

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

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

KEY COMPONENT GREEN REVIEW REPORT

RUNWAY | M25 ALIGNMENT & JUNCTIONS | LOCAL ROADS |  
RIVERS & FLOOD STORAGE | TERMINALS, SATELLITES & APRONS



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# Key Component Green Review Report

## Version

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# CONTENTS

Glossary .....	5
Tables & Figures .....	6
<b>1 Introduction .....</b>	<b>8</b>
<b>2 Executive Summary .....</b>	<b>10</b>
2.1 Recommendations.....	12
<b>3 Cost Efficiency .....</b>	<b>14</b>
3.1 Introduction.....	14
3.2 Context and Approach .....	14
3.3 Estimating Procedures.....	14
3.4 Evaluation Criteria .....	15
<b>4 Runway .....</b>	<b>16</b>
4.1 Introduction.....	16
4.2 Options Summary.....	16
4.3 Evaluation.....	17
4.4 Key Findings .....	23
4.5 Next Steps .....	24
<b>5 M25 Alignment &amp; Junctions .....</b>	<b>25</b>
5.1 Introduction.....	25
5.2 Options Summary - Alignment.....	25
5.3 Evaluation – Alignment .....	26
5.4 Options Summary – Junctions.....	32
5.5 Evaluation – Junctions.....	33
5.6 Key Findings .....	37
5.7 Next Steps .....	37
<b>6 Local Roads.....</b>	<b>38</b>
6.1 Introduction.....	38
6.2 Options Summary.....	38
6.3 Evaluation.....	40
6.4 Key Findings .....	46
6.5 Next Steps .....	47

<b>7</b>	<b>Rivers &amp; Flood Storage .....</b>	<b>48</b>
7.1	Introduction .....	48
7.2	Options Summary – Rivers.....	48
7.3	Evaluation – Rivers.....	49
7.4	Options Summary - Flood Storage .....	55
7.5	Evaluation - Flood Storage .....	55
7.6	Key Findings .....	57
7.7	Next Steps .....	58
<b>8</b>	<b>Terminals, Satellites &amp; Aprons .....</b>	<b>59</b>
8.1	Introduction .....	59
8.2	Options Summary.....	60
8.3	Evaluation.....	65
8.4	Key Findings .....	71
8.5	Next Steps .....	71
<b>9</b>	<b>Review of IFS Reports .....</b>	<b>72</b>
9.1	Introduction .....	72
9.2	Runways & Taxiways .....	72
9.3	M25 & Junctions .....	73
9.4	Local Roads .....	73
9.5	Rivers & Flood Storage .....	74
9.6	Terminals, Satellites & Aprons.....	74
9.7	Summary.....	75
<b>10</b>	<b>Conclusion &amp; Recommendations .....</b>	<b>76</b>
10.1	Conclusion .....	76
10.2	Recommendations for HAL .....	77
<b>11</b>	<b>Appendices.....</b>	<b>79</b>
11.1	Appendix A - Documents Requested and Reviewed .....	79
11.2	Appendix B – Queries & Responses .....	83

## Glossary

Abbreviation	Description	Abbreviation	Description
AC	Airports Commission	HEP	Heathrow Expansion Programme
AGL	Airfield Ground Lighting	IFS	Independent Fund Surveyor
APM	Automated People Movers	LDA	Landing Distance Available
ATM	Air Traffic Movements	LoS	Level of Service
AWG	Airline Working Group	MPPA	Million Passengers Per Annum
BHS	Baggage Handling System	NIS	Noise Insulation Scheme
BRAG	Black / Red / Amber / Green scoring method	NPS	National Policy Statement
CAA	Civil Aviation Authority	NWR	North-West Runway
C/D	Collector Distributors	OAG	Options Approval Group
CPO	Compulsory Purchase Order	OSG	Options Steering Group
CTA	Central Terminal Area	RAG	Red / Amber / Green scoring method
DER	Design Evaluation Report	RAT	Rapid Access Taxiway
DfT	Department for Transport	RESA	Runway End Safety Area
DM	Do Minimum scheme	RET	Rapid Exit Taxiway
DN	Do Nothing scheme	RLB	Red Line Boundary
DoN	Duke of Northumberland channel	SMJ	Stanwell Moor Junction
EA	Environment Agency	SRN	Strategic Road Network
EAAR	Eastern Airside Access Road	SDLT	Stamp Duty Land Tax
EMB	Eastern Maintenance Base	SSSI	Site of Special Scientific Interest
G&T	Gardiner & Theobald LLP	SuDS	Sustainable Drainage System
GIS	Geographic Information System	TORA	Take-Off Run Available
GIFA	Gross Internal Floor Area	TTS	Track Transit System
HAL	Heathrow Airport Limited	WPO	Wider Property Offer
HE	Highways England		

## Tables & Figures

### LIST OF TABLES

Table 1: HAL evaluation criteria and sub-criteria for North-West Runway options .....	16
Table 2. RAG Status for Runway options.....	19
Table 3. Runway Summary - HAL Add-Ons.....	21
Table 4. Runway Options - Property Costs Summary.....	22
Table 5. Runway Options – HAL/Arcadis Business Case RAG Evaluation Comparison.....	22
Table 6. HAL Evaluation Summary – Runway Options.....	23
Table 7: HAL evaluation criteria and sub-criteria for M25 Alignment and Junction Options .....	25
Table 8. M25 Alignment Options - Project Specifics Summary.....	28
Table 9. RAG Status for M25 Alignment Options .....	29
Table 10. M25 Alignment Options – Total Length Comparison Summary .....	29
Table 11. M25 Alignment Options - Property Costs Summary.....	30
Table 12. M25 Alignment Options – HAL/Arcadis Business Case RAG Evaluation Comparison.....	31
Table 13. HAL BRAG Summary – M25 Alignment.....	32
Table 14. M25 Junction Options - Property Costs Summary .....	33
Table 15. M25 Junction Options - Property Costs Summary .....	35
Table 16. M25 Junction Options – HAL/Arcadis Business Case RAG Evaluation Comparison .....	35
Table 17. HAL BRAG Summary – M25 Junctions.....	36
Table 18: HAL evaluation criteria and sub-criteria for Local Roads .....	38
Table 19. RAG Status for Local Roads Options.....	41
Table 20. A4 Pavement Quantities Comparison Summary.....	42
Table 21. A3044 Pavement Quantities Comparison Summary.....	42
Table 22. Local Roads – Property Costs Summary .....	44
Table 23. Local Roads A3044 Options – HAL/Arcadis Business Case RAG Evaluation Comparison .....	45
Table 24. Local Roads A4 Options – HAL/Arcadis Business Case RAG Evaluation Comparison .....	45
Table 25. HAL BRAG Summary – Local Roads.....	46
Table 26: HAL evaluation criteria and sub-criteria for Rivers and Flood Storage .....	48
Table 27. RAG Status for Rivers & Flood Storage Options.....	50
Table 28. Rivers – HAL/Arcadis Summary Comparison Measure .....	51
Table 29. Culvert Benchmark Analysis.....	52
Table 30. Rivers (Conveyancing) options – HAL/Arcadis Business Case RAG Evaluation Comparison .....	54
Table 31. HAL BRAG Summary - Conveyance.....	54

Table 32. Key Conclusions .....	55
Table 33. HAL's option retention and further developments summary .....	58
Table 34. HAL evaluation criteria and sub-criteria for Terminals, Satellites & Aprons Assemblies Options...	60
Table 35. HAL BRAG Summary – Terminals, Satellites & Aprons .....	69
Table 36. HAL Capex Summary Table .....	70
Table 37. IFS Key Component Independent Estimate Reviews .....	72

## LIST OF FIGURES

Figure 1. HAL Scheme Development Process Overview .....	8
Figure 2. Project Risk Process Map .....	15
Figure 3. Northern runway option families depicting length and east-west position. ....	17
Figure 4. M25 Alignment indicative routes (LEFT: <b>AC1 / AC2 / AC3</b> , RIGHT: <b>AA Online / AB Offline</b> ).....	26
Figure 5. Local Roads Indicative Routes.....	39
Figure 6. Current diagrammatic arrangement of existing terminals and satellites at Heathrow.....	60
Figure 7. Future Terminal and Satellite Typologies.....	60
Figure 8. Main Assembly Option 3Ai .....	61
Figure 9. Main Assembly Option 3Aii .....	61
Figure 10. Main Assembly Option 4A.....	62
Figure 11. Main Assembly Option 11C.....	62
Figure 12. Main Assembly Option 12A.....	63
Figure 13. Main Assembly Option 15B.....	63
Figure 14. Challenger Option 9 .....	64
Figure 15. Challenger Option 13 .....	64
Figure 16. Challenger Option 14 .....	65



# 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.

As part of Heathrow Airport Limited's (HAL's) journey towards a fixed development masterplan, HAL has embarked upon an iterative process of identifying Key Components, developing and refining various options and forming criteria against which to evaluate these options.

The process for undertaking the evaluations is laid out in their Masterplan Scheme Development Manual. This manual details the organisation, key principles, evaluation criteria, evaluation methods and governance of this process.

An overview of this process is as shown in the figure below, with the evaluations carried out at Stage 2 known as the Green Reviews.

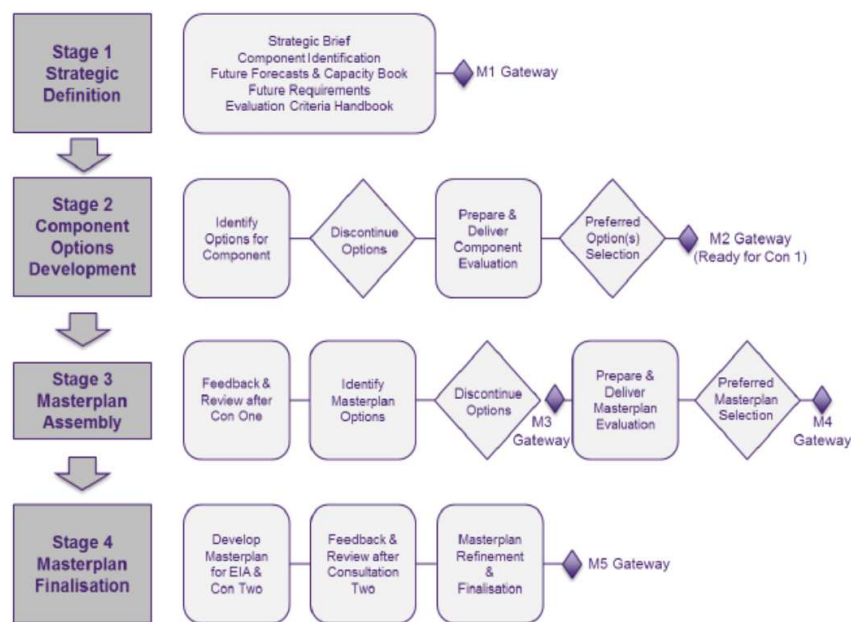


Figure 1. HAL Scheme Development Process Overview

Arcadis' scope of work has been to examine the output of these Green Reviews by analysing and providing assurance that the Key Components which form part of HAL's expansion plans are 'cost efficient'.

The Green Reviews were undertaken based upon design concepts developed ahead of HAL's Consultation 1 and are milestones that conclude work for each of the Key Component options investigated by HAL during Stage 2 of the development process. These Key Components have been identified as:

- Runway
- M25 and Junctions
- Local Roads
- Rivers and Flood Storage
- Terminals, Satellites and Aprons

This report therefore summarises a cost efficiency review of the Key Components that form part of HEP and any associated data made available. As such, this report includes:

- Specific cost efficiency observations
- Summation / extension of the Independent Fund Surveyor (IFS) report findings
- Holistic view of efficiency based on information and data made available to date
- Emerging thoughts for other areas of investigation
- For the purposes of Stage 2 across the Business Case discipline only capex cost was evaluated. Items such as operating costs, financing costs, aeronautical revenue, utilisation efficiency and flexibility have not been reviewed at this stage.

Our scope of work has sought to capture and provide the above information, for the benefit of the CAA, in line with an agreed Project Charter and scope of work described therein. This has been monitored through ongoing conversations between the CAA and Arcadis and via fortnightly Flash Reports.

Given the breadth and scope of the cost efficiency review, Arcadis requested that HAL provide all data and supporting evidence used to undertake their Green Reviews, a summary of which is contained within Appendix A.

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

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 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.

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).

## 2 Executive Summary

This report is intended to complement and be read in tandem with other works provided for the CAA by Arcadis, namely the 'Integrated Baseline Purple Book (0.61) Review Report' and the 'Westerly Option Review Report'.

Arcadis believe that our Key Component Review has been a worthwhile exercise in securing a robust output for this stage of the programme and our review. Our report broadly supports the HAL Green Review recommendations for retention of options to be considered in the Masterplan Assembly and is consistent with the findings of the IFS.

Items common to all components comprise:

- The current design for each of the options within all the Key Components is at a very high level, making capex assessment challenging. Nevertheless, Arcadis consider that HAL's approach to the construction elements is generally in line with industry standards.
- The majority of the Add-On percentages used by HAL are in line with industry standards apart from allowances for project specifics which appear to be insufficient and should be considered for each facility to ensure the allowance reflects the nature of the works.
- Arcadis consider that each option should be considered independently, and the lump sum amounts, or percentages applied for Project Specifics adjusted to reflect delivery challenges specific to each option.
- HAL have applied different approaches for the evaluation of risk for each of the components. The runway, local roads and M25 all have a very specific percentage applied which appears to align with the P50 allowance contained in the Purple Book. Over and above this a further percentage ranging from 75%-125% has been applied for uncertainty. However, for the rivers 15% has been applied for risk and 10% for uncertainty whilst no risk has been included in the evaluation of the terminals and satellites. Arcadis consider that a further review of HAL's approach to risk is required to ensure a robust Risk Management structure is in place which incorporates mitigation measures.
- While HAL have designed best practice principles, they have not necessarily always implemented the procedures correctly resulting in options within components not being fully aligned. Notwithstanding this, these discrepancies overall are relatively minor and have had minimal impact upon the capex RAG status ranking.
- All HAL estimates are at 3Q14 prices to enable direct comparison to the Airports Commission report. Arcadis consider that inflation both to current prices (with particular attention to the costs of property and land take), and over the course of the scheme should be carefully considered at the next stage of the review.
- There is no Black RAG status for capex, none of the options have been discontinued at this stage due to capital cost exceeding the Purple Book baseline.
- Arcadis consider that there are significant value engineering opportunities across all of the Key Components. These can be progressed as each option design evolves and masterplan assembly commences.

**Arcadis' findings specific to each Key Component include:**

### Runway

HAL has considered several runway schemes at different lengths in different option families. Our other key observations include:

- The major differentiator is the requirement to traverse the M4 Spur for the easterly options and the M25 for the westerly options.
- The cost variation between schemes for runway pavement is minimal when compared to motorway crossings and property costs and is therefore not considered to be a key differentiator.

- In terms of overall RAG status against the AC scheme, on a capex basis Arcadis has rated the options in line with HAL's findings except for moving the two Family B options from Green to Amber status.
- Benchmark data has been used by HAL to develop the estimates. The runway rate used by HAL is efficient but Arcadis considers that it represents too much of a stretch to be deliverable in the context of the overall scheme; accordingly we recommend a higher but also stretching cost target rate.

### M25 & Junctions / Local Roads

Both the M25 Alignment & Junctions and the Local Roads Key Components have significant interdependencies and commonalities and can therefore be summarised together. Our key observations include:

- The M25 consists of seven alignment options and eight junction options, while the Local Roads consists of the works to the A4 (five options) and A3044 (six options). Stanwell Moor Junction, T5(X) access, and Central Terminal Area (CTA) access are not considered at this stage.
- Quantitative property assessment has been carried out by HAL for each of the options.
- Benchmark data taken from a number of sources has been used by HAL to develop the estimates. These figures are within tolerance of Arcadis benchmark data for comparable items.
- In terms of overall RAG status against the Airports Commission scheme, on a capex basis Arcadis has rated all of the options largely in line with HAL's findings.
- No junction options have been discontinued against any of the other evaluation criteria.
- None of the local roads options have been suggested for discontinuation against any of the other evaluation criteria.
- M25 Alignment Family AB, utilising offline construction involving local realignment of the M25 between J15 and J14a is lower in cost and risk and has relative ease of construction when compared to Family AA and Family AC.
- Alignment Family AC has the greatest impact on planning and property and has been recommended for discontinuation by HAL based on the impacts to local communities and the environment, while Family AA (maintaining the route of the M25) has the least impact.
- Both of the Family AA alignment options have enormous delivery implications. Option AA0 requires raising of the runway by 5m, leading to severe programme and operational constraints (inoperable linking taxiway gradient), while the temporary works required to deliver AA1 are considered to be infeasible.

### Rivers & Flood Storage

The Rivers (Conveyancing) and Flood Storage have several interdependent options. Our key observations include:

- Arcadis believe that HAL's approach to the construction elements for the rivers is generally in line with industry standards. We would, however, expect to see assessments of the cost of land acquisition. We would also expect to see benchmarks being reviewed from projects other than Heathrow projects, this will then act to challenge the efficiency of previous HAL projects.
- Whilst HAL's capex has rated two options above the AC's scheme and three below, Arcadis has rated all of them below. This is mainly due to the concerns that Arcadis has regarding the benchmark rate that HAL has utilised for the culverts. HAL could potentially discontinue options which have more culverts, whereas from a capex evaluation perspective, Arcadis do not believe that these should be discontinued at this stage.
- For the flood storage, no capex evaluation has been undertaken and the property loss has been evaluated subjectively rather than quantitatively. Arcadis do not concur with this approach and believe a quantitative assessment of capex should be undertaken.

- All these options are complex to deliver. However, there are opportunities to integrate these options into the main expansion works to reduce total cost. This in turn should be captured in the business case.

### Terminals, Satellites & Aprons

The options comprise nine assemblies of Terminals, Satellites and Aprons, consisting of six main options and three “Challenger” options, retaining existing terminals T3 and T4. Our key observations include:

- Arcadis note that a Design Evaluation Report (DER) was not undertaken for this Key Component.
- Gross Internal Floor Area needs to be reviewed and substantiated by the design team for both terminals and satellites. These also need to be benchmarked.
- Although HAL sits within the middle to lower end of the benchmarks noted in the Integrated Baseline Purple Book (0.61) Review Final Report, Arcadis would expect to see benchmark rates being reviewed from projects other than Heathrow; this will then act as a catalyst to challenge the efficiency of previous HAL projects.
- Arcadis recommend the scope requirements for all options is reviewed and fully captured, e.g. Gateways and Eastern Maintenance Base.
- Arcadis consider that HAL should review the pricing of the substructure of the terminals and the sunken H Satellites is revisited and aligned with the Purple Book.
- HAL has not considered replacement expenditure (repex) as part of the Challenger options. The heavy maintenance costs for ageing assets such as the Terminals 3 and 4 have not been included within the estimates.

## 2.1 Recommendations

Arcadis consider that there are significant value engineering opportunities across all of the Key Components. These can be progressed as each option design evolves and masterplan assembly commences.

At the components stage the options are conceptual rather than detailed. The evaluation has therefore been at a relatively high level, using criteria appropriate at this stage.

For the benefit of the CAA, Arcadis has provided recommendations throughout this document that they may wish to be shared with HAL with the aim of collaboration and assisting HAL achieve their objectives when undertaking further iterations of each Key Component at future design stages.

These recommendations specific to each component include, but are not limited to, the following:

### Runway

Ref	Recommendation
1	Refine the options and undertake more detailed assessments to optimise runway length in order to minimise property loss and environmental impact.

### M25 & Junctions / Local Roads

Ref	Recommendation
2	Undertake an assessment of each option in greater detail in order to refine and optimise routes (i.e. by aligning new roads adjacent to existing), minimising property loss and environmental impact.
3	Assess options as holistic packages to understand compatibility and overall operational performance, as each sub-component will have its own set of unique interface issues when put together to form a preferred route assembly.
4	Evaluate options with localised traffic modelling to understand operational performance and traffic distribution; key issues for community connectivity, local noise and air quality assessment.

Ref	Recommendation
5	Assess potential congestion and diversionary impacts during construction. Arcadis consider that these should be looked at in a thorough deliverability and phasing exercise.
6	Consider ground water levels as these have not been studied at the current stage of the design process. Significant dewatering may be required and should be further investigated.
7	Incorporate a capital expenditure view of the mitigation measures which would be required to offset negative impacts on sustainability and local communities.
8	Ensure a robust peer review process is employed to ensure calculation errors (such as that highlighted by Local Roads options 3d, 2ai, 2bi and 3g of the A3044 Family whereby linear meterage was confused with area) are eliminated insofar as possible from future iterations of these estimates.
9	Assess local road combinations with and without a large western apron.
10	Liaise with the Rivers & Flood Storage Key Component to ensure that conveyancing and water storage requirements are achieved across the surface access options. Many of these highway options interface with historic landfill sites and existing water courses and need to be managed appropriately as the design progresses.

### Rivers & Flood Storage:

Ref	Recommendation
11	Develop combined component options that match storage areas to conveyancing, informed by the evaluation undertaken during the Green Review.
12	Undertake more detailed assessments of each option in order to optimise locations / boundaries and minimise property loss / land take and environmental impact.

### Terminals, Satellites & Aprons

Ref	Recommendation
13	Validate the GIFA's for terminals and satellites.
14	Undertake further benchmark analysis and align approach re substructures and superstructure benchmarking.

### General

Ref	Recommendation
15	Review the risk approach for all of the Key Components

## 3 Cost Efficiency

### 3.1 Introduction

The purpose of this report is to enable the CAA to advise the DfT on the cost efficiency of the Key Components of the HAL Expansion Programme by providing high quality, evidence-based advice using benchmarking and data analysis techniques.

Our review was based on the Key Component Green Reviews. We have reviewed the approach under the individual headings as it differs between the components.

In this report we refer to some of HAL's 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.

The IFS has also performed a review of the Key Components and produced an individual report for each. We have reviewed their findings and our comments are included in section 10 of this report.

A combined section with recommendations and next steps from both reviews is included in section 11.

### 3.2 Context and Approach

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

The following procedures have been performed:

- Review of HAL estimating procedures.
- Review of HAL estimating benchmarking procedures.
- Direct Cost review including build-up, quantification, base pricing, and project specifics.
- Benchmark analysis.
- Review of delivery strategy and risk, and assessment of their impact on cost efficiency.
- The component evaluation does not consider procurement options as this is not a differentiator.
- The estimates within the Key Component Green Review inform the option evaluation and subsequent Masterplan preferred option selection. It is therefore of utmost importance that the CAA has assurance over the cost estimates included within the document.

### 3.3 Estimating Procedures

This process has been discussed within the Integrated Baseline Purple Book (0.61) Review Report, however we provide the key points below again for reference.

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 the delivery of a project. This can therefore provide the commercial advice upon which business decisions are made.

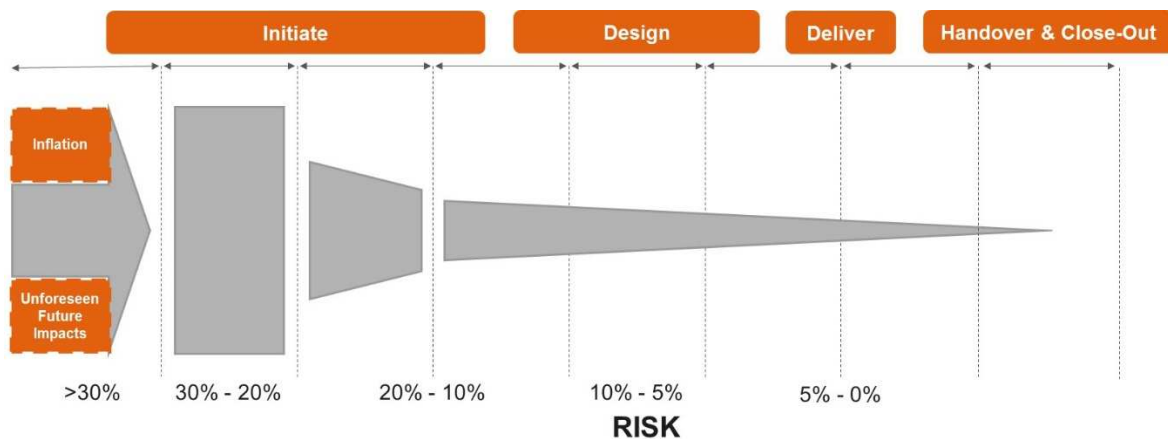


Figure 2. Project Risk Process Map

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.

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. When undertaking the evaluation of options, it is critical that the Basis of Estimate and maturity is aligned for each option estimate and that these then align with the Purple Book which forms the basis of which they are being evaluated against.

### 3.4 Evaluation Criteria

At the components stage the options are conceptual rather than detailed and the evaluation has therefore been at a relatively high level, using those criteria which are appropriate at this stage.

Criteria have been formulated for each option split into individual disciplines (i.e. Operations & Service, Delivery, Sustainability & Community, Planning & Property, and Business Case).

To ensure that a consistent approach is undertaken when applying the evaluation criteria, HAL has developed an evaluation system utilising a four-point BRAG scale as below:

- **BLACK** Unworkable
- **RED** Less preferred
- **AMBER** Satisfactory
- **GREEN** More preferred

An unworkable score (Black) indicates that the option is fundamentally flawed and should be discontinued from further consideration, e.g. due to physical incompatibility, technically or operationally not feasible, or is environmentally unacceptable even with mitigation.

There is no Black rating for capital expenditure at the Green Review. Arcadis consider that this is a reasonable approach to ensure that all options are captured and compared at this stage in the process.

The application of all criteria involves the use of professional judgement based on both qualitative and quantitative data sources, enabling a multidisciplinary approach in which professional judgement and detailed analysis can be applied across subject areas in a coherent and consistent way.



## 4 Runway

### 4.1 Introduction

This component comprises the provision of a new runway to the north-west of the existing airfield.

