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Appraisal Framework Module 14. Operational Efficiency: Ground Infrastructure Heathrow Airport North West Runway

Airports Commission

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Executive Summary

This purpose of this document is to report on the analysis of the Heathrow Airport North West Runway scheme against the Operational Efficiency module of the Airports Commission's Appraisal Framework, April 2014.

The proposed Heathrow Airport North West Runway scheme including an additional runway, taxiways and new terminal, is capable of being delivered as a fully safety and security compliant airport. The proposed scheme would provide capacity for substantially greater numbers of flights, passengers and cargo to be handled by the airport. A few minor safety compliance issues have been identified which should be able to be resolved by detailed design or through adopting appropriate operational procedures.

The proposed additional runway would enable the airport to handle a c 54% increase in air transport movements per annum from the current cap of 480,000 to 740,000. Although a few pinch points in the taxiway network are likely to create congestion at peak times, overall the taxiway network would be able to support those additional movements. The proposed new T6 terminal and its satellite, along with phased expansion of T2 and associated satellites, would enable the airport (along with utilisation of spare capacity at T5) to handle the proposed increase in passenger capacity, with a standard of passenger experience comparable to that currently experienced at the airport.

Although the scalability of stand provision is constrained by some limitations on the dimensions of the expanded airport, there are sufficient stands of a variety of sizes (including sufficient multi-aircraft ramp system "MARS" stands) to meet future demand scenarios. The expanded airport could be expected to meet a wide range of possible future fleet mix scenarios and airline business models, including Code F aircraft. The airport would be able to sustain minimum connection times of 60 to 70 minutes for transfer traffic between terminals. A tracked transit system would facilitate high capacity transfers between terminals and their satellites. While the airport proposed operating model is complex and may be subject to further refinement, it can be developed to meet the proposed demand. Although as with all airports, it becomes more challenging at peak times, the airport's overall resilience and reliability would be enhanced by the additional runway and associated taxiway and terminal infrastructure.

There is some scope to expand terminal and stand capacity further on the proposed land area. Given the constrained site, additional runway capacity would likely require expansion to the south-west or the north-west beyond the proposed third runway. Both options are likely to be challenging given the presence of the reservoirs and motorways respectively.

Contents

1 Introduction

1.1 Purpose

This document consists of the consolidated analysis of the Heathrow Airport North-West Runway proposal (hereafter “the proposal” or “the scheme”). The analysis has been undertaken against the Operational Efficiency module of the Airports Commission’s Appraisal Framework, April 2014. It is the professional assessment of the key metrics, measures and judgments across the individual units within the Operational Efficiency module.

It is structured to report specifically on:

- *Inputs;*
- *Assumptions;*
- *Methodology;*
- *Description;*
- *Analysis; and*
- *Appraisal conclusions.*

It is not an economic, financial or commercial assessment of the scheme, but a technical assessment of the qualities of the scheme according to the specific units within the appraisal modules. Key assumptions are made based on the best available information of current and reasonably anticipated industry practice, but it should be understood that the judgments made in this document could change if significantly different modes of operation or regulatory conditions were implemented that constituted variations to the key assumptions.

Section 2 presents a general overview of the methodology adopted in the assessment. Section 3 provides a high-level overview of the proposed master plan, with Sections 4 to 8 presenting the detail of the assessment of each key component of the master plan from runway to terminal facilities. Each of these sections initially discusses the element of the proposed master plan before presenting the results of the assessment against the Appraisal Framework module unit as set out below. Section 9 briefly comments upon the performance of the scheme with respect to the demand scenarios considered by the Airports Commission.

1.2 Module 14: Operational Efficiency

The Operational Efficiency module is intended to assess how each proposal impacts on the capacity, safety, security, efficiency, reliability, resilience and scalability of the airport and the wider airport system. It is intended to provide an overall appraisal of what the scheme adds to the airport system, enabling comparisons between schemes and a “do-nothing” scenario, and to assess whether the scheme can be implemented to be compliant with safety and security standards, and be sufficiently flexible and scalable to meet changes in demand, modes of operation and safety and security standards.

There are seven units of assessment in this module:

- *Capacity;*
- *Safety and security;*
- *Efficiency;*
- *Reliability and resilience;*
- *Scalability;*

- *Airspace; and*
- *Surface Access.*

This report addresses these units with the exception of the Airspace and Surface Access units, which are being reported upon by NATS and a separate Jacobs report respectively to which reference should be made. In addition, the Civil Aviation Authority (CAA) has undertaken a separate safety analysis of each of the proposals.

There is a considerable overlap between capacity, efficiency, reliability and resilience units, as restrictions on theoretical capacity will also reduce the efficiency, reliability and resilience of the airport, although it is not the only factor. Therefore, the capacity appraisal outlines the overall capacity of the expanded airport, and the limitations on that capacity. These are also referred to in the efficiency, reliability and resilience appraisals to reflect this when relevant.

Scalability includes both the potential for the airport to operate flexibly with different types of traffic and aircraft, and to expand its capacity within the proposed infrastructure, and also the potential to expand beyond its proposed land footprint. It summarises the challenges of such expansion, as these could be on a scale similar to the scheme being considered in this report.

Not all components of the airport's operational processes are relevant to all units of the appraisal. For example, many process elements are important for safety, but not capacity. Table 1-1 sets out which process elements have been assessed according to their relevance to each of the appraisal units.

	Capacity	Safety and Security	Efficiency	Reliability and Resilience	Scalability
Airfield Components					
Runways	✓	✓	✓	✓	✓
RESA's		✓			✓
Runway approach lighting		✓			✓
Public Safety Zones		✓			✓
Aerodrome safeguarding		✓			✓
Navigation aid safeguarding		✓			✓
Taxiways	✓	✓	✓	✓	✓
Stands and aprons	✓	✓	✓	✓	✓
Cargo facilities	✓				✓
Fuel storage	✓			✓	✓
De-icing facilities	✓			✓	✓
Terminal Components					
Existing terminals	✓	✓	✓	✓	✓
New terminals	✓	✓	✓	✓	✓
Transfer facilities	✓	✓	✓	✓	✓

Table 1-1 Airport Process Components and Relevance to Appraisal Units

2 Methodology

2.1 Approach

This section sets out a high level overview of the methodology adopted to complete the analysis. Detailed numerical modelling was not undertaken at this stage. The assessments were therefore primarily based upon desk-top reviews of the proposed master plan including its modes of operation against expectation of industry good practice and by reference to professional experience and observations of comparator airports.

A consistent approach was applied to all schemes short-listed by the Airports Commission. The assessment undertaken was prepared on the basis of a number of key principles including avoidance where possible of relying upon assumptions to form an opinion. In the absence of detailed numerical modelling, opinion has been based largely upon professional judgment and comparison with comparable airports and/or operations. The largely qualitative analysis has been sufficient to generate valid assessments of the schemes within the scope of the appraisal units.

The proposed new infrastructure has been assessed against the appraisal units by comparing how operations will be affected. It is reasonable to assume that an expanded Heathrow would operate at a similar level of safety, security, efficiency, reliability and resilience to that currently experienced at the airport.

2.2 Operational Assessment

To ensure consistency between parallel work streams, a workshop was undertaken with NATS to evaluate the scheme in terms of aircraft ground movements to assess the capacity, efficiency, reliability and resilience of the airfield and coordinate with NATS's assessment of airspace.[1] Each "period" of operation was examined in turn for both arriving and departing aircraft, for each key area of the airfield, under both westerly and easterly conditions. A series of flow diagrams was developed to gain a high level appreciation of flow across the airfield under each of these conditions, identifying areas which may experience congestion when the airport approaches capacity at peak periods; these are provided in Appendix C.

It was assumed that the central runway is always operating in segregated mode. Therefore, the capacity of this runway is typically lower than the other two runways.

It was assumed that "compass departures" and "terminal arrivals" would be applied as general practice, although at peak times, especially when the airport approaches capacity, it is likely that this practice will be more difficult to sustain.

Discussions with NATS indicate that sufficient Standard Instrument Departure routes (SIDs) have been developed to accommodate "compass departures" from all runways. NATS has indicated that airspace capacity should not impact this assessment of airfield movements.

In agreement with NATS it is assumed that when operating in mixed mode, the runway would accommodate around one third of departures and arrivals, with the dedicated arrivals or departures runways taking the remaining two thirds.

[1] See Appraisal Module 14. Operational Efficiency: Airspace Efficiency Report.

2.3 Runways

To assess whether the proposed capacity of the expanded runway system is reasonable, the projected air transport movements (ATM) capacity was examined under the proposed operating parameters. For the purposes of assessment of safety and capacity, the runways were treated in isolation of airspace and airfield constraints, although the previously noted workshop with NATS ensured consistency of assessment.

Independent detailed modelling has not been undertaken at this stage, and therefore a numerical analysis of runway capacity is not provided.

2.4 Taxiways

Taxiways have been checked for physical compliance with European Aviation Safety Agency (EASA) standards. For the purpose of this report, high level flow diagrams have been drawn up in conjunction with NATS. By developing an overarching understanding of aircraft flows across the airport under different operating patterns, a series of 'pinch points' have been identified, where it is anticipated that the effects of congestion will first be felt when approaching capacity. The ultimate capacity of the taxiway network is subject to detailed traffic modelling.

2.5 Stands and Aprons

Proposed stand dimensions were checked against CAA, EASA and International Civil Aviation Organisation (ICAO) standards and Heathrow and comparator airport stand dimension norms.

The current total number of stands by aircraft size and terminal was provided for both the summer and winter season. Typical Code C and Code F stand dimensions in conjunction with internationally regulated inter-stand clearways have been used to identify approximately how many stands could be provided in the future. This will be subject to the mix of aircraft being accommodated and the configuration of the stands at the time of design (e.g. the use of multi-aircraft ramp system (MARS) stands to accommodate wide bodied and narrow bodied aircraft peaks on the same area of apron).

2.6 Ancillary Facilities

Current cargo provision is provided south of the southern runway. Existing buildings, aircraft stands and associated facilities are accommodated around the World Cargo Centre, with additional 'belly cargo' being accommodated across the airfield. A detailed description of proposed cargo facilities is not given at this level of master planning. However, the extended area for potential cargo facilities is provided. A broad comparison of typical cargo tonnage/metre square of facility is discussed. It is anticipated that the processing facilities will be designed to match potential throughput and that improvements in technologies will facilitate improved efficiencies within the cargo area.

A substantial area of land is allocated for ancillary facilities to the east of the proposed runway, although at present a number of airport related businesses currently occupy this area. Some of these are assumed to remain, such as those for aircraft catering and the Airport Police station.

The proposed additional fuel storage provision was compared with the existing provision and the proposed demand to assess the acceptability of area provided for fuel storage.

2.7 Terminals and Transfer Facilities

2.7.1 Terminal Sizing and Phasing

In order to determine whether the proposed terminals would be able to handle the suggested annual throughput of passengers, expressed in million passengers per annum (mppa), the level of service provided to a typical design hour passenger was compared to that in the existing facilities.

A detailed modelled assessment would consider the throughput of the slowest performing passenger process as a limit to the whole complex. It would also consider the provision of terminal processes and identify the floor area of the terminals. However, given the current design stage of the master plan and the uncertainties of the future, only a high level assessment of passenger capacity has been undertaken. A two stage process was adopted to assess whether the proposed terminal and associated satellite and pier infrastructure provide adequate processing capacity.

Firstly, based upon international benchmarks an appropriate “design hour” passenger flow was determined from the annual capacity for the airport. This “passenger design hour” is the hypothetical 30th busiest hour in the year for which the facilities are usually designed. Analysis at a range of international airports demonstrates that the annual throughput drives the factor between that throughput and the passenger design hour. As shown in Figure 2-1, as the annual throughput increases the factor between the throughput and the passenger design hour decreases, i.e. the design hour itself increases, but at a proportionally lower rate than the annual throughput, i.e. the daily (and indeed annual) process becomes less “peaky”.[2]

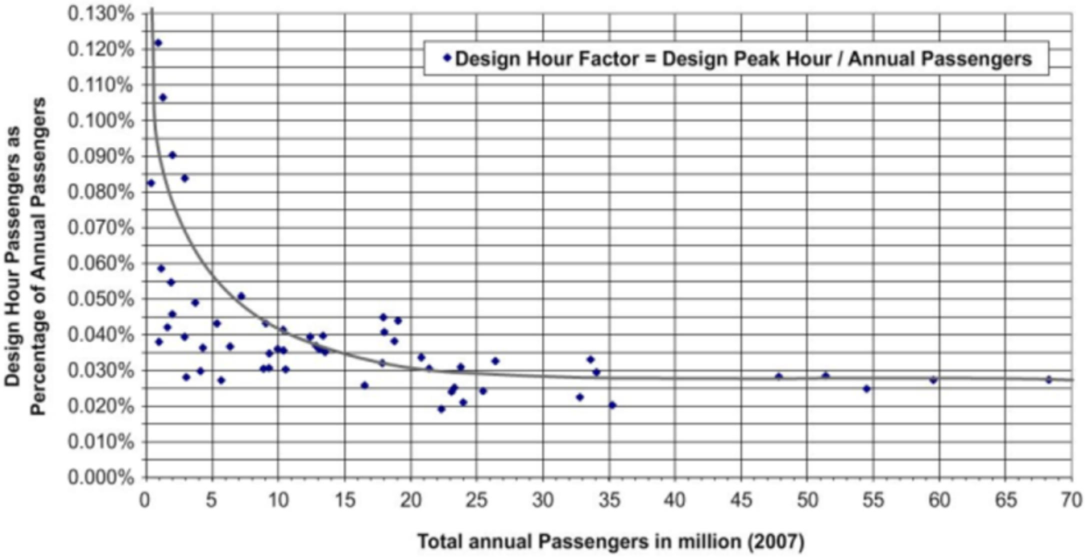

Figure 2-1 Relationship Between Annual Passengers and Design Hour (Source: Airport Evolution and Capacity Forecasting, Bubalo, 2011)

[2] Note that the absolute minimum is 0.016% for a 17h operating airport. This represents an airport with a uniformly distributed, flat profile of passenger flows across the day and year.

Secondly, the resulting space planning factor (the gross terminal floor area per design hour passenger) was determined and compared to industry experience and benchmarking to assess the resulting likely level of service that the terminal facilities would be expected to deliver. In this way, not only the provision of space is assessed, but also the peak characteristics of an airport are reflected in this high level assessment of the terminal buildings. Other metrics are available to determine the appropriate size of a passenger terminal building; however, these metrics may not include the peak characteristics that can be observed in an airport. As any facility at the airport should be designed to appropriately accommodate the peaking characteristic of demand, the adopted space planning factor metric is appropriate to be used.

It is acknowledged that the provision of gross floor area (GFA) per design hour passenger (DHP) has evolved over recent years particularly with the rise of low cost airlines. Although the scale of GFA per DHP is a continuum with no distinct thresholds, for the purposes of this analysis, the following definitions have been adopted largely based upon IATA recommendations (see Airport Development Reference Manual (ADRM)) as well as professional experience:

- *15 to 20 m^2 per DHP was regarded as being at the low end of the benchmarking, i.e. a very cost efficient and value engineered terminal appropriate for a small facility serving predominantly the low cost market with a corresponding passenger experience;*
- *Approximately 20 m^2 to 35 m^2 per DHP was regarded as an average passenger service level appropriate for most mid-range terminal facilities;*
- *Approximately 35 m^2 to 40 m^2 per DHP was seen as a good passenger service level appropriate for many airports;*
- *40 m^2 to 50 m^2 per DHP was regarded as being at the upper end of the benchmarking expectation for a typical western European gateway airport.*

Such comparisons should be treated with care as each airport, likely serving a balance of different market segments, with differing commercial strategies, across terminals of differing sizes and internal configurations, should ideally be treated upon its individual merits. Nonetheless, this approach is considered appropriate at the current level of detail and provides instructive observations that are based upon empirical observation and not only on a theoretical treatment.

These definitions are not absolute and there is no correct interpretation. The above parameters were adopted on the basis that they provide an appropriate range of service levels within a European and UK context. It is noted that many airports aspire to deliver service standards in excess of the upper end of the above range and that in some regions of the world cultural and/or political aspirations drive space provision far in excess of this upper end.

