HELIOS

Management and technology consultants

# Heathrow Hub

## Input to CAA preliminary safety review for the Airports Commission

an egis company

Final 25 September 2014

# Disclaimer and copyright

## Disclaimer

This report is for the sole use of Heathrow Hub Ltd and Runway Infrastructure Ltd as part of their submission to the Airports Commission. It has been produced to provide information to the Civil Aviation Authority in its preliminary safety review.

Any technical information provided by Helios in this report should only be used for the purpose of enabling the Parties named above to consider the merits of the submission as a whole. Helios accepts no liability for any use of this report. The report was prepared based on best available information and endeavours, and should not be considered as regulatory guidance.

## Copyright

# Contents


| | Page |
|---|---|
| Introduction | 5 |
| Claim 1 | 14 |
| Claim 2 | 19 |
| Claim 3 | 40 |
| Claim 4 | 47 |
| Claim 5 | 52 |
| Conclusion | 59 |

## Annexes

| | |
|---|---|
| Workshops | 66 |
| Acronyms | 68 |

# Executive Summary

Heathrow Hub is a proposed long-term solution to the UK airport capacity needs, submitted by Runway Innovations Ltd and Heathrow Hub Ltd to the Airports Commission.

The Airports Commission has requested additional evidence from all options including evidence of the capability:

- to meet industry safety and security standards;
- to maintain and where possible enhance current safety performance with a view to future changes and potential improvements in standards;
- to enhance individual airport and overall airports' system resilience.

The Airports Commission has also requested the CAA to develop a Preliminary Safety Review on the options.

This report has been prepared to provide input to the CAA Review. It presents an argument for safety assurance to address the claim that the Heathrow Hub aviation concept can be acceptably safe in principle.

The claim is divided into 5 sub-claims that cover:

- the establishment of the baseline 2023 concept,
- the assessment of:
  - arrivals operations,
  - runway operations,
  - ground operations,
  - departure operations.

The sub-claims have been assessed through workshops, analysis and comparison with relevant standards. Hazards have been identified, assessed and mitigations identified. Scenarios were used to consider different situations and to identify hazards and suitable mitigations.

The safety argument identifies actions to be undertaken and assumptions to be validated to ensure that each sub-claim is supportable. Subject to these it is therefore claimed that the concept can be acceptably safe in principle.

# Introduction

# Introduction

## Background to Heathrow Hub

Heathrow Hub is a proposed long-term solution to the UK airport capacity needs, submitted by Runway Innovations Ltd and Heathrow Hub Ltd to the Airports Commission, chaired by Sir Howard Davies.

The Airports Commission down-selected three options in its Interim Report in December 2013, calling for one additional runway in South East England by 2023. One down-selected option was Heathrow Hub and the Airports Commission has requested additional evidence from all options to inform its final decision for the additional runway. The requested evidence covers several areas, including evidence of the capability:

- to meet industry safety and security standards;
- to maintain and where possible enhance current safety performance with a view to future changes and potential improvements in standards;
- to enhance individual airport and overall airports' system resilience.

The Airports Commission has requested the CAA to develop a Preliminary Safety Review for the Commission on the options. Figure 1 shows a plan view of the Heathrow Hub concept.

# The Heathrow Hub concept introduces a new “inline” northern runway

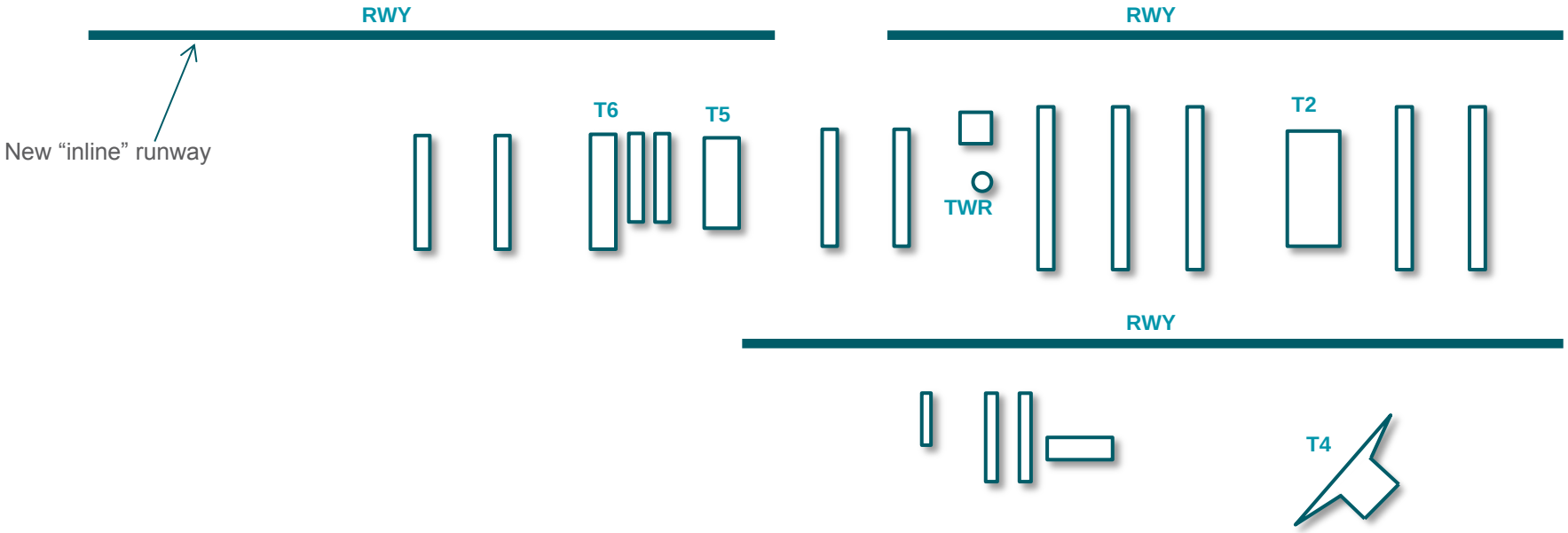



**Figure 1:** Expected plan view of the Heathrow Hub concept

Note that no arrivals or departures will ever occur over an inline runway that is active. They will only occur over an inline runway when it is closed. The predominant use of the northern runways when in westerly operations is shown below. Easterly operations are reversed. All the runway modes are shown on page 8.

