimate.
5. Benchmark Comparison – Selected Items.
6. Affordability.
7. Appendices.

### 8.2 Commentary

The report overall is a concise paper as a high-level cost review document.

Selected direct cost benchmarks and key rates analyses and preliminaries’ benchmarking are useful, although given that these are spread across various facilities among different programmes it makes direct comparison more difficult. A more structured approach and a comprehensive overview of these would have been recommended.

We understand that the project specifics and risk elements of the Purple Book cost estimate are flagged by the IFS and higher percentage allowances are recommended. Given the maturity and the level of detail of the estimate, this is a viable approach, however our recommendation is that a review at facility level within each programme would consider the specific characteristics of the individual projects within the programmes.

Finally, as a general principle, we would expect to see the backup of the calculations in appendices, especially where IFS advise variations from the Purple Book.

Given that our initial conclusions, to cost efficiency and Pound in the Ground were subsequently indirectly validated by the IFS, it re-enforces our view that more detailed review of the Heathrow Expansion Programme is recommended particularly with reference to: benchmarking, project specifics and risk.

More detailed commentary of the IFS report is contained in Appendix C.

## 9 Conclusion and Proposed Next Steps

In undertaking this study, we have completed a review of HAL cost efficiency including direct and indirect costs and incorporated a 'Pound in the Ground' approach. It has involved a thorough review of the Purple Book, associated information, data and a review of HAL's cost estimating processes.

Nevertheless, as the overall 3R project starts to gather momentum, we would expect to work constructively with HAL and the IFS to improve the granularity of our understanding of the level of cost efficiency in HAL's development plans.

We would encourage close and ongoing liaisons between HAL, CAA and Arcadis to understand how HAL intend to action the recommendations contained in this report. Or, where HAL find reason for challenge, discussion to agree what are the most constructive methods of improving the Purple Book's future versions. Throughout this phase of work, HAL has demonstrated a willingness to address recommendations and improve their cost estimating processes.

However, as the CAA's Technical Advisor, Arcadis feel, there is an opportunity for a more integrated engagement between Arcadis, CAA, IFS and HAL to design, and ensure the implementation of, more robust cost estimating processes, emulating industry best practice for the Heathrow expansion programme. Arcadis would encourage a more pre-emptive view of HALs proposed commercial processes to drive efficiency and improve cost estimate accuracy.

### 9.1 Conclusions

- The purpose of the Cost Efficiency Review is to enable CAA to advise the DfT on the cost efficiency of HAL Expansion Programme by providing high quality, evidence-based advice using benchmarking and data analysis techniques.
- Arcadis note that whilst information has been provided, there remain documents outstanding for review and have not formed part of our analysis and assessment. In addition, the date and timing this information becoming accessible has enforced constraints on the level and depth of the Arcadis review and our assessments.
- We believe that the level of information received is sufficient to support the observations included in this report, however additional information would have allowed more detailed procedures to be complete on the areas where only high-level procedures were performed at this stage.
- We understand that HAL has produced a variety of documents where it formalises its approach to the development of the Purple Book and its expansion programme. However, we consider that the structure of the Purple Book and its associated documents could be improved upon to aid understanding and review of the information by others, and recommend that this is developed by HAL in the forthcoming months.
- Arcadis were provided with both a hard copy and an electronic copy of the Purple Book, and we performed a reconciliation between the two documents. The reconciliation identified a difference of ██████m in cost adjustments which should be prevented in the future.
- It is worth noting that this difference has also been identified by the IFS in its review of the Purple Book. Given that our review is mostly based on the electronic version, it is important that we to follow up this difference with HAL and the IFS in due course as to ensure the accuracy of our review of cost estimates.
- We observe that HAL's benchmarks for the terminals, taxiways and stands compare relatively in the middle range to the industry benchmarks. Two different benchmarks that are used for piers and satellites each compare at the highest and lowest end of the industry benchmarks which require attention. Multi-storey car park benchmarks show that HAL figure is the most expensive one both among airports and other commercial projects' benchmarks. This requires attention and Arcadis suggest that HAL widen the benchmark data that they are using.