The proposed runway options were evaluated under five criteria by HAL with related sub-criteria as detailed below:

<b>OPERATIONS &amp; SERVICE</b>	<b>PLANNING &amp; PROPERTY</b>
<ul style="list-style-type: none"> <li>• Reliable and efficient schedule able to deliver noise respite to local communities</li> <li>• Runway length and gradient affecting airfield operations and aircraft usage</li> </ul>	<ul style="list-style-type: none"> <li>• Consistent with Draft NPS, i.e. Northwest scheme, delivery 260k ATM, full length 3500m runway, and support predictable periods of respite</li> <li>• Minimise blight zones and direct impacts on green belt and communities to the east and west</li> </ul>
<b>DELIVERY</b>	<b>SUSTAINABILITY &amp; COMMUNITY</b>
<ul style="list-style-type: none"> <li>• Complexity (increased by motorway crossings)</li> <li>• Volume of earthworks</li> <li>• Interaction with existing airfield operation</li> </ul>	<ul style="list-style-type: none"> <li>Air quality</li> <li>Noise impacts</li> <li>Minimising property loss</li> </ul>
<b>BUSINESS CASE</b>	
<ul style="list-style-type: none"> <li>• Capital Expenditure</li> <li>• Property / Land take</li> </ul>	

Table 1: HAL evaluation criteria and sub-criteria for North-West Runway options

This report concentrates on HAL's Business Case evaluation approach; however, we have given a commentary on their methodology to the evaluation of other criteria and offered high level opinions to this approach in the following sections.

### 4.2 Options Summary

Following the Airports Commission recommendation and subsequent airline stakeholder feedback a list of options was produced to enable evaluation. The options identified were previously pre-screened to narrow down the possible permutations which are contained in the Green Review.

It was agreed that three runway lengths should be tested; 2,800m, 3,200m and 3,500m take-off run available (TORA), each of which being 1,035m north of the existing northern runway

The lengths were assessed in a number of locations resulting in four option families emerging:

- Family A: From Sipson westwards.
- Family B: From the M25 eastwards.
- Family C: From Harlington westwards.
- Family D: From the M4 spur westwards.

Within the option Family B, a runway length of 2,295m was also evaluated; this being the maximum length of runway that would fit between the existing M25 and M4 Spur motorways.

A graphical representation of these options is shown below:

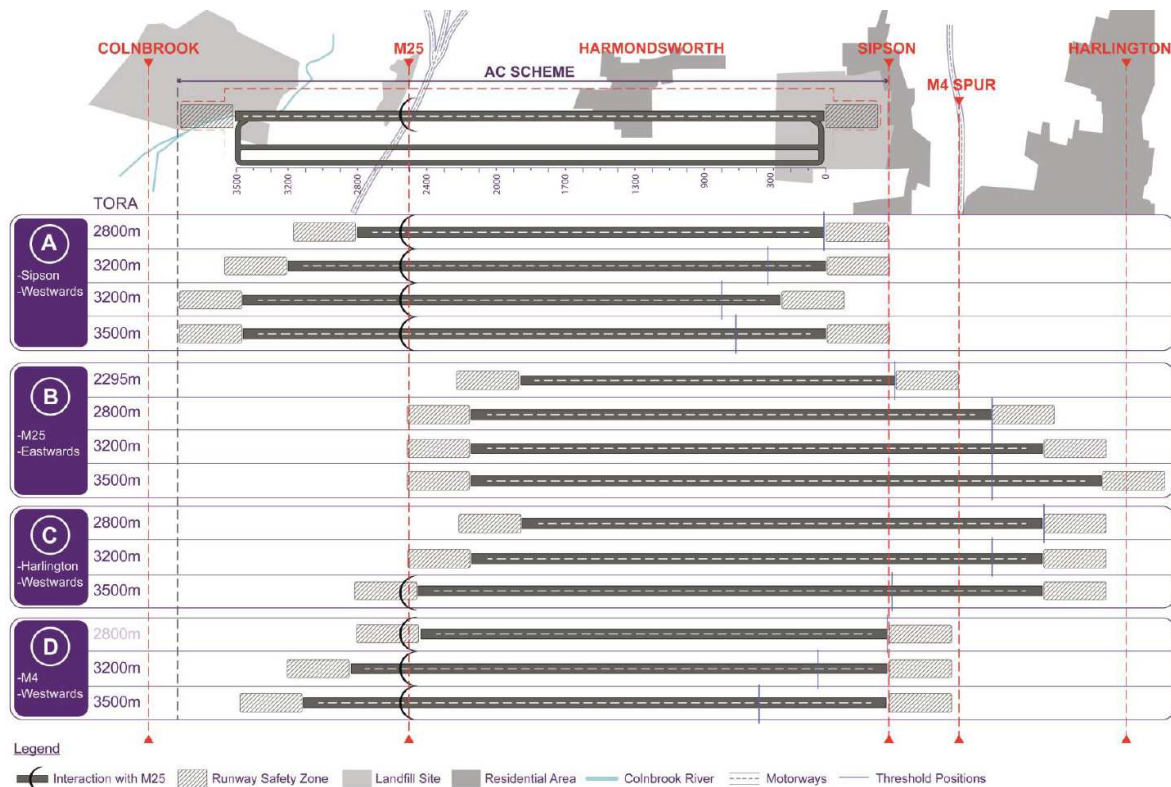


Figure 3. Northern runway option families depicting length and east-west position.

HAL subsequently discontinued Family D due to its significant effects on Sipson. The remaining options were further condensed to just four; a 3,200m and 3,500m option in both Family A and Family B, representing a more westerly and a more easterly runway location respectively. The key physical differentiator between these options being the bridging of the M25 versus the M4 Spur.

This report considers the evaluations process implemented during the Green Review and does not examine the processes adopted beforehand.

## 4.3 Evaluation

What follows is a high-level commentary on HAL’s approach to the Operations & Service, Planning & Property, Sustainability & Community and Delivery evaluation criteria, and a detailed commentary of the Business Case evaluation. HAL’s approach was predicated upon design concepts produced ahead of Heathrow’s Consultation 1; Arcadis note that these concepts have subsequently evolved since the Green Review stage.

### 4.3.1 Operations & Service

For the Green Review, HAL has undertaken a qualitative assessment of the impacts that each of the runway length options will have on the following:

- Ability to deliver noise respite to local communities.
- Airfield operations and aircraft usage.

Runway length is the critical driver for airfield operations and determines which aircraft types can use which runways in terms of Take Off Run Available (TORA) and Landing Distance Available (LDA).

Operationally, a longer runway is more desirable, although there is a point where the benefits of additional length will be outweighed by environmental concerns and community impacts. Runway options greater than 3,500m are unlikely to deliver additional benefits in terms operational capabilities and aircraft usage.

Conversely, runway lengths under 3,200m (such as 2,800m and 2,295m) would be unable to cater for the largest Code F aircraft and therefore not fulfil the operational service requirements required by HAL and stipulated within the NPS.

Based on these criteria, all the 3,200m and 3,500m runway options considered all meet the minimum stipulated operational and service requirements.

### 4.3.2 Planning & Property

In determining the impacts of this criteria, HAL has undertaken both a qualitative and quantitative review considering the following items:

- Minimising blight zones and property loss on communities to the east and west.
- Maintain consistency with Draft NPS.

Consistency with the principle of the Northwest scheme as supported by the Airports Commission and the draft NPS is critical. In particular, this means the scheme must be a “northwest” scheme, deliver the required additional 260k ATMs pa growth, have a full length 3,500m runway and support predictable periods of respite for local communities.

All runway options have an impact upon local residential properties. As a result, HAL commissioned a quantitative assessment of properties affected for each option, with figures based upon outputs extracted from a GIS model of the local area. This model encompasses all property types (commercial, residential, agricultural, industrial, etc) and their respective values, including allowances for compensation and extinguishing businesses.

Arcadis has reviewed the quantitative assessment of property impacts carried out by HAL within the Business Case section.

### 4.3.3 Sustainability & Community

The impact that the new runway would have on quality of life was identified as a key evaluation criterion, in particular on local air quality and the additional noise associated with traffic movements, direct impacts on the natural environment due to the additional infrastructure, and the effect on communities associated with property loss and community severance.

The impact of local airborne noise on communities is influenced significantly by the east-west position of the runway.

The Family B and C options families are likely to result in severe adverse impacts to both local communities, which would require extensive mitigation. Given the scale of the residential property loss within Sipson and Harlington, and impacts on air quality, noise and visual impacts on the local communities affected, which would be inconsistent with the Draft NPS, HAL has recommended that these options are awarded a Black RAG rating and discontinued.

As such HAL’s evaluation has been based upon the qualitative impacts on noise, water, land quality, community and biodiversity.

At this stage Arcadis consider that this subjective view is a reasonable way to evaluate this criterion, however future steps should incorporate a Capital Expenditure (Capex) view of mitigation measures necessary.

### 4.3.4 Delivery

The key considerations for this evaluation criteria are:

- Avoidance of critical constraints.
- Reduction of complexity and risk.
- Minimising construction impacts.
- Delivery within overall programme timescales.
- Minimising materials import and export.
- Delivery of safe and secure construction operations.

A deliverability assessment for each of the options has been undertaken by HAL.

From looking at the proposed layouts, it has been identified that the volume of earthworks required to support raised runway profiles across motorways is significant and is common across all options. The volume of earthworks required for a runway crossing of the M25 on its existing alignment at +9m is considered undeliverable within the required timescales, whereas an off-line M25 option would only require circa +5m.

### 4.3.5 Business Case

The business case is an evaluation of capital cost associated with each of the runway alignment options. The two main considerations here are:

- Capital Expenditure (Capex).
- Property loss / land take.

Arcadis has undertaken a detailed review of HAL's approach to their assessment of capex and property loss / land take which follows:

#### 4.3.5.1 Capital Expenditure (Capex)

HAL has created a bottom-up estimate for each option using elemental rates and rated this against the Purple Book. Arcadis consider that this is best practice at this stage of the project.

The capex output for each option has been constructed using the same format and the result can then be used to rank options. The criteria applied for the ranking status is:

RAG Status	Ranking Criteria
RED	Baseline cost increase of 5% or above
AMBER	Baseline cost between plus 5% or minus 10%
GREEN	Baseline cost reduction of 10% or below

*Table 2. RAG Status for Runway options*

It should be noted that the capex review under the business case evaluation criteria only has a Red / Amber / Green rating. No options are discontinued (given a Black rating) because of capex outputs.

One exception to this is the 2,295m runway option (sitting between the between M25 and M4) as it failed to meet basic criteria and would not have enabled the expansion in air traffic movements required by stakeholders and stipulated in the Airports Commission scheme.

In reviewing the capex, Arcadis has analysed and commented upon the following sections:

- **Quantities**

HAL's estimate is derived using the quantities provided by the designers and the runway lengths stipulated.

Quantities are relatively straightforward for the pavement aspect of the runway options. The runway is based upon 60m width with 7.5m wide shoulders to enable it to take Code F aircraft, so for the 3,500m runway comprises an area of 210,000m<sup>2</sup>, and 192,000m<sup>2</sup> for the 3,200m runway (both excluding shoulders).

- **Rates**

HAL has provided benchmark facility level data of high value items. The key rates utilised for this component include:

- Runway

While HAL has utilised a rate of █████ m<sup>2</sup> for runway construction (inclusive of AGL and surface markings), Arcadis benchmarks suggest a rate of £340/m<sup>2</sup> for the runway is more appropriate. The rate used by HAL is efficient but may represent too much of a stretch to be deliverable in the context of the overall scheme; accordingly, we recommend a higher but also stretching cost target rate.

Arcadis note that this unit rate used by HAL for both runway and shoulder construction is the same. Runway shoulders typically have a lower load bearing capacity, reduced make-up and hence a lower cost, therefore an opportunity to decrease this rate exists subject to further analysis.

Arcadis benchmarks suggest a rate of £190/m<sup>2</sup> for the shoulders may be more suitable.

Notwithstanding the above, the cost variation between schemes for the runway pavement, RETs, RATs and adjacent taxiways is minimal when compared to the property costs and motorway crossings, and is therefore not considered to be a major differentiator by HAL. Arcadis concurs with this assessment.

- Taxiway

Taxiway costs can vary considerably depending on the code of aircraft that they are required to accommodate. HAL has used £████ m<sup>2</sup> for the construction of Code F taxiways able to take the largest aircraft. The HAL rate is close to the low end of the spectrum, with Arcadis benchmarks ranging from £140/m<sup>2</sup> to £340/m<sup>2</sup> with a mean of £220/m<sup>2</sup>. Notwithstanding that the works are on a large scale and shall be undertaken predominantly on a landside non-operational site, Arcadis would suggest that the HAL amount is revisited as the rate may still be too efficient to be deliverable in the context of the overall scheme.

- M25 Box

Estimated costs of the M25 Box are included within the Runway component but also within the M25 Alignment component. In the runway component the box is █████m, while in the M25 Alignment component (option AB2) it is █████m.

Arcadis suggest that this variation is reviewed and carefully considered when the Key Components are brought together for masterplan assembly.

- **Add-ons**

HAL has split up each of the runway options into constituent parts, with the add-ons applied by HAL summarised below:

Runway – Add-Ons Summary					
	Add-Ons	M25 Box	M4 Spur	3500m + Taxiway	3200m + Taxiway
01	Project Specifics				
02	Prelims				
03	OHP				

Runway – Add-Ons Summary					
	Add-Ons	M25 Box	M4 Spur	3500m + Taxiway	3200m + Taxiway
04	Design				
05	L&L				

Table 3. Runway Summary - HAL Add-Ons

HAL has applied the same percentages across all the above component constituents for preliminaries, OH&P, design, leadership & logistics. These percentages are based upon HAL’s previous project experience and appear reasonable for this element of work.

At this early stage it is normal to apply percentages for these items founded upon the base construction cost; hence options with higher capex will attract higher on-costs.

Arcadis would expect to see the phasing reviewed as the design develops, and dependent upon construction complexity different percentages potentially being applied for different options.

Arcadis considers that the project specifics allowance of nil against each of the runway options may be insufficient and should be reviewed. Project specific costs are those which occur due to the particular constraints arising on the programme; as such by not making any allowance HAL has assumed that they will be able to deliver the works without disruption.

Currently a lump sum for project specifics has been applied to the base construction costs of both the M25 box and M4 Spur constituent parts ( █████m and █████m respectively). Including for the complexities of the traffic management required to maintain flow throughout throughout the works (even accounting for the majority of the works being offline), Arcadis consider that the current allowances may be insufficient and should be revisited.

The property costs against the M25 and M4 Spur are limited to the land required directly relating to the highway works, and not the impact of Compulsory Purchase Orders, Wider Property Offer and Noise Insulation Scheme offers; these are covered in the following Property Loss/Land Take section.

- **Risk**

The risk percentages of each of the option constituents varies from approximately █████% to █████%. These are very specific at this early stage of design and Arcadis has queried the reasoning behind this with HAL. This percentage has been derived from a quantitative risk assessment of the baseline at P80 level. However, the order of magnitude of risk is in line with industry norms.

There is an additional *Risk & Uncertainty Adjustment* to the baseline of █████%, █████% or █████% dependent upon a subjective analysis by HAL of the perceived complexity of the works (i.e. construction of the M4 Spur box within a constrained environment attracts █████%, while the offline construction of the M25 Box remains at █████%).

Arcadis consider that this adjustment is at an appropriate level taking into account a subjective review of the constraints at this stage of the design.

#### 4.3.5.2 Property Loss / Land Take

For the Green Review of the Runway options, HAL sought specialist input from CBRE for the property loss assessment, commissioning a detailed study of the area incorporating all property types (commercial, residential, agricultural, industrial, utilities, etc) and their respective values including allowances for extinguishing businesses.

Property and land take forms over █████% of the cost of the runway Key Component across all options. This is split into Compulsory Purchase Order (CPO), Wider Property Offer (WPO) and Noise Insulation Scheme (NIS) costs, as shown in the summary table below:

Runway Options – Property Costs Summary				
Property	Family A		Family B	
	3500m	3200m	3500m	3200m
CPO – Compulsory Purchase Order				
WPO – Wider Property Offer				
NIS – Noise Insulation Scheme				
<b>Total</b>				

Table 4. Runway Options - Property Costs Summary

The different CPO, WPO and NIS allowances listed above comprise:

- CPO** The compulsory purchase zone is the area within the operational boundary of the expanded airport, within which property must be acquired and removed.
- WPO** This is a voluntary purchase scheme for nearby owner-occupied residential property offering █% of market value. The boundary of this scheme has been drawn using defined noise contours as a starting point which have then been extended to sensible natural boundaries so that residential settlements are not cut in half.
- NIS** HAL has utilised defined noise contours to indicate the boundaries of different levels of compensation for local residential property as part of the Noise Insulation Scheme.

The 3,200m option is inherently cheaper in terms of overall property costs than the longer 3,500m option, and both Family A options are cheaper than Family B, as although Colnbrook is less affected, the towns of Sipson and Harlington are more affected.

Arcadis has not seen the data behind the property calculations but consider that HAL has adopted a reasonable approach in evaluating this criteria at this stage.

#### 4.3.6 Arcadis RAG Evaluation

Arcadis have collated their comments from the above section and prepared a revised summary, which compares to HAL’s capex summary as below:

Runway Options – HAL/Arcadis Evaluation Comparison									
Item	AC Baseline	Family A				Family B			
		3500m		3200m		3500m		3200m	
		HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis
Item	£m	£m	£m	£m	£m	£m	£m	£m	£m
Runway Pavement									
Adjacent Taxiways									
M25 Box & Embankment									
Lower M4 Spur & Bridge									
<b>Non-Property Total</b>									
Property									
<b>CAPEX Total</b>									
<b>RAG Status &amp; Rank</b>		4	4	3	3	2	2	1	1

Table 5. Runway Options – HAL/Arcadis Business Case RAG Evaluation Comparison

Our ranking of the options aligns with HAL, however using the same ranking criteria the Arcadis assessment has moved both the Family B options from Green to Amber status (i.e. moving from a reduction of 10% or below the baseline cost, to an amount between plus 5% or minus 10% of the baseline cost).

### 4.3.7 HAL BRAG Summary

HAL has collated the criteria giving an overall rating to each option as evaluated by the respective disciplines. Where a Black rating was given it was considered that the option should be discontinued from further consideration. This is illustrated by the following table:

Runway Options – HAL Evaluation Summary			Operations & Service	Planning & Property	Sustainability & Community	Delivery	Business Case
Family A	← Sipson M25 bridge	2,800m					
		3,200m					
		3,500m					
	← Sipson M25 diversion	2,800m					
		3,200m					
		3,500m					
Family B	M25 → ← M4	2,295m					
	M25	2,800m					
		3,200m					
		3,500m					
Family C	← Harlington	2,800m					
		3,500m					
Family D	← M4	3,200m					

Table 6. HAL Evaluation Summary – Runway Options

Based on the results of each of the above criteria the majority of the options have been discontinued.

It is clear that Family A with a 3,500m runway crossing the M25 is the most preferred at this stage.

Although generally speaking the Business Case criterion has no Black rating, one option was discontinued by this criterion (the 2,295m long runway between the M25 and M4) as it failed to meet the basic criteria and would not have enabled the necessary expansion in air traffic movements required by stakeholders.

## 4.4 Key Findings

The current design for the Runway is at a very high level which makes capex assessment more challenging. However, Arcadis consider that HAL’s approach to the construction elements is generally in line with industry standards.

In terms of overall RAG status against the AC scheme, on a capex basis Arcadis has rated the options in line with HAL’s findings while moving the two Family B options from Green to Amber status.

The cost variation between schemes for runway pavement is minimal when compared to the property costs and motorway crossings and is therefore not considered to be a major differentiator.



Benchmark data has been used by HAL to develop the estimates. We suggest that the runway rate is reviewed as HAL has utilised a rate of [REDACTED] m<sup>2</sup> for runway construction while Arcadis benchmarks suggest a rate of £340/m<sup>2</sup> for the runway is more appropriate.

The majority of the Add-On percentages used by HAL are in line with industry benchmarks. However, Arcadis believe that each option should be considered independently, and the percentages applied for Project Specifics adjusted accordingly.

## 4.5 Next Steps

Next steps include:

- HAL will have the opportunity to refine options and undertake more detailed assessments to optimise runway length in order to minimise property loss and environmental impact.

## 5 M25 Alignment & Junctions

### 5.1 Introduction

This component comprises the changes required to both the alignment of the M25 and associated junctions.

The options identified have been pre-screened during the Orange Review to narrow down the possible permutations. This report considers the evaluations process implemented during the Green Review and does not examine the processes adopted during the Orange Review.

In undertaking their BRAG evaluation HAL has considered five evaluation criteria with related sub-categories as detailed below:

<b>OPERATIONS &amp; SERVICE</b>	<b>PLANNING &amp; PROPERTY</b>
<ul style="list-style-type: none"> <li>• Impact on airport related car journeys</li> <li>• Number of mode choices (resilience)</li> <li>• Additional catchment growth</li> <li>• Connectivity to local communities</li> <li>• Level of service</li> <li>• Off airport affects</li> <li>• Number of alternative routes</li> <li>• Efficiency of landside campus connectivity</li> <li>• Freight operations journey time and capacity</li> </ul>	<ul style="list-style-type: none"> <li>• Extent of property loss/severance</li> <li>• Land take</li> <li>• Alternative/other uses for land</li> <li>• Consistency with local policy designations</li> <li>• Draft NPS, environment and habitat reversion</li> </ul>
<b>DELIVERY</b>	<b>SUSTAINABILITY &amp; COMMUNITY</b>
<ul style="list-style-type: none"> <li>• Buildability</li> <li>• Time</li> <li>• Construction efficiency</li> <li>• Logistics</li> <li>• Safety and security</li> <li>• Bringing asset into service</li> </ul>	<ul style="list-style-type: none"> <li>• Landscape and townscape</li> <li>• Visual</li> <li>• Cultural heritage</li> <li>• Biodiversity</li> <li>• Surface and ground water</li> <li>• Socio-economics and community</li> <li>• Land quality and agricultural land quality</li> <li>• Air quality and noise</li> </ul>
<b>BUSINESS CASE</b>	
<ul style="list-style-type: none"> <li>• Capital Expenditure (Capex)</li> <li>• Property / Land take</li> </ul>	

Table 7: HAL evaluation criteria and sub-criteria for M25 Alignment and Junction Options

This report concentrates on HAL's Business Case evaluation approach. However, we have given a commentary on their evaluation approach to the other criteria and offered high level opinions as to this approach in the following sections.

### 5.2 Options Summary - Alignment

For the Alignment sub-component three option families were identified:

- **Family AA:** Online construction maintaining the existing M25 horizontal alignment, consisting of two sub-options:
  - AA0: current horizontal and vertical position with the airfield level adjusted to suit.
  - AA1: current horizontal position with the road lowered by 4m.

- **Family AB:** Offline construction involving local realignment of the M25 between J15 and J14a. Two sub-options have been identified:
  - AB1: 130m shift to the west, lowered by 4m.
  - AB2: 130m shift to the west, lowered by 4m with collector/distributors.
- **Family AC:** Offline construction requiring major relocation of the M25 with a wider shift to the west. Three sub-options have been identified:
  - AC1: Shifted by approximately 1,100m to the west beyond the new airport boundary.
  - AC2: Shifted under the western end of the new runway.
  - AC3: Split through, requiring a tunnel under Colnbrook and a crossing of the Wraysbury Reservoir.

The routes taken by each option are indicated on the aerial photographs below:



Figure 4. M25 Alignment indicative routes (LEFT: AC1 / AC2 / AC3, RIGHT: AA Online / AB Offline)

## 5.3 Evaluation – Alignment

Below we have provided commentary on HAL’s approach to the five evaluation criteria (namely, Operations & Service, Planning & Property, Sustainability & Community, Delivery and Business Case) against each of the options. HAL’s approach was predicated upon design concepts produced ahead of Heathrow’s Consultation 1; Arcadis note that these concepts have subsequently evolved since the Green Review stage.

### 5.3.1 Operations & Service

For the Green Review, HAL has undertaken a qualitative assessment of the impacts that each of the alignment options will have on the following:

- |  |   |
|--|---|
| <ul style="list-style-type: none"> <li>● Impact on airport related car journeys.</li> <li>● Number of mode choices (resilience).</li> <li>● Additional catchment growth.</li> <li>● Connectivity to local communities.</li> <li>● Level of service.</li> </ul> | <ul style="list-style-type: none"> <li>● Off airport affects.</li> <li>● Number of alternative routes.</li> <li>● Efficiency of landside campus connectivity.</li> <li>● Freight operations journey time and capacity.</li> </ul> |
|--|---|

Due to the low maturity of the designs, no traffic modelling data is available to quantify highway network performance of any of the options. Therefore, HAL has made judgements based upon information derived from existing flow/junction performance data. At this point in the process Arcadis concurs that this approach is reasonable and appropriate.

### 5.3.2 Planning & Property

For planning and property impacts, HAL has undertaken both a qualitative and quantitative review considering the following items:

- Land take.
- Environment and habitat provision.
- Property loss and severance of villages.
- Consistency with draft NPS.

It is clear from a visual inspection of the plans that the AC Family options have by far the greatest impact on both property and the environment, due to major realignment of the M25 and complete remodelling of junction 15. Conversely, the AA Family options have no impact being based within the boundaries of the existing M25, while the AB Family impacts upon an existing industrial estate adjacent to the motorway.

A qualitative assessment of the overall environmental impact has been carried out by HAL through a visual inspection, finding that almost all options impact the green belt and Colne Valley Park. Arcadis recommends that an initial assessment of the costs of habitat re-provision and mitigation is also considered within the Business Case evaluation.

Arcadis has reviewed the quantitative assessment of property impacts carried out by HAL within the Business Case section.

Arcadis believe that this quantitative assessment of property values, alongside a subjective review of environmental considerations is a reasonable way to evaluate the criteria at this stage, notwithstanding the need to evaluate habitat re-provision.

HAL has discontinued the AC Family as it is likely to result in severe adverse impacts to both local communities and the natural environment. Given the scale of residential property loss, the severance of Colnbrook village, impacts on protected species and air quality, noise and visual impacts on the local communities affected, this would be inconsistent with the Draft NPS.

### 5.3.3 Sustainability & Community

The impact that an adjusted M25 alignment would have on the natural environment was identified as a key evaluation criterion, in particular on local air quality and the additional noise associated with traffic movements, direct impacts due to the additional infrastructure, and the effect on communities associated with property loss and community severance.

It is not possible to fully assess the potential indirect impacts for air quality, noise and community without further understanding of the traffic flows and distribution associated with each option. This is dependent upon traffic modelling for each option which at this stage has yet to be undertaken.

As such HAL's evaluation has been based upon the direct land take of each option and qualitative impacts on noise, water, land quality, community and biodiversity.

### 5.3.4 Delivery

The key considerations for this evaluation criteria are:

- Avoidance of critical constraints.
- Minimising materials import and export.
- Reduction of complexity and risk.
- Delivery of safe and secure construction operations.
- Minimising construction impacts.
- Delivery within overall programme timescales.