**Figure 2:** Predominant runway modes when in westerly operation

# Different runway modes apply at different times of day to deliver respite and capacity

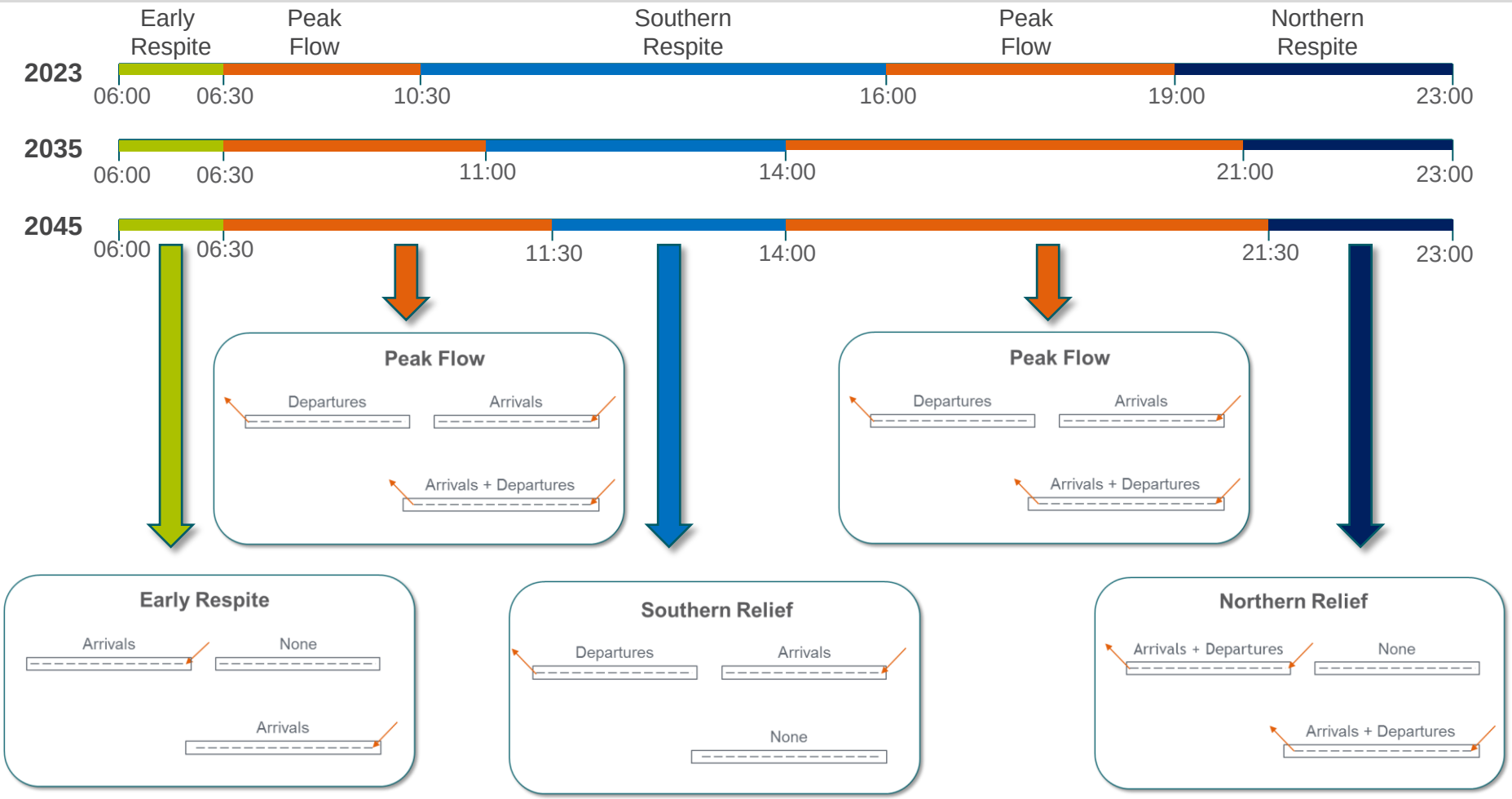



**Figure 3:** Runway modes to deliver respite and capacity – westerlies example

*Not to scale*

# The concept delivers over 700k movements in 2045

Forecasts of demand for annual movements have been provided by Aviation Economics. They are shown in Figure 4 by ICAO aircraft design code (which reflects the aircraft size, with Code F being the largest, eg A380).