To provide an indicative comparator, the DHP space planning factors for a range of airports around the world are depicted in Figure 2-2 below. Each point represents an airport in a continent/region, indicating the relatively wide range of standards for different airports.

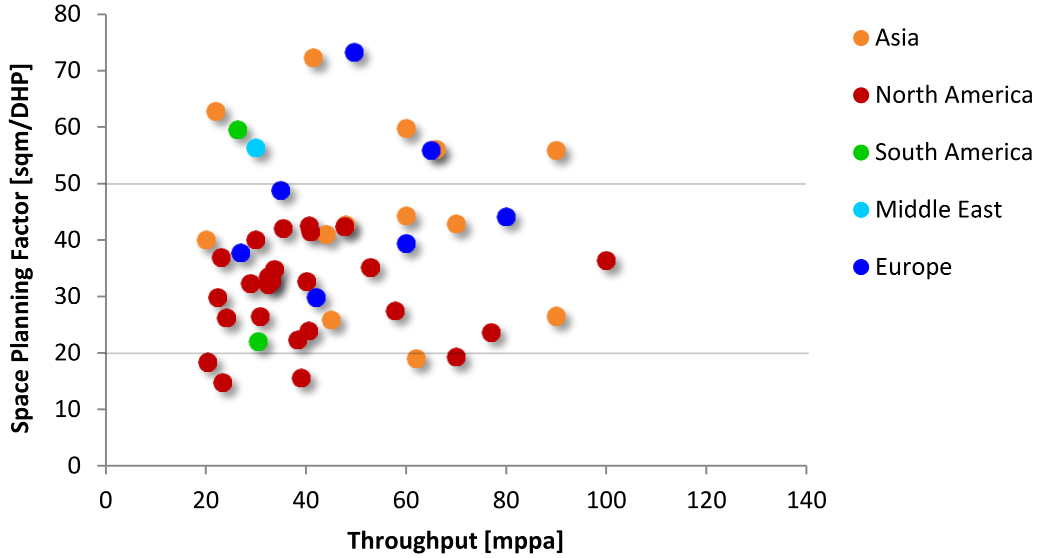

Figure 2-2 Space Planning Factor for Airports with more than 20 mppa

2.7.2 Departures

The departure process, including gates and retail, has been analysed at a high level considering the overall concept of operations.

2.7.3 Gates and Retail

It is not proposed to change the area required for gate processes, so it was not considered necessary to undertake detailed calculations to assess the required area. As the terminal expansion plans are commensurate with the current terminals it was not considered necessary to undertake a more detailed assessment of their impacts on retail provision and therefore a separate section on both gates and retail has not been included.

2.7.4 Arrivals

The arrivals process was analysed at a high level considering the overall concept of operations.

2.7.5 Transfers

The transfer process has been analysed at a step-by-step level to assess the scheme against a reasonable industry benchmarks for airport transfer steps. Minimum connection times (MCTs) were estimated for both passengers and their baggage.

2.7.6 Track Transit System

The proposed track transit system (TTS) system was considered at a high level in comparison to similar such systems at other airports.

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3 Master Plan and Operations

3.1 Master Plan

From an overarching perspective, the proposed master plan (see Figure 3-1) follows general airport planning guidelines. The master plan extends the layout established by the recent and on-going rationalisation and restructuring of the existing infrastructure by building a third parallel runway and associated terminal infrastructure within the following site constraints:

- *The reservoirs to the south-west;*
- *The built up areas concentrated (but not solely) to the south and east of the airport;*
- *The M25 to the west; and*
- *The M4 and the M4/M25 interchange to the north.*

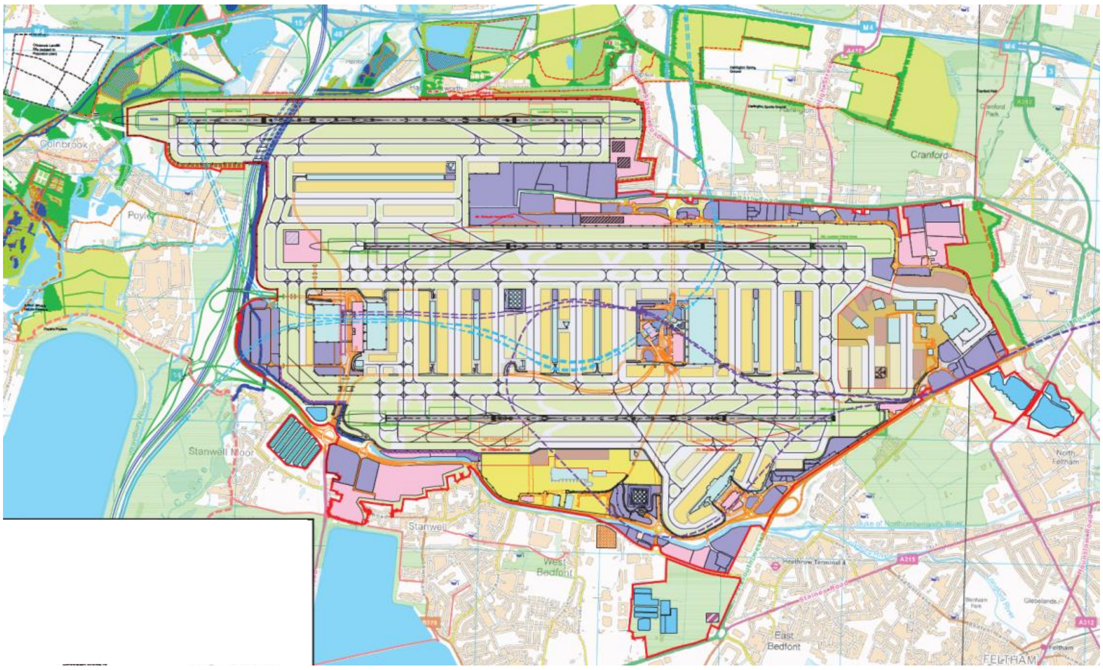

Figure 3-1 Heathrow Airport North West Runway Master Plan

The master plan appears to have been laid out in accordance with CAP168[3], but not entirely to EASA regulations. It is anticipated that it will be also necessary to be compliant with EASA regulations, which are recognised to differ from those of CAP168.[4] The airfield scheme does not comply with EASA regulations in a few instances. It is possible that the UK CAA could seek a permanent variation from EASA regulations for this scheme, based on Heathrow Airport Ltd (HAL) demonstrating that the airport could operate safely with appropriate operating procedures in place. In addition, EASA has issued a consultation paper that

[3] Licensing of Aerodromes, 10th Edition, 2014, CAA.
[4] For example, the UK CAA regulations set out in CAP 168 currently allow for reduced taxiway clearances for Code E/F aircraft in comparison to ICAO recommendations and EASA regulations. These differences are described in the Appendix under inputs. The taxiway clearances identified in CAP 168 were applied after monitoring of aircraft movements where Code E/F aircraft are commonly in operation. Typically, larger aircraft are more likely to follow marked centrelines to a higher degree of accuracy than smaller aircraft enabling the CAA to permit reduced taxiway clearances for larger aircraft.

proposes to reduce taxiway clearances, in line with ICAO proposals to do so from 2016.[5] If the EASA proposals were adopted, then the taxiway clearances requirements would be less onerous than at present.

However, if EASA regulations are confirmed to be mandatory, although this would reduce the space currently allocated to stand depth, airside roads and terminal structure, there nonetheless appears to be sufficient space to accommodate the additional clearances necessary to meet EASA regulations.

3.2 Operations

It is proposed to use one runway in mixed mode and the other two in segregated mode, alternating between runway modes to offer respite and to reflect prevailing winds (and the 'Westerly preference', if retained). It will also use "compass departures"[6] and terminal arrivals throughout the day. However, to maximise throughput at peak times, terminal departures may also need to be adopted. Operations have been assessed on the basis that they will be optimised according to levels of demand.

[5] EASA NPA 2014/21.

[6] Departures are allocated to runways based on their routing with aircraft heading to the north using the northern runway(s) in use and those heading south using the southern runway(s) in use at the time. Such an approach avoids the need to de-conflict departing aircraft in airspace. Reference should be made to Appraisal Module 14. Operational Efficiency: Airspace Efficiency Report.

4 Runways

4.1 Runway System

Heathrow currently has two runways operating in segregated mode, alternated at 1500 hours each day. Heathrow currently handles around 472,000 ATMs per annum, with a regulated cap of 480,000.

The proposed scheme is for a third parallel runway to the north-west with its runway centreline 1,035m offset from the existing northern runway. It is proposed that the new runway will be 60m wide with 7.5m shoulders.[7] This represents a fully compliant EASA/ICAO Code F runway and is in line with ICAO and EASA minimum separation requirements (1,035m) for mixed mode independent runways, subject to the provision of appropriate navigation aids. By operating all three runways the scheme would allow up to 740,000 ATMs. It is recognised that this includes the removal of the Cranford Agreement, and to allow selective mixed mode operations on one runway at any one time.

Heathrow currently declares an hourly peak of 44 arrivals or departures (with a rolling hour peak of 46 movements) per runway.[8] The proposed hourly peak is anticipated to be made up of 128 aircraft across the three runways:

- *42 departure movements*
- *38 landing movements*
- *48 departure/landing movements*

The runway system should be capable of handling all types of aircraft expected and forecast to use Heathrow under typical operating conditions.

4.1.1 Declared Distances

Current and proposed declared distances are depicted in Table 4-1 and Table 4-2 below[9].

The displacement of the thresholds across the airfield is intended to improve the noise impact. A significant direct result of threshold displacement is the loss of Landing Distance Available (LDA). Whereas the LDA at Heathrow currently exceeds 3500m, the proposal is that LDAs across the airfield will be 2800m.

Although this would be shorter than the existing provision, it will still be possible for all aircraft forecast to use Heathrow to land safety within the LDA provided.

Runway	TORA (m)	TODA (m)	ASDA (m)	LDA (m)
09L	3,902	3,902	3,902	3,595
27R	3,884	3,962	3,884	3,884
09R	3,660	3,660	3,660	3,353
27L	3,660	3,660	3,660	3,660

Table 4-1 Current Declared Distances

[7] The master plan does not depict the runway shoulders.
[8] Source: ACL Summer 2014.
[9] TORA: take off run available; TODA: take off distance available, ASDA: accelerate-stop distance available.

Runway	TORA (m)	TODA (m)	ASDA (m)	LDA (m)
09L	3,500	3,500	3,500	2,800
27R	3,500	3,500	3,500	2,800
09C	3,902	3,902	3,902	2,800
27C	3,500	3,500	3,962	2,800
09R	3,661	3,661	3,661	2,800
27L	3,661	3,661	3,661	2,800

Table 4-2 Proposed Declared Distances

4.2 Runway End Safety Area Provision

Full 240m long by 150m wide runway end safety areas (RESAs), as recommended by ICAO, have been provided for all runways under the proposed layout. The displacement of all runway thresholds significantly improves the RESA undershoot provision across the airfield, and is a safety improvement.

4.3 Approach Lighting

Standard 900m full approach lighting system, commensurate with ICAO, EASA and CAP 168 requirements for Category III instrument runways have been assumed based on the new threshold positions. The approach light planes have been assessed and are compliant with ICAO, EASA and CAP requirements.

4.4 Public Safety Zones

The diagram below shows the proposed Public Safety Zone (PSZ) contours.[10] At this stage of planning, the contours should be considered to be indicative only and subject to change dependant on future operating parameters and aircraft mix.

Figure 4-1 Heathrow Airport North West Runway Proposed PSZs

[10] Source of image: HAL submission to the Airports Commission, 2014.

PSZ contours are calculated using criteria set out by the Department for Transport. Key variables in determining the extent and shape of the contours include aircraft mix, number of ATMs, and split of landing and take-off movements.

However, it is noticeable that the proposed contours appear to have a variety of different sizes. The eastern PSZs for the central and southern runways appear to be broadly similar, whereas the western PSZs for these two runways vary significantly. It is unclear why this should be the case. However, it could be a reflection of the current movement distribution which is constrained by the Cranford Agreement, which is expected not to apply in its current form if a third runway is built.

The proposed provision for PSZs raises a series of issues that should be able to be resolved in the detailed design phase:

- *The proposed 10^{-4} PSZ contour marginally exceeds the airport boundary at the western end of the new runway. The current land use appears to be vegetation. Control should be sought over this land to accommodate the PSZ fully;*
- *The boundary of the 10^{-4} PSZ contour for the existing northern runway currently lies outside the airport boundary. Although this may be assumed to be a precedent, this should be considered further in the detailed design phase and be confirmed with the CAA if this land is not to be acquired;*
- *Potentially, around 40 properties lie within the 10^{-5} contour. HAL may have to seek to purchase and manage these buildings as appropriate;*
- *The area between the taxiways and the existing northern runway is currently allocated for car parking accessed by an underground tunnel. The proposed PSZ contours show some infringement of this area. Although not a building or significant place of gathering, the car park will contain people who could be deemed to be at risk. Although it is not uncommon to have car parking within a PSZ, the safety case for this 'landside island' located within a key area of an operational airfield should be reviewed as part of the detailed design work.*

The PSZs are broadly indicative of possible future contours, with the exception of the western PSZ for the southern runway which may be undersized. The areas most sensitively located with respect to any change in the PSZ footprints would be the residential area of Brands Hill near Colnbrook to the west of the proposed new runway, and Stanwell Moor to the west of the southern runway, (given the proximity of houses to the contour boundaries).

Further detailed work needs to be undertaken to address a number of issues in defining the PSZs to enable them to be resolved with the CAA, so as to enable all runways to be compliant.

4.5 Obstacle Limitation Surfaces

Assessment of obstacle limitation surfaces (OLS) safeguarding has been limited to consideration of the approach, take-off and climb and transitional surfaces for areas in the immediate vicinity of the airfield. It is recognised that there are other safeguarded surfaces (inner and outer horizontal and conical surfaces). However, penetrations of these surfaces will either be similar to the existing configuration or are unlikely to have a significant impact on the safety and efficiency of airfield operations sufficient to invalidate the master plan.

4.5.1 Approach Surfaces

The origins of the approach surfaces will reflect the new displaced threshold locations. This has two impacts:

- *Obstacles that may currently infringe the approach surface would subsequently penetrate the surface by less or not at all; and*
- *New obstacles, such as tail fins of aircraft, would infringe the redefined surface at runway holding points.*

The first impact is a safety improvement on the current situation. The second impact raises a safety issue, although this is not an uncommon practice at airports around the world. It is reasonable to assume that this impact could be mitigated by operational procedures.

The area to the east of the proposed new runway, around the village of Sipson, is located in an area where the approach surface is around 20m above threshold level. This indicates that any structures in this area exceeding approximately 20m could be a penetration to the approach surface for Runway 27R. Any penetrations would need to be addressed by HAL in consultation with the CAA.

4.5.2 Take Off and Climb Surfaces

In most cases the declared distances and the take-off and climb surfaces (TOCS), have been defined to make maximum use of the available runway length, with the origin of TOCS located at (or close to) the end of pavement. However, the origin of the Runway 27C TOCS is displaced by around 460m from the end of pavement to accommodate the end around taxiway (EAT) provided at the western end of the central runway. Assuming no change is made to the pavement elevation, aircraft with tails up to around 22m in height could safely taxi on the EAT without impediment during operations on the central runway. However, Code F aircraft tails are around 24m. As such, either minor changes to pavement gradient and further refinement in the detailed design phase would be needed to allow Code F aircraft to use that EAT, or larger Code F movements may be restricted to the westernmost EAT only.

As described above in relation to the approach surfaces, the village of Sipson lies close to the airport boundary. The height of the 09L TOCS in this area is around 5m to 10m. Any buildings, structures or trees exceeding this height will be a penetration to the TOCS in the immediate vicinity of the airport. Any penetrations would need to be addressed by HAL in consultation with the CAA.

In addition, closer inspection of the elevation of the reservoir is required to ensure that the 27R TOCS is not infringed by the reservoir retaining wall.