- Whilst we have received a number of documents with regards to the procurement strategy as listed in Appendix A, we encourage HAL to prioritise developing their detailed procurement strategy and the methodology of packaging of different contracts. From a cost efficiency point of view, the procurement strategy in place has direct impacts on cost and schedule. We conclude that given the level of detail and the maturity of documents provided, this cost efficiency study cannot be included as part of our report and we would strongly advise that Procurement is identified for further investigation and assessment.
- HAL scores relatively well regarding indirect cost efficiency. However, in all benchmarking comparisons there were instances where other airports scored higher than HAL suggesting opportunities for improvement exist. The benchmarking also suggests that there are opportunities to improve efficiency by adopting best practice from non-aviation organisations. Our Pound in the Ground benchmarking suggests where there are opportunities for improvement.

## 9.2 Proposed Next Steps

For the CAA to effectively discharge its statutory requirements for S16 and cost efficiency we recommend that for future iterations of the Purple Book:

- A review of the 'Basis of Estimate' and maturity assessment of benchmarks is performed by HAL once included in the Purple Book.
- HAL undertakes major reviews into material elements of the Purple Book:
  - This should cover most key programmes areas (i.e. H2R, HEP, HEM).
  - HAL should advise when this data is available. Given the emerging level of masterplan maturity we anticipate it being available soon.
  - Detailed benchmarking of costs and review of benchmarking results with HAL.
  - Review of structure of application and benchmarking of preliminaries, overhead and profit, leadership and logistics.
  - Analysis of scheme enablers such as property purchase and noise insulation scheme.

## 10 Appendices

### 10.1 Appendix A – Documents Requested and Reviewed

A summary of data requested from HAL and the review completed by Arcadis is provided below.

The level of review was determined by relevance and date of receipt. All data received prior to 09/08/2017 has been reviewed in full. Data received during the period of 09/08/17 to 14/08/17 has been reviewed at a high level.

Information Requested	Requested	Received	Level of Review
Purple book (Hard Copy)	05/07/2017	05/07/2017	Reviewed
Master Plan Scheme Development Manual	W.C.10/07/17	17/07/2017	Reviewed
PowerPoint shared with Airline Community re future Engagement	W.C.10/07/17	02/08/2017	Reviewed
MACE Delivery Reports (Further refined report by the end of 2015)	W.C.10/07/17	15/12/2017	High Level Review
Group Work Structure Breakdown Structure	W.C.10/07/17	15/08/2017	Reviewed
'Purple Book' 40 Line Summary and Mid-Level Summary	W.C.10/07/17	28/07/2017	Reviewed
High Level Programme Visual	W.C.10/07/17	15/08/2017	Reviewed
Electronic Copy of the Purple Book	Post NDA (signed 27/07/17)	28/07/2017	Reviewed
HAL '95-page presentation' on Runway Options	Post NDA (signed 27/07/17)	27/07/2017	High Level Review
IFS 'Cost' Report (once completed)	W.C. 24/07/17	09/08/2017	High Level Review
IFS 'PMO' Report (once completed)	W.C. 24/07/17	09/08/2017	High Level Review
Heathrow packaging and procurement strategy	20/07/2017	15/08/2017	High Level Review
Supporting Benchmark Documentation for Purple Book	21/07/2017	15/08/2017	Reviewed
Backup calculations to Benchmark documentation	12/12/2017	15/12/2017	Reviewed
Details of Property Purchase Cost	W.C.17/07/17	Awaiting Document	Not Reviewed
Cost Efficiency Risk Register	19/07/2017	Awaiting Document	Not Reviewed
Supporting Measurements for Masterplan	19/07/2017	Awaiting Document	Not Reviewed
Runway Masterplan layouts	11/07/2017	27/07/2017	High Level Review
HAL's Integrated Design Team Procedures	11/07/2017	Awaiting Document	Not Reviewed
Governance Procedure around Pink/Orange/Green Reviews	11/07/2017	Awaiting Document	Not Reviewed
Heathrow Baseline History – For Discussion with CAA, 5th July 2017	14/08/2017	15/08/2017	Reviewed
Heathrow Turner & Townsend Expansion Benchmarking, Draft v.1.1, April 2016	14/08/2017	15/08/2017	Reviewed

Table 10: Information for Requests

## 10.2 Appendix B – Benchmarking Figures

### 10.2.1 Appendix B1 – Benchmarking References

The table below show how HAL’s 24 benchmark references individually feed into six different programme of works. All in all, benchmarked rates constitute 30% of the direct costs, which provides more cost certainty around the programmes. However, from the cost efficiency point of view, it is important to further examine how these benchmarks are normalised and applied.