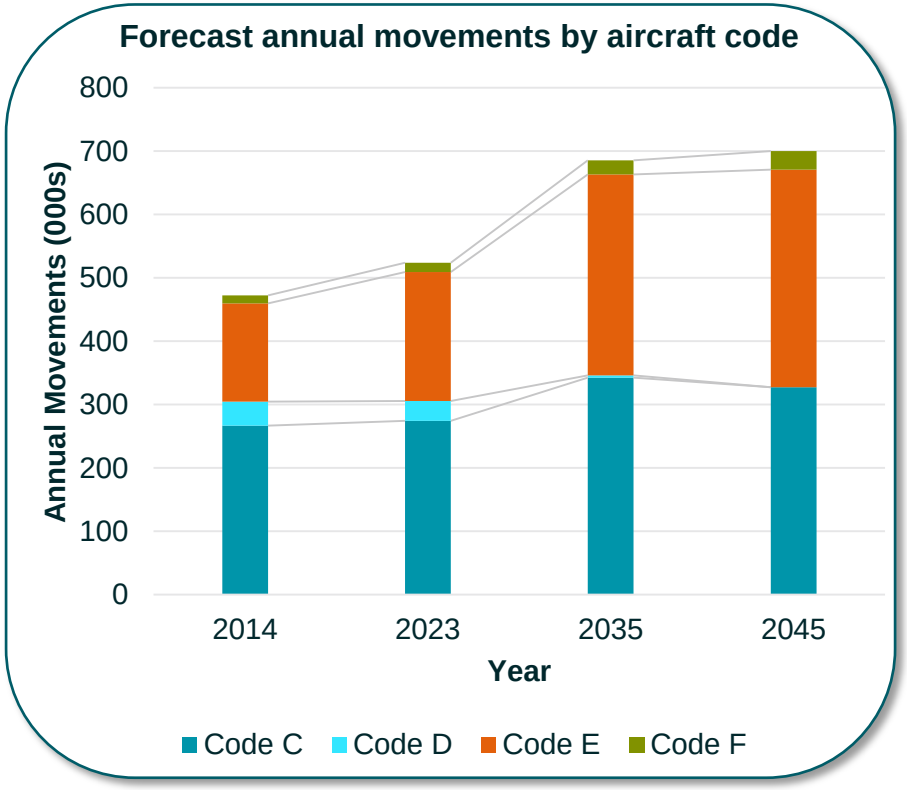



**Figure 4:** Forecast annual movements by aircraft code

The demand is accommodated through the runway modes shown previously and has been demonstrated in the simulations described in Claim 4. The airport capacity is shown in Table 1.

| Airport capacity | 2023 | 2035 | 2045 |
|---|---|---|---|
| | | | |
| **Hourly movements** | | | |
| Early respite | 70 | 76 | 74 |
| Morning peak flow | 124 | 125 | 123 |
| Southern respite | 81 | 84 | 82 |
| Afternoon peak flow | 128 | 129 | 129 |
| Northern respite | 87 | 83 | 83 |
| | | | |
| **Daily movements** | 1,709 | 1,922 | 1,949 |
| | | | |
| **Annual movements** | 623,602 | 701,347 | 711,385 |

**Table 1:** Simulated airport capacity

# This document provides a safety argument of the new concept

## Purpose of this Document

This document provides Heathrow Hub's input to the CAA in the form of a safety argument of the Heathrow Hub aviation concept. It provides supporting evidence and expert judgement for safety assurance to demonstrate that the concept can be acceptably safe.

In particular this document:

- develops expert judgement in the area of procedure geometry modelling (for missed approach, baulked landings and go-arounds);
- considers the impacts of shorter, independent inline runways and interactions with RESAs, including ILS positioning;
- considers integration with baseline independent parallel arrivals/departures, ground infrastructure runway/taxiway movements;
- considers ATC/Tower coordination associated with the new runway modes and changes between modes.

To ensure the assessment supports and aligns with CAA expectations, the Heathrow Hub Safety Assessment team have met with the CAA on the following dates in 2014:

- 23rd May: initial meeting;
- 3rd July: to introduce the concept of operations and hazard assessment output;
- 21st July: to introduce and agree the safety argument structure, confirming key activities;
- 20th August: to present and preview the Safety Argument;
- 9th September: to discuss CAA comments following their review of the draft Safety Assessment.

## Scope of the Safety Argument

The scope is to the extent of where the Heathrow Hub concept affects the baseline concept for aerodrome, ATM and airspace at the time of transition into operation.

For the purpose of this assessment, in line with the Airports Commission assumptions on traffic, 2023 has been assumed as the baseline year to commence phasing the Heathrow Hub concept into operation. This report therefore identifies assumptions on the likely operations, traffic and technology in 2023, and therefore the changes to this baseline that the Heathrow Hub concept will introduce.

# The safety argument focusses on the changes introduced by the Heathrow Hub concept after the 2023 baseline

## Safety argument

The argument for safety assurance (hereon referred to as the 'Safety Argument') is described based on the flight and ground profile/plan perspectives where affected by the Heathrow Hub concept, including interfaces with other infrastructure and airspace. This also includes assurance that protected surfaces are not penetrated.

The focus of the safety argument and supporting evidence or expert judgment is therefore based on the following:

- Identified assumptions of the expected 2023 baseline concept of operations and operating environment, including assumptions on acceptably safe baseline operations.
- Changes introduced to the baseline and their impact on the following elements:
  - Arrivals;
  - Runways;
  - Ground operations;
  - Departures.

Figure 5 provides an overview of the high-level safety argument to make the overall claim that the 'Heathrow Hub aviation concept can be acceptably safe in principle'. The claims within this figure form the structure of this document.

Sub-claims have been then identified in the workshops and through analysis. These are linked to evidence or expert judgement to support the overall safety argument.

Changes introduced by the new concept have been identified by analysing scenarios showing a range of operations. Risk assessment has been conducted based on the changes against the background of the scenarios. Key areas were addressed through hazard identification and then identification of existing and/or new mitigating evidence or expert judgement to ensure reduced risk associated with the concept design.

The mitigations to reduce risk associated with the changes are described in this report, including where the concept design has been adapted as a result.

The top-level safety argument is that the Heathrow Hub aviation concept can be acceptably safe in principle. It is supported by 5 sub-arguments.