Arcadis would instead suggest utilising a composite rate for carriageway construction, as compared to the bottom-up measure employed by HAL which increases the risk of misinterpretation.

The criteria applied for the rating status is:

RAG Status	Ranking Criteria
RED	Baseline cost increase of 15% or above
AMBER	Baseline cost plus or minus 15%
GREEN	Baseline cost reduction of 15% or below

Table 9. RAG Status for M25 Alignment Options

It should be noted that the capex review under the business case evaluation criteria only has a Red / Amber / Green rating. No options are discontinued (given a Black rating) because of capex outputs.

In reviewing HAL’s estimates Arcadis has looked at the following items:

- Quantities.
- Risk and Uncertainty.
- Rates.
- Property Loss / Land Take.
- Add-Ons.

These are investigated in greater depth below:

• **Quantities**

HAL’s estimate is derived using the quantities provided by the designers. Arcadis queried whether HAL had undertaken a check on these quantities; HAL confirmed that they had but have not provided any evidence of the same.

Arcadis has undertaken our own verification of the quantities utilising the drawing file layouts overlaid on Google Earth Pro. Due to Arcadis’ approach there will be a level of tolerance in the measurements abstracted. A comparison of the two is shown below:

	Family AA				Family AB				Family AC					
	AA0		AA1		AB1		AB2		AC1		AC2		AC3	
	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis
Total length (m)	615	650	-	-	2,556	2,560	3,212	3,220	8,265	10,950	8,491	8,500	7,213	10,750

Table 10. M25 Alignment Options – Total Length Comparison Summary

- AA Family – Arcadis-measured quantities closely align with the figures provided by HAL for option AA0. As mentioned previously, option AA1 has not been assessed.
- AB Family – Arcadis quantities closely align with the figures provided by HAL for both option AB1 and AB2.
- AC Family – While both Arcadis and HAL measurements for option AC2 are closely matched, the HAL lengths for options AC1 and AC3 are significantly below those measured by Arcadis. The Arcadis lengths have been used to undertake a revised capex summary for comparison purposes, however it is envisaged that this is unlikely to change the RAG status or ranking of the options and will only serve to move these outliers even further away from the base scheme.

• **Rates**

Arcadis requested benchmark data utilised by HAL for the high-value items common to all the options; such as pavement, piling and structural concrete. HAL provided benchmarks for highway construction taken from a number of sources; including Highways England, other Heathrow projects and international

schemes. These are within tolerance of Arcadis benchmark data for comparable items, and generally represent cost efficient rates which are deliverable in the context of the overall scheme.

HAL has an allowance for Third Party Statutory undertakers within AA0, AB1 and AB2 estimates, however this is excluded from junctions and local roads as it is included in a separate site wide task order.

It was noted that there is no allowance for the demolition and remediation of the existing M25 once the new alignment is in service for any of the AC Family options. Arcadis consider that this element should be included within this task order, although this is unlikely to affect the rankings as these options are already significant outliers.

Arcadis undertook a bottom up exercise to verify the price per linear metre, which are within an acceptable tolerance of the corresponding HAL rates.

- Add-ons**

HAL has applied the same percentage add-ons across all options for preliminaries (█%), OH&P (█%), design (█) and leadership and logistics (█).

Phasing has not been included and when questioned HAL's response was that this would be similar across all options. Whilst in part Arcadis accept this principle we would expect all on costs to be applied.

At this early stage in the design it is normal to apply percentages for these items based on the base construction cost; hence options with higher capex will attract higher on costs. We would however expect to see the phasing reviewed and dependent upon construction complexity different percentages potentially being applied against different options.

However, because there is no Black rating for capex at this Green Review stage those options which are more complex to deliver have been captured in the Delivery section evaluation.

Arcadis consider that the Project Specifics allowance of █m against each of the Family AB and Family AC options appears to be insufficient and should be reviewed. An allowance of █% would be more prudent, as has been allowed for by HAL within the Local Roads Key Component.

- Risk**

The risk percentage of each of the options is the same at █. This percentage has been derived from a quantitative risk assessment of the baseline at P80 level.

There is an additional *Risk & Uncertainty adjustment* to the baseline of █, █% or █ dependent upon a subjective analysis by HAL of the perceived complexity of the works.

The online construction required as part of the AA Family has resulted in an adjustment of █, while both the AB and AC option families remain at █%.

### 5.3.5.2 Property Loss / Land Take

The table below shows the quantitative assessment of property loss against each option. HAL's figures are based upon outputs extrapolated from a GIS model of the local area. This model encompasses all individual properties affected and their respective values, including allowances for extinguishing businesses.

M25 Alignment Options – Property Costs Summary							
	Family AA		Family AB		Family AC		
Add-Ons	AA0	AA1	AB1	AB2	AC1	AC2	AC3
Property							

Table 11. M25 Alignment Options - Property Costs Summary

HAL has been consistent across each option, and while Arcadis agree with this general process, we have requested further information upon how the values were arrived at and whether allowances have been made for those properties not directly affected by the revised alignment but blighted by increased noise, loss of amenity or severance.

It should be noted that minor adjustments in the alignment of each option may have a major impact on the property costs. It is clear from a simple visual inspection of the plans that the AC Family of options has by far the greatest impact on property, while the AA Family has no impact being based within the boundaries of the existing M25.

### 5.3.6 Arcadis Business Case RAG Evaluation - Alignment

Arcadis has collated their comments from the above Business Case section and prepared a revised summary, which compares to HAL’s Business Case summary, see table below. Our ranking of the options aligns with HAL.

M25 Alignment Options – HAL/Arcadis Evaluation Comparison												
Item	Family AA		Family AB				Family AC					
	AA0		AB1		AB2		AC1		AC2		AC3	
	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis
	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m
Base Construction												
Project Specifics												
Prelims & OHP												
L&L & Design												
Risk & Uncertainty												
Property												
Capex Total												
RAG Status & Rank	3	3	1	1	2	2	6	6	4	4	5	5

Table 12. M25 Alignment Options – HAL/Arcadis Business Case RAG Evaluation Comparison

### 5.3.7 HAL BRAG Summary – Alignment

HAL has collated the evaluation criteria to give an overall rating to each option and have drawn the following key feedback.

- Property & planning:
  - Generally, the greater the shift, the bigger the impact.
  - Options AC1 and AC2 score poorly due to unacceptable property loss and severance of existing settlements in areas where land take was never contemplated by the NPS.
- Sustainability & Community:
  - Option AB1 and AB2 are the preferred options.
  - Whilst operational impacts of AA1 are expected to be minimal, likely impacts during construction are considered to represent a significant risk, given the anticipated scale of traffic and transport impacts.
  - The AC Family of options is considered likely to result in severe adverse impacts to both local communities and the natural environment, which would require extensive mitigation. Given the scale of these impacts HAL has recommended that these options are discontinued.



- Delivery:
  - The most preferred options are the ones that can be delivered with the least impact to the M25. Therefore, options that can be constructed off-line are preferable to those on existing alignments.
  - All layouts present significant challenges with regards to safety and security. However, some layouts incorporate higher risks due to constraints such as the complexity of engineering solutions (bridging local roads, motorways or other obstructions) or the proximity of existing communities and assets.
- Business case:
  - Family AB has the lowest Capex, while the AC family has far greater expenditure, due to the length and complexity of the proposed routes.
- Operations & Service:
  - Option AB2 provides the most resilience to the highway network and would remove the requirement for weaving in runway structures.
  - Preferred options are the ones that provide the greatest resilience to airport connectivity and ensuring no deterioration to the operations of the M4 and M25.
  - Options promoting Collector/Distributors are preferable as these are likely to provide additional capacity and resilience to both the M25 and airport access, also improving safety and wayfinding.

HAL's BRAG Summary is:

M25 Alignment Options – HAL BRAG Status							
		AA0	AB1	AB2	AC1	AC2	AC3
1	Operations & Service	Yellow	Yellow	Green 1	Yellow	Yellow	Yellow
2	Planning & Property	Green	Yellow	Yellow	Black	Red	Black
3	Delivery	Red	Yellow	Green 1	Red	Red	Red
4	Sustainability & Community	Red	Yellow	Green 1	Red	Red	Black
5	Business Case / CAPEX	Yellow	Green 1	Green	Red	Red	Red

Table 13. HAL BRAG Summary – M25 Alignment

Based on the results of each of the above criteria, two of the options (AC1 and AC3) have been discontinued (Black RAG rating). Due to unacceptable impacts of the proposed new motorway routing on local community and the environment.

It is clear that AB2 (offline shifted 150m to the west with collector/distributors) is the most deliverable and provides the best operational results.

## 5.4 Options Summary – Junctions

The junction subcomponent comprises alterations required to J14 and J14a of the M25. Four option families have been identified:

- Family JA: Two junctions, no lane segregation.
- Family JB: Two junctions, with lane segregation (collector/distributors).
- Family JC: One junction, no lane segregation, comprising five sub options differentiated by various slip-road alignments (options JC1-JC5).
- Family JD: One junction comprising two sub-options; option JD3 with collector/distributors to segregate traffic, reduce weaving and increase capacity, and option JD4 as per option JD3 but with a layout designed for compatibility with the Western Apron.

## 5.5 Evaluation – Junctions

Below we have provided commentary on HAL’s approach to the evaluation criteria against each of the M25 Junction options:

### 5.5.1 Operations & Service

For the Green Review, as with the M25 Alignment options, HAL has undertaken a qualitative assessment of the impacts that each of the Junction options will have on criteria such as airport related car journeys and connectivity to local communities.

Due to the low maturity of the designs limited traffic modelling data is available to quantify highway network performance of any of the options in detail. Therefore, HAL has made judgements based upon information provided from existing flow/junction performance data.

### 5.5.2 Planning & Property

For the planning and property impacts, HAL has undertaken a quantitative assessment of property loss against each option (as shown in the summary table below) with figures extrapolated from the GIS model of the local area.

This GIS model encompasses all property types (commercial, residential, agricultural, industrial, utilities, etc) and their respective values including allowances for compensation and the extinguishing of businesses and is shown in the table below.

M25 Junction Options – Property Costs Summary								
	JB Family	JC Family					JD Family	
Add-Ons	JB1	JC1	JC2	JC3	JC4	JC5	JD3	JD4
Property								

Table 14. M25 Junction Options - Property Costs Summary

It is clear from the simple review of the layouts and the results from the model that even minor adjustments in the alignments of the junction feeder roads could have a major impact on the property costs.

Arcadis recommends that key properties are identified; either by their value, potential alternative uses, pre-existing planning permissions or their difficulty to acquire (i.e. the Spout Lane allotments, where there are several owners in a relatively small area), where subsequent micro planning of junction alignments could realise key savings.

### 5.5.3 Sustainability & Community

The impact that an adjusted J14 and J14a would have on the natural environment was identified as a key evaluation criterion, in particular on local air quality and the additional noise associated with traffic movements, direct impacts on the natural environment due to the additional infrastructure, and the effect on communities associated with property loss and community severance.

However, a major limitation of the evaluation at this stage in the process is the lack of traffic data. It is not possible to assess the potential indirect impacts for air quality, noise and community without further understanding of the traffic flows and distribution associated with each option.

As such HAL’s evaluation has been based upon the direct land take of each option and qualitative impacts on noise, water, land quality, community and biodiversity.

## 5.5.4 Delivery

The key considerations for this criterion are the same as those utilised for evaluation of the M25 Alignment options. From looking at the plans, Arcadis has identified that the JD4 option appears significantly more complex to deliver than the JC1 option. However, the allowance provided by HAL for each junction option is identical at █m.

Arcadis consider that this allowance could be insufficient and should be revisited. The significant deliverability challenges posed by each option need to be considered independently and included in the Business Case evaluation.

## 5.5.5 Business Case

The business case is a simple evaluation of capital cost associated with each of the M25 junction options. The two main considerations here are:

- Capital Expenditure (Capex).
- Property loss / land take.

No consideration has been given to future operating expenditure (opex) due to the assumption that the new highway junction assets shall be maintained and operated by a third party.

Arcadis has undertaken a detailed review of HAL's approach to their assessment of capex and property loss / land take.

### 5.5.5.1 Capital Expenditure (Capex)

HAL has built up a bottom up estimate for each option and rated this against the Purple Book. The criteria applied for the rating status is identical to that utilised for the M25 alignment options.

In reviewing this we have reviewed the following sections:

- **Quantities**

HAL's estimate is derived using the quantities provided by the designers. Arcadis queried whether HAL had undertaken a check on these quantities; HAL confirmed that they had but have not provided any evidence of the same.

- **Rates**

As with the alignment options, HAL provided benchmarks for highway construction taken from a number of sources. These are within tolerance of Arcadis benchmark data for comparable items.

- **Add-ons**

HAL has applied the same percentages across all options for preliminaries (█%), OH&P (█), design (█) and leadership and logistics (█) based on their analysis of previous HAL projects.

Phasing has not been included and when questioned HAL's response was that this would be similar across all options. Whilst in part Arcadis accept this principle we would expect all on costs to be applied.

At this early stage in the design it is normal to apply percentages for these items based on the base construction cost; hence options with higher capex will attract higher on costs. We would however expect to see the phasing reviewed and dependent upon construction complexity different percentages potentially being applied against different options, particularly comparing option JC1 and option JD4.

However, because there is no Black rating for capex at this Green Review stage those options which are more complex to deliver have been captured in the Delivery section evaluation. As mentioned previously Arcadis consider that the Project Specifics allowance of █m against each option may be insufficient and should be reviewed.

- **Risk**

As with the M25 Alignment options the risk percentage is the same and remains at █. This percentage has been derived from a quantitative risk assessment of the baseline at P80 level.

There is an additional *Risk & Uncertainty adjustment* to the baseline of ■■, ■■■% or ■■■ dependent upon a subjective analysis by HAL of the perceived difficulty of the works. On this basis all options have been adjusted to ■■■ due to the complexity of the junction works, apart from JC1 which remains at ■■■%.

Notwithstanding the above Arcadis consider that this is a suitable allowance at this stage of the scheme.

### 5.5.5.2 Property Loss / Land Take

HAL has utilised a detailed GIS model to undertake evaluation of the Property Loss / Land Take. The results of which are shown in the summary table below:

M25 Junction Options – Property Costs Summary									
	JB Family		JC Family					JD Family	
Add-Ons	JB1	JC1	JC2	JC3	JC4	JC5	JD3	JD4	
Property									

Table 15. M25 Junction Options - Property Costs Summary

HAL has been consistent across each option and Arcadis agree with the general process. Arcadis has queried whether allowances have been made for those properties not directly affected by the revised alignment but blighted by increased noise, loss of amenity or severance.

Arcadis consider that minor adjustments in the alignment of each option would have a major impact on the property costs by avoiding the need to utilise high-value or difficult to acquire land, which could realise key savings and optimise the route.

### 5.5.6 Arcadis Business Case RAG Evaluation – Junctions

Arcadis has collated HALs comments from the above Business Case section and prepared a revised summary table overleaf, comparing Arcadis' view with HALs.

Our ranking of the options aligns with HAL viewpoint.

M25 Junction Options – HAL/Arcadis Capex Evaluation Comparison																
	JB Family		JC Family										JD Family			
	JB1		JC1		JC2		JC3		JC4		JC5		JD3		JD4	
	HAL	Arc	HAL	Arc	HAL	Arc	HAL	Arc	HAL	Arc	HAL	Arc	HAL	Arc	HAL	Arc
Item	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m
Base Construction																
Project Specifics																
Prelims & OHP																
L&L & Design																
Risk & Uncertainty																
Property																
<b>Capex Total</b>																
<b>RAG Status &amp; Rank</b>	5	5	1	1	4	4	3	3	8	8	2	2	6	6	7	7

Table 16. M25 Junction Options – HAL/Arcadis Business Case RAG Evaluation Comparison

### 5.5.7 HAL BRAG Summary – Junctions

HAL has collated the evaluation criteria to give an overall rating to each option, they have drawn the following key feedbacks from this:

- Property & planning:
  - Generally, the greater the intervention and interaction with existing settlements, the worse the RAG status.
  - There is a Site of Special Scientific Interest to the west; although it is understood that Natural England may accept some encroachment.
  - Impact on Stanwell Moor in options JC3, JC4 and JC5 would cause residential property loss into areas where never previously contemplated.
  - Importance of avoiding allotments from a property and planning perspective.
- Sustainability & Community:
  - Option JC1 is the most preferred, given minimal additional infrastructure and associated footprint when compared to alternatives.
  - Options which would shift Junction 14 South or introduce significant elements of infrastructure adjacent to Stanwell Moor, are likely to result in major adverse impacts on both the natural environment and the amenity of residents, and in the case of option JD4 the severance of an existing community.
  - There are considered to be significant impacts to the local community associated with options JC3, JC5, JD3 and JD4.
- Delivery:
  - Options that call for new elevated sections over the existing motorway will require foundations to be constructed within the existing carriageway, necessitating lane closures and contraflows.
  - Majority of the J14 options suggest significant and complex traffic management will be required throughout the construction works.
- Business case:
  - Generally speaking, simpler junction options (JC1) result in a lower capex outlay rather than those junctions requiring wholesale reconfiguration (JC4).
- Operations & Service:
  - JB1 scored the highest amongst the junction options. This provide opportunities to future proof any changes to the mainline and maximise access options for all transport modes to and from the Western Campus.
  - Options promoting Collector/Distributors are preferable. These are likely to provide additional capacity and resilience to both the M25 and airport access as well as improving safety and wayfinding.
  - Junction options that provided one junction link from the M25 into the Western Campus were less preferable. Potential to improve preference if high resilience alternatives can be provided within Local road network options.

HAL's BRAG Summary is:

M25 Junction Options – HAL BRAG Status									
		JB1	JC1	JC2	JC3	JC4	JC5	JD3	JD4
1	Operations & Service	1							
2	Planning & Property		1						
3	Delivery		1						
4	Sustainability & Community		1						
5	Business Case / Capex		1						

Table 17. HAL BRAG Summary – M25 Junctions

Based on the results of each of the above criteria, none of the options have been discontinued (Black RAG rating) at this stage. It is clear that JC1 is the most deliverable, but JB1 offers the best operational results (providing two junction J14 and J14a with Collector/Distributors).

## 5.6 Key Findings

The current design for the M25 alignment and junctions is at a very high level which makes capex assessment more challenging. However, Arcadis consider that HAL's approach to the construction elements is generally in line with industry standards.

Benchmark data taken from a number of sources has been used by HAL to develop the estimates. These figures are within tolerance of Arcadis benchmark data for comparable items.

The majority of the Add-On percentages used by HAL are in line with industry standards. However, the Project Specifics allowances applied against both the alignment and junction options appear insufficient in many cases and should be reviewed.

In terms of overall RAG status against the Airports Commission scheme, on a capex basis Arcadis has rated all of the options in line with HAL. HAL has confirmed that there is no Black rating on the capex within the DER.

No junction options have been discontinued against any of the evaluation criteria. However, alignment options AC1 and AC3 have been recommended for discontinuation by HAL based on the impacts to local communities and the environment.

Both of the Family AA alignment options have enormous delivery implications. Option AA0 requires raising of the runway by 5m, leading to severe programme and operational constraints (inoperable linking taxiway gradient), while the temporary works required to deliver AA1 are considered to be infeasible.

## 5.7 Next Steps

Next steps include:

- Evaluating options with localised traffic modelling to gain a greater understanding of operational performance.
- Assess alignment, junction and local road options as holistic packages to understand compatibility and overall operational performance.
- Potential congestion and diversionary impacts during construction have not been assessed. Arcadis consider that these should be looked at in a thorough deliverability and phasing exercise.
- HAL will have the opportunity to refine options and undertake more detailed assessments to optimise routes in order to minimise property loss and environmental impact; i.e. optimising junction alignments along existing roads.
- Ground water levels have not been considered at the current stage of the design process. Significant dewatering may be required and should be further investigated.
- Arcadis believes that there are significant value engineering opportunities which can be progressed as the design evolves

## 6 Local Roads

### 6.1 Introduction

This component comprises changes required to the major non-motorway routes in the vicinity of the existing airport boundary that will be affected by the expansion plans, these consist of the A4 to the north and the A3044 to the west.

Changes to Stanwell Moor Junction and proposed new access routes to T5(X) and the existing Central Terminal Area have not been considered as part of this evaluation at this stage.

In undertaking their Black / Red / Amber / Green (BRAG) evaluation HAL has considered five evaluation criteria with related sub-categories as shown below:

<b>OPERATIONS &amp; SERVICE</b>	<b>PLANNING &amp; PROPERTY</b>
<ul style="list-style-type: none"> <li>• Impact on airport related car journeys</li> <li>• Number of mode choices (resilience)</li> <li>• Additional catchment growth</li> <li>• Connectivity to local communities</li> <li>• Level of service</li> <li>• Off airport affects</li> <li>• Number of alternative routes</li> <li>• Efficiency of landside campus connectivity</li> <li>• Freight operations journey time and capacity</li> </ul>	<ul style="list-style-type: none"> <li>• Extent of property loss/severance</li> <li>• Quality of replacement (local roads)</li> <li>• Consistency with local policy designations</li> <li>• Consistency with draft NPS</li> </ul>
<b>DELIVERY</b>	<b>SUSTAINABILITY &amp; COMMUNITY</b>
<ul style="list-style-type: none"> <li>• Buildability</li> <li>• Time</li> <li>• Construction efficiency</li> <li>• Logistics</li> <li>• Safety and security</li> <li>• Bringing asset into service</li> </ul>	<ul style="list-style-type: none"> <li>• Landscape and townscape</li> <li>• Visual</li> <li>• Cultural heritage</li> <li>• Biodiversity</li> <li>• Surface and ground water</li> <li>• Socio-economics and community</li> <li>• Land quality and agricultural land quality</li> <li>• Air quality and noise</li> </ul>
<b>BUSINESS CASE</b>	
<ul style="list-style-type: none"> <li>• Capital Expenditure (Capex)</li> <li>• Property / Land take</li> </ul>	

Table 18: HAL evaluation criteria and sub-criteria for Local Roads

This report concentrates on HAL's Business Case evaluation approach. However, we have also provided a commentary on their evaluation approach to the other criteria and offered high level opinions as to this approach in the following sections.

### 6.2 Options Summary

A number of options have been identified for both the A4 and A3044, as listed below:

- **A4:** Five routes have been identified to enable continued east-west local access following expansion of the airport:
  - A4\_2e: 4.0km section moved between 400-1100m north of existing position to remain outside the expanded airport boundary.

- A4\_6c: 3.5km section moved around 200m south of existing position to remain largely within the boundary of the expanded airport in a sunken cut-through requiring taxiway crossovers.
- A4\_DM: No replacement of the A4 and therefore no continued east-west access, but provision of links to local areas cut off by the expanded airport boundary
- A4\_1a: Similar to option 2e but starts from Holloway Lane.
- A4\_3a: Similar to option 2e but starts from the M4 Spur.
- **A3044:** Six options have been identified for the A3044 linking the A3113 and A4:
  - A3044\_2ai: Repositioned approximately 250m to the west of the M25.
  - A3044\_2bi: Repositioned immediately adjacent to the east side of the M25.
  - A3044\_3g: Major relocation between 1-2km to the west of the M25.
  - A3044\_2a: extension of option 2ai, tunnelling under the runway to connect A4 option 2e.
  - A3044\_2b: extension of option 2bi, tunnelling under the runway to connect A4 option 2e.
  - A3044\_3d: Following route of option 2ai then combining with the west portion of A4 option 6c skirting around the new airport boundary.

The map excerpt below has been overlaid with the existing road network, A4 options 2e and 6c, A3044 options 2ai, 2bi and 3g, as well as the location of Stanwell Moor Junction.



Figure 5. Local Roads Indicative Routes

Each of the above options have been assessed independent of each other but obviously have a significant overlap with the eventual alignment and junction option chosen for the M25.



## 6.3 Evaluation

The following section provides a high-level commentary on HAL's approach to the Operations & Services, Planning & Property, Sustainability & Community and Delivery evaluation criteria, and a more detailed commentary of the Business Case evaluation criteria for each of the options. HAL's approach has been predicated upon design concepts produced ahead of Heathrow's Consultation 1; Arcadis note that these concepts have subsequently evolved since the Green Review stage.

### 6.3.1 Operations & Service

For the Green Review, HAL undertook a qualitative assessment of the impacts that each of the local road options will have on the following:

- Highway network impacts and contribution towards the emerging Surface Access Strategy;
- Resilience of the Highway network;
- Effects on surrounding local communities and sustainable / public transport network;
- Impact on the Strategic Road Network (SRN).

Due to the low maturity of the designs, no traffic modelling data is available to quantify highway network performance of the options in any significant detail. Therefore, HAL's judgements have been made by extrapolating flow performance data from existing routes.

Arcadis believe that this is currently the most appropriate way to carry out an assessment of each of the local roads options. As the designs are developed specific flow modelling can be carried out to refine the conclusions drawn against these criteria.

### 6.3.2 Planning & Property

HAL has undertaken both a qualitative and quantitative review of this criterion taking into consideration of the following elements:

- Land take;
- Property loss / severance of villages;
- Environment / habitat provision;
- Consistency with draft NPS.

A qualitative assessment of the overall environmental impact of each option has been carried out by HAL through a visual inspection of habitat impact. Arcadis recommends that an initial assessment of the costs of habitat re-provision and mitigation should be considered within the Business Case evaluation.

Notwithstanding the need to evaluate habitat re-provision, Arcadis believe that this subjective review of environmental considerations alongside a quantitative assessment of property values is a reasonable way to evaluate the criteria at this stage.

As with the estimates produced for the M25 alignment and junctions, HAL has carried out a quantitative assessment of property loss against each of the local roads options. A review of which can be found within the Business Case section.

### 6.3.3 Sustainability & Community

As with the M25 and Junctions section, the key objectives for this evaluation criteria were identified as the impacts on the natural environment, in particular air quality and noise impacts associated with traffic movements, direct impacts on the natural environment due to the additional infrastructure, and effects on communities associated with property loss, severance and impacts on amenity.

A limitation of the evaluation is the lack of traffic modelling data. It has not been possible to assess the potential indirect impacts for air quality and noise without further understanding of the traffic flows and distribution associated with each option.

HAL's evaluation has therefore been based upon the direct land take of each option and qualitative impacts on noise, water, land quality, community and biodiversity.

### 6.3.4 Delivery

Key considerations for this evaluation criteria are:

- Avoidance of critical constraints;
- Reduction of complexity and risk;
- Minimising construction impacts;
- Delivery within overall programme timescales;
- Minimising materials import / export;
- Delivery of safe and secure construction operations.