4.5.3 Transitional Surfaces

The master plan layout does not appear to indicate any significant new penetrations to the transitional surfaces.

4.5.4 Obstacle Free Zone

The obstacle free zones (OFZ) for each runway operation configuration show that the proposed surfaces are clear of obstacles. Aircraft holding on the de-icing pads at the ends of each runway would penetrate the OLS approach surface, but would be outside the approach surface for the OFZ. As a mobile obstacle essential for the operation of the airport it is understood that the position of the de-icing bays is appropriate. However, further discussion with the CAA is recommended to ensure operational procedures can ensure safe operations with regards to the approach surfaces.

4.6 Navigation Aid Safeguarding

Careful detailed planning will be necessary regarding taxiways and glide path locations. ICAO recommends around 210m lateral distance from the runway centreline to be safeguarded for the glide path critical area.[11] This distance is subject to local terrain and the mix of aircraft using a particular runway. As such, current provision for the northern runway is around 190m.[12] This will impact the separation of the parallel taxiway to the runway centreline and sufficient clearance should be maintained, or operational restrictions will need to be in place to prevent taxiing aircraft affecting the glide path beam. This factor will need to be reviewed during detail design to ensure that the glide path beam is not compromised.

The proposal is for a distance of around 170m for the new runway, which extends approximately 20m outside the proposed airport fence line. The critical areas are subject to detailed design, but could be compromised by the proposed master plan. During the detailed design phase it will need to be reviewed as to whether control of, or permission to manage this land should be sought to ensure the glide path beam is not compromised.

The glide path critical area for Threshold 09C is also infringed by around 20m by land identified for ancillary facilities. It is assumed that the airport would have direct control of this land and that it could be safeguarded appropriately.

Given the expectation that current instrument landing system (ILS) technology will be phased out and replaced with newer technology over time, the operational impact of this element of the master plan may reduce. Should that not be the case, this issue would require adequate treatment during the detailed design phase or the necessary operational mitigations as agreed with the CAA at the time.

4.7 M25 Tunnel under Proposed North West Runway

The new runway would be built over the M25, requiring the M25 to be relocated into a tunnel beneath the runway. Whilst this raises safety, security and scalability issues with respect to the highway network, it also raises potential issues for the airfield.

The new tunnel creates a potential risk for the proposed runway in the event of a major incident on the M25 either in or near the tunnel, and conversely a risk for the M25 from aircraft on the taxiways and runway. For the highway, the tunnel would be built to EU safety standards to contain fire or explosive blasts effectively. It is also proposed to construct an appropriately sized runway strip over the tunnel entrances to protect them from the airport. The proposed tunnel may create a scalability restriction for further expansion of the airport west across the M25, primarily due to the difficulty, and therefore increased construction cost, of relocating and diverting

[11] ICAO Annex 10 indicates that ‘the lateral placement of the glide path antenna system with respect to the runway centre line is normally not less than ‘120m’. Typical calculations of the glide path critical area indicate that the lateral distance from the aerial to the next object could be in the order of 90m depending on local terrain.
[12] The existing glide path aerials for the existing northern runway are around 130m from the runway centreline, with a further 55m to 60m to the airport boundary fence.

the M25 during construction of a new or extended tunnel south of the proposed tunnel.

4.8 Appraisal

4.8.1 Safety and Security

The proposed third runway does not present any significant issues in terms of safety and security and appears capable of being delivered to relevant safety and security standards. The consequence of the scheme appears to be to maintain and in some cases incrementally improve the safety of the airport. No elements have been identified that are inconsistent with known likely future changes in safety and security standards.

Some minor issues have been identified that could be reasonably expected to be resolved through detailed design or the adoption of appropriate operating procedures:

- *The forecast PSZs exceed the airport boundary or infringe other areas in a couple of locations. This should be addressed during detailed design.*
- *Some local buildings are recognised to be very close to the aerodrome safeguarded obstacle limitation surfaces. HAL will need to enter into discussions with land owners as part of the development process.*
- *Code F aircraft taxiing along the EAT at the western end of the central runway would be likely to penetrate the TOCS. This should be addressed during detailed design or by restricting Code F aircraft to the western EAT only.*
- *Closer inspection of the elevation of the reservoir is required to ensure that the 27R TOCS is not infringed by the reservoir retaining wall. This should be addressed during detailed design.*
- *Aircraft holding on the de-icing pads at each end of the runways would penetrate the approach surface. Operating procedures should be developed to ensure that this can be managed safely.*
- *The glide path critical area for the new runway currently lies outside the boundary and therefore does not appear to be adequately protected, and this should be subject to further review at the detailed design phase.*

4.8.2 Capacity

Table 4-3 states the current usage and capacity, and future estimated capacities.

	2014 Actual Usage[a]	2014 Capacity	2026[13] Capacity	2050 Capacity
ATMs	471,936	480,000	740,000	740,000

Table 4-3 Throughput and Proposed Capacity

The proposed future ATM capacity is considered to be realistic. Heathrow currently declares up to a rolling hour peak of 46 movements per runway, and has proposed an hourly peak of up to 128 movements across the three runway system.

[13] Note: 2026 is the earliest that the Airports Commission considers that planning and regulatory processes would enable the scheme to be opened.

The anticipated departure and landing rates appear to be commensurate with current operations, with a slight improvement for the one runway operated in mixed mode at any one time. Given that Heathrow does not operate its runways in full mixed mode now, it is not unreasonable to assume that this improvement is achievable. A comparison can be drawn with other airports, efficiently operating mixed mode, such as Gatwick which currently declares up to 55 movements per hour, or Stansted which declares 50 movements per hour.[14]

Only one runway is proposed to operate in mixed mode at any one time, with two operating in segregated mode. This would be expected to support 740,000 ATMs with sufficient capacity to ensure higher levels of reliability than at present. If more than one runway were to operate in mixed mode, this capacity declaration could be higher. If all three runways operated in segregated mode, the capacity declaration would be lower.

The additional runway would have a positive net impact on capacity in the wider London airport system and is not anticipated to reduce capacity at other major airports, subject to re-configuration of the London airspace system. However, it may present constraints on expanding utilisation of RAF Northolt given its proximity. NATS is undertaking a specific analysis of the impacts of the scheme on RAF Northolt and is reporting separately on this.

4.8.3 Efficiency

The proposed runways appear to be capable of efficiently handling the proposed ATMs in total and at the proposed peak levels of departures and arrivals per hour, subject to appropriate slot co-ordination.

The runway system would appear to be able to handle a wide range of commercial aircraft up to and including Code F.

The proposed third runway will enable the airport to operate in various modes of operation, depending on prevailing winds, commitments to offer respite from noise and peak periods of demand for departures and arrivals.

The third runway should enhance the airport's efficiency, as the additional capacity should help reduce delays on the ground and in the air. The proposed capacity declaration should help enable this efficiency to be maintained. It is proposed that only one runway will operate in mixed mode at any one time. Although it is not part of the scheme, it would be technically possible to operate two runways in mixed mode, but not all three. However, there is some dependency between the central runway and the other runways due to its location, which would constrain the flexibility of such an operation.

All three runways could operate in fully segregated mode, but again there would remain some dependency between the central runway and the other two in managing that operation.

In conclusion, the design of the runway system should be adequate to allow efficient operation of the airport.

[14] Source: ACL Summer 2014.

4.8.4 Reliability and Resilience

The proposed new runway will add reliability and resilience to the airport. Even at peak times it should represent an improvement on current conditions, due to the added flexibility and capacity inherent in a three runway airport, with at least one runway operating in mixed mode. Should one of the runways be unavailable, the remaining two should be able to function effectively. Given the current lack of capacity to accommodate delays due to unplanned events, this should represent an improvement on current conditions.

As described in Section 4.8.2, the proposed hourly throughput rate is less than at other runways currently operating in the UK, albeit single runways, suggesting that some resilience has been retained in the runway system to facilitate a more reliable airport operation.

Given the additional flexibility inherent with an additional runway, the airport is expected to achieve improved levels of resilience against severe weather than it does at present, and is expected to improve further as technology for automated landings continues to develop.

4.8.5 Scalability

The proposed runways are compatible with a wide range of fleet mix scenarios that may accompany different commercial models the airport may pursue. This includes Code E and Code F aircraft, and all current and envisaged aircraft likely to be used by different types of airlines and for different varieties of airline traffic.

The proposal is to operate two runways in segregated mode and only one runway in mixed mode. It would be technically feasible to operate two of the runways (north west and southern) in mixed mode simultaneously with the central runway on arrivals only. This may allow an increase in the capacity declaration, but would have to be subject to detailed modelling, and consideration of its wider economic, social and environmental implications (particularly noise).

The Operational Efficiency module of the Appraisal Framework includes consideration of the further scalability of schemes. Therefore, the potential for further runway development at the site of each shortlisted scheme has been assessed, to provide a high level indication of the likely challenges. This does not represent a comprehensive assessment of the scope or case for the further runway options under consideration.

Development of an additional runway beyond the proposed third runway presents challenges that go beyond those involved in the Heathrow North West Runway scheme.

Following construction of a third runway, the Heathrow site would remain constrained for major expansion. The presence of built up areas to the south, east and north, reservoirs to the south west and west, and the M25 to the west, the M4 to the north and the interchange between them all constrain the ability to expand the airport site easily on the scale required for an additional runway. The development of any options for further expansion will need to take account of their effects on residents, businesses and the need to reconfigure or relocate major infrastructure, and will likely require acquisition and removal of many properties.

Submissions to the Airports Commission prior to its 2013 Interim Report, examined the potential for adding a fourth runway to the south-west of the site. This option is not precluded under the current submission. However, it is recognised that the impact on the local area including the reservoirs would be very significant and costly. The capacity of the central runway would already be reduced under the three runway scenario. It is not, therefore, unreasonable to assume that a fourth runway may further restrict the movements of that runway and the existing southern runway, and further work would be required to assess whether or not it would result in significant additional capacity.

An additional runway to the north of the proposed North West runway would require relocation of the M25/M4 interchange and realignment/tunnelling of significant sections of motorway. It would appear to be a more challenging project than the proposed third runway.

It may also be possible to implement the concept of an in-line runway extension (Heathrow Airport Extended Northern Runway scheme); however, the tunnelled M25 is likely to create a scalability challenge for any proposals for further expansion of the airfield westward immediately south of the M25, as the options to relocate the motorway temporarily to maintain adequate capacity appear significantly constrained.

5 Taxiways

5.1 Proposed Taxiway Network

The proposal is for an expansion of the taxiway network to service the new runway and associated stands and terminal.

The proposed network would appear to be adequate to manage aircraft efficiently on the airfield. However, some bottlenecks have been identified in the network that could cause congestion during peak periods. These have been highlighted in Figure 5-1 below.

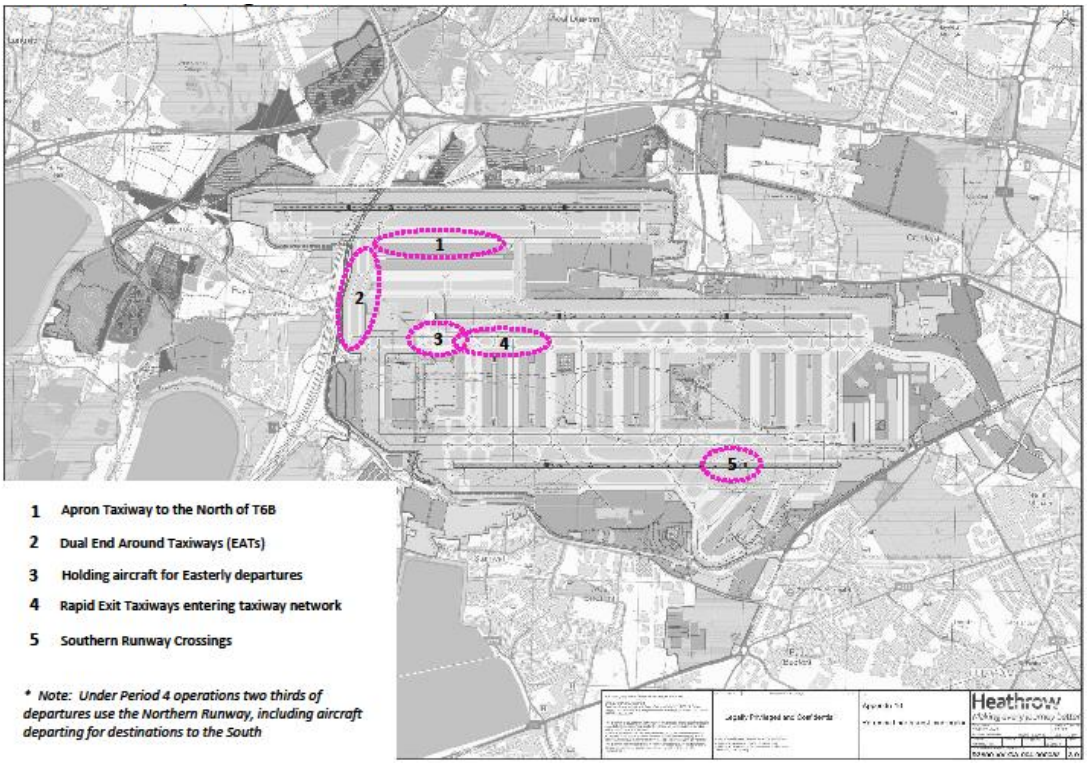

Figure 5-1 Taxiway Operational Pinch Points

The new taxiways appear to have been planned for Code F aircraft, and in accordance with CAP168. The apron taxilane clearances around the new T6B satellite are compliant with CAP168 but fall short of EASA recommendations for Code F aircraft. An additional 1.5m in clearance should ideally be sought during design phase. Given the current provision for stand depth and terminal facilities, additional space could be provided in line with European Standards. However, the CAA may seek to apply for a dispensation from EASA standards to allow 95m clearances rather than the currently stated 97.5m clearance. This would need to be addressed in the detailed design phase in consultation with the CAA. In addition, EASA is currently consulting on a proposal to amend taxiway clearance requirements.[15] If adopted, this proposal would mean that the taxiway clearance requirements would be less onerous than currently required.

[15] EASA NPA 2014/21.

5.2 Runway Access Taxiways

Three runway access taxiways (RATs) are proposed for each end of the new runway, in addition to those at the existing runways. This is commensurate with current operations and is considered to be good design practice.

The proposed RATs are suitable for the overall master plan, would meet safety and security standards and be adequate to service the proposed capacity of the airport.

5.3 Rapid Exit Taxiways

The existing northern and southern runways are equipped with a variety of taxiway exits, with two rapid exit taxiways (RETs) in each runway direction. The current positioning of the RETs is in line with the existing threshold positions, current fleet mix and number of runway movements. It appears likely that some of the RETs will need to be moved to optimise runway throughput. Although this does not appear to have been assumed in the master plan, it is anticipated that these works could be included in the wider airfield improvement tasks and would not impede the development of the airfield.

Two RETs in each direction are proposed for the new runway and are positioned to enter the taxiway network at either end of the apron taxiway. These RETs are positioned appropriately in accordance with threshold positions. Care will need to be taken in the detailed design phase, as relocation of these RETs could risk positioning them directly opposite the apron. This may result in delays to aircraft taxiing along the parallel taxiway and cause interference with apron movements, potentially affecting capacity at peak times.

The proposed RETs would appear to meet safety and security standards and be capable of meeting the proposed capacity of the airport adequately, although additional RETs could improve efficiency and resilience across the runway/taxiway network and should be considered during detailed design.

5.4 Runway Crossings

No additional runway crossings are proposed. Aircraft will continue to cross the southern runway for access to and from Terminal 4. However, this is a feature of current operations and is not expected to change operating conditions or limit the capacity of the airport significantly.

5.5 Parallel Taxiway Network

It is proposed to extend the parallel taxiway system to serve the new runway and to link the new terminal T6A to both the north and south. The T6A taxiway would provide additional resilience to the taxiway network, allowing aircraft to bypass the potentially busy area to the north of T5A/B when taxiing to or from the southern runway.

The parallel taxiway system extends to both ends of the new runway and is capable of accommodating Code F aircraft. There appears to be the potential for congestion at the central section of the inner taxiway during peak periods as a result of aircraft pushing-back from the north of new satellite T6B. This could affect taxiway movements around the new runway.