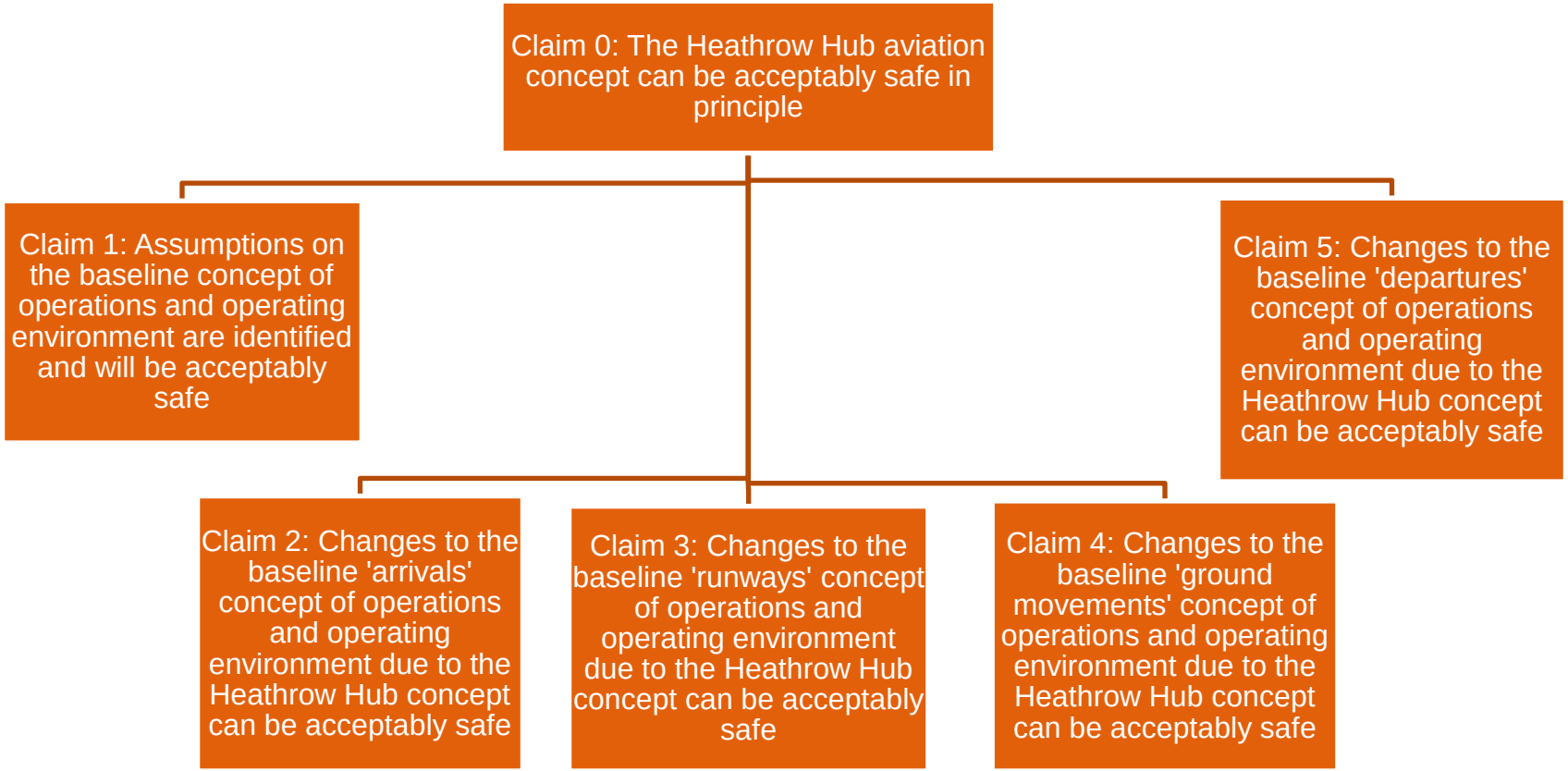



**Figure 5:** Top-level safety argument that the Heathrow Hub aviation concept can be acceptably safe in principle

# The new concept will need to be safely phased-in. A terminology is given for the inline runways in this report

## Phasing-in of the Heathrow Hub concept

A safe transition and 'phasing-in' of the Heathrow Hub concept in stages to full operation is required. The phasing will start from initial third runway building works, through existing north runway shortening, ILS antennas and lighting commissioning/ decommissioning, to phased familiarisation of the new runway modes.

Steps should include the opening of new terminal stands in 'tranches' to aid pilot and ATC familiarisation and validate the proposed airport operation procedures.

Each operational change will require an individual safety case.

## Report terminology for the new inline runways

There is no international standard for naming inline runways. A proposal would therefore need to be made and accepted, either via ICAO or EASA, for the naming of the northern inline runways.

In this report, the following terminology is used:

The furthest runway is described as the extended runway, ie:

- 09L/09Lext, with the new runway identified as 09L and the shortened existing runway identified as 09Lext;
- 27R/27Rext, with the shortened existing runway identified as 27R and the new runway identified as 27Rext.

This is shown in Figure 6.


**Figure 6:** Naming of existing and extended northern runways

# Claim 1

Claim 1: Assumptions on the baseline concept of operations and operating environment are identified and will be acceptably safe

# Claim 1: Assumptions on the baseline concept of operations and operating environment are identified and will be acceptably safe

To identify the changes introduced by the Heathrow Hub concept assumptions on the baseline operation need to be made. There is also an expectation that the baseline operations will be acceptably safe. Figure 7 shows the further two claims to reflect this reasoning.

| Claim 1: Assumptions on the baseline concept of operations and operating environment are identified and will be acceptably safe | |
|---|---|
| | **Sub-claims** |
| 1.1 | Baseline changes are identified (pages 16, 17) |
| 1.2 | Baseline operations will be acceptably safe (page 18) |

**Figure 7:** Claim 1 and sub-claims

# Claim 1.1: Baseline changes are identified

It is assumed that the Heathrow Hub concept will commence transition into operations in 2023. The plan view of the Heathrow runway configuration up until that time will be as per today, as shown in Figure 8. Note that for some time prior to 2023 the current runway 09L/27R will be shorter due to construction work (shown by the blue dotted line).