HAL consider that all options present significant challenges with regards to safety and security, with some routes incorporating higher risks driven by complexity of engineering solution or proximity to existing communities and assets.

Project specific items are currently unknown; but as each option will have costs associated with their levels of disturbance to an existing major road or community, a subjective evaluation has been undertaken by HAL and a █% allowance has been made to cover such costs across all A4 and A3044 options.

Although this is an appropriate way to account for deliverability considerations at this stage, Arcadis believe that each option should be considered independently, and the percentages applied for project specifics adjusted to reflect delivery challenges specific to each option.

### 6.3.5 Business Case

The business case is a simple evaluation of capital cost associated with each of the Local Roads options. The two main considerations here are:

- Capital expenditure (Capex)
- Property loss / land take

No consideration has been given to future operating expenditure due to the assumption that the new highway assets created shall be maintained and operated by a third party.

We have undertaken a detailed review of HAL’s approach to their assessment of capex and property loss / land take.

#### 6.3.5.1 Capital Expenditure (Capex)

HAL has assembled bottom-up estimates utilising component-level benchmarks. Each option has then been rated against the Purple Book. Arcadis believe that this approach is best practice at this stage of the project.

Each option’s capex has been built up in the same format and the result can then be used to rank and rate options. The criteria applied for the rating status is:

RAG Status	Ranking Criteria
RED	Baseline cost increase of 15% or above
AMBER	Baseline cost plus or minus 15%
GREEN	Baseline cost reduction of 15% or below

Table 19. RAG Status for Local Roads Options

It should be noted that the capex review under the business case evaluation criteria has a Red / Amber / Green rating only, meaning that no options are discontinued (given a Black rating) due to capex results. Arcadis concur with this approach at this stage, as capex will become a defining factor in future evaluations.

In reviewing HAL’s estimates, as well as the property loss and land take, Arcadis has analysed the following items:

- Quantities
- Rates
- Add-ons
- Risk and uncertainty

These are investigated in greater depth below:

- **Quantities**

HAL's estimates have been derived using quantities provided by the designers. Arcadis challenged HAL as to whether they had undertaken an exercise to verify these quantities and they confirmed that they had.

High-level layouts provided for the majority of the A4 and A3044 options have enabled Arcadis to measure and corroborate HAL's pavement quantities as per the tables below. Due to this approach there will inherently be a level of tolerance in the measurements abstracted.

<b>A4 Pavement Quantities – HAL/Arcadis Comparison</b>										
	<b>1a</b>		<b>3a</b>		<b>DM</b>		<b>2e</b>		<b>6c</b>	
	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis
Pavement Length (m)	4,210	4,100	6,320	6,060	1,900	1,860	4,900	4,960	4,700	3,790
Pavement Area ('000m <sup>2</sup> )	89	87	133	128	40	19	103	105	99	80

Table 20. A4 Pavement Quantities Comparison Summary

The majority of the measurements above are similar to HAL's figures, apart from option DM and 6c of the A4 Family.

Scope related to the DM option is not clear. From the information presented by HAL it seems to relate to an upgrade of two isolated stretches of existing local road.

The pavement area option DM has been measured by Arcadis as approximately 50% less than HAL. Although measurement of the new pavement length concurs with HAL, the roads required under this option are short no-through roads designed to link areas cut off from the existing road network due to the expanded airport. As such Arcadis has assumed that these localised link roads shall be single carriageway only, while HAL has applied dual carriageway width across all the options.

The 20% difference in option 6c appears to arise directly from the Arcadis measure taken from the layout drawings.

The table below consists of the pavement quantity comparison for the A3044:

<b>A3044 Pavement Quantities – HAL/Arcadis Comparison</b>												
	<b>2a</b>		<b>2b</b>		<b>3d</b>		<b>2ai</b>		<b>2bi</b>		<b>3g</b>	
	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis
Pavement length (m)	2,810	2,760	2,815	2,790	2,845	3,040	1,350	1,480	2,500	2,470	1,850	2,430
Pavement area ('000m <sup>2</sup> )	59	58	59	59	0.6	64	0.8	31	2.5	52	1.9	51

Table 21. A3044 Pavement Quantities Comparison Summary

A major discrepancy highlighted by the above table is that HAL has made a calculation error within the estimate by confusing linear meterage with area for options 3d, 2ai, 2bi and 3g of the A3044 Family.

Arcadis suggest that a more robust review process is employed to ensure such errors are eliminated as much as possible from future iterations of these estimates.

The 30% difference in option 3g appears to arise directly from the Arcadis measure taken off the drawings.

Arcadis has undertaken their own assessment of the local roads options utilising the Arcadis measurements and therefore any impacts will be captured within our view of the capex and associated ranking.

- **Rates**

The key rates utilised within the local roads section include:

- Site Clearance

Demolition and removal of the existing A4 and A3044 has not been included within the scope. This is part of the overall site clearance which has been allowed for elsewhere in the masterplan. Arcadis consider that these works should be brought within the purview of the Local Roads component.

- Pavement

Arcadis note that the pavement rate of █ m<sup>2</sup> utilised by HAL for all local roads options is lower than the £█ m<sup>2</sup> allowance used within the M25 and junctions component, even though both have identical carriageway build-ups (consisting of 600mm capping, 300mm sub-base, 180mm base course, 60mm binder course and 40mm surface course).

The rate utilised by HAL is very efficient but Arcadis consider that this represents too much of a stretch to be deliverable in the context of the overall scheme; accordingly we recommend a higher but also stretching cost target rate of £125/m<sup>2</sup>.

Upon request, HAL has provided Arcadis benchmark data for highway construction taken from a number of sources; including Highways England, other HAL projects and international published sources.

These benchmarks indicate a rate of £█ m<sup>2</sup> as more appropriate for pavement construction, therefore Arcadis suggest that this is reviewed.

Arcadis has undertaken their own assessment of the local roads options utilising the £125/m<sup>2</sup> rate therefore any impacts will be captured within our view of the capex and associated ranking.

- Tunnel

A number of options require the provision of a cut and cover tunnel estimated by HAL at █ m. When expressed as £/m<sup>3</sup> (assuming a 21.1m wide and 5m high tunnel) this becomes █ m<sup>3</sup>, closely aligning with both benchmark data provided by HAL and Arcadis benchmarks for structures with similar construction requirements.

- **Add-Ons**

HAL has applied the same percentages across all options for project specifics (█%), preliminaries (█%), OH&P (█), design (█%) and leadership and logistics (█) based on their analysis of previous HAL projects.

At this stage of design, it is normal to apply percentages for these items founded upon the base construction cost; hence those options which are more complex and with higher capex will attract higher on-costs.

Each option has its own unique set of issues. Phasing, traffic management and temporary works will be more extensive in option 6c than option DM. The works are also likely to be subject to additional constraints being outside the boundary of the airfield.

Arcadis would therefore expect to see the phasing reviewed and dependent upon the construction complexity of each option different percentages being applied against different options for the project specifics.

We also note that HAL's estimate for option 2b of the A3044 Family has double-counted project specifics; the █% allowance is included both within the add-on and base construction cost sections. This has been amended in the Arcadis view but has not affected the overall capex RAG status or ranking of this option.

- **Risk & Uncertainty**

As is common practice at this stage of a project, HAL has applied a percentage of █ for risk across all options, which is higher than the █% allowance applied to the M25 and Junctions component.

There is an additional uncertainty adjustment to this baseline risk amount of █ , █% or █ , dependent upon a subjective analysis by HAL of the perceived complexity of the works when compared to the other options.

As option 6c of the A4 Family bisects the expanded airport and existing long stay car parks (i.e. facing substantial deliverability challenges and requiring significant phasing) this has an uncertainty adjustment of █ . While option 3g of the A3044 Family travels through agricultural areas (i.e. a simpler offline green field site) so has been assessed by HAL at █% of the baseline risk. All other options remain at the base risk allowance of █ .

Although Arcadis broadly concurs with these interpretations, we would expect to see risks identified in a risk register which could then be used to verify the percentages applied against the value this generates.

### 6.3.5.2 Property Loss / Land Take

As with the estimates created for the M25 and Junctions options, HAL has undertaken a quantitative assessment of property loss against each option (as shown in the summary table below) with figures extrapolated from a GIS property model of the local area.

This model encompasses the respective value of individual properties, including allowances for compensation and the extinguishing of businesses.

Local Roads – Property Costs Summary											
	A4					A3044					
Property	1a	3a	DM	2e	6c	2a	2b	3d	2ai	2bi	3g
Property											

Table 22. Local Roads – Property Costs Summary

HAL has been consistent across each option and Arcadis agree with the general process but has requested further information upon how the values were arrived at and whether allowances have been made for those properties not directly affected by the revised alignment but blighted by increased noise, loss of amenity or severance.

For instance, although the property costs are relatively minimal, option 3g of the A3044 Family is likely to result in severe adverse impacts to the natural environment and severance of local communities, bisecting both greenfield sites and the village of Colnbrook.

HAL has stated that option DM of the A4 Family has no associated property costs. However, on further inspection this option, although negating the need to construct a new localised east-west route, still requires surface access connections to areas cut off by the expanded airport (i.e. Lakeside Road to the west and Saxon Way to the east). Consequently, Arcadis considers that there will be property costs associated with this option.

Arcadis also consider that minor adjustments in the alignment of each option could have a major impact on property costs by avoiding the need to utilise high-value land (both in terms of cost and amenity), thereby realising savings.

Arcadis believe that whilst HAL have generally adopted a reasonable approach in evaluating this criterion, HAL need to confirm whether they have taken account of severed properties.

### 6.3.6 Arcadis Business Case RAG Evaluation

Arcadis has collated their comments from the above Business Case section and prepared a revised capex summary for the A3044 and A4, comparing it to HAL’s capex summary as shown in tables below.

For the A3044, our rating of the options aligns with HAL, with option 2ai moving from Green (reduction of over 15% below the baseline cost) to Amber (baseline cost plus or minus 15%).

Local Roads – A3044 Options – HAL/Arcadis Evaluation Comparison												
Item	A3044											
	2a		2b		3d		2ai		2bi		3g	
	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis
	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m
Base Construction												
Project Specifics												
Prelims & OHP												
L&L & Design												
Risk & Uncertainty												
Property												
<b>Capex Total</b>												
<b>RAG Status &amp; Rank</b>	6	6	4	4	5	5	3	3	2	2	1	1

Table 23. Local Roads A3044 Options – HAL/Arcadis Business Case RAG Evaluation Comparison

Likewise, the comparison of the A4 options follows the same order and remain within the same RAG status boundaries.

Local Roads - A4 Options – HAL/Arcadis Evaluation Comparison										
Item	A4									
	1a		3a		DM		2e		6c	
	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis
	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m
Base Construction										
Project Specifics										
Prelims & OHP										
L&L & Design										
Risk & Uncertainty										
Property										
<b>Capex Total</b>										
<b>Capex RAG Status &amp; Rank</b>	2	2	3	3	1	1	5	5	4	4

Table 24. Local Roads A4 Options – HAL/Arcadis Business Case RAG Evaluation Comparison

### 6.3.7 HAL BRAG Summary

HAL has collated the evaluation criteria to give an overall rating to each option, drawing the following key feedback:

- Operations and service:
  - Options that realign local roads outside the development site are preferred.
- Property and planning:
  - A4 options which avoid cutting through Aggregate Industries site are preferred.

- A3044 options have significant property impacts; option 2ai (west of M25) results in the loss of 11 commercial properties and six residential; option 2bi (east of M25) affects allotments and option 3g significant community severance in Colnbrook.
  - Sustainability and community:
- For the A3044, options 2ai and 2bi are preferred over option 3g, which is likely to adversely impact a greater number of residential properties in Colnbrook
  - Delivery:
- The completion of the new A4 and A3044 is critical to the demolition of the existing roads and subsequent completion of earthworks and airfield. The interface and delivery phasing of both the existing and new A4 with the diverted M25 is critical.
- The preferred options are the ones that can be delivered with the least impact on the existing road network during construction. This will need to be further assessed as the scheme develops.
  - Business case:
- For the A3044, option 2bi has minimal property cost, while 3g does not allow for the upgrade of Stanwell Road to dual carriageway. Capex for options 2a, 2b and 3d is increased due to greater property requirements / greater embankment construction and the provision of a cut and cover tunnel.
- A4 option 2e requires a tunnel through contaminated ground, leading to significantly high costs.

HAL's BRAG Summary is:

Local Roads Options – HAL BRAG Status												
		A4					A3044					
		1a	2e	DM	3a	6c	2a	2b	3d	2ai	2bi	3g
1	Operations & Service	Green	Red	Yellow	Yellow	Green	Red	Yellow	Yellow	Yellow	Yellow	Green
2	Property	Yellow	Yellow	Green	Yellow	Red	Red	Yellow	Green	Yellow	Green	Yellow
	Planning	Yellow	Yellow	Yellow	Yellow	Red	Yellow	Red	Green	Yellow	Green	Green
3	Delivery	Red	Red	Green	Yellow	Yellow	Red	Green	Yellow	Yellow	Yellow	Red
4	Sustainability & Community	Green	Yellow	White	Green	Yellow	Yellow	Red	Yellow	Green	Green	Green
5	Business Case / Capex	Red	Yellow	Green	Red	Green	Green	Green	Yellow	Yellow	Red	Red

Table 25. HAL BRAG Summary – Local Roads

Based on the results of each of the above criteria, none of the options have been discontinued (given a Black RAG rating) at this stage.

## 6.4 Key Findings

The current design for the local road options is at a very high level which makes capex assessment challenging. However, Arcadis consider that HAL's approach to the construction elements is generally in line with industry standards.

Benchmark data taken from a number of sources has been used by HAL to develop the estimates. These figures are within tolerance of Arcadis benchmark data for comparable items.

The majority of the Add-On percentages used by HAL are in line with industry standards. However, Arcadis believe that each option should be considered independently, and the percentages applied for Project Specifics adjusted to reflect delivery challenges specific to each option.

Arcadis suggest that a more robust peer review process is employed to ensure calculation errors (such as that highlighted by options 3d, 2ai, 2bi and 3g of the A3044 Family whereby linear meterage was confused with area) are eliminated insofar as possible from future iterations.

In terms of overall RAG status against the AC scheme, on a capex basis Arcadis has rated the options largely in line with HAL's findings.

HAL has confirmed that there is no Black rating on the capex within the Green DER, notwithstanding this none of the local roads options have been suggested for discontinuation against any of the other evaluation criteria.

## 6.5 Next Steps

Next steps include:

- Evaluating options with localised traffic modelling to understand operational performance and traffic distribution; key issues for local noise and air quality assessment.
- Assess M25 alignment, junction and local road options as holistic packages to understand compatibility and overall operational performance. Each sub-component will have its own set of unique interface issues when put together to form a preferred route assembly, as such a compatibility matrix is required.
- Potential congestion/diversionary impacts during construction have not been assessed. Arcadis believe these should be considered in a deliverability and phasing exercise.
- HAL will have the opportunity to refine options and undertake more detailed assessments to optimise routes in order to minimise property loss and environmental impact.
- Dedicated cycle routes separate from carriageway require further consideration.
- Community connectivity needs adequate consideration moving forward.
- Many local roads options interface with historic landfill sites and existing water courses, which need to be managed appropriately through further design. Close liaison with rivers and flood storage to ensure that conveyance and water storage requirements are achieved across the local roads options.
- Assess local road combinations with and without a large western apron.
- Arcadis believe that there are still significant value engineering opportunities which can be progressed as the design evolves.



## 7 Rivers & Flood Storage

### 7.1 Introduction

This component comprises the rivers (conveyancing) and flood storage. These two subcomponents have been assessed independently by HAL.

The options identified were pre-screened during the Orange Review to narrow down the possible permutations and combinations. This report considers the evaluations process implemented during the Green Review and does not analyse the processes adopted during the Orange Review.

In undertaking their Black / Red / Amber / Green (BRAG) evaluation HAL has considered four evaluation criteria with sub-categories as detailed below:

DELIVERY	PLANNING & PROPERTY
<ul style="list-style-type: none"> <li>• Buildability</li> <li>• Time</li> <li>• Construction efficiency</li> <li>• Logistics</li> <li>• Safety and security</li> <li>• Bringing asset into service</li> </ul>	<ul style="list-style-type: none"> <li>• Extent of property loss/severance</li> <li>• Land take</li> <li>• Alternative/other uses for land</li> <li>• Consistency with local policy designations</li> <li>• Draft NPS, environmental &amp; habitat requirements</li> </ul>
BUSINESS CASE	SUSTAINABILITY & COMMUNITY
<ul style="list-style-type: none"> <li>• Capital Expenditure (Capex)</li> <li>• Property / Land take</li> </ul>	<ul style="list-style-type: none"> <li>• Landscape and townscape</li> <li>• Visual</li> <li>• Cultural heritage</li> <li>• Biodiversity</li> <li>• Surface and ground water</li> <li>• Socio-economics and community</li> <li>• Land quality and agricultural land quality</li> </ul>

Table 26: HAL evaluation criteria and sub-criteria for Rivers and Flood Storage

It should be noted that the capex review under the business case evaluation criteria has a Red / Amber / Green rating only, meaning that no options are discontinued (given a Black rating) due to capex results. Arcadis concur with this approach at this stage, as capex will become a defining criterion in future evaluations.

This report concentrates on HAL's Business Case evaluation approach; however, we have also provided a commentary on their evaluation approach to the other categories and offer high level opinions as to this approach.

### 7.2 Options Summary – Rivers

Two option families have been identified for the rivers (conveyancing) subcomponent, namely:

- **Family C1:** Options that interact and / or are dependent upon runway alignment and height. These are diverted under the runway and three sub-options have been identified:
  - C1a: all rivers located under the runway;
  - C1b: as C1a but Duke of Northumberland (DoN) diverted north to the River Crane;
  - C1c: as C1a but Colne Brook diverted around the airport.
- **Family C2:** Options requiring rivers to be diverted westward, consisting of two sub-options:
  - C2a: River Colne and Wraysbury diverted west to Colne Brook and twin rivers under the runway;
  - C2b: River Colne and Wraysbury diverted west separate from Colne Brook and twin rivers under the runway.

## 7.3 Evaluation – Rivers

What follows is a high-level commentary on HAL's approach to the Planning & Property; Sustainability & Community and Delivery evaluation criteria, and detailed commentary of the Business Case evaluation. HAL's approach was predicated upon design concepts produced ahead of Heathrow's Consultation 1; Arcadis note that these concepts have subsequently evolved since the Green Review stage.

### 7.3.1 Planning & Property

For the Green Review HAL has not undertaken any quantitative assessment of the property loss numbers. They have instead undertaken a subjective review considering the following impacts:

- Whether contained within the Red Line Boundary;
- Land take;
- Property loss;
- Severance of villages.

Whilst this subjective view provides some worthwhile evaluation (e.g. it is reasonably clear from a visual inspection of the plans that option C1a has the least impact on property), we believe that, at this stage, a high-level view of the likely land take / property loss numbers should be carried out.

This could identify key properties which, for various reasons i.e. value, potential alternative uses, or their difficulty to acquire (allotments, which are likely to have several owners for a relatively small area) would be ideal to avoid. Subsequent micro-planning of river alignment may therefore realise cost savings and optimise the route.

Following raising this with HAL they reacted to our comments and have now undertaken a property assessment; our review of this is covered in section 7.3.4.2. This reinforces HAL's commitment and approach to working with Arcadis.

Consideration has also been given to those options where existing channels are utilised, and the alignment can follow natural, property and planning boundaries. Overall environmental impact has also been considered.

Arcadis believe that the evaluation of this criteria should contain some quantitative assessment alongside the subjective review undertaken.

### 7.3.2 Sustainability & Community

The key objectives for this evaluation criteria were identified as the impacts on the natural environment, particularly on habitat connectivity, maintaining natural light penetration and those options which can deliver enhancement.

Achieving some of the above is dependent on the runway height and high viaduct options improving light penetration. Low culvert options are not preferred unless off set with new open water courses which improve connectivity.

HAL has identified that a net loss/gain calculation for biodiversity will be required for all options and compensation will be subject to regulatory negotiation. The capex impact of this has not been considered within the Green Review. This will need to be considered when preferred options have been identified.

HAL has also commented that parcels of land must be multi-functional including river conveyance, habitat creation and green infrastructure. There are currently no details of how this will be provided but once there is the associated capex impacts will need to be assessed.

A subjective view of the Sustainability and Community criteria has been undertaken. Arcadis believe that the next steps would need to incorporate a capex view of any mitigation measures required.

### 7.3.3 Delivery

The key considerations for this evaluation criteria are:

- Avoidance of critical constraints;
- Amount of complexity and risk;
- Minimising construction impacts;
- Delivery within overall programme timescales;
- Minimise materials import / export;
- Deliver safe and secure construction operations.

A subjective evaluation has been undertaken and the following key points have been identified:

- All options are complex to deliver;
- There are opportunities to integrate some of the works with the main expansion works;
- Linked to the last point there is a risk of intensifying activities and creating more dependencies and interfaces.

Arcadis believe that the outputs from this evaluation need to be reflected in the Business Case evaluation. Currently a consistent percentage for project specifics has been applied to the base construction cost, meaning that those options with a higher capex will inherently attract a higher level of project specifics. We consider that each option should be considered independently, with the percentages applied for project specifics adjusted to reflect the deliverability of each option.

### 7.3.4 Business Case

The two main considerations here are:

- Capital Expenditure (Capex)
- Property loss / land take

No consideration has been given to Operating Expenditure (opex) costs, however in our opinion this would not be a key differentiator at this stage.

We have undertaken a detailed review of HAL’s approach to their assessment of capex and property loss / land take.

#### 7.3.4.1 Capital Expenditure (Capex)

HAL has assembled bottom-up estimates utilising component-level benchmarks. Each option has then been rated against the Purple Book. Arcadis believe that this approach is best practice at this stage of the project.

Each option’s capex has been built up in the same format and the result can then be used to rank and rate options. The criteria applied for the rating status is:

RAG Status	Ranking Criteria
RED	Greater than 15% above Airport Commission scheme capex cost
AMBER	0%-15% above/below Airport Commission scheme capex cost
GREEN	Greater than 15% below the Airport Commission scheme capex cost

Table 27. RAG Status for Rivers & Flood Storage Options

In reviewing HAL’s estimates we have looked at the following items:

- Quantities
- Rates
- Add-Ons
- Risk and Uncertainty
- Property Loss / Land Take

These are investigated in greater depth below:

- Quantities**

HAL's estimate is derived using the quantities provided by the designers. Arcadis challenged HAL as to whether they had undertaken an exercise to verify these quantities and they confirmed that they had, however they have been unable to provide evidence of this.

Arcadis has undertaken their own verification of the quantities utilising the high-level design contained within the Task Order 5.1/5.2 Evaluation Briefing document. Due to this approach there will inherently be a level of tolerance in the measurements abstracted. We have requested dwg files from HAL and will verify our measurements if these are received. However, we do not believe this will make a significant difference to the overall outputs.

Rivers (Conveyancing) Options– HAL/Arcadis Summary Comparison Measure										
	C1a		C1b		C1c		C2a		C2b	
	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis
Item	km	km	km	km	km	km	km	km	km	km
Modified Channel	1	1	1	2	1	1	9	9	1	1
Open Channel	4	3	8	7	5	3	9	9	9	8
Colne Brook Culvert	0.80	0.86	0.80	0.86						
Wraysbury / Colne Culvert	0.90	0.84	0.90	0.84	0.90	0.84				
DoN / Longford Culvert	0.90	0.94	0.90	0.94	0.90	0.94	0.90	0.94	0.90	0.94
Discontinued Channel	13	9	20	14	13	9	23	22	14	14

Table 28. Rivers – HAL/Arcadis Summary Comparison Measure

Within our overall analysis we have utilised our measurements however, none of the differences above affect the ranking of the options.

- Rates**

The key rates utilised for this component are:

- Culverts

Within the estimates HAL utilised a rate of █ m<sup>3</sup>. Arcadis would expect to see the rate expressed as £/m and therefore requested supporting benchmark data.

HAL provided this benchmark data expressed as a £/m metric as well as £/m<sup>3</sup>; however, the two sets of data did not align. HAL has provided further detail which shows that the █ m<sup>3</sup> rate is based on the Lima Taxiway tunnels and includes for services which will not be required to the same extent in the culverts. We have therefore adjusted this, producing a revised rate is £645/m<sup>3</sup>.

HAL subsequently provided further substantiation providing details of the Eastern Airside Access Road (EAAR) which goes under Lima Taxiway and which they have based their rate on. Within this document there are other tunnel benchmarks; and the EAAR is at the top end of the range. Arcadis would advocate the use of an average rate or undertaking further interrogation of the EAAR rate to see what is driving the costs up and possibly challenge this rate.

Arcadis undertook a bottom up exercise to verify these rates, the Arcadis rates were within an acceptable tolerance of the HAL £/m rates however below the £/m<sup>3</sup> benchmark rate that HAL has utilised in their estimate.

In applying a high rate for the culverts, the outputs could show that the options with a greater extent of culverts may be ranked lower.

Arcadis has undertaken our own assessment of the river options utilising the Arcadis measurements and rates and therefore any impact of this will be captured within the Arcadis view of the capex and associated ranking and rating.

Below we have captured the analysis of the culvert rates:

Culverts	HAL	Arcadis
£/m <sup>3</sup> in options analysis		-
£/m <sup>3</sup> in benchmark analysis		-
£/m in benchmark analysis (average)		56,940
£/m in benchmark analysis expressed as £/m <sup>3</sup>		528

*Table 29. Culvert Benchmark Analysis*

– **New river channels**

Arcadis requested backup / benchmark data to support the rates utilised by HAL. Arcadis were advised that there were no benchmarks and that these rates were estimator’s experience. However, HAL subsequently provided analysis of the T5 river diversions. Arcadis would question the relevance of the T5 Western Perimeter Corridor as an equivalent benchmark for new river channels in reasonably rural areas.

Arcadis has however utilised our own experience to verify these rates and believe that they are sufficient for the earthworks to create open river channels.

– **Modified river channels**

Arcadis asked HAL to provide substantiation of the scope of works for the modification of existing river channels as this is currently twice the allowance for new river channels.

Arcadis were initially advised that there were no benchmarks and that these rates were estimator’s experience. However, HAL subsequently provided analysis of the T5 river diversions as part of the Western Perimeter Corridor project. The scope of works is to divert the twin rivers within new concrete river channels, Arcadis would question whether this is reflective of the scope required to modify existing channels which may, or may not, be engineered structures.