There is currently a single taxiway shown around the east of T6B. A dual taxiway would improve circulation at peak times and would provide additional resilience to the taxiway network. The land beyond the taxiway to the east of T6B is designated for Ancillary Facilities and is therefore assumed to be under airport control under the Master Plan. Therefore, provision of a dual taxiway in this area may be accommodated and would be commensurate with a longer term strategic plan to safeguard the land for long term terminal development should it be needed.

The parallel taxiway network would meet safety and security standards and be capable of adequately meeting the proposed capacity of the airport.

5.6 End Around Taxiways

Dual end around taxiways (EATs) are proposed at the western end of the central runway linking the new runway with the existing airfield. Appropriate taxiway clearances have been provided, and the EAT sits far enough away from the end of the central runway to allow appropriate clearances for the Safeguarded Surfaces, assuming that a small (1m to 2m) reduction in ground height can be accommodated in the vicinity of the EATs. This is addressed further in this document in the section corresponding to Take-Off Surfaces.

The appropriate taxiway clearances do not exactly meet EASA regulations for Code F aircraft. Further discussion of this issue is at Section 3.1. Obstacle safeguarding (which also affects the location and dimensions of EATs) is addressed at Section 4.5.2.

The provision of dual EATs is a necessary element of the scheme to enable it to function effectively. Although a full description of how aircraft would circulate using the EAT to new satellite T6B is not available, there appears to be sufficient capacity and resilience within the dual EAT provision to accommodate aircraft movements efficiently.

It is noted that EATs are not proposed for the southern runway. Aircraft from T4 or the Cargo Aprons will therefore have to cross the southern runway (as today) if landing or departing on either of the other two runways. Given that this is current practice, it is unlikely to present a fundamental problem for taxiway capacity.

The EATs would appear able to meet safety and security standards and be capable of adequately meeting the proposed capacity of the airport.

5.7 Taxiway Operations

Taxiway circulation has been evaluated in conjunction with NATS to ensure coordination with arrival and departure airspace operations. Indicative flow routes have been identified in order to ascertain whether there are likely to be particular areas of congestion in the future. Independent computer modelling of aircraft movements has not been undertaken. However, it is recognised that detailed modelling will be required prior to detailed design.

Four Modes of Operation have been proposed in order to provide noise respite to residents. Taxiway flow is dictated by these Modes of Operation. Westerly operations currently account for around two thirds of movements at Heathrow.[16] Further illustration of this analysis in depicted in Appendix C and Table 5-1.

Period	Runway	Arrival	Departure
1	North West	✓	✓
	Central	✓	✗
	Southern	✗	✓
2	North West	✓	✓
	Central	✗	✓
	Southern	✓	✗
3	North West	✓	✗
	Central	✗	✓
	Southern	✓	✓
4	North West	✗	✓
	Central	✓	✗
	Southern	✓	✓

Table 5-1 Proposed Modes of Operation

Overall, taxiway circulation appears to be acceptable. However, the following areas were identified as potentially affecting capacity, efficiency or resilience at peak times.

5.7.1 Apron Taxiway to the North of T6B

Aircraft push-backs from the stands along the north face of T6B may restrict free flow movement of aircraft using the apron taxiway along the north of the apron. It is anticipated that operational procedures and careful sequencing of aircraft could be used to manage this area.

It is proposed that the RETs for the new runway join the taxiway network at either end of the T6B apron. These positions appear reasonable. However, any future detailed plans to reposition the RETs would be complicated by the proximity to the apron taxiway.

5.7.2 Dual End Around Taxiways

The EATs need to accommodate significant northbound flows (using both taxiways simultaneously), significant southbound flows (using both taxiways simultaneously), and two way flows, at different periods of the day. The taxiway design will need to be sufficiently robust to accommodate these flows, and allow seamless switching between them, to ensure an efficient operation.

A failure on either EAT could present a major reliability issue. Although the dual taxiway and three runways help to mitigate this, a significant event impacting the capacity of the EAT would be likely to have an airport wide effect that would require operational procedures to mitigate. It is likely that 90 degree runway crossings will be utilised which may result in some delays on parallel taxiways and for departing/arriving aircraft.

[16] This includes the "Westerly preference" allowing aircraft to continue to land to the west with up to a 5 knot tail wind thus providing some degree of noise respite. For the purpose of analysis, it is assumed that the preference remains in position.

5.7.3 Holding Aircraft for Easterly Departures on the Central Runway

Under Modes of Operation 2 and 3 the central runway is dedicated to departures. It is assumed that in these circumstances around two thirds of all departing aircraft will use this runway.

Aircraft waiting to depart in Easterly conditions would be held to the north of T5. This could result in a bottleneck to through traffic. It is recognised that the taxiway around the south of T5/6 would, however, provide an alternative route to T6.

Assuming that the stands along the north of T5A remain, aircraft pushing back from these stands could exacerbate congestion in the area. It is not clear at this stage if the northern stands along T5 would be significantly affected by jet blast from aircraft holding to enter the runway.

Given that aircraft are circulating to the new and southern runways, holding aircraft around the central runway inherently leads to an increased likelihood of congestion causing knock-on effects to taxiing aircraft. Mitigation measures could be considered to reduce this, such as on-time departure sequencing and increased management of arrivals through A-CDM.

5.7.4 Central Runway Rapid Exit Taxiways

Under Modes of Operation 1 and 4 the central runway is the primary runway for arriving aircraft, with around two thirds of all arrivals using this runway. During Westerly operations, the RETs enter the taxiway system to the north of the T5 Campus. Through traffic may be restricted or routed around the south of T5/6.

This area of potential congestion should be carefully considered when detailed modelling is undertaken, although it is not expected to be as significant a problem as holding aircraft for Easterly departures on the central runway.

5.7.5 Southern Runway Crossings

When the southern runway is operating purely for arrivals traffic, departing aircraft from T4 will be required to cross the runway for departure on one of the two other runways. Similarly, when operating in departures-only mode, arriving aircraft will be required to cross the runway to access T4.

Runway crossings will reduce the overall capacity of the runway, and present a safety concern with regards to runway incursions. However, this practice is not significantly different to current operations and is therefore likely to be acceptable.

5.8 Appraisal

5.8.1 Safety and Security

The proposed taxiway network is consistent with relevant safety standards and recommendations in most cases.

There are some specific issues that will need to be resolved during the detailed design phase as follows:

- *The apron taxilane clearances around the new satellite are compliant with CAP168 but not EASA for Code F aircraft. This may be addressed in the* *detailed design phase, by a dispensation from CAA, and/or if proposals for amendments to EASA regulations on taxiway clearances are adopted;*

- *Dual EATs at the west end of the existing northern runway have insufficient clearance for Code F aircraft. This may be addressed in detailed design or by appropriate operational measures.*

5.8.2 Capacity

The proposed taxiway network should provide adequate capacity to support the efficient operation to the stated runway capacity.

The area to the north of T5 has been identified as a potential bottleneck affecting the flow of aircraft around the airfield. Appropriate contingency has been provided by allowing for a taxiway around the south of T5.

Aircraft from T4 or the cargo aprons will have to continue crossing the southern runway (as today) if landing or departing on either of the other two runways. Given that this is current practice, it is unlikely to restrict taxiway or runway capacity more than at present, unless there is expansion of terminal capacity south of the southern runway.

5.8.3 Efficiency

The proposed taxiway network should be capable of handling the proposed maximum capacity of the airport. There are sufficient RETs and RATs to allow for the efficient use of all of the runways and the proposed dual taxiway to the west of the proposed T6A will improve efficiency at peak times, and when two-way traffic is flowing around the T5/T6 area.

Aircraft push-backs to the apron taxiway along the north of T6B may impact the efficient flow of aircraft to and from the new runway at peak times.

5.8.4 Reliability and Resilience

The proposed taxiway network appears to be adequate to enable a reasonable standard of resilience and reliability of operations. However, the failure of one of the EATs at peak times could have a significant airport-wide effect on congestion.

Resilience could be further enhanced by:

- *Allowing for a dual taxiway around the eastern end of new satellite T6B; and*
- *Examination as to whether improvements could be made to taxiway circulation around the north of T5.*

These should be considered at the detailed design phase.

5.8.5 Scalability

The proposed taxiway network is designed to fit within the master plan's development for the third runway and associated stands and terminals. However, if a new terminal T6C is developed (as the next scalable expansion of terminal capacity), it would require additional capacity beyond the proposed EAT configuration in the master plan.

Long term aspirations beyond the current forecast to develop a T6C are unlikely to be efficient with the current EAT configuration. The flow of aircraft at peak times, and the lack of overall resilience, would demand consideration of a parallel taxiway along the north of the central runway. The EAT configuration could therefore be a single constraining point in the longer term. There is no option to introduce any additional taxiways linking the T6B to the rest of the airfield, without crossing the central runway, or extending over the M25.

6 Stands and Aprons

6.1 Proposed Stands and Aprons

There are 170 stands available at present (excluding cargo stands) at the airport, of which 60 are located at T5, with one third Code C/D and two thirds Code E/F. Although details are not provided, a significant increase in the number of stands is proposed.

Given that the predicted throughput of the new terminal T6 is likely to be similar to that of T5, it is not unreasonable to assume that the stand provision should be broadly similar. The apron allocation across the new development is safeguarded for Code F aircraft, allowing maximum flexibility in terms of stand development. Provision has been made for close contact stands along the western face of new terminal T6A with direct access to both the northern and southern taxiway systems. It is proposed that the new satellite terminal T6B has stands on either side of the building with a remote apron to the south of the terminal building.

Improvements to the eastern airfield campus around T2 will also increase the efficiency of stand allocation in existing areas of the airfield by progressively redeveloping the area with a “toast rack” layout, which also allows for phased expansion of stands according to demand.

The stand provision is considered to be acceptable, and is sufficiently flexible to accommodate different combinations of aircraft types.

6.2 Appraisal

6.2.1 Safety and Security

The proposed stands and aprons can be safely laid out in accordance with EASA standards. The proposed stands and aprons would support the continued safe and secure operation of the airport.

6.2.2 Capacity

It appears that there is sufficient capacity in terms of numbers of stands and apron capacity to meet the runway capacity proposed. A wide range of aircraft types will be able to use the airport.

6.2.3 Efficiency

The proposed stands and apron will support the efficient operation of the airport and a range of aircraft types. The proposed restructuring and development of the airport into a “toast rack” configuration will enhance its overall efficiency and enable efficient access to and from taxiways.

6.2.4 Reliability and Resilience

The proposed stands and aprons would appear to support reliable and resilient operation of the expanded airport. The spread of stands across the airfield should enable adequate provision of capacity at peak times. The “toast rack” layout allows for relatively straightforward re-allocation of aircraft in the event of stands becoming unavailable.

6.2.5 Scalability

The “toast rack” layout lends itself to phased development according to need up to the capacity of the runway system. There is scope to develop stand capacity further in association with the envisaged terminal T6C adjacent to the new runway. There is also land allocated for ancillary facilities opposite T6A which could be redeveloped as stand space if required. The proposed stand allocation would be able to accommodate a wide range of commercial aircraft types.

7 Ancillary Facilities

7.1 Introduction

A wide range of ancillary facilities are provided at the airport including, but not limited to offices, hotels, catering, power, and fuel farms. Much of the land within the boundary shown in the master plan is already under the control of the airport. The use of the land split between these facilities will be dependent on demand over time. This report does not seek to determine whether the scheme design appropriately reflects future demand for office space or other specific facilities. However, it is recognised that HAL will utilise all land available to the airport, and that additional independent support facilities will inevitably grow in the immediate vicinity of the airport, whether under the direct operation of the airport or otherwise.

Particular comment has been given to the provision of cargo, fuel and de-icing facilities.

7.2 Cargo Facilities

The current facilities at the airport process an annual cargo throughput of 1.5m tonnes.

It is proposed that the total cargo capacity could be doubled to handle 3m tonnes per annum. With around 13.3ha of land allocated, this is a 30% increase on the current area allocated to cargo, and is achieved by reallocating underutilised airfield space adjacent to the current facilities, and redeveloping some existing dated facilities.

The increase in footprint, improved efficiencies and processing facilities appears to be appropriate to support the proposed increase in cargo throughput.

If required, the scheme's long term terminal strategy could include the closure of Terminal 4, relocating those flights to the new and expanded terminals at the T5/T6 and CTA campuses. This would provide a significant increase in potential airfield space to expand further the stands and cargo handling facilities if required.

7.3 Fuel Storage

HAL is not responsible for the fuel infrastructure. However, the scheme increases the fuel farm provision from 6 tanks in the midfield, to 12 in the midfield, with an additional 9 tanks at a new site on the south of the airfield.

At the completion of the scheme's fuel storage strategy, approximately three days of supply is provided to meet the needs of the increase in capacity from 480,000 to 740,000 ATMs. The proposed provision appears to be sufficient to maintain adequate storage for the expanded airport, given it is a significant increase on the current provision, and there is further land that may be utilised for expansion of these facilities if required.

7.4 De-icing Facilities

The scheme provides three de-icing pads to be integrated into the parallel taxiway infrastructure at each runway threshold. This allows for multiple aircraft to be de-iced simultaneously at either end of each runway depending on weather conditions. Implementation of de-icing zones as indicated would be an improvement on the current situation in terms of reliability and resilience, and there is sufficient area to expand this further if required.

However, the de-icing pads are located within the safeguarded surfaces (but outside the obstacle free zone associated with a missed approach). This should be addressed at the detailed design phase and with appropriate operational procedures to ensure the safe operation of the airport.

It is also noted that the use of these pads will present a ground support operation challenge as each pilot is required to satisfy himself that his aircraft is in a safe condition to fly. This check is readily undertaken on stand, but may be more difficult to achieve on a remote pad. Nonetheless, the safety benefit of de-icing immediately prior to take-off is noted and it does not appear unreasonable to assume that an effective operation could not be configured that meets airline and pilot requirements.

7.5 Appraisal

7.5.1 Safety and Security

The cargo, fuel and de-icing infrastructure can reasonably be expected to be built to the prevailing safety and security standards at the time and so are likely to have no net effect on safety and security at the airport. The location and operation of the de-icing pads will have to be finalised at the detailed design phase to ensure that they can operate safely given their proposed location within the safeguarded surfaces and with respect to airline and pilot requirements. De-icing immediately prior to take-off would be expected to improve safety compared to de-icing on stand.

7.5.2 Capacity

Providing a doubling of air cargo area capacity against the c 54% increase in total ATMs capacity appears to be a reasonable response to possible future demand for air cargo. Given that the current constraint on cargo capacity is runway capacity, and that there is significant flexibility to develop capacity based on demand, the proposed provision appears reasonable.

Significant provision has been made for sites to allow for expansion of fuel storage to over three times the current capacity. This is likely to be scalable and will not be a restriction on the utilisation of the airport’s capacity.

The proposed scope for de-icing facilities is an increase on the current provision. As de-icing facilities by the nature of their operations, tend to be subject to demand peaks when required, it is likely that when required, the need for de-icing will constrain the airport’s capacity. However, it is the prevailing climate conditions, not the lack of de-icing facilities that creates this constraint, as de-icing adds time to the departure process. It would appear likely that if demand increase for such facilities, that there will be scope for additional de-icing facilities to be offered.

7.5.3 Efficiency

The proposed expansion of cargo, fuel storage and de-icing facilities are all likely to add to the overall incremental efficiency of the airport.

7.5.4 Reliability and Resilience

The proposed provision of additional fuel storage and de-icing facilities are likely to enhance the resilience of the airport in the event of disruption of fuel supplies and severe weather respectively.

The additional fuel storage would appear to exceed the requirement to maintain storage only at current levels. The additional capacity would improve the resilience of the airport, in terms of the length of time that it could continue to operate in the event of an interruption to incoming fuel supply. Given the increase in total capacity, this enhanced resilience appears to be a reasonable approach.

The provision of the de-icing pads located within the departure process immediately prior to take-off should increase the resilience of the departure process, avoiding the need for an aircraft to return to its stand to be de-iced again should its taxi time from stand to runway have been delayed.