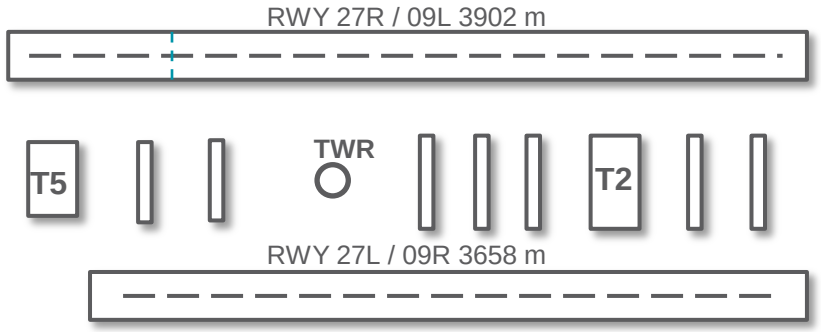



**Figure 8:** Expected 2023 Heathrow baseline runway configuration

The following assumptions are made of the expected 2023 baseline operations. These are consistent with the UK Future Airspace Strategy and current expectations of the London Airspace Modernisation Programme.

## Airspace

- Independent parallel arrivals will be operated, using RNP path extensions and an RNP RF leg turn to establish aircraft onto the ILS.
- Aircraft separations will be based on current separation standards from NATS and CAP493. Some exemptions today that allow reduced separations in certain circumstances have not necessarily been assumed.
- Time Based Separations (TBS) will be applied, supported by the necessary speed conformance tools.
- Specific arrival routes from the hold fix to each runway end in operation will be available, including paths connecting the northern stacks to the southerly runway and vice versa.
- Arrival and departure routes will be strategically de-conflicted.
- Independent parallel departures will be operated with RNP SIDs. Where possible, these will be organised according to compass departures (i.e. by direction of travel).
- Airspace capacity will not constrain the arrival or departure flows.

# Claim 1.1: Baseline changes are identified (cont.)

## Technology

- Arrivals/surface/departure manager tools (known as AMAN/SMAN/DMAN) will be used to control and smooth traffic in, through and out of the airport.
- Instrument Landing System (ILS) will be the approach and landing system for low visibility operations. (The Ground Based Augmentation System or Microwave Landing System may be used if available.)

## ATC/Tower organisation

- One ATCO (TWR) will be assigned to each runway.
- The lighting panel operator position in the tower will no longer be required because of automation of the air-ground lighting.
- Automatic conformance monitoring of runway centre lines during independent parallel approaches will be applied.

## Ground infrastructure

- The Visual Control Tower (VCT) will penetrate the inner horizontal surface (IHS) as at present.
- All taxiways will be suitable for Code F aircraft.

## Runway modes

- There will be 3 runway modes per day (northerly arrivals, southerly arrivals and some use of dual-arrivals) with 2 main mode transitions early in the morning and at 15:00.
- 09L departures and 09R arrivals will be in use.

Figure 9 shows expected arrivals, ground and departure profiles for the 2023 baseline.

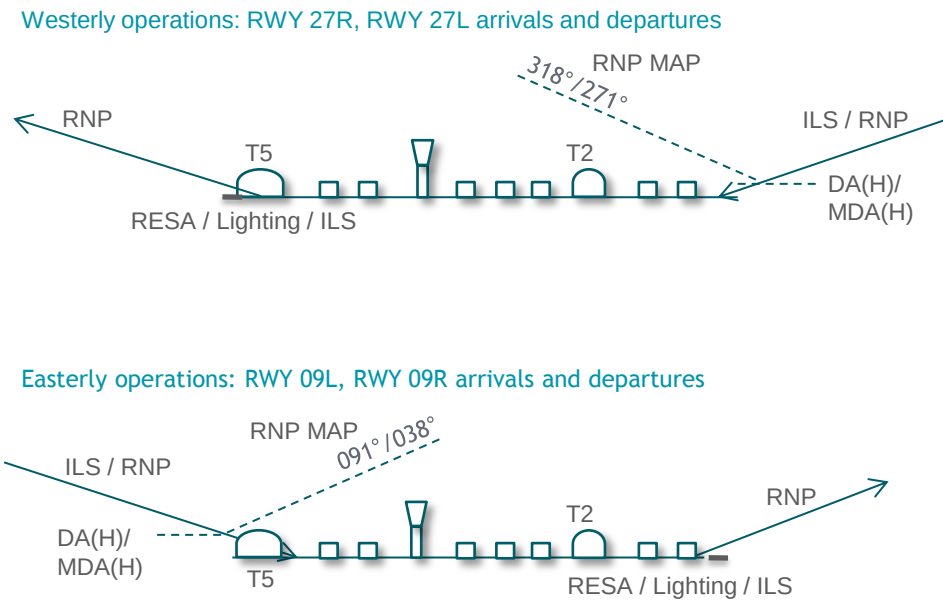



**Figure 9:** Profiles for the 2023 baseline runway configuration

# Claim 1.2: Baseline operations will be acceptably safe

It is assumed that each new concept introduced by the 2023 baseline will be implemented and phased into operation based on an approved safety case and updated unit safety case in accordance with Tower and Air Navigation Service Provider safety management systems and with appropriate regulatory approval.

Each operational change transition will require a safety case including a hazard analysis associated with building, construction, protected areas and impact to existing operations (eg overnight transition from operations on one runway to another during building works and ILS antenna construction, release of new stands, etc).