Apart from option C2a the quantity of modified river channels is low and therefore would not impact the outcome. Whilst Arcadis do not concur with the benchmark rate used we believe that the adjustment of the rate would be minimal and therefore not affect any outputs.

Arcadis would expect to see further benchmark rates sourced and implemented as the design becomes more detailed.

• **Add-ons**

As with the other Key Components, HAL has applied the same percentage across all options for preliminaries (█%), OH&P (█), design (█) and leadership and logistics (█) based on their analysis of previous HAL projects.

Phasing has not been included and when questioned HAL’s response was that this would be similar across all options. Whilst in part Arcadis accept this principle we would expect all on costs to be applied.

At this early stage in design it is normal to apply percentages for these items based upon the Base Construction Cost and hence options which are more complex and with higher capex will attract higher on costs. We would however expect to see the phasing reviewed and dependent upon construction complexity different percentages potentially being applied against different options.

However, because there is no Black rating for capex at this Green Review stage the evaluation of those options which are more complex to deliver will be captured in the Delivery section evaluation.

- **Risk & Uncertainty**

HAL has applied a percentage across all options of ■■ for risk and ■■% for uncertainty not derived from P80 values.

Whilst the application of a consistent percentage is fairly common practice the assumption that capex and risks are directly proportionate may not necessarily be the case. We would expect to see risks identified in a risk register which could then be used to verify the percentages applied against the value this generates.

### 7.3.4.2 Property Loss / Land Take

For the Green Review, HAL did not undertake any assessment of the cost of land acquisition or quantify the actual property loss numbers.

This was questioned with HAL and they subsequently performed this exercise.

Arcadis has reviewed HAL's approach to this. HAL has not been consistent with the inclusion of the area required for the culverts as this was excluded from the C1 options but included in the C2 options. As the culverts lie within the red line boundary Arcadis believes that the land take property loss will be included elsewhere in the Purple Book. Arcadis has therefore excluded this from our assessment.

HAL has sought specialist input for the property loss assessment. A high-level assessment of average property values has been applied against all options, except C1b, with an average value of approximately ■■■■■ per hectare. Option C1b has a value of ■■■■■ per hectare. HAL's explanation was that there were more expensive properties required for this option. Arcadis has undertaken a visual review of the land required and for option C1b HAL's logic appears reasonable. However, looking at options C2a and C2b, these potentially require land with a higher value. HAL has stated that they have not made an allowance for property costs resulting from a widening of the existing channels. Whilst this may not affect the overall evaluation Arcadis believes that this should be considered.

### 7.3.5 Arcadis Business Case RAG Evaluation

Arcadis has collated our comments from the above Business Case section and prepared a revised summary table comparing against HAL's capex summary.

Taking the Arcadis assessment all the options are within the current allowance contained within the Purple Book. Our ranking of the options generally aligns with HAL except options C1c and C2a where the rankings are transposed.

Rivers (Conveyancing) Options – HAL/Arcadis Evaluation Comparison										
	C1a		C1b		C1c		C2a		C2b	
	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis	HAL	Arcadis
Item	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m
Base Construction										
Project Specifics										
Prelims & OHP										
L&L & Design										
Risk & Uncertainty										
Property										
<b>Capex Total</b>										
<b>RAG Status &amp; Rank</b>	4	4	5	5	3	2	2	3	1	1

Table 30. Rivers (Conveyancing) options – HAL/Arcadis Business Case RAG Evaluation Comparison

### 7.3.6 HAL BRAG Summary

HAL has collated the evaluation criteria to give an overall rating to each option, and have drawn the following key feedback from this:

- Property & planning: rivers under the runway are preferable
- Sustainability & Community: Culverted rivers are less favourable than diversions to the west.
- Delivery: Rivers under runway more favourable as less construction impacts and conflicts with other land uses.
- Business case: Those with fewer under runway structures are favoured.

The key conclusions that they have drawn are:

- No over-riding benefits from the Duke of Northumberland channel north of the airport.
- Diversion of Colne Brook around the runway is preferable to under the runway.
- Low headroom option for rivers under the runway limits environmental requirements. HAL to investigate a hybrid option with mitigation channels westwards.
- Rivers diverted westwards favoured for sustainability reasons but otherwise not favoured.

HAL's BRAG summary is:

Rivers (Conveyancing) Options – HAL BRAG Status								
Discipline	C1a		C1b		C1c		C2a	C2b
	High (i & ii)	Low (iii)	High (i & ii)	Low (iii)	High (i & ii)	Low (iii)	-	-
1 Planning	1	1	2	2	1	1	2	2
2 Property	1	1	3	3	1	1	2	2
3 Delivery	1	1	2	2	1	1	3	
4 Business Case	2	2	3	3	1	1	1	1
5 Environment	2	3	2	3	2	3	1	1
<b>RANKING</b>	2	4	6	7	1	3	5	8

Table 31. HAL BRAG Summary - Conveyance

HAL has then drawn the following key conclusions:

Option Family	Sub-Option	Conclusion
C1 Rivers under Runway	C1a	Park
	C1b	Park
	C1c	Take forward from C1 Family
C2 Rivers diverted westward	C2a	Take forward revised / optimised version, as "western spur" for mitigation combined with C1c
	C2b	

Table 32. Key Conclusions

Based upon the HAL BRAG rating and Arcadis review we would question the decision to park option C1a.

The overall rating of C1a High (i&ii) is Green, ranked second and C1a Low (iii) is Amber ranked fourth. In our analysis of the business case the rating of these options are raised from Red / Amber to Green.

## 7.4 Options Summary - Flood Storage

This component is more flexible, with a mix of storage locations available to meet the requirements of different conveyancing options.

The storage component options can be summarised as follows. There is no option S6.

- S1: Maintain existing online storage;
- S2: New storage within red line boundary (RLB), under runway and expanded western apron;
- S3: New storage west of RLB, land between Colne Brook and Horton Brook;
- S4: Catchment-wide approach, application of Sustainable Drainage Systems (SuDS) and water sensitive urban design, including retrofitting;
- S5: New storage upstream of RLB, Upper Colne catchment, M40 to M4 and M4 to runway;
- S7: New storage downstream of RLB at Stanwell Moor;
- S8: New storage on River Crane east of airfield.

Within the above the sites have been divided into 24 geographic locations.

## 7.5 Evaluation - Flood Storage

Arcadis has provided commentary on HAL's approach to the evaluation criteria below, together with a detailed review of the Business Case criteria.

It should be noted that at this stage it is not possible to rule out any storage options as they will need to respond to the river conveyancing options under consideration.

### 7.5.1 Planning & Property

HAL has not undertaken any quantitative assessment within the business case evaluation. In this category they have undertaken a subjective review looking at the following impacts:

- Extent of land take, area and number of properties;
- Site potential, areas to the north and west could be used for displaced/associated development opportunities;
- Shared use, ecological value is critical as stated in the NPS that habitat re-provision will be on a 2:1 ratio.

Option S1 has not been rated by HAL.



## 7.5.2 Sustainability & Community

The key objectives for this evaluation criteria were identified as those options with the least impact on the natural environment and those options which can deliver enhancement.

A subjective evaluation comparing the schemes has been undertaken, taking into consideration the following factors:

- Extent of water regime changes should be limited to the River Colne catchment area.
- Storage options need to respond to river conveyancing options.
- Storage options in close proximity to the airport will work better environmentally and will be more efficient with the conveyance options.
- Whilst new storage options within the RLB may be acceptable there would need to be a refinement of the engineering solution, though there could be water harvesting benefits. Further work is likely to be required in order to satisfy the regulator.
- It is important to keep options local to the airport to provide opportunities for habitat creation and green infrastructure enhancements.
- The groundwater regime will be a key determinant; options are likely to be re-considered following ground investigations.

Parcels of land will need to be multifunctional; able to encompass flood storage provision, habitat creation and green infrastructure.

## 7.5.3 Delivery

The key considerations for this evaluation criteria are:

- Avoidance of critical constraints;
- Amount of complexity and risk;
- Minimising construction impacts;
- Delivery within overall programme timescales;
- Minimise materials import and export;
- Deliver safe and secure construction operations.

A subjective evaluation of this criteria has been undertaken however HAL has stated that due to the limited amount of information that will materially impact upon construction delivery, they have assessed flood storage under a single "construction" criterion basing the scoring on the location considered and the likely impact on construction activities (i.e. the further the flood storage, the lower the impact).

The BRAG rating criteria applied are:

- **BLACK**      Overlap with land required during construction
- **RED**         *No criteria noted*
- **AMBER**      Some impact but feasible
- **GREEN**      Further from the site and least impact

HAL need to identify the criteria which constitute the red rating, and then re-rate the options taking this into consideration.

Option S2 has been discontinued because of the high impact on construction. Timing is also critical as it is understood that additional flood storage will be required during construction and overlaying the quantum of the flood storage required with construction operations within the site is not viable in our view.

Option S5iii has been discontinued because the flood storage areas identified conflict with land allocated to construction logistics and stockpiling around the M4 Spur.

## 7.5.4 Business Case

The two main considerations here are:

- Capital Expenditure (capex)
- Property loss / land take

No consideration has been given to operating expenditure (opex) costs, however in our opinion this would not be a key differentiator at this stage.

### 7.5.4.1 Capital Expenditure (Capex)

HAL has stated that the capex in constructing the flood attenuation facilities is negligible in comparison to the cost of acquiring the rights to the land which is the biggest driver, and that this assumption can be further tested once additional design information is made available.

Whilst the capex maybe low compared to the overall programme costs Arcadis believe that it could differ significantly between options.

The design is currently at a very low level of maturity however Arcadis believe that a high-level view of how the capex compares between the options should be undertaken.

### 7.5.4.2 Property Loss / Land Take

HAL has undertaken a high-level assessment of the property loss / land take required for each sub option. They have then undertaken a BRAG review based on the following conditions rather than on value:

- **BLACK** Agricultural and amenity land
- **RED** Impacts upon residential/commercial properties or areas with notably high capital cost
- **AMBER** Agricultural land with impacts upon farm buildings and/or poor quality industrial uses
- **GREEN** Impacts upon a large number of residential properties or very high value land use

Arcadis believe that by rating this category subjectively they have duplicated the rating of the planning category which has also been rated subjectively using similar criteria. Arcadis believe that this category should be rated on the actual land value.

Whilst the property value has not been used in the BRAG rating Arcadis has still reviewed HAL's approach. The assessment has been built up based on average land values dependent on the type of property needing to be acquired.

In undertaking this high level average approach, HAL has applied a rate of ██████ per hectare to option 1.3 giving a total value for the land required of under █m. Following further investigation of this option, HAL completed a detailed review of the property requirements indicating a value of █m, obviously a substantial difference. Arcadis has challenged HAL on the average £/Ha approach and whether a peer review of all options has been undertaken. HAL responded that they have.

Arcadis has undertaken their own assessment of the average value applied to the land and have questioned HAL on a couple of point, HAL has responded justifying their assumptions.

## 7.6 Key Findings

For the rivers sub-component, the current design is at a very high level which makes the capex assessment more challenging.

Arcadis believe that HAL's approach to the construction elements is generally in line with industry standards. We would however expect to see assessments of the cost of land acquisition. We would also expect to see benchmarks being reviewed from projects other than Heathrow ones, this will then act to challenge the efficiency of previous HAL projects.

Whilst HAL’s capex has rated two options above the AC’s scheme and three below, Arcadis has rated all of them below. This is mainly due to the concerns that Arcadis has regarding the benchmark rate that HAL has utilised for the culverts. HAL could potentially discontinue options which have more culverts, whereas from a capex evaluation perspective, Arcadis do not believe that these should be discontinued at this stage. HAL has however confirmed that there is no Black rating on capex within the Green DER.

Arcadis believe even though some of the options fall within the Purple Book there are still significant value engineering opportunities, and this should be progressed as the design evolves.

For the flood storage, no capex evaluation has been undertaken and the property loss has been evaluated subjectively rather than quantitatively. Arcadis do not concur with this approach and believe a quantitative assessment of capex should be undertaken.

## 7.7 Next Steps

Following the Green Review, HAL will develop combined component options that match storage areas to conveyancing options, informed by the evaluation.

With both rivers and flood storage HAL will have the opportunity to refine options and more detailed assessments will be required to optimise locations / boundaries in order to minimise property loss / land take and environmental impact.

HAL’s evaluation conclusions are summarised in the table below:

Options	Description	Rationale
01 Preferred outcome of evaluation process	Conveyance primarily through/under the airport, daylighting where possible. Storage provided upstream of M4 or downstream of airport (e.g. C1c i/ii plus S7 or S5).	This composite option best agrees with the outcomes of the evaluation process.
02 The ‘greener’ option	A new composite option blending the best parts of C1c and C2a – in which water is primarily routed through / under the airport with the addition of a ‘western spur’ for connectivity.	The regulator’s position on acceptable mitigation and compensation is not yet defined – it is possible that a more naturalised option may be the only way to satisfy the WFD Article 4.7 case. Moreover the western spur may be required to access new areas of flood plain storage if other options are hydraulically unfeasible.
03 The ‘flood risk’ option	A composite option developing C1c and utilising storage on the western edges of the airport and between airport and M4.	The scheme will not be consented unless it can be demonstrated that flood risk will not be increased to others. The effectiveness of storage upstream of the M4 alone is not proven, an option which presents a more credible flood risk solution needs to be retained.

Table 33. HAL’s option retention and further developments summary

## 8 Terminals, Satellites & Aprons

### 8.1 Introduction

HAL's approach to this component was to produce multiple terminal, satellite and apron arrangements and then compile different configurations of the same into component assemblies.

To reduce the number of assemblies / options to be evaluated Heathrow applied a set of Discontinuation Rules:

#### Discontinuation Rules arising from evaluation process

1. Western Campus should have a capacity of at least 65mppa to accommodate hub traffic growth.
2. Additional capacity should be delivered without significant negative impact on existing operations.

#### Discontinuation Rules at Orange Review

3. Provide a competitive passenger experience at an affordable cost.
4. All options must be capable of delivering sufficient hub capacity in time to meet demand.
5. Additional apron capacity should be built between the runways, where land is available to do so, as opposed to development beyond or outside the runways.
6. Maximise apron between existing runways to reduce passenger journeys from the central spine.
7. Make efficient use of Heathrow's existing infrastructure and land within the airport boundary where it is feasible [and cost effective] to do so, e.g. T2A site, T3 site.
8. All new core landside terminal capacity will be located on the public transport spine. Note: Gateways might provide additional landside processing capacity (to be determined).
9. Spatially and operationally efficient, modern terminals with significant asset value will be retained, i.e. T5A and T2A with T3 closing.

The final evaluation options comprise nine such assemblies, consisting of six main options and three "Challenger" options. The Challenger options have been included as they may offer cost savings by retaining existing terminals T3 and T4. However, the overriding aim is to increase current capacity at Heathrow to 130mppa.

In applying the above Discontinuation Rules and in line with criteria reviewed for the other components, it can be seen from HAL's analysis that the main sub criteria are as tabled below:

OPERATIONS & SERVICE	PLANNING & PROPERTY
<ul style="list-style-type: none"> <li>• Maintaining airfield operations, passenger experience, hub connectivity, baggage systems and surface access levels of service.</li> <li>• Increasing capacity to co-locate key hub carrier and strategic partners in the Western Campus.</li> <li>• Passengers should remain on the existing transport spine where possible to encourage public transport use.</li> <li>• Ensuring minimum capacity requirements of 65mppa in the Western Campus.</li> </ul>	<ul style="list-style-type: none"> <li>• Minimum terminal capacity required to be increased to 130mppa.</li> <li>• Heathrow remains as an aviation hub with an increase in connections proportional to the current percentage.</li> <li>• Assemblies of terminals and satellites need to promote hub-connecting passengers.</li> <li>• Maximise volume of connecting passengers who can connect on foot.</li> </ul>
DELIVERY	SUSTAINABILITY & COMMUNITY
<ul style="list-style-type: none"> <li>• Expanding existing facilities is likely to be more complex and phase intensive than building stand alone.</li> <li>• Manageable scale and complexity of build and impact on passenger experience.</li> <li>• Preferred simple to manage construction logistics.</li> </ul>	<ul style="list-style-type: none"> <li>• Impacts on the natural environment reduced seeing as most works within the airport layout.</li> </ul>

**BUSINESS CASE**

- Fewer, larger terminals are preferred due to economies of scale and lower anticipated opex.
- Small H can only accommodate 18mppa and this might prove too small for the business case.
- Minimum of 20mppa considered effective to generate retail income in decentralised departure lounge configurations.

Table 34. HAL evaluation criteria and sub-criteria for Terminals, Satellites & Aprons Assemblies Options

While Heathrow undertook an evaluation of this component there was no formal ‘Design Evaluation Report’ produced.

This report concentrates on HAL’s Business Case evaluation approach. However, we have also provided a commentary on their evaluation approach to the other criteria and offered high level opinions as to this approach in the following sections.

## 8.2 Options Summary

Each of the options greatly affects the current airport layout. The diagrammatic arrangements below show the existing layout, with the numbers adjacent to T5A, T3, T2A and T4 indicating the current passenger numbers (totalling approximately 75mppa), and the proposed future Terminal and Satellite typologies.

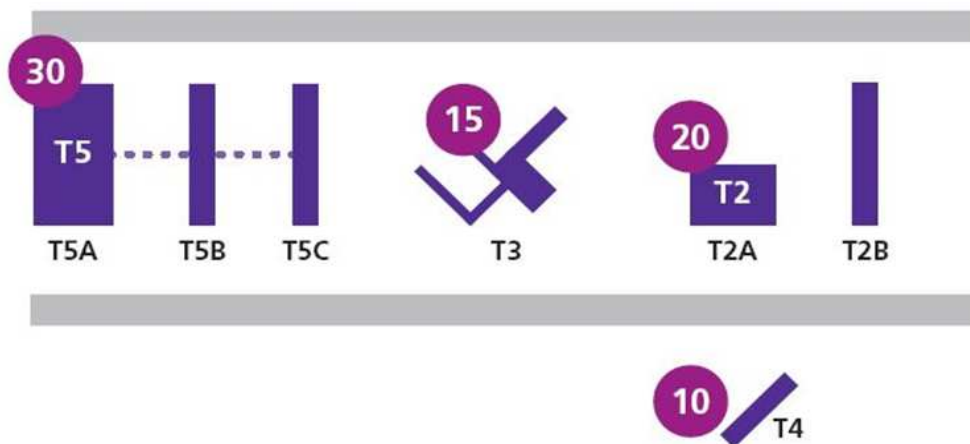


Figure 6. Current diagrammatic arrangement of existing terminals and satellites at Heathrow

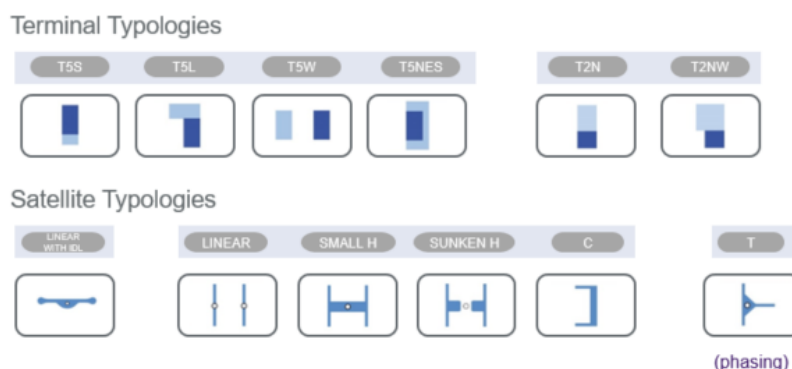


Figure 7. Future Terminal and Satellite Typologies

These typologies for each of the terminals and satellites are used throughout the following component option synopses:

• **Assembly 3Ai**

This is an updated version of the Airports Commission Scheme. The Eastern campus provides 56mppa and the Western 63mppa representing a total of 119mppa. East includes demolition of T3, extension of T2A and new T2C, D and E, retention of existing Pier 6 connected to T2A. Baggage and passenger connectivity from T2A to T2E and to T2C. West comprises a new Terminal T6W connected via link bridge to T5, new north apron satellite. APM and baggage connectivity from T6W to northern satellite. T4 remains. Consolidation of the Eastern Maintenance Base. Note it is assumed that T6 25mppa is a separate independent item.

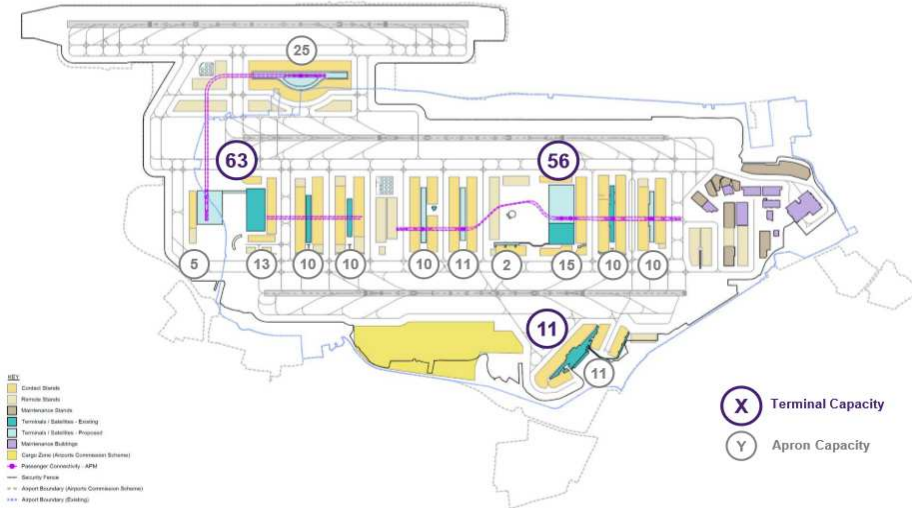


Figure 8. Main Assembly Option 3Ai

• **Assembly 3Aii**

Eastern campus provides 52mppa and West 67mppa totalling 119mppa. East includes demolition of T3, extension of T2A and new T2C formed as an H configuration with existing T2B, H configuration of T2D and E, retention of existing Pier 6 connected to T2A. Baggage and passenger connectivity from T2A to T2E and to T2C. West comprises an extension to T5A at the northern end, new north apron satellite. APM and baggage connectivity from T5A to northern satellite. T4 remains. Consolidation of the Eastern Maintenance Base.

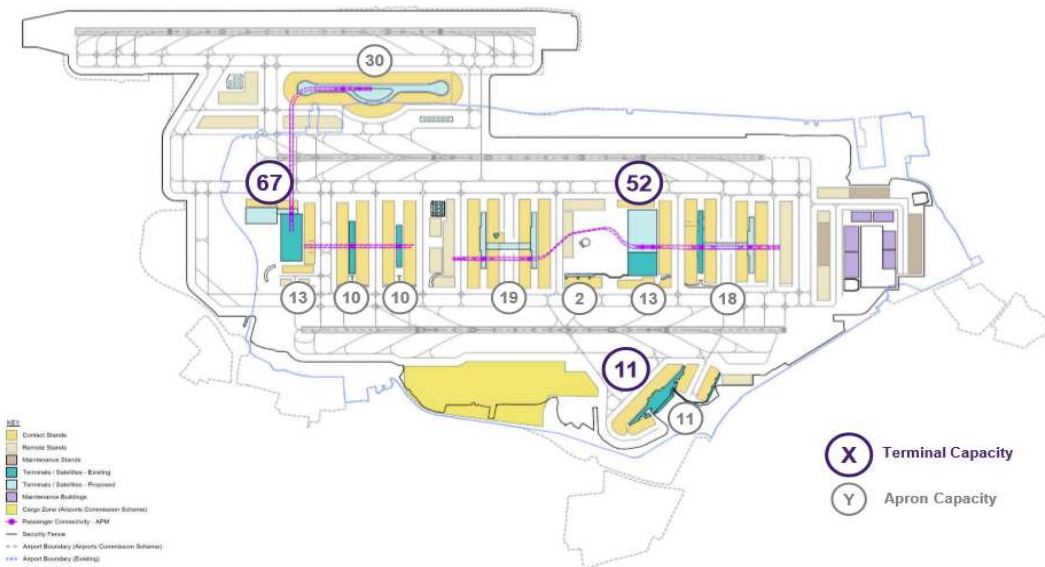


Figure 9. Main Assembly Option 3Aii

• **Assembly 4A**

Eastern campus provides 54mppa and West 76mppa totalling 130mppa. East includes demolition of T3, extension of T2A and new T2C formed as a below ground H configuration with existing T2B, below ground H configuration of T2D and E, retention of existing Pier 6 connected to T2A. Baggage and passenger connectivity from T2A to T2E and to T2C. West comprises a new Terminal T6W connected via an airside walk along a linking corridor to T5, new north apron satellite. APM and baggage connectivity from T6W to northern satellite. T4 shut. Provision of 3 gateways used to process departing passengers linking, via POD, to the decentralised H and northern satellites. Arriving passengers will be processed in the terminal then travel to private transport facilities via POD. Consolidation of Eastern Maintenance Base.

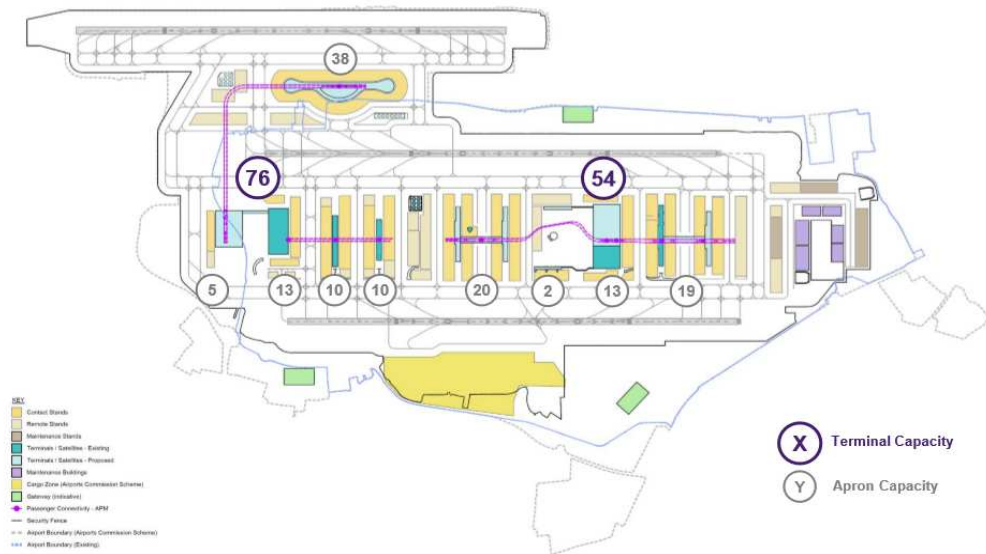


Figure 10. Main Assembly Option 4A

• **Assembly 11C**

Eastern campus provides 45mppa and West 74mppa. East includes demolition of T3, extension of T2A and new T2C, D (on the site of the existing maintenance base), and retention of existing Pier 6 connected to T2A. Baggage and passenger connectivity from T2A to T2D. West comprises a new Terminal T6W connected via an airside walk along a linking corridor to T5 supplemented with a separate landside walk. T5A is extended to the south. APM and baggage connectivity, along the south, from T6W via T5A extension to T5 D and E.