7.5.5 Scalability

The proposed expanded cargo, fuel storage and de-icing facilities are all able to be expanded further within the boundaries of the airport, according to demand.

8 Terminals

8.1 Concept of Operations

The scheme provides a phased set of improvements to terminal capacity as follows:

- *Additional runway and associated aircraft stands to allow greater utilisation of T3 and T5;*
- *Phased expansion of a new T6 with a satellite parallel to the new runway;*
- *Phased expansion of T2, with a new satellite to the east and two additional satellites to the west parallel to T5B and T5C.*

It is proposed to close T1 and T3 and replace them with the expanded T2. These expansions are intended to enable the airport to move progressively from its current maximum capacity to forecast capacity through a modular design.

The proposed concentration of development around the T5/T6 campus and the central terminal area (CTA) with T2 centralises most departure and arrival passenger movements onto two sites, referred to as the Western and Eastern Campus respectively, albeit with T4 retained.

Access to T6 is proposed from the access road system that currently serves T5 and the T5 railway/London Underground station complex. The expanded T2 will continue to be served by the CTA railway/London Underground stations complex and existing access road system expanded by a second tunnel access. As the current CTA landside access area could be observed as constrained by the surrounding airfield, a similar situation will be created with the T5/T6 campus development. Careful design of the forecourt will, therefore, be required to minimise bottlenecks at times of peak demand.

The scheme includes a tracked transit system (TTS) that would connect all terminals and piers (except T4) to facilitate passenger movements and transfer connections. This is a capital intensive solution, but one that would provide relatively fast travel times and would be a superior passenger experience compared to lower cost solutions such as airfield buses.

Currently T5A (the main processing terminal building) is connected in this way with its satellites: T5B and T5C. Departing or arriving passengers use the TTS to move to/from the aircraft from/to the main terminal where all passenger processes (e.g. security), retail and food and beverage (F&B) are located. Transfer passengers also use it on arrivals to access the transfer security screening in T5A before returning to their departing aircraft (which could be located at T5A, B or C). When a transfer connection is deemed time critical, it is possible for a passenger to be security screened in the pier itself.

Hence, at the moment, Heathrow operates with almost entirely “centralised” security, retail and F&B. Centralising these facilities results in a better usage of staff and facilities themselves. However, for transfer passengers, the journey to/from the main terminal might be observed as being relatively long. It should be noted that piers T5B, T5C and T2B do have some limited retail and F&B, but not to the same extent and range as in the main terminals’ departure lounges.

The scheme proposal is for the airport to operate decentralised security, retail and F&B to enhance transfer passengers' experiences and make connections easier. Every transfer passenger would be screened at the departing flight pier. Operating in this way mainly impacts the provision of security checkpoint lanes, retail and the design of the TTS.

8.2 Phasing

The proposed phasing of development is in six steps comprising the following stages, as shown in Figure 8-1 on the following page:

- *Additional aircraft stands – capacity of 80 mppa;*
- *Phase 1 of T6A and T6B and closure of T3 – capacity of 85 mppa;*
- *Phase 2 of T6A and T6B – capacity of 100 mppa;*
- *Opening T2E and Phase 2 expansion of T2A – capacity of 110 mppa;*
- *Opening T2D – capacity of 120 mppa;*
- *Opening T2C and Phase 3 expansion of T2A – capacity of 130 mppa.*

These stages build upon and partially overlap the development of the "toast rack" two-runway master plan that HAL intends to follow irrespective of whether the Heathrow North West Runway scheme is approved.

8.2.1 Terminal 6

T6 is planned as a facility to the west of T5 to largely replicate the concept of T2 and T5. The proposed floor area of T6A is similar to that of T5A, whereas T6B is equivalent to that of T5B and T5C combined.

The planned T6B satellite, and long term proposal for a T6C satellite, follows closely that of T5B, T5C and T2B. It would be a longer satellite building[17] than T5B or T5C. Therefore walking distances from the proposed TTS station to the end gates will be higher than currently experienced at T5, although not unlike current walking distances experienced at T2 and T3.

[17] 1,130m as measured from HAL's submission to the Airports Commission.

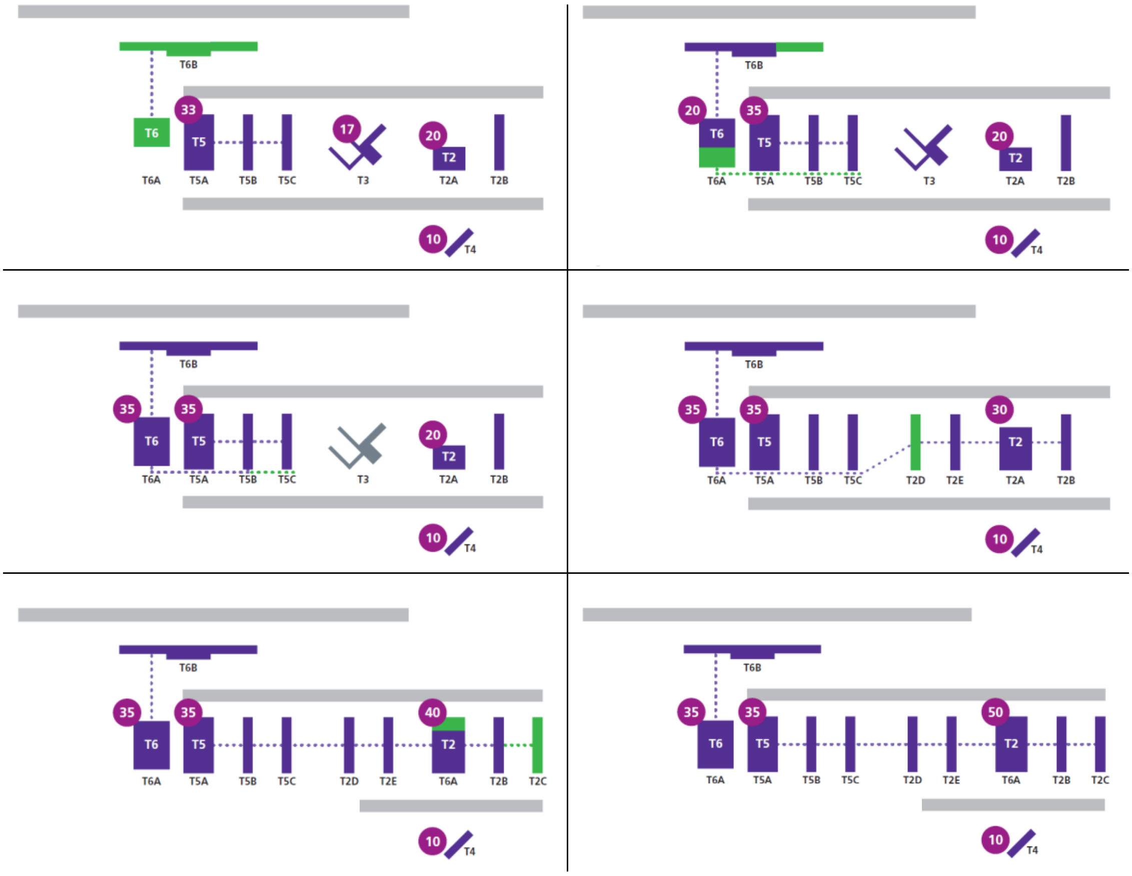

Figure 8-1 Proposed Terminal Phasing

8.2.2 Terminal 2

It is proposed to expand T2 incrementally to become ultimately the only terminal in the current CTA (Eastern Campus), replacing T1 and T3. The existing terminal building (T2A) is planned to be expanded in a modular manner, with new satellites built parallel to it to enable a continuous ‘toast rack’ layout from the Eastern to Western Campuses. This approach corresponds with the two runway master plan proposed by HAL in 2012.[18]

8.3 Sizing

Following the approach set out in Section 2.7, the passenger service standard implicit in the space allocation by design hour passenger was assessed for each development phase. Table 8-1 below presents a summary of that analysis. Note that phases have been named to reflect the most important change (e.g.: T3 demolition is included in the figures but not mentioned in the caption).

[18] Heathrow Strategic Capital Business Plan 2013: http://www.heathrowairport.com/file_source/HeathrowAboutUs/Downloads/PDF/SCBP-2013/strategic-capital-business-plan-2013_full-document_LHR.pdf (accessed August 2014).

Phase	GFA (m²)	Capacity (mppa)	DHP	Space Planning Factor (m²/DHP)
Existing	971,000	80	22,000	44
With T6 Phase 1	1,025,000	85	23,375	44
With T6 Phase 2	1,212,300	100	27,500	44
With T2 Phase 2	1,438,000	110	30,250	48
With T2D	1,483,000	120	33,000	45
With T2 Phase 3	1,618,000	130	35,750	45

Table 8-1 Proposed Terminal Sizing and Space Allocation

Given that the GFA is a difficult number to pinpoint exactly, for reference a 5% increase or decrease in floor area would correspondingly increase or decrease the space planning factor by 2.2m²/DHP.

With reference to Section 2.7, Table 8-1 and Figure 8-2 demonstrate that the airport, at its current capacity, operates at a reasonable level of space allocation that appropriately reflects the nature of its operation and types of airlines that use it. Throughout the phases, the resulting level of space allocation improves slightly over the longer term. This level of service can be regarded as towards the upper end for a typical western European gateway airport.

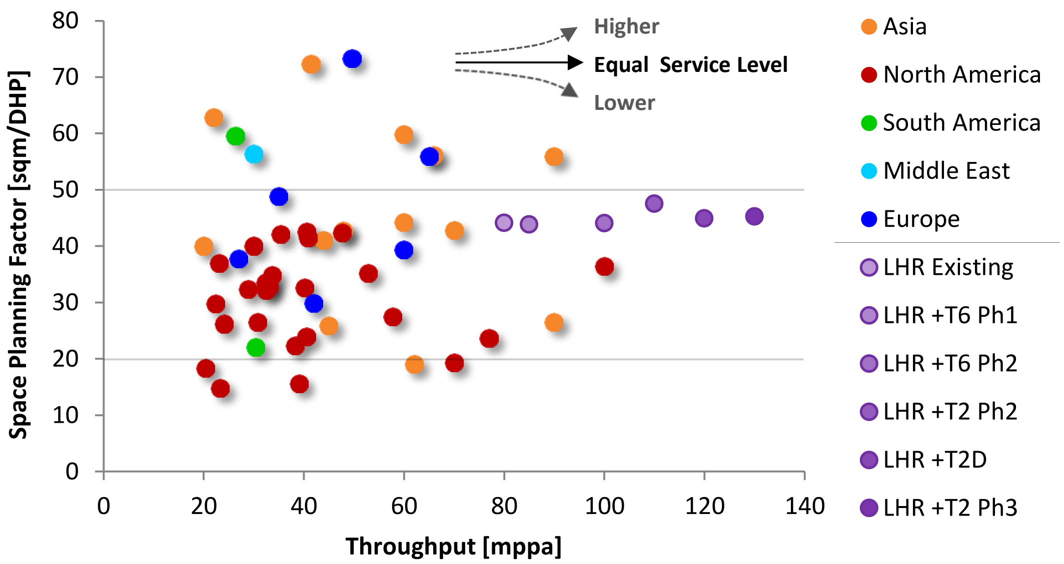

Figure 8-2 Space Planning Factor for Airports with more than 20 mppa, Showing All Phases of the Proposed Scheme

It should be noted that this benchmark serves as an indication of space provision. Two factors can have an impact on the level of space provision and level of service experienced in two airports close to each other in the benchmark: the number of international and, to a lesser extent, transfer passengers. As the former require separate facilities as opposed to domestic passengers (immigration for example) and their dwell times are often longer, more space ought to be provided within the terminal building. Similarly transfer passengers require separate facilities and longer dwell times can be observed to increase the space requirement of the terminal. As the scheme is already acceptable in terms of space provision, there are no significant potential issues with the proposed volume of international and/or transfer passengers transacting at these terminals.

8.4 Departures

Although a detailed analysis has not been undertaken there is no reason to assume that the departures capacity of any of the terminals would not be acceptable. Four areas or processes are discussed in more detail below.

8.4.1 Check-In

Over the past 10 years, the check-in process has changed significantly, mainly driven by technology enhancements such as ease of internet access and smartphones. Given these developments (e.g. self-service check-in, bag drop, bag tagging at home, remote check-in, permanent bag tags, etc.) it is likely that the current requirements for the design of the check-in area and the hall as a whole will change.

It is likely that less space will be required for a passenger to check-in hold baggage. Given that assumption, it is likely that different functions may be provided instead. It is therefore important that this area remains flexible in terms of its design. Within the footprint of all of the expanded and new terminals, it appears that there is sufficient space for a check-in hall to meet the proposed capacity of the airport.

8.4.2 Security

Similarly security regulations have changed significantly over recent years. These changes have significantly influenced process and space requirements for security at terminals. As it is likely that change will continue, it is similarly important that this area be designed to be as flexible as possible.

Given that the scheme facilitates passenger movement and transfer connections between terminals and piers via an underground TTS, every transfer passenger will be screened at the pier of departure. In order to facilitate this, every pier will need to have sufficient security lanes. However, history has shown that volumes of transfer passengers tend to be volatile: there are large variations throughout the day and even between similar days of the week or season. This makes it more difficult to plan staff and design facilities accurately. At centralised facilities, the aggregation of these streams of passengers ensures that the total is less variable. However, with a security checkpoint at each pier, designing sufficient lanes for the design hour of the year becomes more difficult, as there is a need to understand all of the intricacies of transfer passengers, aircraft stands and airline splits between piers. This will have an operational cost consequence as well as capital infrastructure requirement.

8.4.3 Gates and Retail

The scheme provides gate operations that would be similar to the existing open gate system in T2 and T5.[19] Passengers would be able to access the gate of departure at any point until boarding closes. This enables flexible use of available seating and standing capacity, and allows passengers to make maximum use of available time for retail and F&B purchases. However, it can slow boarding as some passengers may choose to leave the gate area (or not arrive at it until the final call) to utilise other terminal facilities.

Open gates tend to be favoured by airports as they increase the likely exposure of passengers to retail facilities (as passengers in closed gates are restricted from

[19] The exception is gates for flights to destinations that require additional passport control (e.g. USA, Israel)

leaving them), and also because they increase gate flexibility as seating at gates with lightly loaded or smaller aircraft is available for passengers on heavily loaded or larger aircraft at nearby gates. Passengers are more likely to prefer open gates given the increased freedom of movement available. Airlines prefer closed gates because of the increased likelihood of more reliable boarding times.

Similar to the security decentralisation, retail will be decentralised for transfer passengers and be provided in every terminal and pier. However, as the proposed terminals and satellites will have a similar design to the existing ones at Heathrow, they are likely to operate at a sufficient level of service to all passengers.

8.5 Arrivals

The most important arrivals processes are immigration and baggage reclaim. The former is managed by UK Border Agency and is largely outside of the airport's control. Baggage reclaim is largely dependent on the number of checked-in bags. There is no reason to assume that the proposed expanded terminals would not be able to manage the capacity stated for arrivals.

8.6 Transfers

The scheme facilitates transfers within terminals by decentralising transfer security at all terminals and satellites. Passengers transferring within a terminal building/satellite will be expected to do so by passing through security at that building and then entering the departure lounge. Passengers transferring between terminals/satellites will use the TTS system between buildings and then use security at the destination building to enter the departure lounge. Baggage will be transferred through a dedicated system as at present.

An assessment of minimum connection times (MCT's) has been undertaken to determine the reliability of the proposed transfer times. IATA Resolution 765 defines the MCT Interval as the shortest time interval required to transfer a passenger and luggage from one flight to a connecting flight, in a specific location.[20] This time interval should allow for a reasonable amount of queuing at the processes encountered by the transfer passenger.

The MCT is commercially important as it determines the lower limit of time between flight pairs that may be sold by airlines in a single ticket. These MCTs have to be agreed by a working group (the Local Minimum Connecting Time Group or LMCTG).

An analysis of each step an international to international transfer passenger would take for the longest conceivable transfer (T2C to T6B) is summarised in Table 8-2 on the next page.