Transitions will also require simulation, operational planning, and ATCO training and familiarisation.

During the transition phase, lower traffic levels and other restrictions may apply while ATCOs and pilots become familiar with the new operations.

# Claim 2

Claim 2: Changes to the baseline 'arrivals' concept of operations and operating environment due to the Heathrow Hub concept can be acceptably safe

# Claim 2: Changes to the baseline 'arrivals' concept of operations and operating environment due to the Heathrow Hub concept can be acceptably safe

This claim concerns the arrivals operations in the Heathrow Hub concept.

Workshops and discussions identified a number of sub-claims to be addressed, and these principally relate to:

- Changes to normal operations procedures, ensuring inline runway traffic remains within ICAO protected surfaces and runways can operate.
- Changes to ILS antennas positioning associated with the inline runways arriving traffic.
- Changes to the positioning of the runways affecting normal arrivals, focusing on pilot perception.
- How changes to runway modes and new threshold positions may affect independent parallel arrivals.

The claim is supported by analysing issues such as the proposed arrival procedure designs and the impact of missed approaches and baulked landings based on differing aircraft types with maximum payloads. This is supported by a qualitative analysis of the runway and arrival procedures geometries and impacts of go-arounds associated with aircraft on the departures runway. Considerations include interactions with operations of Northolt airfield.

It is assumed that the building works associated with the phases of Heathrow Hub transition will not infringe the protected areas.

Figure 10 shows the sub-claims.

# Claim 2 overview

**Claim 2: Changes to the baseline 'arrivals' concept of operations and operating environment due to the Heathrow Hub concept can be acceptably safe**

| | Sub-claims |
|---|---|
| 2.1 | Arrivals will be protected by the ICAO obstacle limitation surfaces (pages 22-24) |
| 2.2 | One engine inoperative (OEI) operations will remain clear of obstacles (pages 25-28) |
| 2.3 | Missed approach procedures will be flyable and in compliance with ICAO (pages 29-31) |
| 2.4 | Missed approach procedures will take account of Northolt airfield (page 32-33) |
| 2.5 | Public Safety Zones (PSZs) will be protected (page 34) |
| 2.6 | Changes to ILS positioning will not introduce disruptions to arrivals (page 35) |
| 2.7 | Changes to runway positioning and modes will take account of Human Factors aspects (pages 36) |
| 2.8 | New runway modes and changed threshold positions will not affect independent parallel arrivals (page 37) |
| 2.9 | Break-outs on parallel approaches will be handled in compliance with ICAO (page 38) |
| 2.10 | There will be no significant wake turbulence risk when approaching staggered runways (page 39) |

**Figure 10:** Claim 2 and sub-claims

# Claim 2.1: Arrivals will be protected by the ICAO obstacle limitation surfaces

Aircraft are required to be protected by the standard ICAO obstacle surfaces[1]. This has been considered by URS (the masterplan developers) as described below.

Checks have also been made on both the Transitional surfaces around the automated people mover and areas such as Windsor against the Approach and Take-off Climb surfaces. Initial modelling of the Baulked Landing surface indicated that a 600m inter-runway zone would be sufficient and this has been explored in more detail in this report.

On the basis of the investigations to date URS has not identified any significant new infringements of the obstacle limitation surfaces, much of which are unchanged by the proposition.

Three surfaces are key and discussed in the following pages:

- The take-off and climb surface;
- The ILS missed approach surface;
- The baulked landing surface.

Note that the Visual Control Tower (VCT) currently infringes the IHS and exemptions are already applied. These are assumed to continue to apply. The new flight paths are no closer laterally to the Tower than for the existing situation.

The surfaces do not apply for an aircraft with one engine inoperative. This scenario is discussed in claim 2.2.

[1] ICAO Doc 8168, Procedures for Air Navigation Services, Volume II - Construction of Visual and Instrument Flight Procedures

# Claim 2.1: Arrivals will be protected by the ICAO obstacle limitation surfaces (cont.)

## ILS missed approach surface

The proposed missed approach procedures for the inline runways would see an initial climb along runway heading to 500 feet followed by a turn to take the aircraft away from other aircraft operating on the next runway. The aircraft executing a missed approach would need to clear an obstacle by 30m (98ft) in the intermediate phase of climb to be compatible with ICAO requirements from Doc 8168.

The gradient assumed for the ILS missed approach obstacle clearance surface is 1 in 40 commencing from a point 900m along the arrival runway.

If it climbed at the shallowest rate provided for by the obstacle surfaces an aircraft on a missed approach would safely clear the tail of an A380 (the tallest obstacle that could be there, at 79ft) sitting at the start of its take-off run on the inline runway. The height of the surface at this point is 226ft, as shown in Table 2, and it is 147ft above the tail of an A380.

## Baulked landing surface

A baulked landing is "*a landing manoeuvre that is unexpectedly discontinued at any point below the obstacle clearance altitude/height (OCA/H)*"[1].

The baulked landing surface has a gradient of 1 in 30 commencing from a point 1800m along the arrival runway (see Figure 11 and Table 2). For the inline runways the baulked landing surface is more constraining than the ILS missed approach surface but it still safely clears the tail of an A380. At the 27Rext threshold, the baulked landing surface is a height of 202ft (Table 2) which is 123ft higher than an A380 tail.