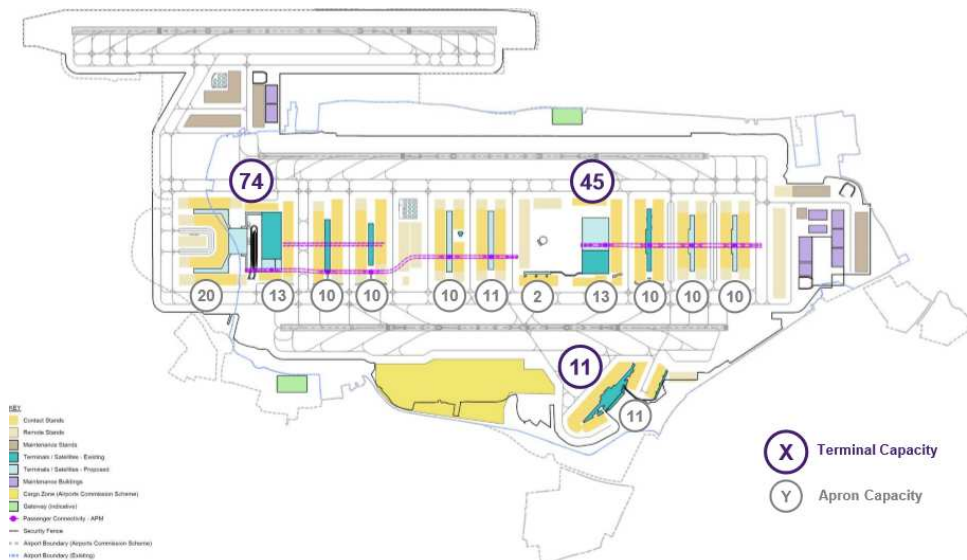


Figure 11. Main Assembly Option 11C

• **Assembly 12A**

Eastern campus provides 72mppa and West 58mppa totalling 130mppa. East includes demolition of T3, extension of T2A and new satellites T2C and northern apron satellite, retention of existing Pier 6 connected to T2A. Baggage and passenger connectivity from T2A to T2C and T2A to northern satellite. West comprises an extension to T5A at the northern end and new T5D and E. APM and baggage connectivity, along the north, from T5A extension to T5 D and E. T4 is shut.

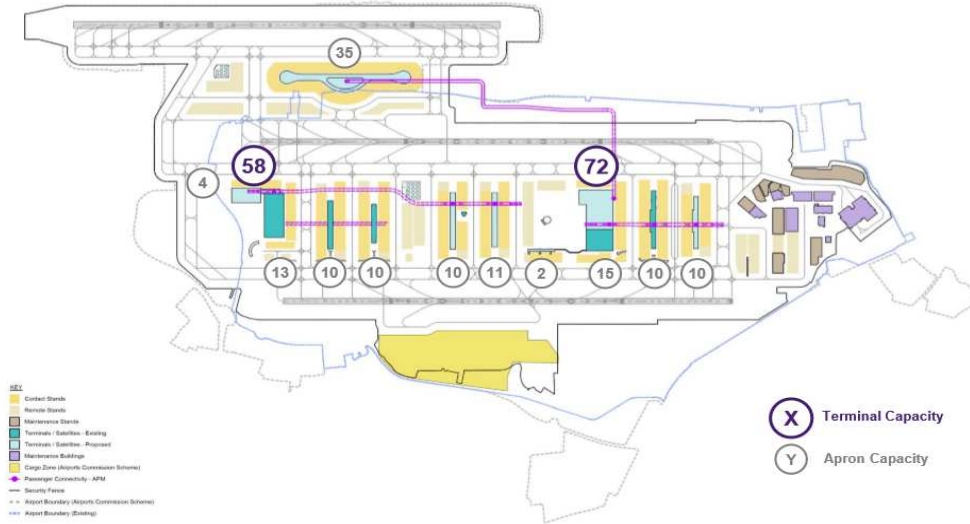


Figure 12. Main Assembly Option 12A

• **Assembly 15B**

Eastern campus provides 41mppa and West 78mppa totalling 119mppa. East includes demolition of T3, extension of T2A and new T2C formed as an H configuration with existing T2B, retention of existing Pier 6 connected to T2A. APM and baggage connectivity from T2A through to T2D. West comprises an extension to north, south and east of T5A with an underground H connection to T5B, a new above ground H shaped T5D connected to T5C. New northern apron satellite. APM and baggage connectivity from T5 to northern satellite. Eastern Maintenance Base split and consolidated.

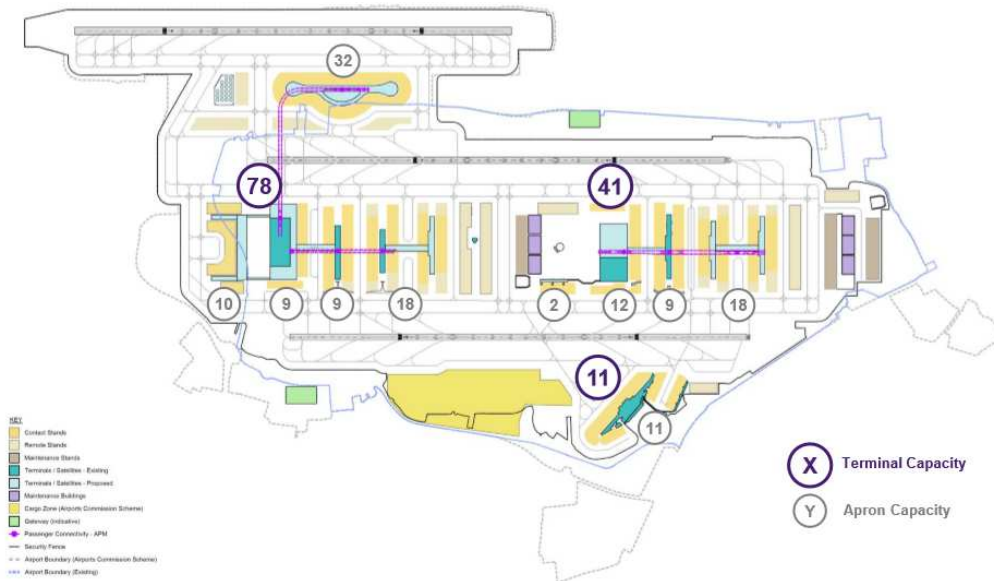


Figure 13. Main Assembly Option 15B



• **Assembly 9 (Challenger)**

Eastern campus provides 69mppa, West 33mppa (as existing) and T3 17mppa totalling. East includes retention of T3, extension of T2A and new satellites T2C and northern apron satellite. Baggage and passenger connectivity from T2A to T2C and T2A to northern satellite. No works to the Western campus. Eastern Maintenance Base consolidated as per Airports Commission scheme.

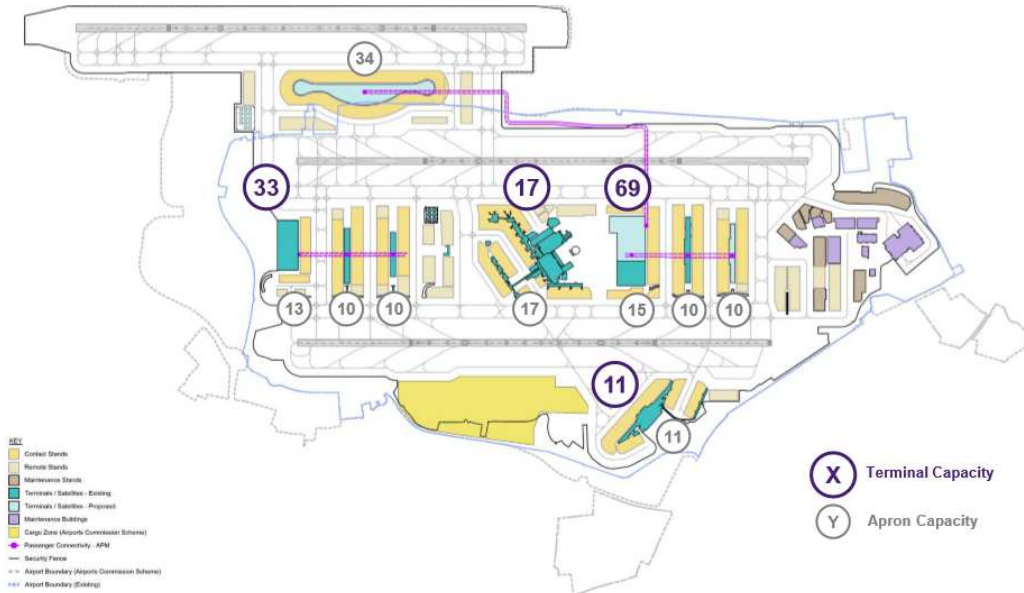


Figure 14. Challenger Option 9

• **Assembly 13 (Challenger)**

Eastern campus provides 33mppa, West 33mppa (as existing), T3 17mppa and Northern 36mppa totalling 119mppa. East includes retention of T3, extension of T2A and new satellites T2C. Baggage and passenger connectivity from T2A to T2C. New T6 in the north with connected pier and satellite. APM and baggage connection from T6 to satellite. Passenger shuttle connection to T2A. No works to the Western campus. Eastern Maintenance Base consolidated as per Airports Commission scheme.

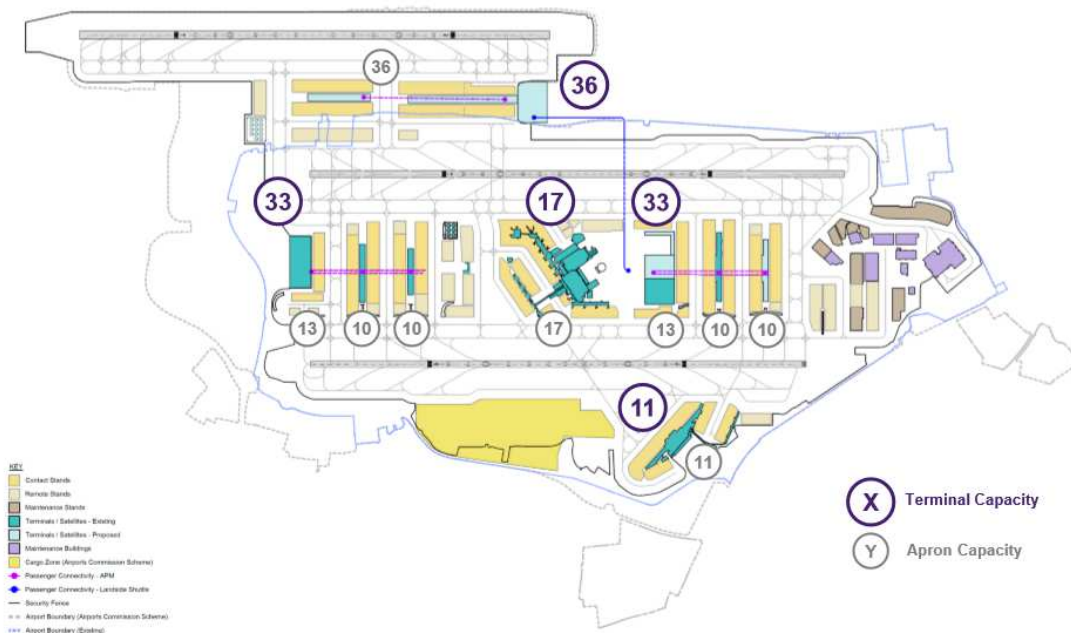


Figure 15. Challenger Option 13

- **Assembly 14 (Challenger)**

Eastern campus provides 33mppa, West 33mppa (as existing), T3 17mppa and Northern 36mppa totalling 119mppa. East includes retention of T3, extension of T2A and new satellites T2C. Baggage and passenger connectivity from T2A to T2C. New T6 in the north with two connected piers. Passenger shuttle connection to T5A. No works to the Western campus.

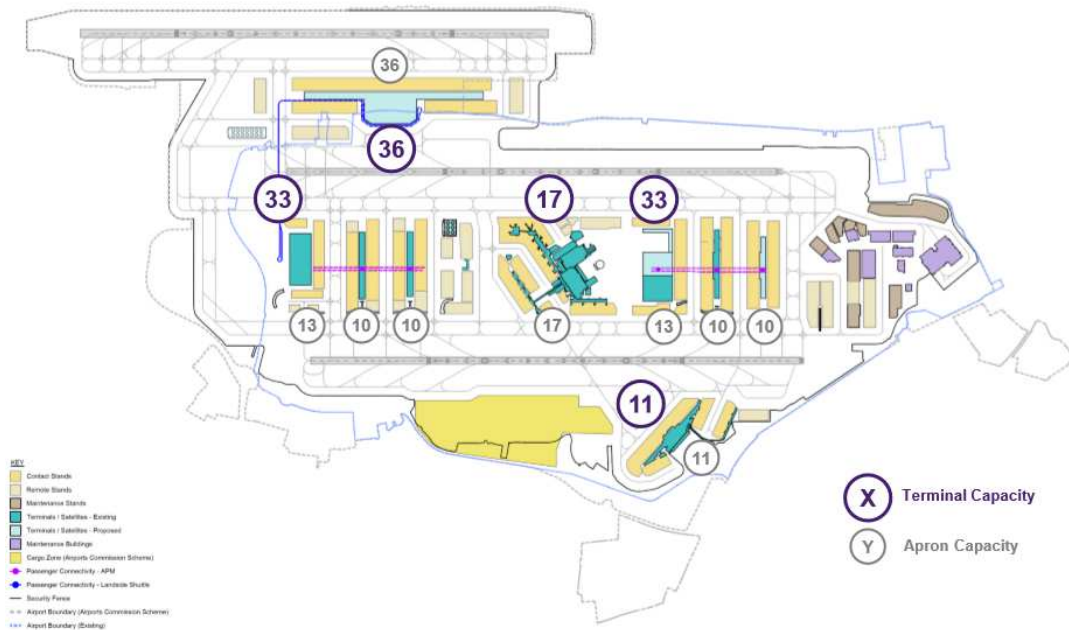


Figure 16. Challenger Option 14

## 8.3 Evaluation

Arcadis has provided commentary on HAL’s approach to the evaluation criteria below, together with a detailed review of the Business Case criteria. HAL’s approach was predicated upon design concepts produced ahead of Heathrow’s Consultation 1; Arcadis note that these concepts have subsequently evolved since the Green Review stage.

### 8.3.1 Operations & Service

For the Green Review, HAL undertook a qualitative assessment of the impacts of each option against:

- Airfield operations;
- Passenger experience;
- Hub connectivity;
- Baggage, and;
- Surface access.

Under each of the above they identified key notes, least preferred and most preferred options giving evidence of what has driven those findings.

BRAG ratings were then applied to the options.

### 8.3.2 Delivery

HAL noted that the delivery of the gateway element of certain options has not been assessed as their form is not sufficiently defined.

Arcadis believe that whilst this may be the case the delivery of the gateways is critical to those options and needs to be considered to ensure an equal evaluation across all options.

### 8.3.3 Sustainability & Community

The key objective for evaluation of this criteria is the impact on the natural environment. However, as most of the works will be carried out within the existing airport layout there are no show stoppers or significant differentiators at component level.

Evaluation has considered where taxiways are located nearer to the boundary and will therefore impact local residents.

No consideration on the impact of the Gateways has been considered and again Arcadis believe that to equally evaluate the options the impacts of the Gateways has to be taken into consideration.

### 8.3.4 Planning & Property

This section focuses on land take and the promotion of public transport. Again, further work is required to ensure those options with Gateways are equally evaluated.

### 8.3.5 Business Case

The business case is an evaluation of capital expenditure (capex) associated with each of the Terminals, Satellites and Aprons options.

We have undertaken a detailed review of HAL's approach to their assessment of capex below.

#### 8.3.5.1 Capital Expenditure (Capex)

HAL has assembled estimates utilising facility-level benchmarks. Each option has then been rated against the Purple Book. Arcadis believe that this approach is best practice at this stage of the project.

Each option's capex has been built up in the same format and the result can then be used to rank and rate options. However different options generate differing Gross Internal Floor Areas and hence different passenger capacity.

It should be noted that the capex review under the business case evaluation criteria has a Red / Amber / Green rating only, meaning that no options are discontinued (given a Black rating) due to capex results. Arcadis concur with this approach at this stage, as capex will become a defining factor in future evaluations.

In reviewing the capex, Arcadis has analysed and commented upon the following sections, highlighting any errors, differences or discrepancies as follows:

- **Scope**

HAL has scoped out each of the options however some of the scope required for certain options has not been captured within the estimate, namely:

- Some options include gateways which provide a full connectivity model and link to each of the decentralised satellites with stops in the landside terminal zones. The gateways will have processing facilities. There is a discrepancy between the documents as to which options have gateways. This needs to be clarified and then included in the estimates accordingly.
- Some options state that they require works to or relocation of the Eastern Maintenance Base, the extent of which needs clarification and the cost of these works has not been included within any estimate.

The cost of both the above items could be significant and would impact on the evaluation of these options. Arcadis recommend that these should be taken account of in the evaluation.

- **Quantities**

- HAL confirmed that areas have been provided by the designers and have been utilised by HAL within the estimates to price the terminals, satellites and stands.
- HAL confirmed that an analysis of existing T5 and T2 campuses was undertaken to establish m<sup>2</sup>/mppa for the expansion in these locations. The results are
  - Western campus expansion of [REDACTED] m<sup>2</sup>/mppa
  - Eastern campus expansion of [REDACTED] m<sup>2</sup>/mppa.
  - Satellites have been based on [REDACTED] m<sup>2</sup>/mppa.
- There is no provenance provided for the basis of the area for the satellites.
- Arcadis are unable to reconcile the areas between the different options.
- The Purple Book is based upon approximately [REDACTED] m<sup>2</sup>/mppa.
- Arcadis has carried out sense checks on various measures. Although most are accurate a few anomalies have been found which we suggest are revisited. For example, HAL should be asked to clarify if the area provided for Option 3Aii should include a separate item for Remote Aprons or if the 6,622m<sup>2</sup> is supposed to be included elsewhere. However, this total is included in the overall total GIFA of 667,000m<sup>2</sup> but there does not appear to be a separate cost included for this item.
  - Arcadis note that the stand area used within each of the estimates is 6,000m<sup>2</sup>, whereas the Purple Book benchmarks are based on 5,700m<sup>2</sup> and meetings with HAL in January 2018 have suggested a figure of 6,500m<sup>2</sup> as more appropriate. This variance in size may have implications for the number of stands and aircraft type which can fit within each option, therefore Arcadis suggest that this is revisited.
  - Arcadis has found arithmetical errors in the sanity check spreadsheet tab for option 11C, resulting in an overall error of minus £[REDACTED]m. Despite this, the correct total figure has been transferred into the summary tab for option 11C.
- The Design Team have not provided any evidence to support the m<sup>2</sup>/mppa. One of the reason for the differences in planned m<sup>2</sup>/mppa ([REDACTED] m<sup>2</sup> v [REDACTED] m<sup>2</sup>) between Western and Eastern campus is the size of planned satellites versus terminal head-house space. In this analysis T5 has greater satellite space over T2, which has greater terminal area. This therefore appears to dilute the Western campus area ratio. Whilst T5 appears to be very efficient this could represent too much of a stretch to be deliverable it may be prudent to apply a higher but also stretching target area.
- To, evaluate the capex HAL has applied benchmark rates against these areas and looked at the displaced facilities.
- Arcadis recommend revisiting the m<sup>2</sup>/mppa; the existing T2 does not have baggage facilities, which are currently in T1, and as such does not have a deep basement. Benchmarking the areas against the existing T2 therefore may not be comparable if a new baggage system is required as the implications are that area allowances may need to increase. Arcadis recommend that HAL undertakes additional external benchmarking drawing from international projects as well as domestic.
- Arcadis recommends a review of the terminal / satellite areas to ensure that they are comparable and that the evaluation is being undertaken on a like for like basis.
- Arcadis recommends that a sense check be undertaken between the number of contact stands and the available terminal / satellite frontage.

- **Rates**

- Rates, mostly abstracted from the Purple Book, have been used by HAL to establish the different estimates.
- HAL have used the following rates:
  - T2 Extension                   £[REDACTED] m<sup>2</sup>
  - T2 Satellites                   £[REDACTED] m<sup>2</sup>

- T5 Extension                    £ [REDACTED] m<sup>2</sup>
  - T5 Satellites                    £ [REDACTED] m<sup>2</sup>
  - T6 Terminal                    £ [REDACTED] m<sup>2</sup>
  - Apron North Satellite        £ [REDACTED] m<sup>2</sup>
- The Purple Book uses the above rates however they apply different rates for the substructure. Arcadis would recommend that HAL align their approach or adjust the rates in the options evaluation to reflect substructure and superstructure.
  - The rate in the recent T2A Final Account information provided by HAL is [REDACTED] m<sup>2</sup> which is the overall net construction cost at 3Q14. This figure is split £ [REDACTED] m<sup>2</sup> for substructure and [REDACTED] m<sup>2</sup> for superstructure.
  - The rates utilised have been based upon T2 and T5 final accounts and when Arcadis questioned HAL regarding the differences they were advised that there were two contributing factors; different market conditions at the time of tendering; T5 mainly unconstrained landside site whilst T2 is constrained and airside.
  - Terminal 5 extensions have been priced according to the T5 final account and the same for T2. T5 is a different type of building to T2A with different m<sup>2</sup>/mppa and different basement and baggage provisions.
  - The same Satellite rate of [REDACTED] m<sup>2</sup> has been used for both the Eastern and Western campus.
  - HAL has not employed different costs for above and below ground satellite structures or indeed a more complex H-style satellite. Arcadis believe that these rates should be refined further in future iterations of each estimate to ensure cost efficiency.
  - Arcadis have queried with HAL whether the removal and rebuilding of the north end curtain wall glazing of T2A to enable T2X to be built has been included within the overall metre square rates.
  - Arcadis note that option 3Ai has used what appears to be an incorrect rate of [REDACTED] m<sup>2</sup> for the Terminal 2 satellites item rather than the [REDACTED] m<sup>2</sup> rate as shown elsewhere. Correcting this increases the base construction cost by approximately [REDACTED] m resulting in an additional [REDACTED] m gross capex cost.
  - Arcadis has requested HAL demonstrate the basis of cost and benchmark data behind the allowance of £ [REDACTED] m for the demolition of Terminal 3 and £ [REDACTED] m for the demolition of Terminal 3 and the Sofitel hotel.
  - HAL has undertaken a subjective evaluation of the baggage and APM based upon a high level overview of the extent of the facility required compared to the Purple Book. This has been expressed as a percentage difference with the Purple Book being [REDACTED] %.
- **Add-Ons**
- HAL has applied identical allowances for surveying and monitoring of £6m across each of the estimates, and the same percentage across all options for preliminaries ([REDACTED] %), OH&P ([REDACTED] %), design ([REDACTED] %) and leadership and logistics ([REDACTED] %).
  - The design fees of [REDACTED] are the same as for civils works within the M25 and Local Roads Key Components, however for the construction of terminal buildings a higher design fee may be expected. Arcadis consider that this should be reviewed.
  - HAL has allowed an additional [REDACTED] % percentage on top of the total base construction costs for project specifics, designed to encompass phasing, night work and operational disruption. This does not align with the Purple Book.
  - Arcadis recommend that the allowance for phasing reflects the option components as the requirements could be very different depending on the extent of extensions and working within the existing airport boundary compared to work within the new Northern apron.

- **Risk**

- Arcadis note that HAL has not included any allowance for risk within the cost estimates. As this is an optioneering exercise as long as this is consistent across the options and compared to the Purple Book exclusive of risk this approach is reasonable. Although it should be noted that due to the percentage uplift for risk, for options which have a higher capex than the Purple Book this increase would be compounded.
- Arcadis believe that a risk register should be generated for future iterations of the capex plan to encompass option-specific risks. For instance, the Challenger options which rely upon the expansion and reutilisation of existing buildings may require a higher risk allowance due to existing structure risk.

### 8.3.6 Arcadis RAG Evaluation

Arcadis has not currently undertaken their own RAG evaluation. There are currently a number of outstanding queries which we are awaiting HAL's response on and we would like to discuss further with HAL the method of building up the estimates prior to undertaking our own analysis.