Excluding any form of queuing and assuming no dwelling by these passengers, the MCT could be 64.4 minutes. A more conservative assessment allowing for queuing times at various steps would result in a MCT of 73.2 minutes. Additional queuing or unforeseen situations that occur on day-to-day operations are not included in this time as it is seen as a minimal connection time. It should be noted that passengers transferring to a domestic flight would require longer as they would need to go through immigration. Transfer to/from T4 is likely to take longer too as it would not be connected to the TTS linking the other terminals and piers.

[20] Source: IATA Passenger Services Conference Resolutions Manual 30th edition, June 2010.

Process Element	Analysis (minutes)
Disembarkation	15.0
Transfer connection desk	3.0 to 6.0
Walk to TTS platform	6.3
Wait for TTS	2.0
TTS to T6	18.3
Walk to transfer security	2.5
Boarding pass check	0.2 to 1.0
Transfer security	0.5 to 5.5
Walk to gate	11.6
Arrival at gate pre-closure	5.0
Total	**64.4 to 73.2**

Table 8-2 Transfer Process Elements and Times

8.6.1 Baggage Handling for Transfers

The baggage MCTs were estimated as total MCTs require baggage as well as passengers to be transferred in a timely manner to reach the connecting flight.

The scheme connects all terminals and piers via underground baggage tunnels that would allow bags to be transferred around the airport without requiring airside vehicles as depicted in Figure 8-3. For departing bags, a destination coded vehicle (DCV) system is proposed, which delivers each bag on a separate tray to the head of the aircraft stand or to the centre of a pier. From those make-up areas bags or universal load devices (ULDs) will be transported and loaded to the aircraft. For arriving bags, the choice between the existing tug-and-dolly system or a DCV system, would be determined in a detailed planning and business case exercise.

As the whole airport will be connected by the DCV system, the travel times for bags will be significantly reduced, similar to the TTS system for passengers. However, this integrated approach is relatively capital intensive and more susceptible to system failures than a more disaggregated one. An IT problem in one of the terminals might cause problems in other tunnels, piers or terminals for example. Furthermore, there is only a limited number of DCV trays present in the system. Therefore, this would have to be designed appropriately but may still cause problem in unforeseen situations (e.g. if a significant amount of bags are being checked in, but aircraft are unable to depart). Finally, only one tunnel is proposed between T5 and T6 (and its pier) and between T2 and its piers. This may create problems should tunnel capacity become disrupted and there is a risk of decreased reliability compared to the current operations: for example two tunnels are provided between T5 and its piers.

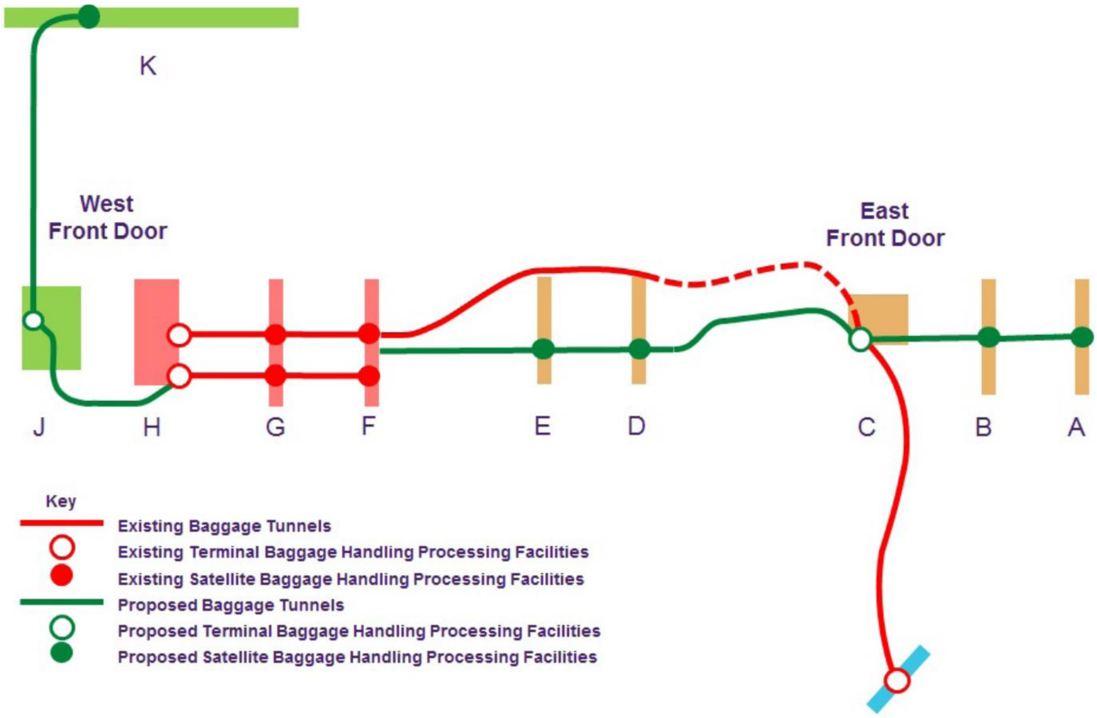

Figure 8-3 Proposed Baggage System

8.7 Tracked Transit Systems

The scheme includes a new airside TTS to facilitate access between terminal buildings and satellites, in addition to the existing system between T5A and T5B/C as depicted in Figure 8-4. It is a critical element to providing rapid access from terminal buildings to the proposed satellites for T6 and T2, but also for facilitating transfers between flights.

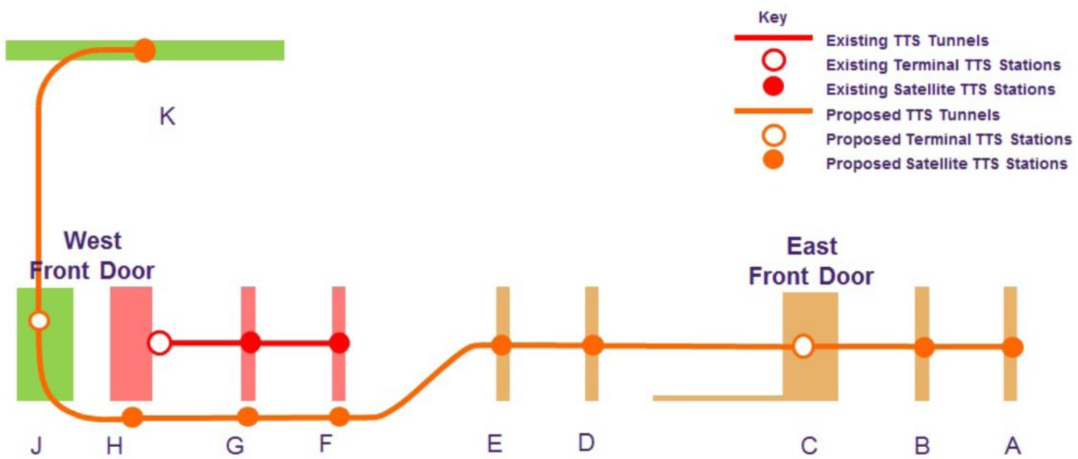

Figure 8-4 Proposed Airside Passenger Movement System

Departing passengers will be transferred after security to the respective satellites “clean” (UK security screened). For arriving passengers, the proposed system will transfer them “dirty” (not UK security screened) to the respective terminal building to clear immigration, collect baggage and clear customs. However, the proposed system will mean that on certain parts of the network at any one time it could be carrying a mix of “clean” passengers and “dirty” passengers to satellite buildings.

The TTS will therefore be required to segregate these different groups of passengers, so that the “dirty” passengers are screened at the satellite security facility, but not “clean” passengers. It is anticipated that new technology may be available by 2025 to accelerate this process, although this should not be assumed. The potential for inefficient operations is acknowledged and it is suggested that 6 car trains may be required as opposed to 5 with automatic screening.

Furthermore, because of the passenger segregation and the transport of “dirty” and “clean” passengers, the platforms will also need to facilitate appropriate segregation. Not dissimilar to the centralisation/decentralisation discussion above, the appropriate design and provision of segregated platforms, corridors and potentially vertical circulation cores requires detailed knowledge of the volatile streams of transfer passengers. Furthermore, TTS platforms and vertical circulation cores can be regarded as relatively inflexible, i.e. once designed and built it is difficult to vary capacity.

It appears possible to design the airside TTS to deliver the required capacity, but there are some potential risks in the proposed concept that need to be addressed in the design of the TTS, its platforms, corridors, vertical circulation cores and operational procedures.

8.8 Appraisal

8.8.1 Safety and Security

The proposed designs for the terminals appear consistent at this stage with the construction of safe and secure terminals. It is reasonable to assume that at the detailed design phase, the latest standards for construction, fire and other hazard safety and security will be incorporated in the design.

8.8.2 Capacity

The scheme increases terminal capacity progressively after the opening of the third runway with the major increase in capacity arising from the opening of T6. Beyond this opening phase, the proposed phased development of T6 and T2 and their satellites would appear to provide adequate terminal capacity to service the proposed runway capacity.

The proposed T6, expanded T2 and their satellites would appear able to deliver a good level of passenger experience (based on floor space per passenger) similar to that experienced at the airport today. It is likely that the overall passenger experience will improve substantially on the opening of new terminal capacity and moderate as that capacity is used, but remaining at an acceptable level at the stated capacity.

Many of the gates at the proposed expanded terminal system will be MARS compatible and sufficiently flexible to support a wide fleet mix, ranging from Code C or smaller aircraft through to Code F.

8.8.3 Efficiency

The proposed T6 and expanded T2 appear able to provide an efficient operation to meet increased demand.

The proposed new T6 and its satellite would appear to be able to provide an efficient operation, with the satellite most efficiently supporting utilisation of the new runway.

8.8.4 Reliability and Resilience

The proposed T6 and satellite, and the expanded T2 should be capable of providing similar or better levels of reliability than at present, in part due to the increased efficiency of the proposed ‘toast rack’ layout, but also because of the significant increase in supply of gates suitable for a wide variety of aircraft.

Improved links between the CTA and T5/T6 will improve resilience by providing alternative access to and from the CTA should the tunnel be out of service.

It is estimated that the MCTs are likely to be around 64 to 73 minutes.

The proposed TTS presents challenges to detailed design and to resilient operations seeking to segregate “clean” and “dirty” passengers within one train and through the station infrastructure. Whilst this could be designed to operate well if all elements of the process, including the passenger, follow the correct process, the system may be somewhat less resilient to errors (for example a passenger who fails to exit the TTS at his/her correct satellite) or to system disruption. This however could be mitigated by careful design.

8.8.5 Scalability

The proposed T6 and its satellite, and the expansion of T2 and three new satellites are all proposed to be constructed in phases. Within each phase, the opportunity would exist to scale stands and passenger processing facilities to meet different mixes of aircraft types, and to match terminal design to aircraft demand. There is additional scope to develop a new T6C if demand justifies it, adjacent to T6B. The modular nature of T2 lends itself to additional expansion. Given this scope for expansion, including possible reutilisation of the T4 site, it is unlikely that the ability to expand terminal capacity will be a constraint on overall airport capacity in the absence of runway expansion beyond a third runway. In such circumstances, the provision of land to support such a runway would appear to be a less difficult challenge compared to siting the runway itself.

9 Comparison with Demand Scenarios

The Airports Commission has developed a range of demand scenarios that consider a range of forecast drivers and their impact upon demand at Heathrow Airport. Additional airport infrastructure would be required at different points in time depending on the particular demand scenarios. The runway and associated airfield infrastructure is dependent on the forecast ATMs whereas the terminal development depends on forecast passengers. The date of opening of the third runway and associated infrastructure is further dependent upon the relevant regulatory and planning processes.

As described in Section 8.2, the terminal development is designed to be modular allowing the provision of infrastructure when required by the forecast. The scheme provides each phase of additional capacity in line with demand such that the passenger service standard is maintained as set out in Figure 8-2.

It is noted that the majority of scenarios considered forecast passenger throughput to reach around 135 mppa by 2050, limited by the available 130 mppa design capacity. However, it is also noted that the “Global Growth Carbon Traded” forecast predicts 149 mppa by 2050 resulting in an additional 19 mppa above design capacity. Against such a growth scenario, it would be expected that the airport would seek to expand terminal capacity beyond the current design capacity of the scheme. In the absence of such additional capacity the space planning factor would reduce to 39 which, although still a good passenger service level, is lower than today’s. This would be likely to mean that longer queue times than today would be observed, increasing congestion, reducing reliability and resilience, and, given the reduction in airside dwell time, reducing non-aeronautical income.

Appendix A Glossary

ADRM	Airport Development Reference Manual, IATA
APM	Automated people mover
ASDA	Accelerate-stop distance available
ATM	Air transport movement
CAA	UK Civil Aviation Authority
CAT II	ICAO ILS category with a Runway Visual Range of at least 1,200 feet, and Decision Height of between 200ft and 100ft
CAT III	ICAO ILS category with a Runway Visual Range of 700 ft, 150ft or zero respectively (for CAT III a, b or c), and Decision Height of less than 100ft.
CTA	Central terminal area
DCV	Destination coded vehicle
DHP	Design hour passenger(s)
EAT	End around taxiway
EASA	European Aviation Safety Agency
F&B	Food and beverage
GFA	Gross floor area
HAL	Heathrow Airport Limited
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
ILS	Instrument landing system
IT	Information technology
LDA	Landing distance available
MARS	Multi-aircraft ramp system
MCT	Minimum connection time
mppa	million passengers per annum
NATS	UK National Air Traffic Services
OFZ	Obstacle free zone
OLS	Obstacle limitation surface(s)
PSZ	Public Safety Zone
RAT	Runway/rapid access taxiway
RESA	Runway end safety area
RET	Rapid exit taxiway
SID	Standard instrument departure route
STAR	Standard arrival route
TOCS	Take-off climb surface
TODA	Take-off distance available
TORA	Take-off run available
TTS	Tracked transit system
ULD	Universal load device

Appendix B Scheme Changes Compared to the Heathrow Airport Ltd Proposal

No changes have been made between the scheme assessed in this report and the scheme presented by HAL to the Airports Commission.