The easterly geometry is symmetric to the westerly geometry for both surfaces so the same clearance is provided from that direction. No change from the baseline is assumed for the southern runway

[1] CAA CAP168, Licensing of Aerodromes

# Claim 2.1: Arrivals will be protected by the ICAO obstacle limitation surfaces (cont.)

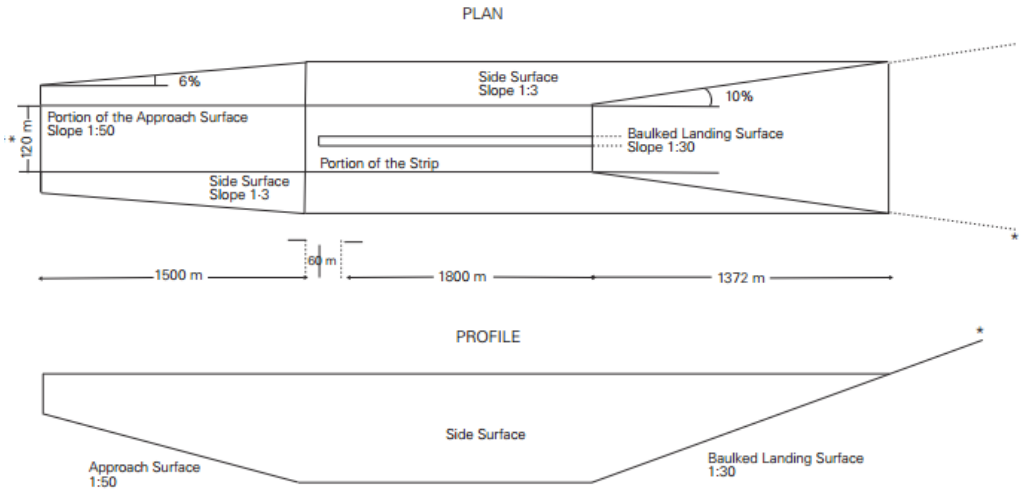



**Figure 11:** Obstacle assessment surfaces, example 27R approach

| | Gradient | Height when over closest obstacle |
|---|---|---|
| **Baulked landing surface** | 1:30 from 1800m along arrival runway | 202ft |
| **ILS missed approach surface** | 1:40 measured from 900m along arrival runway | 226ft |

**Table 2:** ICAO obstacle clearance surface calculations for inline runways

# Claim 2.2: One engine inoperative (OEI) operations will remain clear of obstacles

This claim considers the vertical separation between arriving aircraft with one engine inoperative (OEI) and departing aircraft.

## Assumptions

In this analysis, when considering late baulked landings, it is assumed that the OEI baulked landing will start at or before the end of the touchdown zone (TDZ).

It is important that aircraft land by the end of the TDZ or make a clear decision or execute a missed approach/baulked landing.

To ensure that this happens, the following mitigations may be applied:

- High intensity lights situated at the end of the TDZ (as used at London City) and an instruction in the UK Aeronautical Information Publication (AIP) to pilots that this indicates the latest landing point.
- An automated system is technically possible (eg wheels touching ground) to monitor arrivals and ensure that they have landed by the end of the TDZ. This system would raise an alarm to the controllers if the aircraft had not landed by the end of the TDZ.
- The use of stable ILS approaches by default by flight crews (required to meet ICAO requirements for Simultaneous Operations to Independent Runways, SOIR) which will reduce the likelihood of landing long.
- The use of speed conformance tools (required to implement TBS) on final approach, as assumed in the baseline, which will reduce the likelihood of landings with excessive speed.

## Scenarios considered

Two scenarios are considered in Figures 12 and 13:

- A ‘typical’ OEI missed approach. In this case the aircraft performs a missed approach from ILS CAT I minima (200ft). This is a not uncommon scenario.
- A late OEI baulked landing[1]. In this case, the aircraft performs a baulked landing from touch down at the end of the TDZ. This is an extremely rare scenario.

The purpose of the analysis is to determine when the arriving aircraft (executing the missed approach or baulked landing) reaches a height of 500ft. At this time the aircraft should be capable of following a missed approach that requires a turn away from the extended centreline by 15° according to the missed approach procedures.

# Claim 2.2: One engine inoperative (OEI) operations will remain clear of obstacles (cont.)

An assessment has been made of representative aircraft types that fly to Heathrow and they will all achieve at least 1000ft agl before reaching the turn initiation point.