It can be seen that the Heathrow 2R Programme (H2R) and Heathrow Expansion Programme (HEP) are two streams with the highest number and value of benchmarked costs, whereas Heathrow Expansion Surface Access (HEM) has no benchmark.

The table below shows the benchmarked / not benchmarked breakdown according to the programmes:

ABS Code	Programme Description	Benchmarked (£m)	%	Not Benchmarked (£m)	%	Direct Costs Total (£m)
H2R	Heathrow 2R Programme		49%		51%	
H2X	Heathrow 2R_3R Overlap		10%		90%	
H2Y	2R Commercial Opportunities		34%		66%	
H2Z	2R Q6 Overlap		2%		98%	
HEM	Heathrow Expansion Surface Access		-		100%	
HEP	Heathrow Expansion Programme		21%		79%	
	<b>TOTAL (£m)</b>		<b>30%</b>		<b>70%</b>	

Table 11: Programme Cost Breakdown: Benchmarked vs Not Benchmarked

Item	Benchmark Reference	H2R (£m)	H2X (£m)	H2Y (£m)	H2Z (£m)	HEM (£m)	HEP (£m)	Total (£m)
1	APM - Car (Innovia)							
2	APM - Station Fitout rate							
3	APM - Tunnel Fitout & Line Equipment							
4	APM - VCC Bank (Lift + Escalator)							
5	Car Parking - Decked - B0.2							
6	Car Parking - Multi-storey - B0.2							
7	Control Posts - B0.2							
8	Control Tower - B0.2							



Item	Benchmark Reference	H2R (£m)	H2X (£m)	H2Y (£m)	H2Z (£m)	HEM (£m)	HEP (£m)	Total (£m)
9	Operational Readiness & Training Cost (T2A) - m2 of Terminal Building	█	█	█	█	█	█	█
10	Roads (A/S & L/S) - D1AU - B0.2	█	█	█	█	█	█	█
11	Roads (A/S & L/S) - D2AU - B0.2	█	█	█	█	█	█	█
12	Runway Only - B0.2	█	█	█	█	█	█	█
13	Satellite Buildings - B0.2	█	█	█	█	█	█	█
14	Satellite Buildings T2B (P.2) - B0.2	█	█	█	█	█	█	█
15	Satellite Buildings T2B (P.2) Substructure - B0.2	█	█	█	█	█	█	█
16	Satellite Buildings T2B (P.2) Superstructure - B0.3	█	█	█	█	█	█	█
17	Satellite Buildings T5C Superstructure - B0.2	█	█	█	█	█	█	█
18	Stands - B0.2	█	█	█	█	█	█	█
19	Taxiways Only - B0.2	█	█	█	█	█	█	█
20	Terminal Buildings - B0.2	█	█	█	█	█	█	█
21	Terminal Buildings (T2A) - B0.2 Superstructure	█	█	█	█	█	█	█
22	Tunnels - Bored - B0.2	█	█	█	█	█	█	█
23	Tunnels - Cut and Cover - B0.2	█	█	█	█	█	█	█
24	Tunnels - Fitout - B0.2	█	█	█	█	█	█	█
<b>TOTAL (£m)</b>		£ █	█	█	█	█	█	█