Appendix C Operational Assessment Flow Diagrams

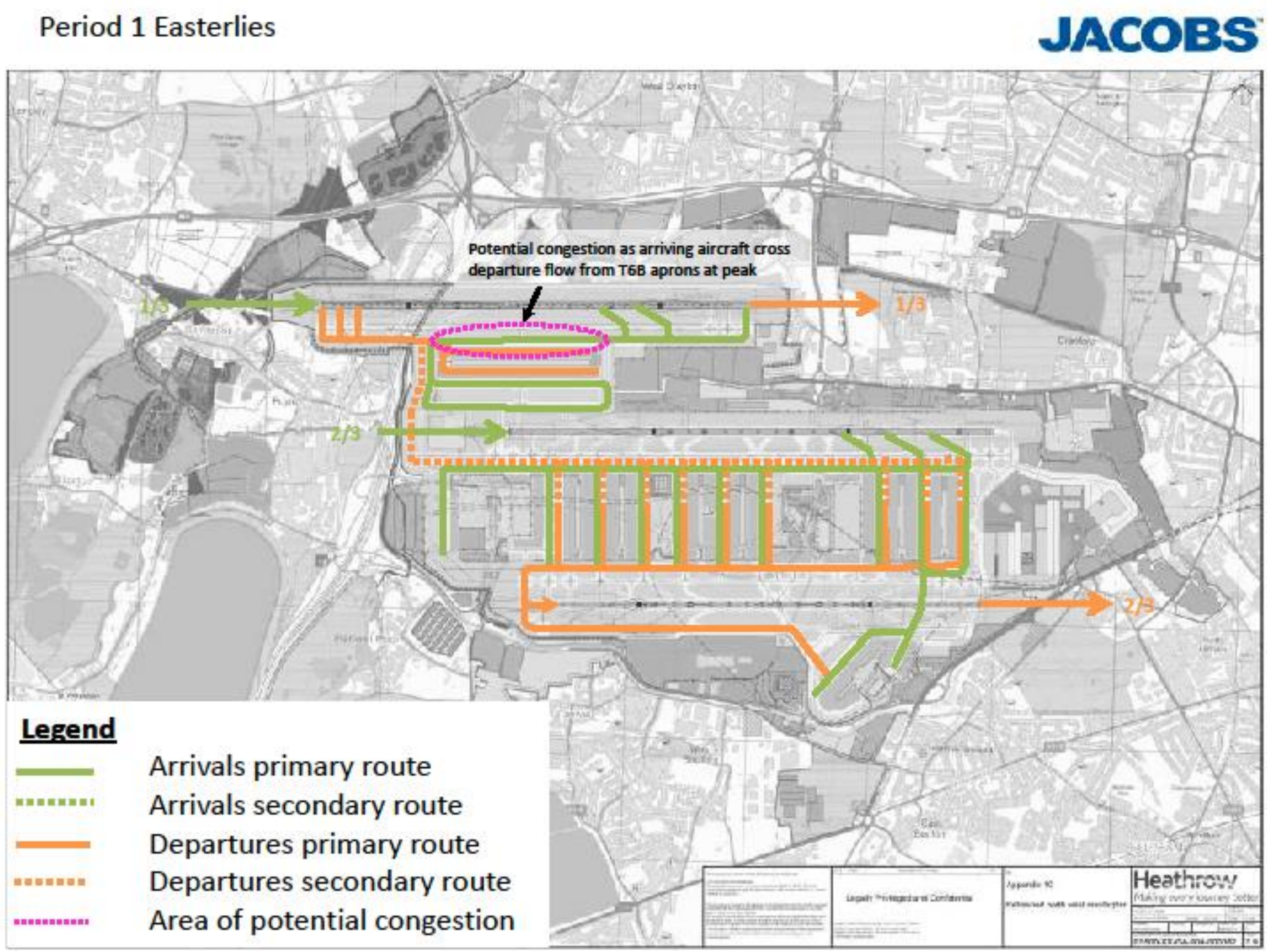

Figure B-1 Easterly Operations Airfield Assessment – North West Mixed Mode, Central Arrivals, Southern Departures

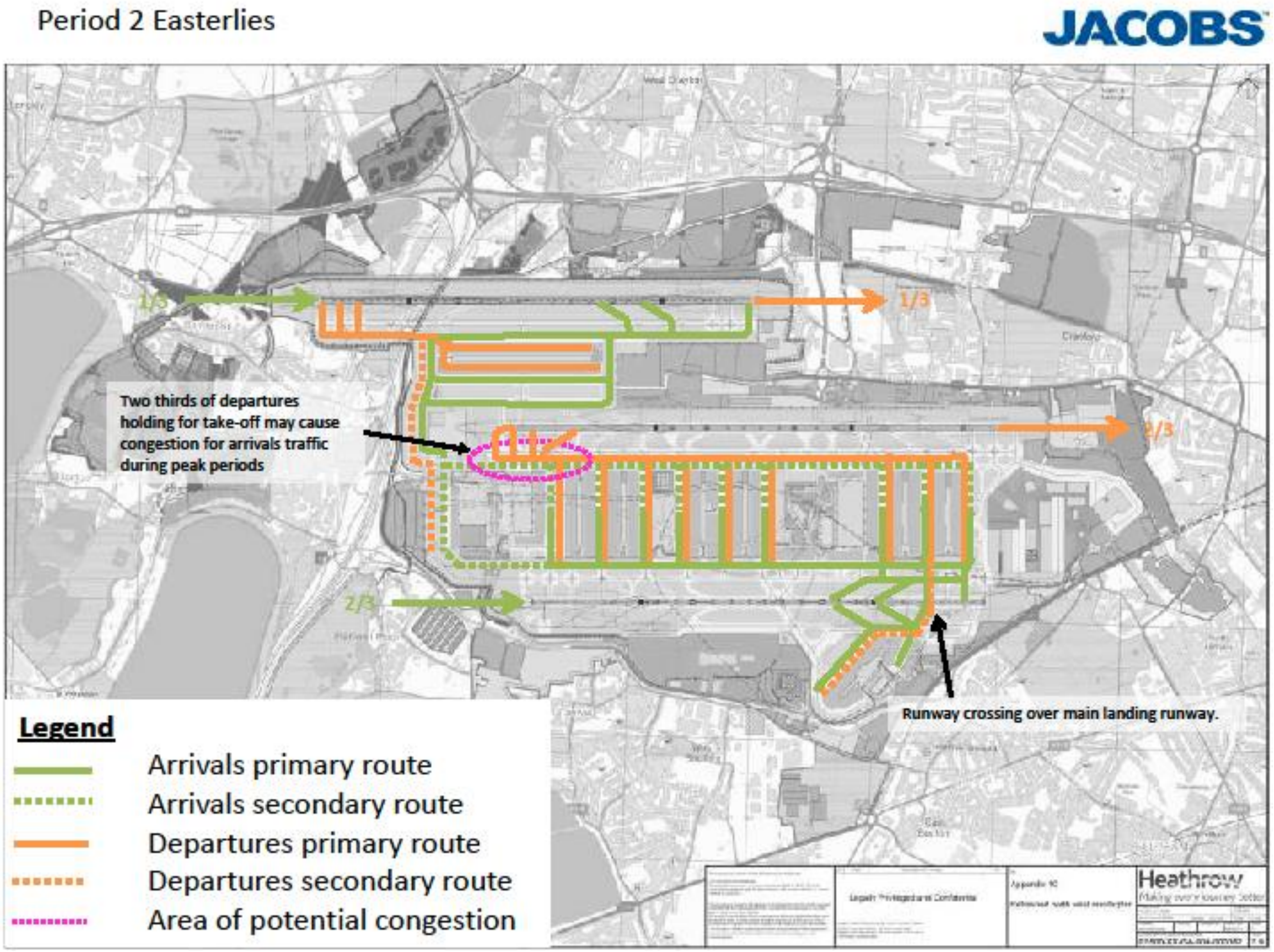

Figure B-2 Easterly Operations Airfield Assessment – North West Mixed Mode, Central Departures, Southern Arrivals

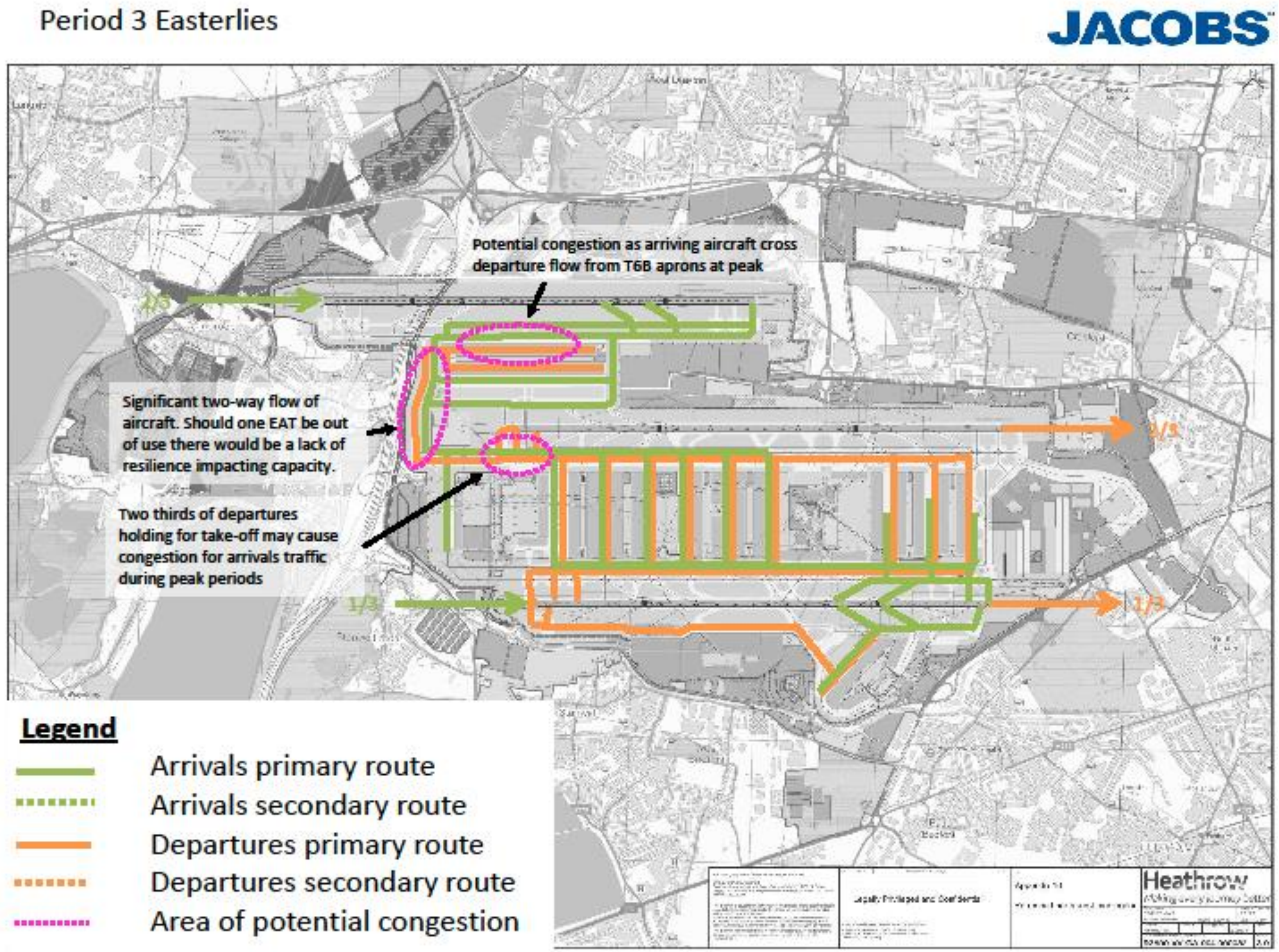

Figure B-3 Easterly Operations Airfield Assessment – North West Arrivals, Central Departures, Southern Mixed Mode

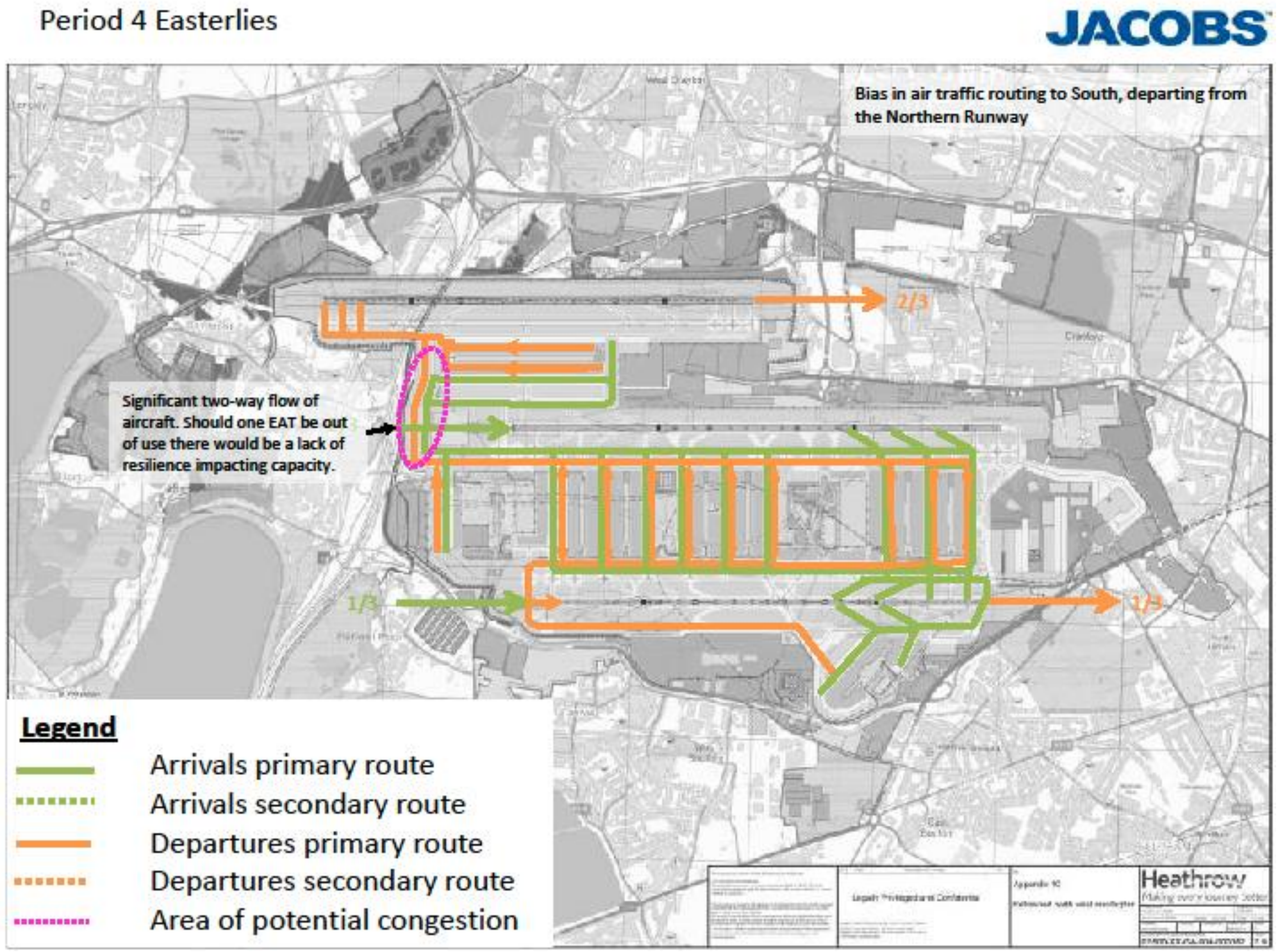

Figure B-4 Easterly Operations Airfield Assessment – North West Departures, Central Arrivals, Southern Mixed Mode

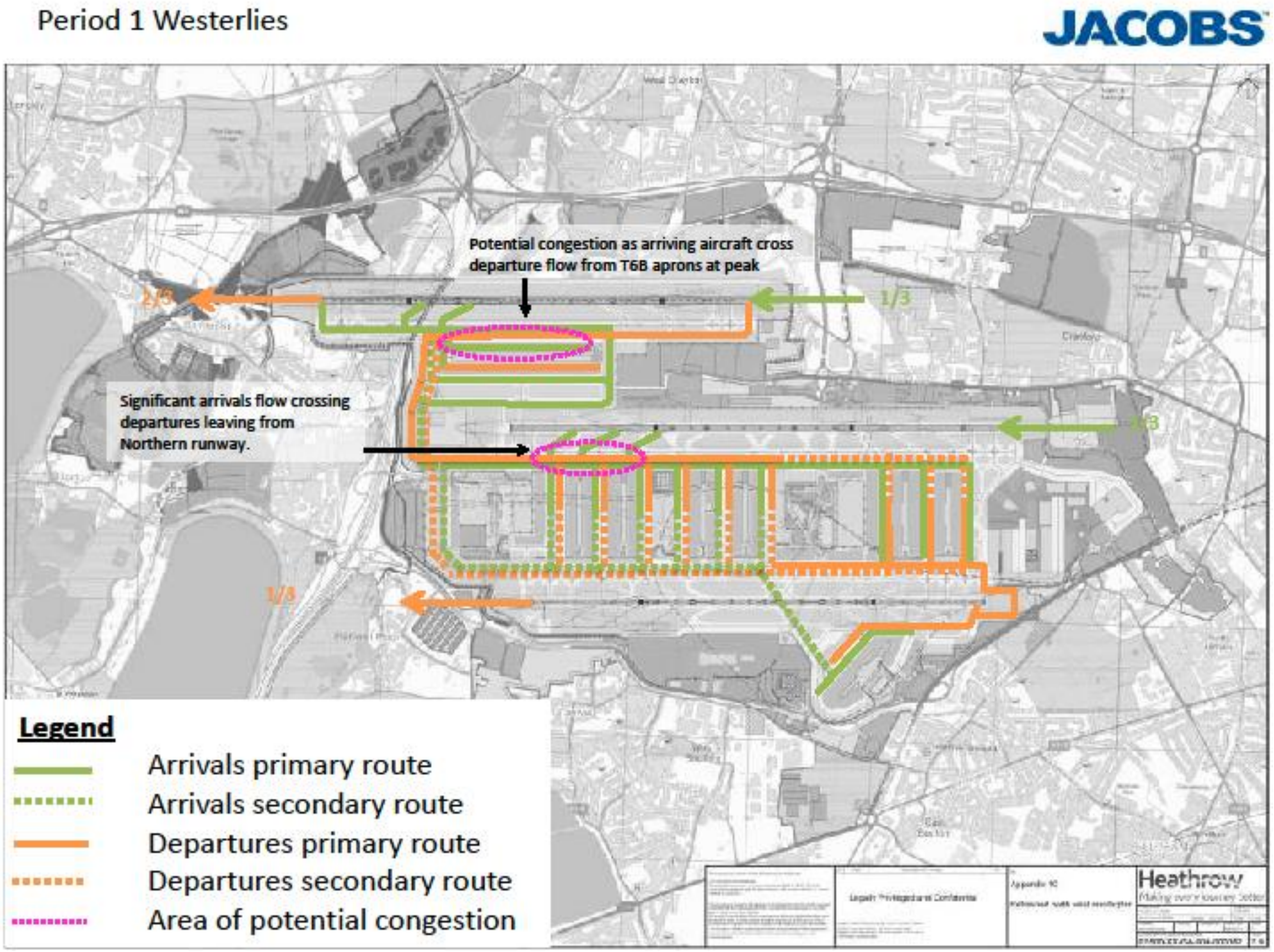

Figure B-5 Westerly Operations Airfield Assessment – North West Mixed Mode, Central Arrivals, Southern Departures