### 8.3.7 HAL BRAG Summary

HAL's BRAG Summary is:

Terminals, Satellites & Aprons – HAL BRAG Summary									
Option	3ai	3aii	11c	4a	12a	15b	9	13	14
<b>1 Operations</b>									
Airfield	Green	Yellow	Red	Green	Green	Yellow	*1	*1	Yellow
Pax Experience	Yellow	Green	Yellow	Yellow	Red	Yellow	Red	Red	Red
Hub	Red	Yellow	Yellow	Yellow	*2	Green	*2	*2	Red
Baggage	Yellow	Green	Red	Yellow	Red	Yellow	Yellow	Yellow	Yellow
Surface Access	Green	Green	Green	Green	Green	Green	Yellow	Red	Yellow
<b>2 Business Case</b>									
Capex (£bn)	Yellow	Black	Yellow	Black	Red	Black	Red	Black	Green
Revenue	Yellow	Green	Red	Green	Green	Yellow	Red	Red	Red
<b>3 Delivery</b>	Green	Yellow	Red	Green	Red	Red	Yellow	Yellow	Green
<b>4 Sustainability</b>	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Red	Yellow
<b>5 Planning</b>	Yellow	Yellow	Green	Yellow	Yellow	Yellow	Green	Yellow	Yellow
<b>BRAG SUMMARY</b>	Green	Green	Red	Yellow	Black	Green	Black	Black	Yellow

Table 35. HAL BRAG Summary – Terminals, Satellites & Aprons

\*1 - Lack of airfield resilience

\*2 - Insufficient capacity in the west

### 8.3.8 HAL's Summary of the options

The proposed options were evaluated by HAL using a RAG (Red, Amber, Green status) as follows:

Terminals, Satellites & Aprons Capex Summary					
Option & RAG Status	GIFA '000m <sup>2</sup>	Cost £m	APM (% uplift from 0.61)	Baggage (% uplift from 0.61)	Comments
3Ai	599				Updated AC scheme. Loss of T3 driving additional GIFA in T2 (+ Satellites) – APM requirement broadly comparable with AC scheme, no impact to Eastern Maintenance Base.
3Aii	667				Larger T6 and additional stand infrastructure compared to 3Ai – opportunity for reduction in TTS, however introduction of H's into Eastern Campus (T2D and E) and remote stands East of T2C would have additional complexity and costs (T2C demolition / re-provision of Eastern Maintenance Base – priced elsewhere).
4A	758				Loss of T4 creating requirement for additional GIFA to be created (150,000m <sup>2</sup> above 3Ai. This along with additional stand frontage is driving cost. Would also require works in Eastern Maintenance Base, priced elsewhere).
9	438				Retention of T3 and T4 keeping cost down as less GIFA required. Impact of additional repex to support aging T3 / T4 infrastructure to be assessed in future.
11C	612				Loss of T3 driving additional GIFA requirement albeit in a different location to 3Ai, which means there is less APM distance required. Between the existing runways would require even more work of the Eastern Maintenance Base (uncosted as considered elsewhere albeit would be significant).
12A	694				Focus on T2 campus meaning that Northern Terminal / Satellite would require a longer, more complex APM / Baggage connectivity solution. T3 and T4 loss create the need for additional GIFA across the new build infrastructure. Connecting the Northern Apron to T2 requires new Satellites to the West of T5 to be connected to the Western Campus (T5) increasing APM / Baggage further. Eastern Maintenance Base would be unaffected.
13	360				Retention of T3 and T4 keeping cost down as less GIFA required. Impact of additional repex to support ageing T3 / T4 infrastructure to be assessed in future. No APM from West to North and simple landside connectivity.
14	360				Retention of T3 and T4 keeping cost down as less GIFA required. Impact of additional repex to support ageing T3 / T4 infrastructure to be assessed in future. No APM from West to North and simple landside connectivity. Additionally there is not APM in the Northern Satellite.
15B	706				Replacement of T3 with significant increase to Western Apron. T Bar and H Satellites in East and Western Campus' / Second largest incremental GIFA with longer APM. Eastern Maintenance Base relocation is significant (but not priced, as considered elsewhere).

Table 36. HAL Capex Summary Table

APM costs are summarised as a percentage uplift from the Purple Book differentiated by the number of stations, line distance and connectivity. They are inclusive of cut and carve tunnels, line equipment and rolling stock which are not sufficiently understood at this stage to be priced independently.

For these APM percentages there are calculations and measures to back them up. Arcadis believe that this should be the same for the Baggage percentage adjustments, but these are currently shown as plus or minus percentages for each option in the summary with no calculations shown.

## 8.4 Key Findings

Arcadis' key findings include:

- Arcadis note that a Design Evaluation Report (DER) was not undertaken for this Key Component.
- GIFA needs to be reviewed and substantiated by the design team for both terminals and satellites. These also need to be benchmarked.
- Arcadis would expect to see benchmark rates being reviewed from projects other than Heathrow this will then act as a catalyst to challenge the efficiency of previous HAL projects.
- Arcadis recommend the scope requirements for all options is reviewed and fully captured, eg Gateways and Eastern Maintenance Base.
- Arcadis consider that HAL should review the pricing of the substructure of the terminals and the sunken H Satellites is revisited and aligned with the Purple Book.
- HAL has not considered replacement expenditure (repex) as part of the Challenger options. The heavy maintenance costs for ageing assets such as the Terminals 3 and 4 have not been included within the estimates.

## 8.5 Next Steps

Next steps include:

- Arcadis consider that there are significant value engineering opportunities which HAL can progress as the number of options are reduced.
- Clarify the role and impact of gateways onto master plan assemblies.
- Clarify the impact of works to the Eastern Maintenance Base.
- Undertake a more in-depth review of APM and baggage.
- Reviews following HAL's further benchmarking analysis on GIFA's and rates.
- Revisit estimates to ensure scope alignment.



## 9 Review of IFS Reports

### 9.1 Introduction

HAL and the Heathrow Airline Community commissioned Gardiner & Theobald as an Independent Fund Surveyor (IFS) to analyse HAL's findings against the Key Components and provide an independent estimate review for each.

The IFS has produced individual reports against each of the Key Components as listed below:

IFS Key Component Reports			
	Key Component	Date Issued to HAL	Date Issued to Arcadis
1	Runway & Taxiways	27 September 2017	08 December 2017
2	M25 & Junctions	20 December 2017	15 January 2018
3	Local Roads	13 December 2017	15 January 2018
4	Rivers & Flood Storage	16 January 2018	01 February 2018
5	Terminals, Satellites & Aprons	08 January 2018	15 January 2018

Table 37. IFS Key Component Independent Estimate Reviews

The IFS has reviewed the estimates against the HAL original identifying all developments and ultimately comparing their views across the range of cost categories including:

- Direct Construction Costs
- Preliminaries
- Project Specifics
- Design Fees
- Leadership & Logistics
- Risk Contingency

Other costs such as land purchase are included within the estimates but have not been included within the IFS review as it is not within their remit to advise.

Arcadis has conducted a high level appraisal of these reports contained within the following sections, including comments upon any findings captured by both the IFS and Arcadis and highlighting any potential issues.

### 9.2 Runways & Taxiways

In the case of the Runways and Taxiways scope, the IFS were required to review two key options under Family A and Family B which represent a more westerly and a more easterly runway location respectively. The key differentiator between these options is the bridging of the M25 versus the M4 Spur.

The IFS report (27 September 2017) sets out their findings regarding the capex estimates and the differences between the two options. Their key observations are as follows:

- Following initial IFS feedback and presentation to the Options Steering Group, HAL commissioned a further study into key construction elements include the earthworks design for each option and the bridge structure for the M25.
- A number of meetings occurred between HAL and the IFS to discuss both parties differing views on the rates utilised in the estimates. These meetings were constructive and resulted in movement in both parties' views producing a more robust estimate.
- The base construction costs were resolved to within 10% for the M4 scheme and 14% for the M25 scheme. In both cases, this range is considered reasonable.
- The more significant differences in view between the HAL and IFS teams lay in the risk contingency provision and Project Specific costs, also highlighted by Arcadis.

### 9.3 M25 & Junctions

The IFS report (20 December 2017) compares capex estimates undertaken by HAL for each of the seven component options for realignment of the M25 and eight options covering reconfiguration of Junction 14.

Their key observations are as follows:

- The IFS raised a number of inconsistencies in the scope, quantification and rates across the initial option estimates. These have been largely addressed by HAL in subsequent discussions and iterations of the estimates.
- Out of the eight component options identified for the M25 alignment, the IFS considers that only two are sufficiently detailed for meaningful estimate comparison. The remaining options have been calculated on a pro-rata basis of their respective carriageway lengths.
- IFS found that the Green Review component options for the M25 junctions ranged from £■■■■ to ■■■■m.
- IFS found that three out of the eight M25 junction options were within the Purple Book estimate for ■■■■m, with junction options JC1 and JC5 highest ranked in respect of the business case. Five of the remaining options were over ■■■■ higher than the Purple Book estimate comparison value.
- The two Green Review component options reviewed for the M25 Alignment were evaluated at ■■■■m and £■■■■m respectively.
- Alignment option AB1 was lower than the Purple Book estimate comparative value of £■■■■m and option AB2 was within ■■■■ over this value.
- IFS view on Project Specifics costs is expressed in terms of an identical percentage allowance for each option; their view is that these costs are higher than those proposed by HAL. This has also been noted by Arcadis.
- IFS view on Preliminaries is expressed in terms of a percentage in line with their recommendation at Purple Book level. They support the creation of a target reduction based on specific opportunities across the expansion programme.
- The IFS consider that the risk position warrants further debate.

### 9.4 Local Roads

The IFS report (13 December 2017) into the Local Roads comments upon five options for the A4 and six for the A3044, setting out their observations regarding the capex estimates and on the differences between the options for each element.

Their key observations are as follows:

- The IFS has noted that it has not been possible to check any measurements in detail due to a lack of design information, with quantities remaining unsubstantiated and unverified at this stage.
- A review was conducted for rate uniformity across components to align with the M25 and Junctions estimates.
- Base Construction costs are assessed to within ■■■■% tolerance between the independently derived estimates (IFS & HAL). This concurs with the Arcadis view.
- The RAG ranking for capex options is retained for the A4 and similar for the A3044. This concurs with Arcadis view.
- IFS have provided benchmark data of the base construction costs for A-road upgrade schemes.
- IFS indicate that the A4 and A3044 options show interdependences and creates a limitation on the options available. Arcadis concur with this assessment on the basis of review of the routes but have not seen a definitive compatibility matrix.
- IFS view on Project Specifics costs is expressed in terms of an identical percentage allowance for each option; their view is that these costs are higher than those proposed by HAL. Arcadis would expect to see the phasing reviewed and dependent upon construction complexity, different percentages potentially being applied against each option.

- HAL has not included allowance for traffic management, phasing and some temporary works, utility diversion, environmental mitigation works, and both the IFS and Arcadis consider that allowance should be made given that these elements of the work will be subject to operational constraints in the control of others outside the airfield.
- IFS view on Preliminaries is expressed in terms of a percentage in line with their recommendation at Purple Book level. They support the creation of a target reduction based on specific opportunities across the expansion programme.
- The IFS consider that the risk position warrants further debate.

## 9.5 Rivers & Flood Storage

The IFS report (16 January 2018) into Rivers (Conveyancing) and Flood Storage sets out their observations regarding the total capital cost estimates and the differences between the options for each element. Their key observations include:

- IFS review has highlighted that further detailed design and scope definition are required to secure a robust output for this stage. HAL recommendation at Green Review is to retain all identified options for consideration in Masterplan assemblies.
- Base construction costs do not include any Flood Storage scope or costs.
- A comparison between the independently derived estimates (IFS and HAL) indicates significant differences.
- Further work is required to provide reliable data to support the selection of a preferred option.
- Within the HAL figures, there is considerable potential to reduce costs – particularly in respect of the estimate for the covered culvert structure.
- The influence of the Environment Agency is key and therefore more design and price certainty is needed before these options are refined / narrowed down.
- An allowance has been added to the estimates for project specifics costs.
- The IFS view on Preliminaries is expressed in terms of a percentage in line with the previous recommendation at Purple Book level. The establishment of a reduced target figure is supported based on specific opportunities across the expansion programme.
- The IFS view on risk is expressed for this individual masterplan component based on HM Treasury Green Book. The risk position warrants further debate.

## 9.6 Terminals, Satellites & Aprons

The IFS report (08 January 2018) into the Terminals, Satellites and Aprons sets out their observations regarding the order of magnitude costings undertaken by HAL associated with the component Assemblies Summary.

Their key observations are as follows:

- The IFS reviewed each of various component option estimates for the Terminals, Satellites and Aprons designed to provide capacity of 130mppa through nine different configurations;
  - Six main options provide new terminal / satellite space at T2 and T5/T6. Of these 4 options retain T4
  - Three 'Challenger' options retain T3 and T4.
- These options exclude interfaces with related infrastructure such as baggage handling, track transit systems, or the impact that will have on the Eastern Maintenance Base (EMB). These are not captured within the cost estimate but baggage and TTS are mentioned in terms of relativity between options.
- Following meetings between the IFS and HAL in late November / early December 2017 to discuss the estimates, the IFS note that HAL has not updated the estimates in respect of any of the IFS queries and observations.

- The IFS comment that a key driver of the entire scheme is the Terminals, Satellites & Apron component, at approximately █% of the total base construction cost.

## 9.7 Summary

The reports overall are concise high-level cost review documents. A number of key findings are repeated across the IFS reports:

- IFS view on Project Specifics costs is expressed in terms of a percentage allowance. Generally, their view is that these costs are higher than proposed by HAL.
- IFS view on Preliminaries is expressed in terms of a percentage. They support the creation of a target reduction based on specific opportunities across the expansion programme.
- IFS view on risk is that it warrants further debate, suggesting significantly higher than HAL's █%; more like █ .
- The IFS also note that at this stage there is a high level of exposure in respect of the quantification of the various options across the Key Components, due to the low maturity of the design information received.
- The IFS recommend that regular comparison of the Purple Book estimate is undertaken to allow the direct and progressive review of affordability of the various component options. In addition, it may be beneficial to review the risk position on completion of each Green Review to ensure that the overall contingency provision remains appropriate to design development maturity.

## 10 Conclusion & Recommendations

### 10.1 Conclusion

The Key Component Review has been worthwhile in securing a robust output for this stage and broadly supports the HAL Green Review recommendations for retention of options to be considered in Masterplan Assembly, and indirectly validates the IFS findings. Arcadis' findings common to all Key Components include:

- The current design for each of the options within all of the Key Components is at a very high level, making capex assessment challenging. Nevertheless, Arcadis consider that HAL's approach to the pricing of early stage design for the construction elements is generally in line with industry standards.
- The majority of the Add-On percentages used by HAL are in line with industry standards apart from allowances for project specifics which appear to be insufficient. Arcadis consider that each option should be considered independently, and the lump sum amounts, or percentages applied for Project Specifics adjusted to reflect delivery challenges specific to each option.
- There is an inconsistent approach to risk in the different component reviews. Arcadis would like the opportunity of interrogating HAL's risk approach further to ensure a consistent approach in the options evaluation and the implementation of a robust Risk Management process when the review of the preferred Masterplan option is evaluated.
- All HAL estimates are at 3Q14 prices to enable direct comparison to the Airports Commission report. Arcadis consider that inflation both to current prices (with particular attention to the costs of property and land take), and over the course of the scheme should be carefully considered at the next stage of the review.
- There is no Black RAG status for capex, and although some options within each of the Key Components score poorly against environmental and operational criteria, none have been discontinued at this stage due to capital cost exceeding the Purple Book baseline.
- While HAL has generally followed reasonable procedures, they have not necessarily always implemented the procedures correctly resulting in options within components not being fully aligned. Notwithstanding this, any discrepancies which result are on the whole relatively minor and have had minimal impact upon the capex RAG status ranking.
- Arcadis believes that there are significant value engineering opportunities which should be progressed as the designs evolve.

Findings particular to each component include:

#### Runway:

- In terms of overall RAG status against the AC scheme, on a capex basis Arcadis has rated the options in line with HAL's findings while moving the two Family B options from Green to Amber status.
- The cost variation between schemes for runway pavement is minimal when compared to the property costs and motorway crossings and is therefore not considered to be a major differentiator.
- Benchmark data has been used by HAL to develop the estimates. We suggest that the runway rate is reviewed as HAL has utilised a rate of █████ m<sup>2</sup> for runway construction while Arcadis benchmarks suggest a rate of £340/m<sup>2</sup> for the runway is more appropriate. Further benchmark comparisons can be used to challenge the cost efficiency of each option.

#### M25 & Junctions:

- Benchmark data taken from a number of sources has been used by HAL to develop the estimates to promote the cost efficiency of the options. These figures are within tolerance of Arcadis benchmark data for comparable items.
- In terms of overall RAG status against the Airports Commission scheme, on a capex basis Arcadis has rated all of the options in line with HAL.
- No junction options have been discontinued against any of the evaluation criteria. However, alignment options AC1 and AC3 have been recommended for discontinuation by HAL based on the impacts to local communities and the environment. Both of the Family AA alignment options have enormous

delivery implications. Option AA0 requires raising of the runway by 5m, leading to severe programme and operational constraints (inoperable linking taxiway gradient), while the temporary works required to deliver AA1 are considered to be infeasible.

- Family AB, utilising offline construction involving local realignment of the M25 between J15 and J14a is lower in cost and risk and has relative ease of constriction when compared to both Family AA and Family AC.

#### Local Roads:

- Benchmark data taken from a number of sources has been used by HAL to develop the estimates to ensure cost efficiency of the options. These figures are within tolerance of Arcadis benchmark data for comparable items.
- Arcadis suggest that a more robust peer review process is employed to ensure calculation errors (such as that highlighted by options 3d, 2ai, 2bi and 3g of the A3044 Family whereby linear meterage was confused with area) are eliminated insofar as possible from future iterations of these estimates.
- In terms of overall RAG status against the AC scheme, on a capex basis Arcadis has rated the options largely in line with HAL's findings.

#### Rivers & Flood Storage:

- Arcadis would expect to see assessments of the cost of land acquisition. We would also expect to see benchmarks being reviewed from projects other than Heathrow ones, this will then act to challenge the cost efficiency of previous HAL projects.
- Whilst HAL's capex has rated two options above the AC's scheme and three below, Arcadis has rated all of them below. This is mainly due to the concerns that Arcadis has regarding the benchmark rate that HAL has utilised for the culverts. HAL could potentially discontinue options which have more culverts, whereas from a capex evaluation perspective, Arcadis do not believe that these should be discontinued at this stage.
- For the flood storage, no capex evaluation has been undertaken and the property loss has been evaluated subjectively rather than quantitatively. Arcadis do not concur with this approach and believe a quantitative assessment of capex should be undertaken.

#### Terminals, Satellites & Aprons:

- Arcadis consider that HAL should review the pricing information regarding the sunken H Satellites as only an average rate for satellites has been used within the estimates. Therefore for example the costs used for option 15B are unlikely to be reflective of the overall costs for a sunken satellite.
- Arcadis note that a Design Evaluation Report (DER) was not undertaken for this component.
- We would also expect to see benchmarks being reviewed from projects other than Heathrow Terminal 2 and Terminal 5; this will then act as a catalyst to challenge the cost efficiency of previous HAL projects.
- HAL has not considered replacement expenditure (repex) as part of the Challenger options. The heavy maintenance costs for aging assets such as the old Terminals 3 and 4 have not been included within the estimates and neither have costs for the Eastern Maintenance Base presuming that they have all been considered in other components.

## 10.2 Recommendations for HAL

Arcadis consider that there are significant value engineering opportunities which can be progressed as each option design evolves and masterplan assembly commences. As detailed in our report, some of our recommendations for HAL specific to each component include:

#### Runway:

- Refine the options and undertake more detailed assessments to optimise runway length in order to minimise property loss and environmental impact.

### M25 & Junctions / Local Roads:

Both the M25 Alignment & Junctions and the Local Roads Key Components have significant interdependencies and commonalities and can therefore be considered together:

- Undertake an assessment of each option in greater detail in order to refine and optimise routes (i.e. by aligning new roads adjacent to existing), minimising property loss and environmental impact.
- Evaluate options with localised traffic modelling to increase understanding of operational performance and traffic distribution; key issues for community connectivity, local noise and air quality assessment
- Assess potential congestion and diversionary impacts during construction. Arcadis consider that these should be looked at in a thorough deliverability and phasing exercise.
- Consider ground water levels as these have not been studied at the current stage of the design process. Significant dewatering may be required and should be further investigated.
- Liaise with the Rivers & Flood Storage Key Component to ensure that conveyancing and water storage requirements are achieved across the surface access options. Many of these highway options interface with historic landfill sites and existing water courses, and need to be managed appropriately as the design progresses.

### Rivers & Flood Storage:

- Develop combined component options that match storage areas to conveyancing, informed by the evaluation undertaken during the Green Review.
- Undertake more detailed assessments of each option in order to optimise locations / boundaries and minimise property loss / land take and environmental impact.

### Terminals, Satellites & Aprons

- Validate the GIFA's for terminals and satellites.
- Undertake further benchmark analysis and align approach regarding substructure and superstructure benchmarking.

## 11 Appendices

### 11.1 Appendix A - Documents Requested and Reviewed

A summary of data requested from HAL is provided below.

Information Received / Requested	Date Requested	Date Received	Level of Review
<b>Miscellaneous</b>			
Arcadis Briefing Meeting 24.11.17	30/11/17	01/12/17	Detailed
<b>Runway</b>			
<b>01 Design Information</b>			
HEP TO 2.1 Runways and Taxiways Evaluation Briefing 06_04_2017 (PDF)	30/11/17	11/12/17	Detailed
<b>02 Capex Cost Plan</b>			
Runway Options – Costs v1.3 (XLS)	30/11/17	07/12/17	High Level
Runway Options – Costs v1.7 030817_KP JH response (002) (003) (XLS)	30/11/17	11/12/17	Detailed
Runway Options – Costs v1.8 (aligns to Green Day 9 June 2017) (XLS)	30/11/17	08/12/17	Detailed
Runway Options – for issue to IFS 08062017 (XLS)	30/11/17	08/12/17	Detailed
<b>03 Evaluation Output</b>			
TO 2.1 Runways – Family A v B Analysis at 3200 and 3500 – As Presented to OSG 20170609 (PDF)	30/11/17	07/12/17	Detailed
TO 2.1 Runways – Family A v B Analysis at 3200 and 3500 – As Presented to OSG 20170609 (PPT)	30/11/17	07/12/17	High Level
TO 2.1 Runways Green Day – 11 May 2017 – FINAL (PDF)	30/11/17	11/12/17	Detailed
<b>04 IFS Report &amp; Documents</b>			
TBA HEP IFS Report Runways Taxiway Green Review (PDF)	30/11/17	08/12/17	Detailed
<b>M25 &amp; Junctions</b>			
<b>01 Design Information</b>			
5153556-SK-AA1 Alignment (PDF)	-	24/10/17	High Level
5153556-SK-AB1 Alignment (PDF)	-	24/10/17	High Level
5153556-SK-AB2 Alignment (PDF)	-	24/10/17	High Level
5153556-SK-AC1 Alignment (PDF)	-	24/10/17	High Level
5153556-SK-AC2 Alignment (PDF)	-	24/10/17	High Level
5153556-SK-AC3 Alignment (PDF)	-	24/10/17	High Level
Options AA1 Alignment (PDF)	-	24/10/17	High Level
Options AB1 Alignment (PDF)	-	24/10/17	High Level
Options AB2 Alignment (PDF)	-	24/10/17	High Level
Options AC1 Alignment (PDF)	-	24/10/17	High Level
Options AC2 Alignment (PDF)	-	24/10/17	High Level
Options AC3 Alignment (PDF)	-	24/10/17	High Level
5153556-SK-JB1 Junction (PDF)	-	24/10/17	High Level
5153556-SK-JC1 Junction (PDF)	-	24/10/17	High Level
5153556-SK-JC2 Junction (PDF)	-	24/10/17	High Level
5153556-SK-JC3 Junction (PDF)	-	24/10/17	High Level