Table 12: Benchmark Breakdown

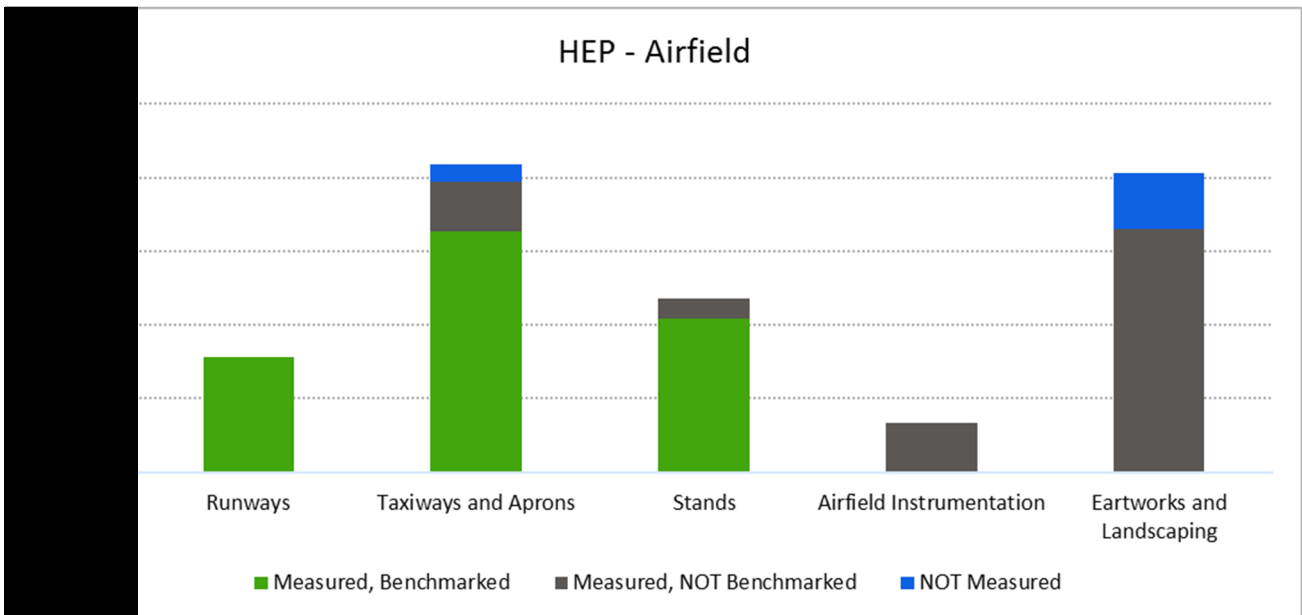
### 10.2.2 Appendix B2 – HEP Programme benchmarking by facility

Portion of base construction cost is yet to be measured and/or benchmarked as shown below. The table contains the relevant information for Graph 2 on page 15:

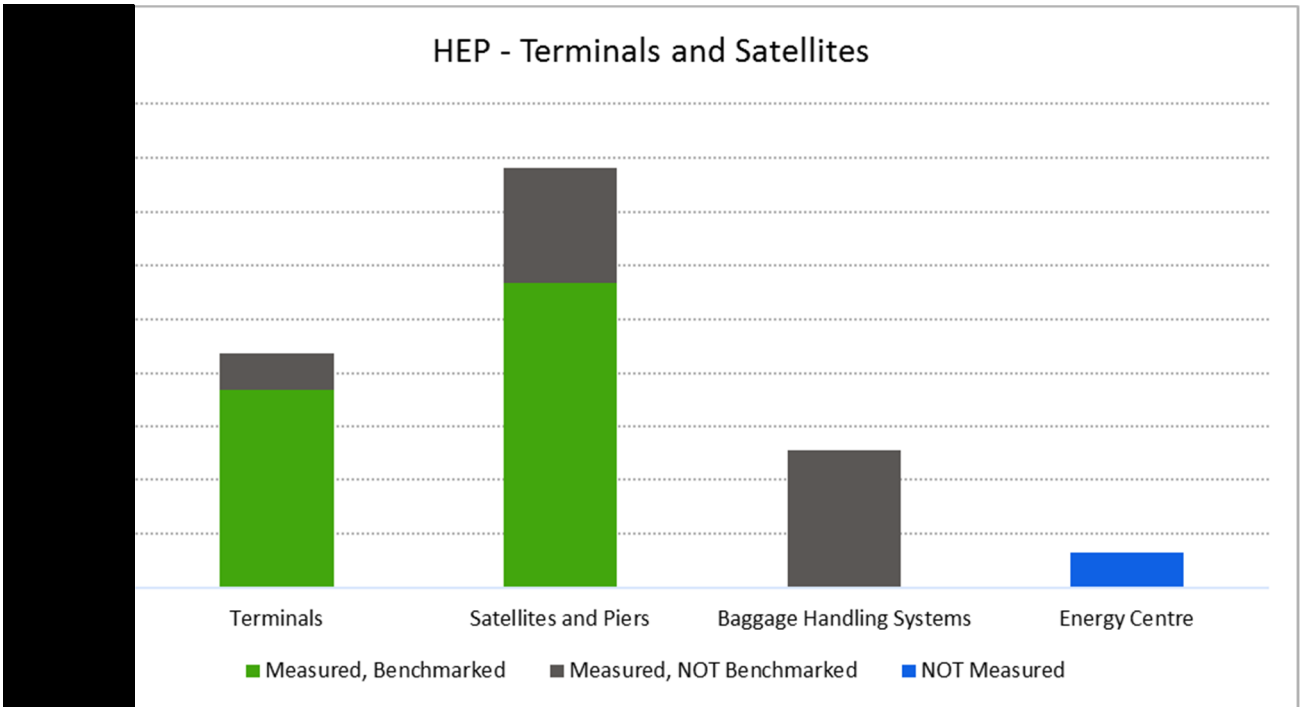
Facility	Measured, Benchmarked (£m)	Measured, NOT Benchmarked (£m)	NOT Measured (£m)	TOTAL (£m)
Enabling Works				
Airfield				
Airside Facilities				
Terminals and Satellites				
Roads and Car Parks				
Utilities				
Operational Readiness				
Water Course Diversions				
Archaeology and Ecology				
<b>TOTAL (£m)</b>				

Table 13: Measured Benchmarking Costs

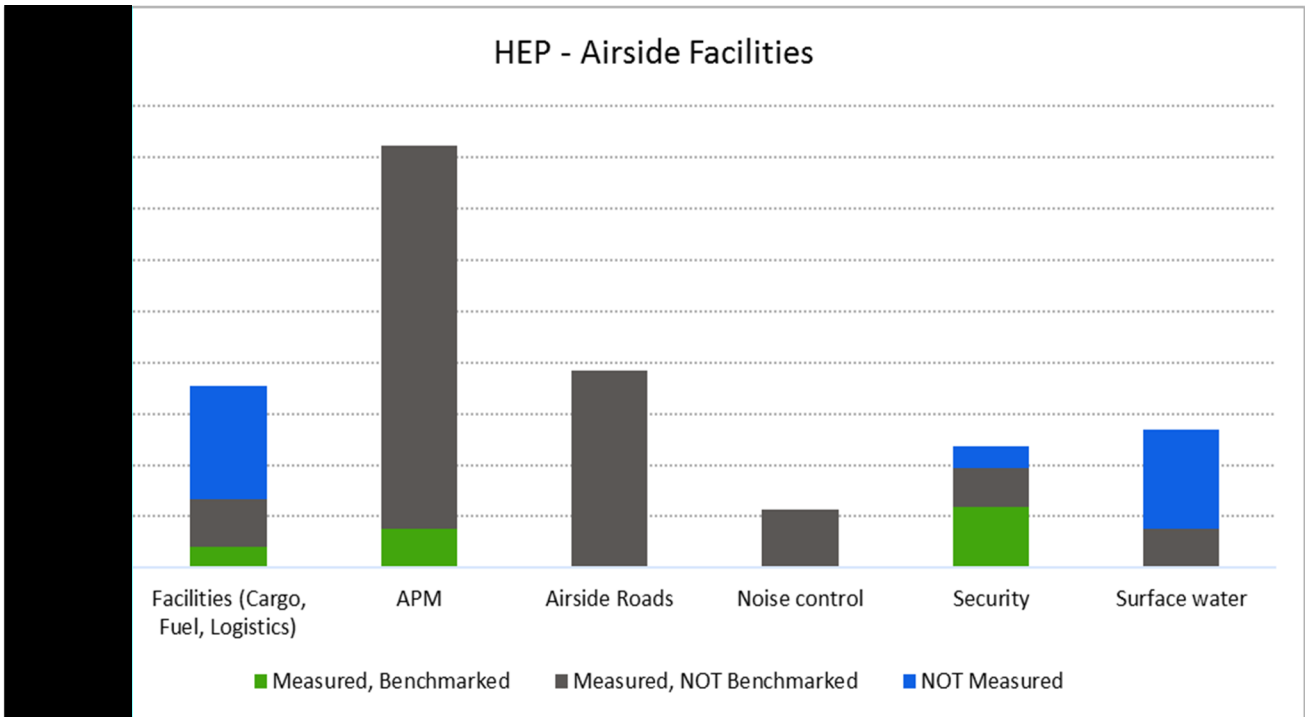
Arcadis has analysed the facilities at a further level to look at the sub-categories. The below set of graphs show the benchmarked / not benchmarked / not measured categories for the HEP:



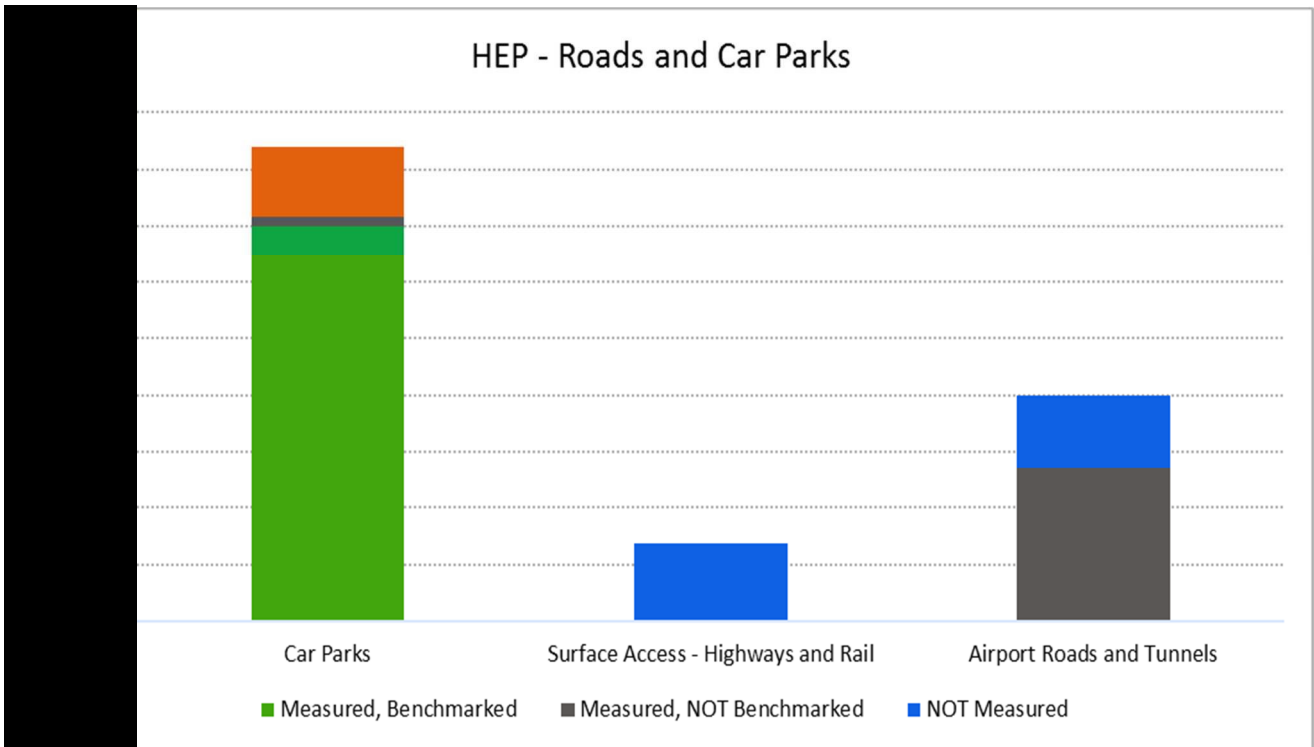
Graph 16: HEP - Airfield



Graph 17: HEP - Terminals and Satellites



Graph 18: HEP - Airside Facilities



Graph 19: HEP - Roads and Car Parks

### 10.2.3 Appendix B3 – Purple Book benchmarking rates

The table below is taken from the Purple Book, showing the utilised benchmark rates for the airport expansion:

Item	Benchmark Reference	Rate (£)	Unit	Value (£)	Notes
1	APM - Car (Innovia)		Item		Original rate of £ [redacted] car inflated to base date.
2	APM - Station Fitout rate		m2		Original rate of £ [redacted] car inflated to base date.
3	APM - Tunnel Fitout & Line Equipment		m		-
4	APM - VCC Bank (Lift + Escalator)		Item		-
5	Car Parking - Decked - B0.2		Spaces		Maintain B0
6	Car Parking - Multi-storey - B0.2		Spaces		Reinforced Concrete Framed
7	Control Posts - B0.2		Item		Based on CP24 (Lane inbound)
8	Control Tower - B0.2		Item		Initial Reduction - More detailed analysis to follow
9	Operational Readiness & Training Cost (T2A) - m2 of Terminal Building		m2		T2 Programme Heathrow - Logistics & Operational Readiness Heathrow Ltd, Turner Townsend 22 January 2015, Author: Ana Bell

Item	Benchmark Reference	Rate (£)	Unit	Value (£)	Notes
10	Roads (A/S & L/S) - D1AU - B0.2		m		Dual Carriageway, Single Lane
11	Roads (A/S & L/S) - D2AU - B0.2		m		Dual Carriageway, Dual Lane
12	Runway Only - B0.2		m2		Includes Earthwork Re-instatement
13	Satellite Buildings - B0.2		m2		Based on T2B Phase 2 rate is increased 5% increase f design
14	Satellite Buildings T2B (P.2) - B0.2		m2		Based on T2B Phase 2 rate is increased 5% increase f design
15	Satellite Buildings T2B (P.2) Substructure - B0.2		m2		T2B Phase 2 sub-structure rate with no adjustments for roof design
16	Satellite Buildings T2B (P.2) Superstructure - B0.3		m2		Based on T2B Phase 2 superstructure rate of increased to match the 5% on total benchmark for roof design fully apportioned to this rate
17	Satellite Buildings T5C Superstructure - B0.2		m2		Based on T2B Phase 2 superstructure rate of increased to match the 5% on total benchmark for roof design fully apportioned to this rate
18	Stands - B0.2		m2		Includes FEGP, Lighting and Barriers to new stands, and local drainage
19	Taxiways Only - B0.2		m2		T2B Bravo Taxiway, Includes earthworks re-instatement
20	Terminal Buildings - B0.2		m2		Based on Terminal 5
21	Terminal Buildings (T2A) - B0.2 Superstructure		m2		Based on Terminal 2A Superstructure
22	Tunnels - Bored - B0.2		m3		Based on SWOTT T5
23	Tunnels - Cut and Cover - B0.2		m3		Based on Baseline 0
24	Tunnels - Fitout - B0.2		m		-
<b>TOTAL BENCHMARKED VALUE (£)</b>					