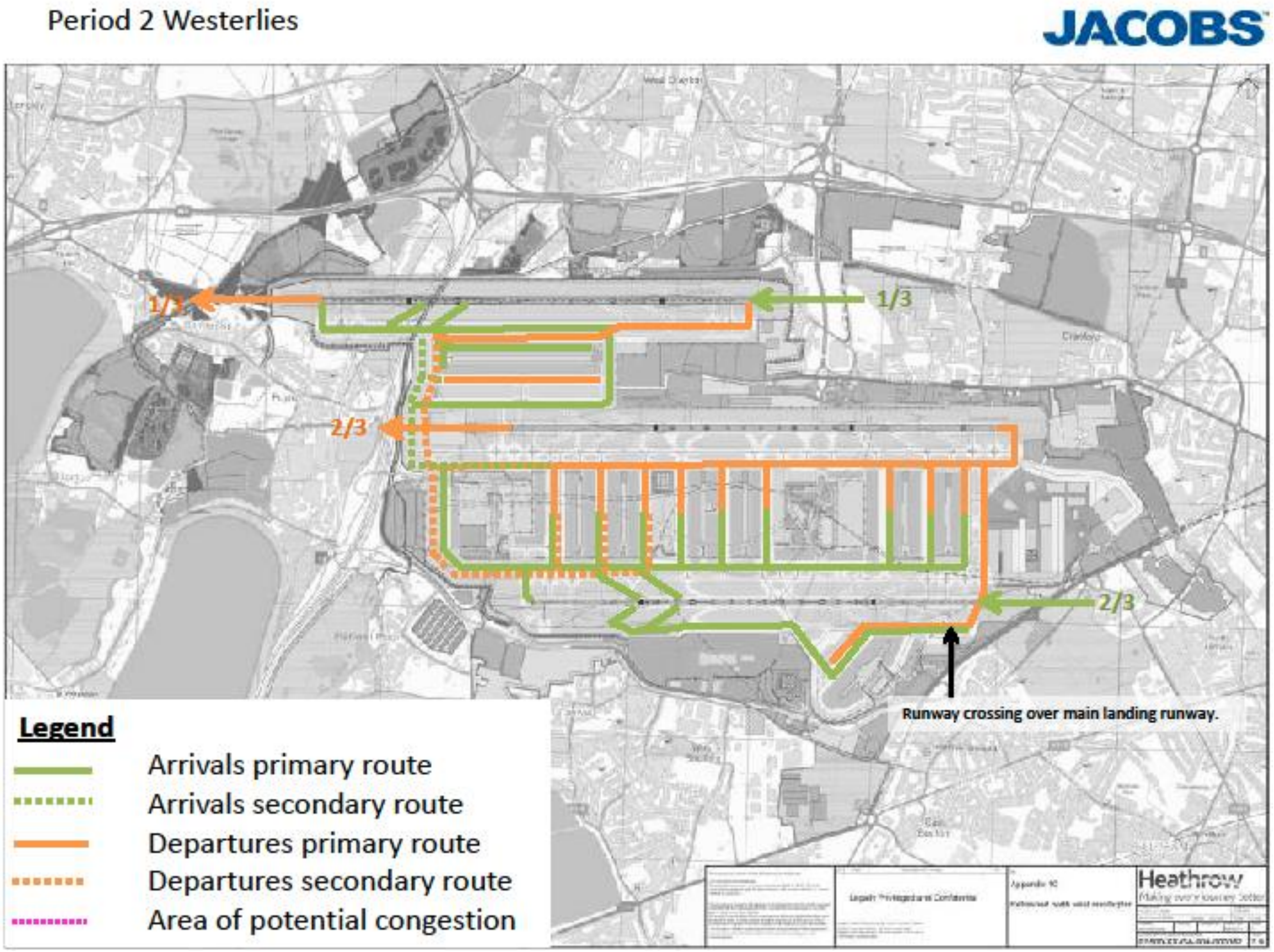

Figure B-6 Westerly Operations Airfield Assessment – North West Mixed Mode, Central Departures, Southern Arrivals

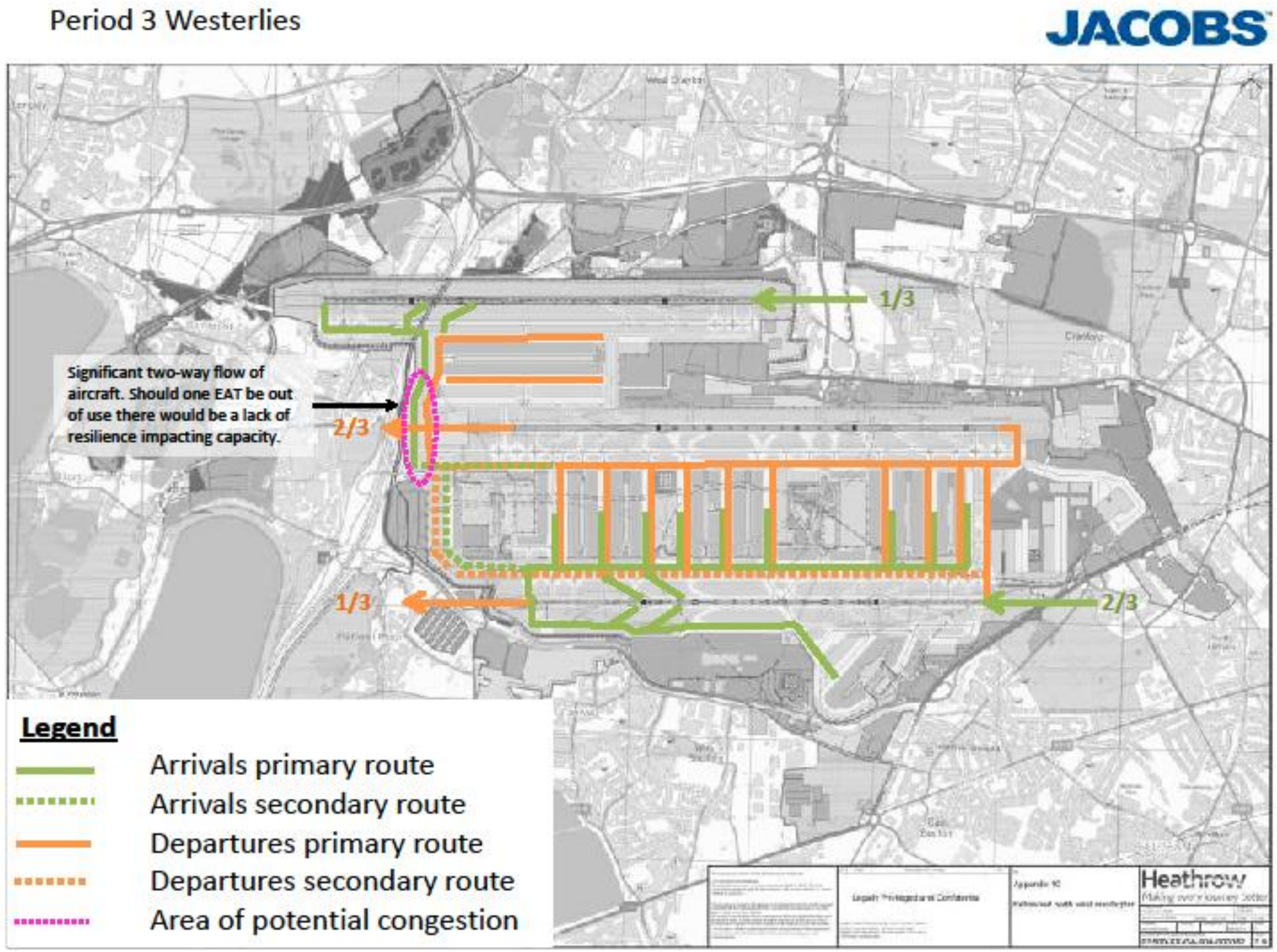

Figure B-7 Westerly Operations Airfield Assessment – North West Arrivals, Central Departures, Southern Mixed Mode

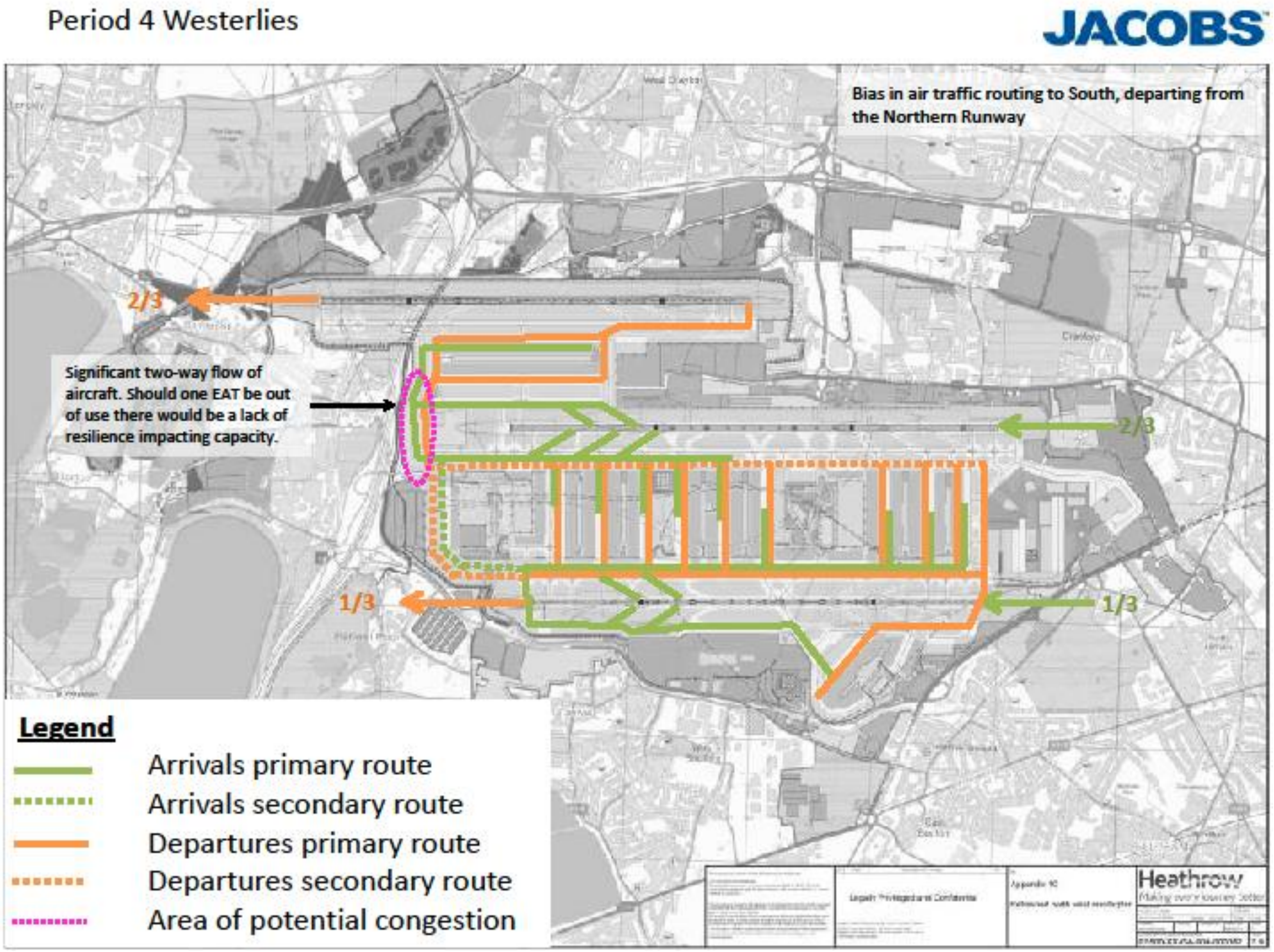

Figure B-8 Westerly Operations Airfield Assessment – North West Departures, Central Arrivals, Southern Mixed Mode

Appendix D Summary Appraisal

Element	Safety and Security	Capacity	Efficiency	Reliability and Resilience	Scalability	Comment
Proposed runway					• Potential options to construct a fourth runway to the southwest or northwest, but either option is likely to be more disruptive and challenging than the proposed third runway.	
Proposed runway RESA						
Existing runway/s amended					• Conceptually possible although challenging to extend existing runways westward given presence of proposed M25 tunnel.	
Existing runway RESA						
Runway Approach Lighting						
Public Safety Zones	• Several PSZ boundaries lie outside the airport's boundaries and control, and another incorporates a car park. These will need to be considered at detailed design phase to ensure the PSZs are adequate.				• Further expansion of the PSZs would require the airport to obtain control of land currently outside the airport's boundaries.	
Aerodrome Safeguarding System – Protect surfaces	• TOCS and approach surfaces will need to be considered at detailed design phase to ensure aircraft can be held safely at the EATs at the western end of the Central Runway.					
ATC and Navigational Systems	• Safeguarded areas for ILS glide path aerials to be identified at detailed design phase.				• Expansion would involve iteration with designs for taxiways	
Taxiways	• Apron taxilane clearances around the new satellite are CAP 168 compliant, but not EASA compliant. • Dual EATs at the west end of the existing northern runway have insufficient clearances.	• Detailed airfield modelling could help mitigate potential pinch points in the taxiway network.			• Additional taxiways are possible to support further planned terminal expansion (T6C)	Amendments to EASA requirements on taxiway separations are proposed, and if adopted would mean that the taxiway clearances requirements would be less onerous than at present.
Stands and Aprons						
Cargo facilities						
Fuel storage						

Element	Safety and Security	Capacity	Efficiency	Reliability and Resilience	Scalability	Comment
De-Icing Facility			• Operational restrictions from airline and pilot requirements to confirm safe de-icing may limit efficiency of operation – though need to de-ice given weather conditions likely to be more disruptive in any event.			
Existing terminals					• Primarily scope to expand T2 site subject to closure and demolition of T1 and T3.	
New terminals						
Transfer facilities				• Proposed MCTs unlikely to be achieved before TTS complete between T6/T5 and T2 satellites.	• Complexity of proposed operations may limit flexibility to manage substantial asymmetries in demand.	
M25 tunnel					• Once completed may make additional western extension of airfield across M25 particularly challenging	From airfield perspective only

(grey)	Not applicable
(red)	Significant issues with no identified resolution or mitigation.
(amber)	Significant issues, options to address are difficult/complex
(yellow)	Minor issues, but can be addressed during detailed design phase, or by dispensations or specific operational procedures
(green)	No significant issues/limitations, subject to finalisation at detailed design phase