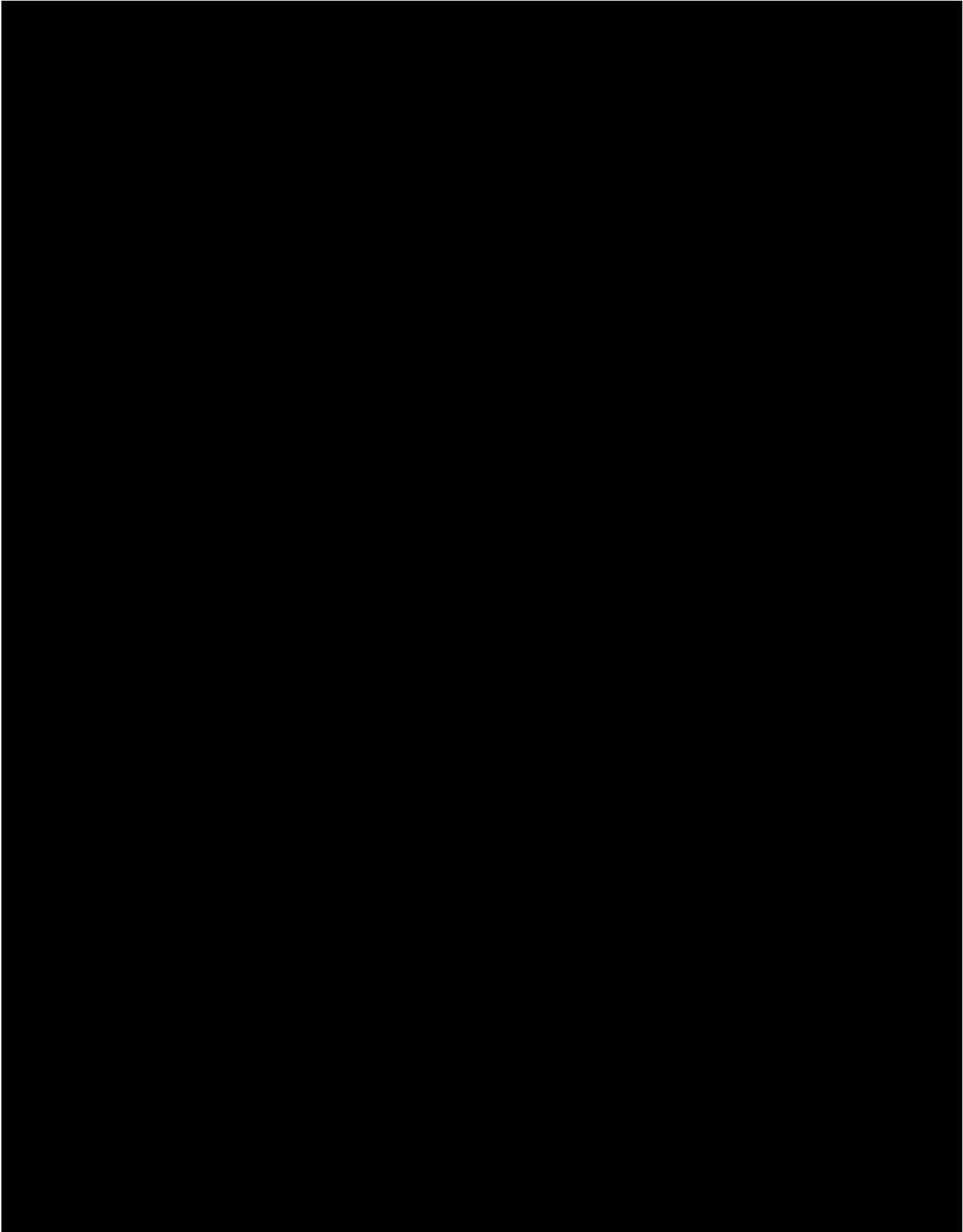


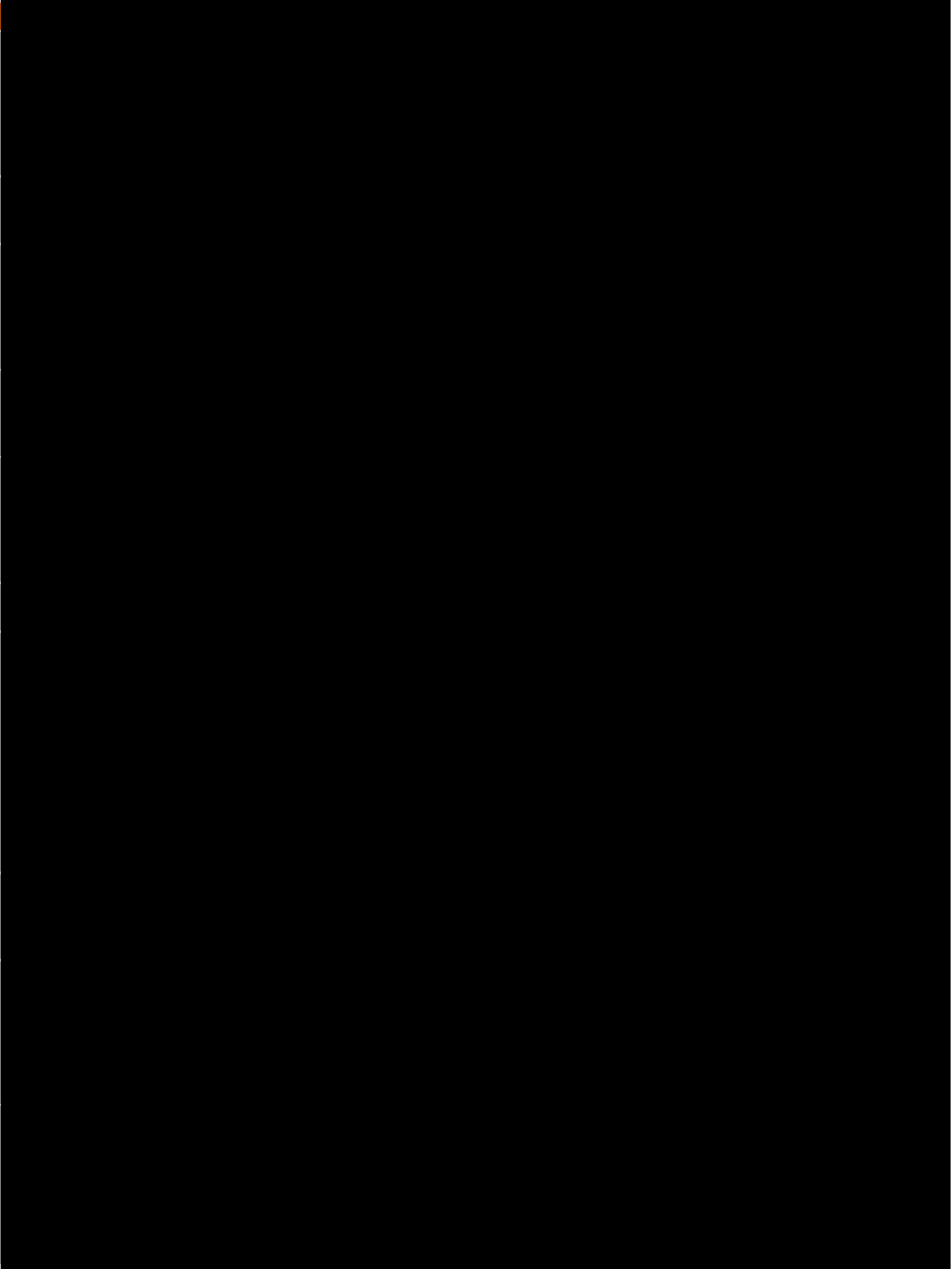
Information Received / Requested	Date Requested	Date Received	Level of Review
5153556-SK-JC4 Junction (PDF)	-	24/10/17	High Level
5153556-SK-JD3 Junction (PDF)	-	24/10/17	High Level
5153556-SK-JD4 Junction (PDF)	-	24/10/17	High Level
Heathrow Expansion Programme – June 2017 – Horizontal Alignment Construction Issues (PPT)	-	24/10/17	Detailed
Heathrow Expansion Programme - June Update – Assumptions (PPT)	-	24/10/17	Detailed
Heathrow Expansion Programme – Supp Info 1 June 22 (PPT)	24/11/17	24/11/17	Detailed
TO 4.2 Evaluation – June Refresh – Evaluator Briefing Overview & Summary (PPT)	-	24/10/17	Detailed
2017-09-29 Appendix A TO 4.6 - 2nd DER Green Review M25 and junctions (PDF)	-	24/10/17	Detailed
M25 Alignments - Google Earth Pro (KMZ)	04/12/17	06/12/17	Detailed
M25 Junctions - Google Earth Pro (KMZ)	04/12/17	06/12/17	Detailed
<b>02 Capex Cost Plan</b>			
HEP M25 – Alignment 2 <sup>nd</sup> Eval. Jun-17 v2 (IFS post-review HAL position) (XLS)	30/11/17	30/11/17	Detailed
HEP M25 – Alignment 2 <sup>nd</sup> Eval. Jun-17 v2 (IFS submission) (XLS)	30/11/17	30/11/17	High Level
HEP M25 – Junctions 2 <sup>nd</sup> Eval. Jun-17 (IFS post-review HAL position) (XLS)	30/11/17	30/11/17	High Level
HEP M25 – Junctions 2 <sup>nd</sup> Eval. Jun-17 (IFS submission) (XLS)	30/11/17	30/11/17	High Level
07062017_HAL_3R_M25_Options_PCE_v5 (XLS)	30/11/17	30/11/17	Detailed
<b>03 Evaluation Output</b>			
TO 4.2 M25 & Junctions Component Options Evaluation Business Summary for Green Review (PDF)	-	24/10/17	Detailed
<b>04 IFS Report &amp; Documents</b>			
Junction JB1 Sketch (PDF)	-	24/10/17	High Level
IFS Green Review Report M25_15.11.17 (PDF)	30/11/17	15/01/18	Detailed
HEP M25 – Junctions 2 <sup>nd</sup> Eval. Jun-17 (IFS)_KP Rev A (XLS)	-	24/10/17	Detailed
M25 Junction Options_KP (XLS)	-	24/10/17	High Level
<b>Local Roads</b>			
<b>01 Design Information</b>			
A3044_2ai Dual (PDF)	-	24/10/17	High Level
A3044_2bi Dual (PDF)	-	24/10/17	High Level
A3044_3g Dual (PDF)	-	24/10/17	High Level
A3044_Option_2a_D (PDF)	-	24/10/17	High Level
A3044_Option_2b_D (PDF)	-	24/10/17	High Level
A3044_Option_3d_D (PDF)	-	24/10/17	High Level
A4_2E Dual (PDF)	-	24/10/17	High Level
A4_6C Dual (PDF)	-	24/10/17	High Level
A4_Option_1a_D (PDF)	-	24/10/17	High Level
A4_Option_3a_D (PDF)	-	24/10/17	High Level

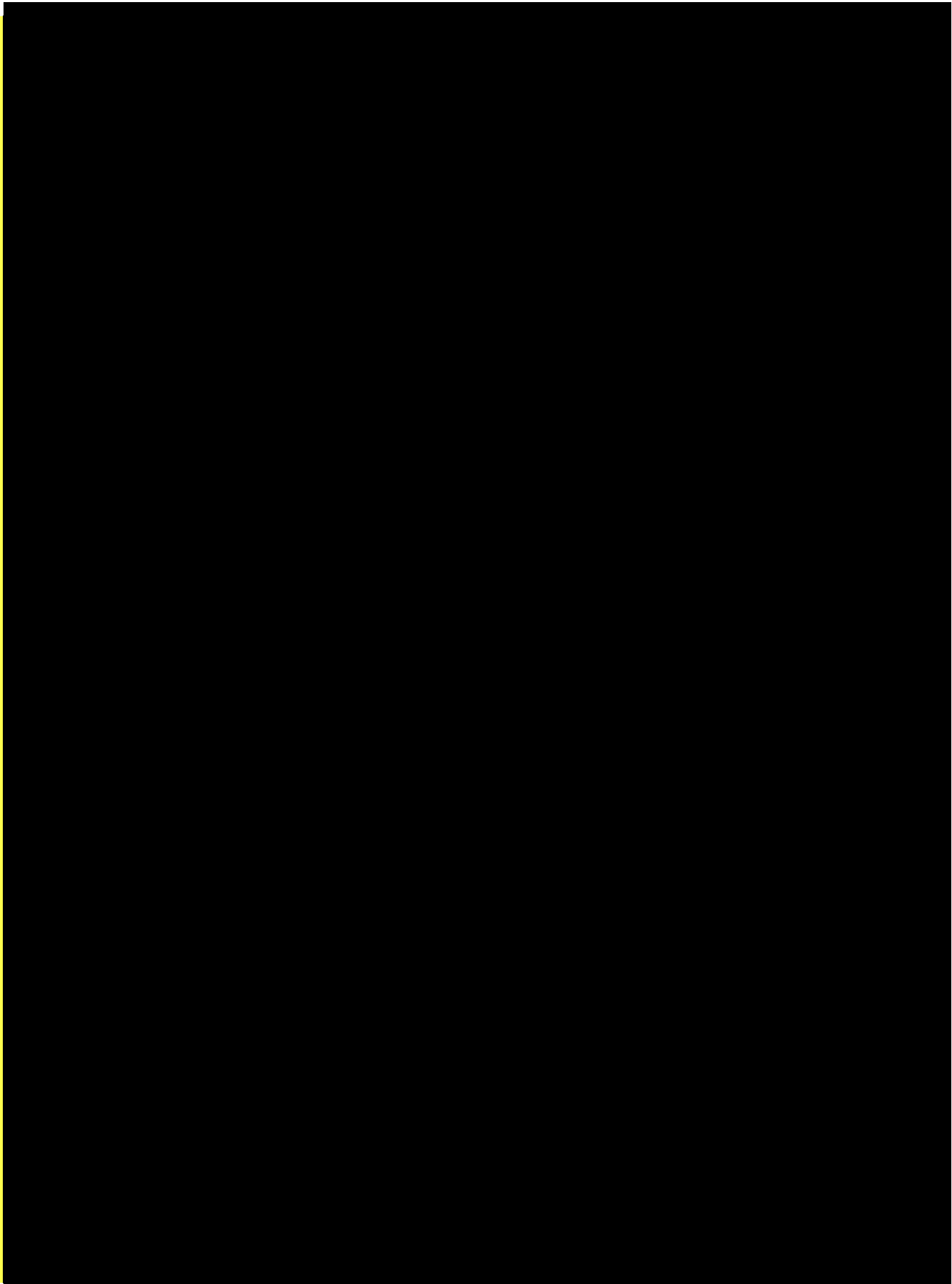
Information Received / Requested	Date Requested	Date Received	Level of Review
2017-09-29 Appendix B TO 4.6 - 2nd DER Green Review for Local Roads (PDF)	30/11/17	30/11/17	Detailed
TO 4.3 Second Evaluation Briefing Final (PPT)	30/11/17	30/11/17	Detailed
Local Roads – A3044 Google Earth Pro (KMZ)	04/12/17	06/12/17	Detailed
Local Roads – A4 Google Earth Pro (KMZ)	04/12/17	06/12/17	Detailed
<b>02 Capex Cost Plan</b>			
301062017_HAL 3R_Local Roads PCE_V4 (XLS)	30/11/17	30/11/17	Detailed
HEP Local Roads – A4 A3044 2 <sup>nd</sup> Eval Final v2 (post-review HAL Position) (XLS)	30/11/17	30/11/17	Detailed
<b>03 Evaluation Output</b>			
2017-09-29 Appendix B TO 4.6 – 2 <sup>nd</sup> DER Green Review for Local Roads (PDF)	-	24/10/17	Detailed
<b>04 IFS Report &amp; Documents</b>			
170712 HEP Local Roads - A4 3044_my comments (XLS)	-	24/10/17	Detailed
A3044 Options_my file (XLS)	-	24/10/17	High Level
HEP IFS Local Roads_rev 2.pdf	30/11/17	15/01/18	Detailed
A4 Options_my file (XLS)	-	24/10/17	High Level
<b>Rivers and Flood Storage</b>			
<b>01 Design Information</b>			
170424_Water Evaluation Briefing v1.0 (PPT)	-	24/10/17	High Level
River Diversions Options Descriptions (XLS)	-	24/10/17	High Level
Storage Area Options Description (DOC)	-	24/10/17	High Level
<b>02 Capex Cost Plan</b>			
04052017_HAL 3R_Flood Storage Options PCE_V2 (XLS)	-	24/10/17	Detailed
Task Order 5.1 Estimate v 0.3 (002) IFS Review (XLS)	-	28/11/17	High Level
Task Order 5.1 Estimates v0.4 incl Property (XLS)	-	04/12/17	Detailed
TO 5.1 – Culvert Benchmarking (PDF)	30/11/17	01/12/17	Detailed
TTBT Lima PAX HAL INDEX IFS	-	14/12/17	Detailed
RIVER DIVERSION BM – AS T5 WPC River Diversion	-	14/12/17	Detailed
Data Information Sheet (WP) WPC Inc Design APPROVED (2)	15/01/18	15/01/18	High Level
TUNNELS C&C SUMMARY	15/01/18	15/01/18	Detailed
<b>03 Evaluation Output</b>			
2017-09-29 Appendix D TO 5.1-5.2 Rivers and Flood Green DER (PDF)	-	24/10/17	Detailed
5.1 Component Evaluation - Rivers - Business Case v0.4 (DOC)	-	24/10/17	Detailed
51-52 Component Evaluation - Flood Conveyance Options (XLS)	-	24/10/17	High Level
<b>04 IFS Report &amp; Documents</b>			
IFS slides JF Draft (PDF)	04/12/17	07/12/17	High Level
HEP IFS Rivers and Flood Storage_V5 (PDF)	30/11/17	01/02/18	High Level
<b>Terminals, Satellites &amp; Aprons</b>			
<b>01 Design Information</b>			

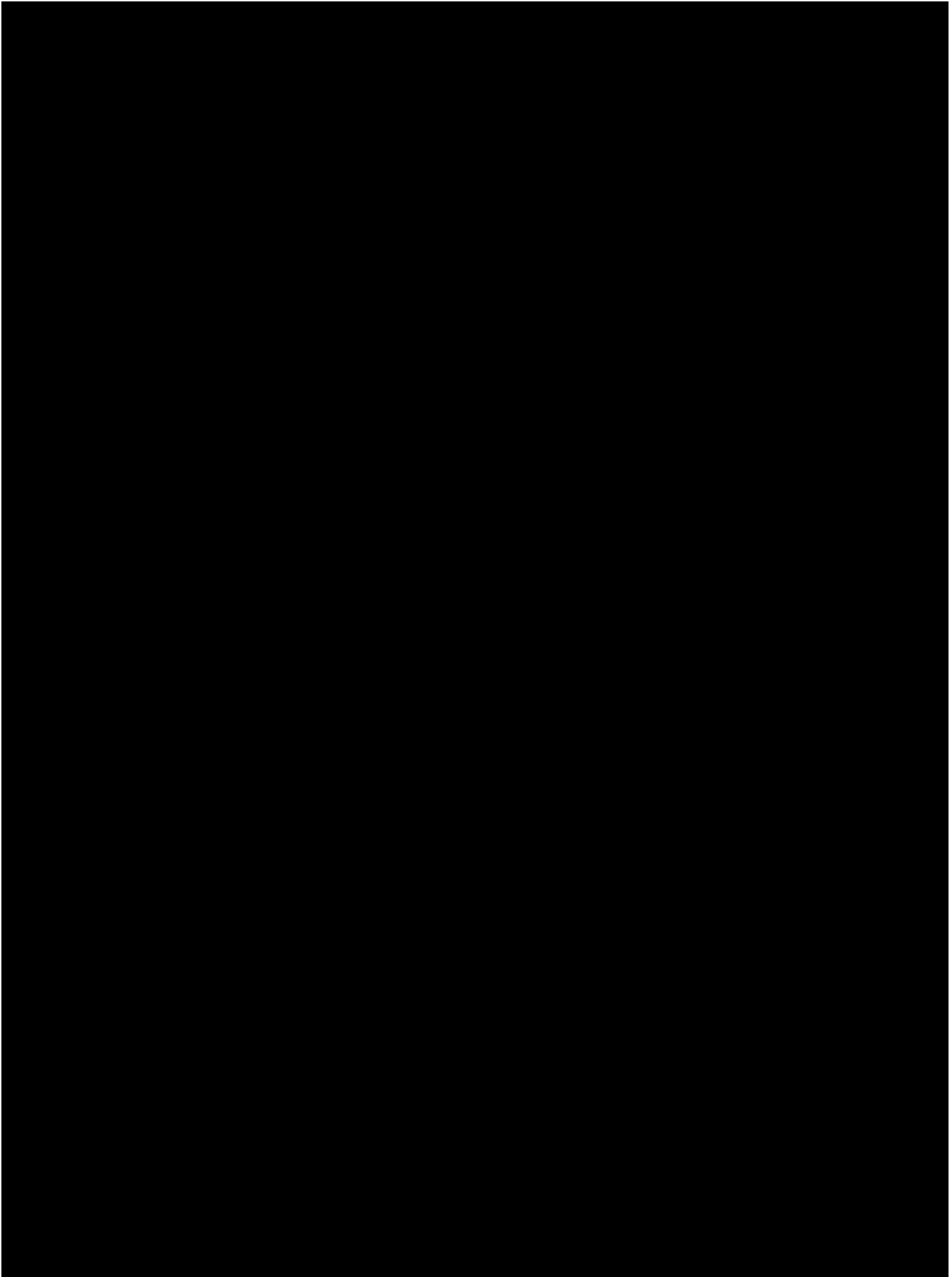
Information Received / Requested	Date Requested	Date Received	Level of Review
TO3.1 Assemblies Summary for Green Evaluation v1.2 (PDF)	30/11/17	01/12/17	Detailed
<b>02 Capex Cost Plan</b>			
Green Review for IFS April 2017 (JH reviewed 231017) (XLS)	-	24/10/17	Detailed
Copy of T2A Final Account plus notes	11/01/18	11/01/18	Detailed
TTBT T2A March 2016 HAL Index (1)	11/01/18	11/01/18	Detailed
Copy of TTBT T5A March 2016 HAL Index Notes Added	11/01/18	11/01/18	Detailed
<b>03 Evaluation Output</b>			
TO3.1 Terminals, Satellites & Aprons cost update – OAG dated 14/12/2017 (PPT)	11/01/18	12/01/18	Detailed
<b>04 IFS Report &amp; Documents</b>			
HEP IFS Terminals Satellites Aprons FINAL 8-1-18 (PDF)	11/01/18	15/01/18	Detailed

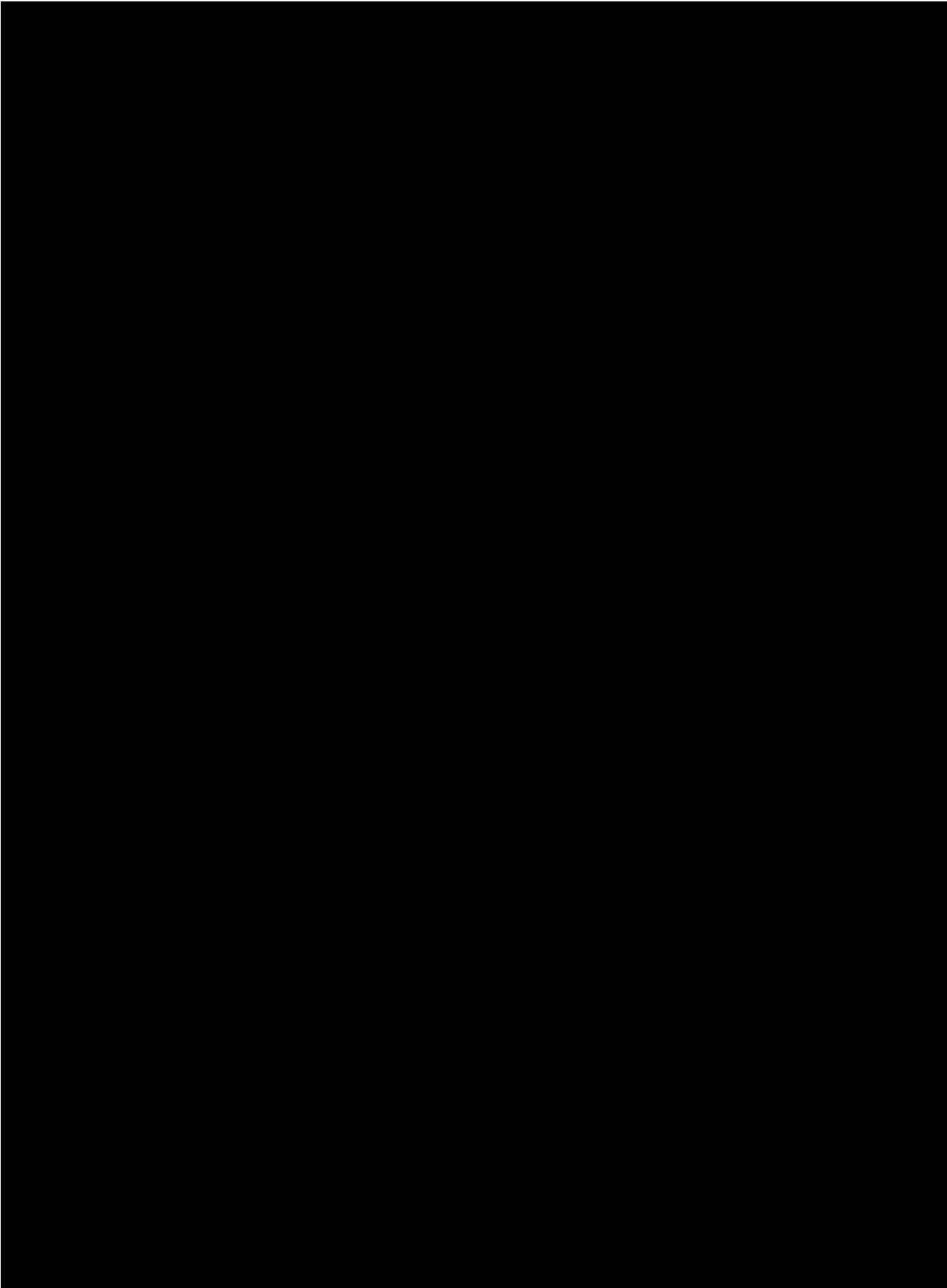
## 11.2 Appendix B – Queries & Responses



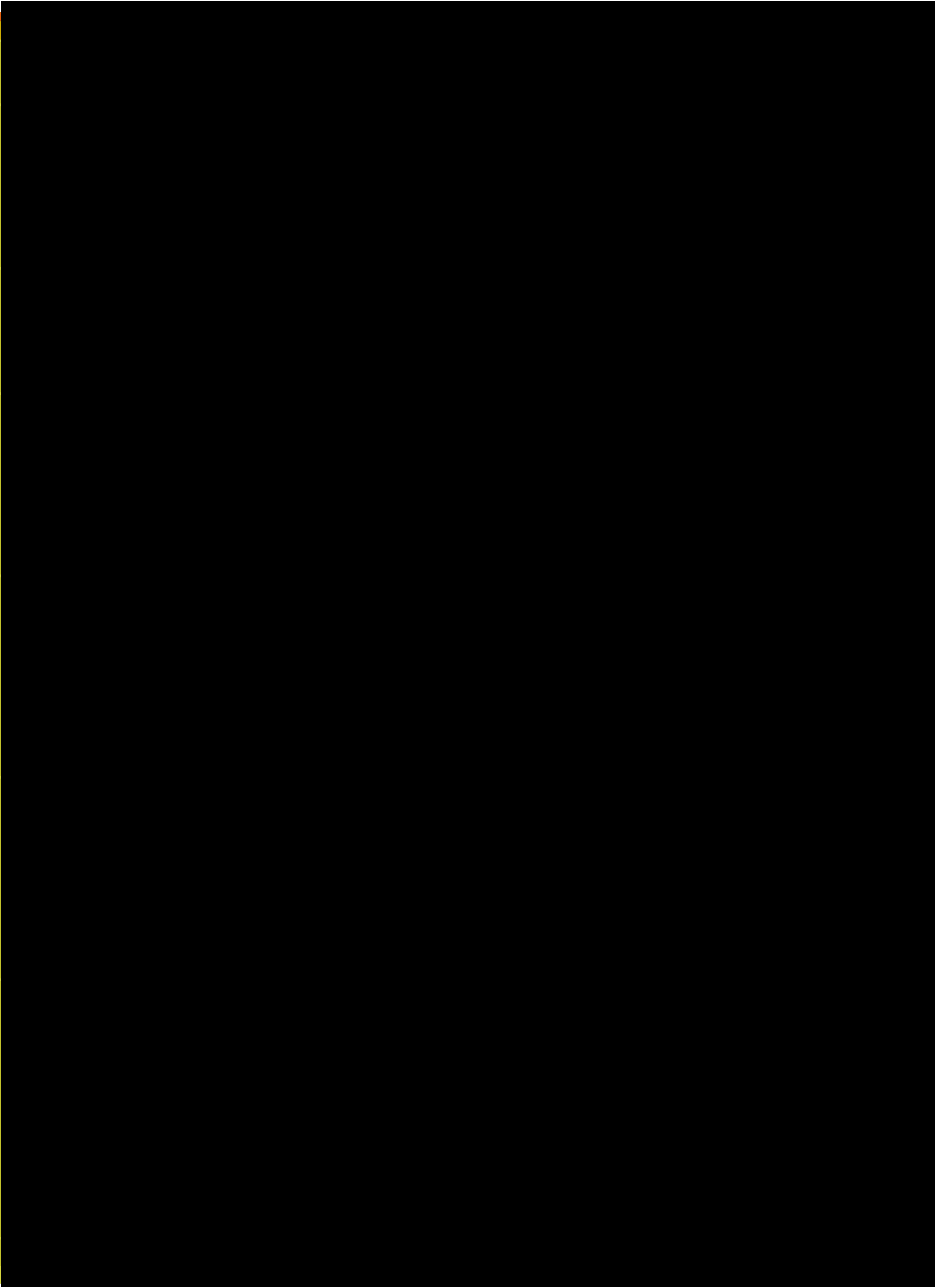














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