Table 14: Breakdown of Utilised Benchmark Rates

## 10.3 Appendix C – Arcadis Review of IFS report

### Section 1 – Executive Summary:

- The table accompanying the chart on Page 5 does not add up to [REDACTED] bn. Clarification is required as to why the direct construction works vary by [REDACTED] bn. In addition, design costs are not included in the table. There is also a difference in the overall risk value, as well. IFS's recommendation of £[REDACTED]m additional direct cost variation needs to be substantiated and/or referenced to detailed sections. Clarity is required whether this difference is based on some selected rates or as a result of a more comprehensive overview. We recommend that the project specifics and risk to be reviewed in detail at facility level rather than as a generic percentage at programme level.
- The table accompanying the chart on Page 6 does not add up to £[REDACTED] bn (HEP+HEM). Clarification is required as to why the direct construction works vary by [REDACTED] bn. Again, design is not included in the table. IFS's recommendation of £[REDACTED]m additional direct cost variation needs to be substantiated. We recommend that the project specifics and risk to be looked in detail at facility level rather than a generic percentage at programme level.
- IFS Key Points on Page 7 refer to the Purple Book as a “Capital Plan” rather than as a detailed cost plan based on the current maturity level. This is understandable at this stage, however following the meetings with HAL, we identified that various detailed in-depth review sessions and sprint studies have been performed with regard to runway and other components. We recommend that this more recent information with increased level of detail and certainty resulting from the studies undertaken in the interim between creation of the Purple Book and today is incorporated into the new version of the cost estimate in due course following a mutually agreed procedure and structure with the relevant stakeholders.
- We strongly agree with another IFS Key Point on Page 7 that an integrated approach to development of the estimate for all capacity expansion (2R / 3R) scope is required.
- IFS Key Point on Page 8 refer to inflation and advise that it should be treated as a cost category. We agree to recognise the impact of inflation given the estimate base date is 3Q14, however this could be covered either as part of the cost estimate or the business case.
- The executive summary does not include the potential impact of different masterplan components on cost efficiency and landing charges. We recommend setting out overarching principles and procedures.

### Section 2 – Introduction to Purple Book Cost Estimate Content:

- The Summary of Baseline CAPEX Figures on Page 12 has six sections (programmes), whereas the table on Page 11 has only four.

### Section 3 – Cost Estimate Structure and Content:

- The values on the graph of Baseline Development of Cost Estimate since Airports Commission Submission on Page 17 are said to be sourced from HAL presentation on “Baseline History” dated 25th April 2017. However, all the values from the AC submission through Purple Book 0.61 are shown differently on HAL's “Baseline History” document dated 5th July 2017. If this is due to pro-rata addition of risk allowances, we recommend that this intermediate step to be shown. This detail is further shown on Page 21. In addition, more detail and context need to be added to elaborate the cost increases and cost reductions.
- IFS have advised that the risk provision to be 35% to 50% multiple times in the report. However, the recommendation on Page 26 suggests 35% risk provision is appropriate rather than recommending a 35% - 50% range. Clarity from the IFS and/or HAL is required as to the risk provision applied.
- We recommend the use of relevant Tender Price Indices as opposed to inflation that the IFS advised under the subheading “Benchmarking” on Page 27.

### Section 4 – Detailed Analysis of Cost Estimate:

- The overall risk percentage as proportion of the overall cost is inconsistent across pages and sections. The detailed analysis of cost estimate on Page 31 shows the risk at 16% in line with what is shown on Page 21.

However, the chart on Page 33 shows the risk as 15% of [REDACTED], whereas the key info on Page 34 shows at 18%.

- The baseline cost analysis on Page 34 show the percentage of different cost categories without touching the cost impact. These percentages are not benchmarked either. Further work is required to get into detail and draw conclusions about what these percentages mean in terms of the estimate maturity and cost impact.

### **Section 5 – Benchmark Comparison – Selected Items**

- We recommend showing what proportion of the key rates have been analysed and whether the analysis is based on spot checks. (Pages 37, 38, 39) It is not clear how the rates are showing “less than 10% variation” as stated on Page 38.
- We recommend that where key rates are stated to be as expectations, a definition of “as expected” criteria are included (Page 39).

### **Section 6 – Affordability**

- No observations

### **Section 7 – Appendices**

- Reference to Appendix C, IFS Estimate Content Analysis – Individual Purple Book Sections, the pie charts provide a good basis to analyse the costs. However, kept at programme level, these percentages are not able to indicate a significance from the cost efficiency point of view. We recommend to further dissect each programme to its facilities and review. This can be found in our “Purple Book” section and relevant appendices.
- HEP – Heathrow Expansion Programme detail suggests that only 5% to 10% of the direct costs are benchmarked, whereas our analysis show that this is at 21% including the pre-construction elements such as the land purchase, levies, and environmental mitigation measures and community assets.
- Appendix D refers to a number of schedules which are currently not part of the report.

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