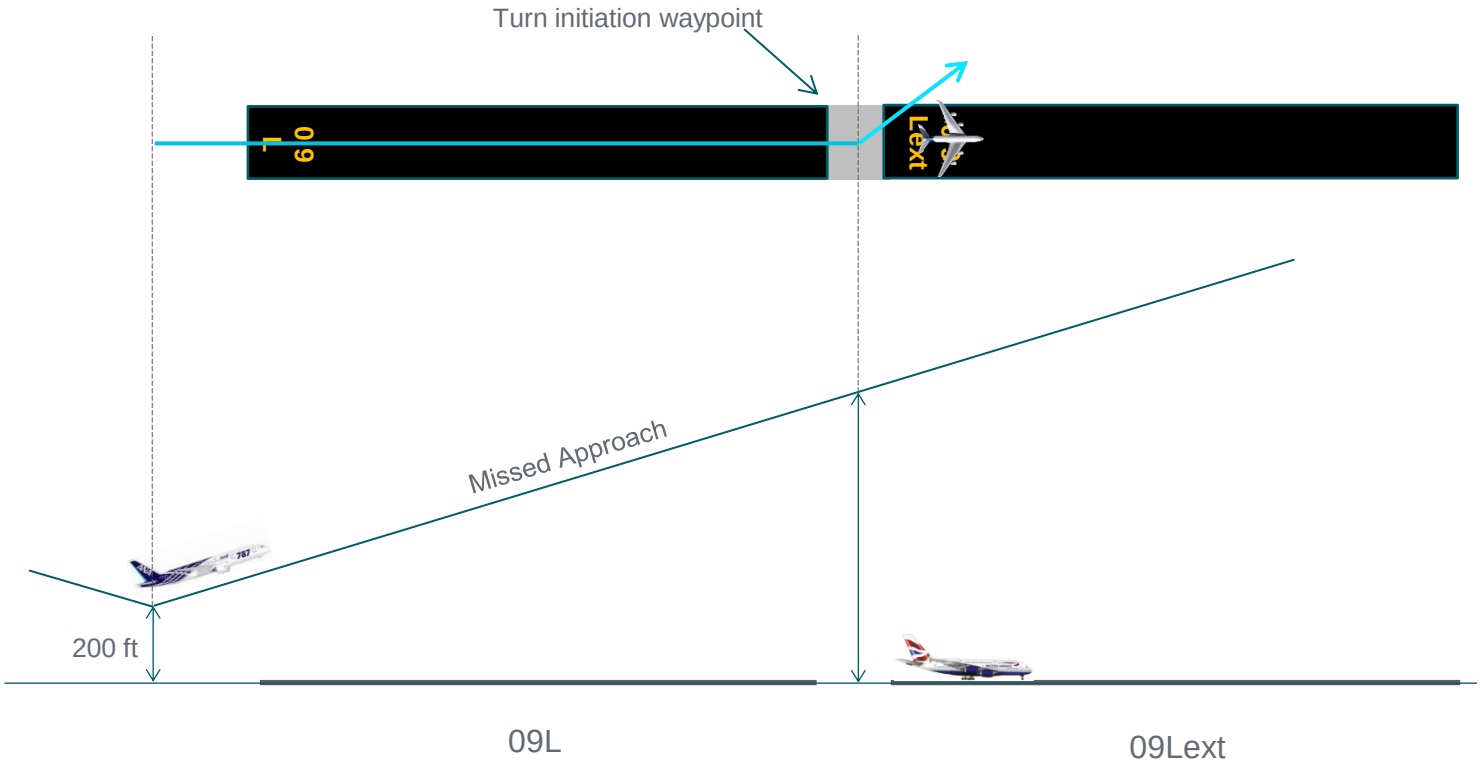



**Figure 12:** Scenario 1: Typical OEI missed approach

# Claim 2.2: One engine inoperative (OEI) operations will remain clear of obstacles (cont.)

An assessment has been made of representative aircraft types that fly to Heathrow and they will all achieve at least 500ft agl before reaching the turn initiation point.

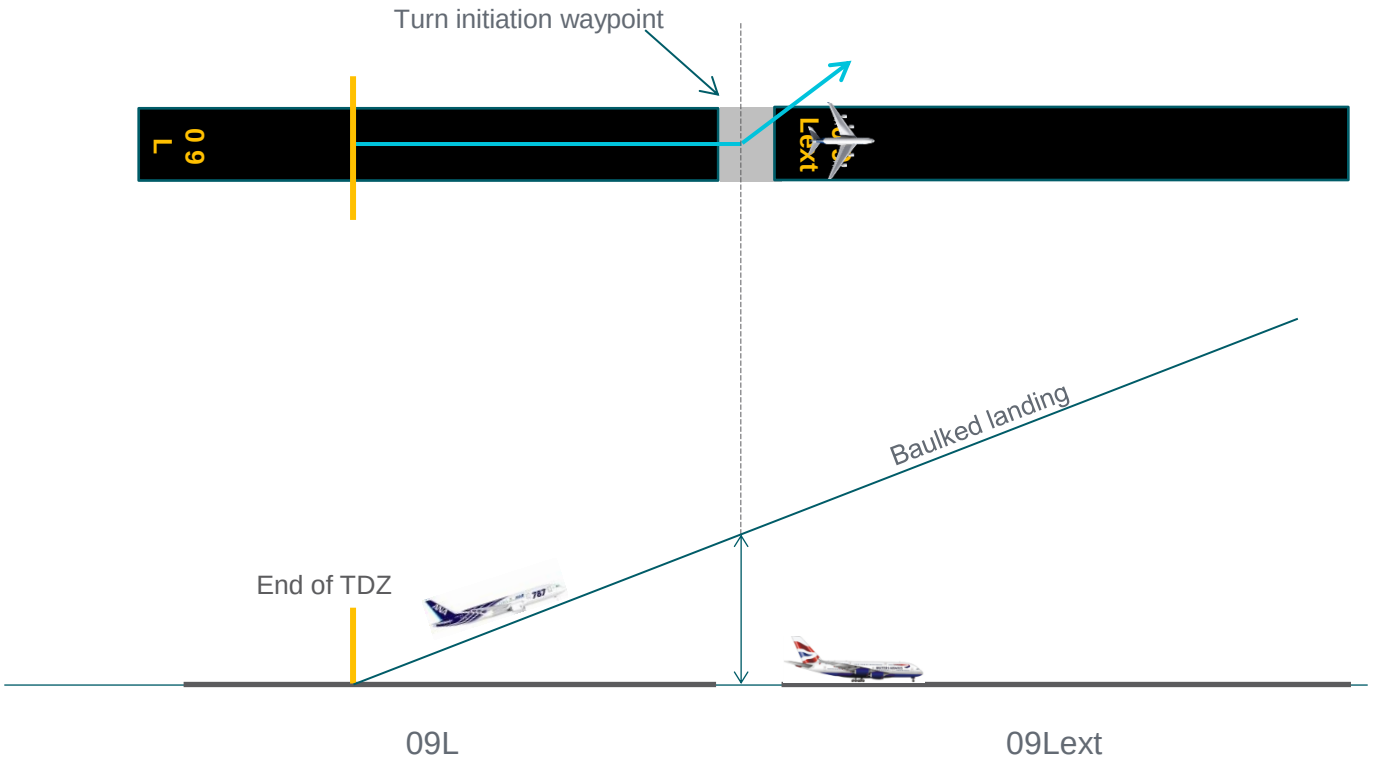



**Figure 13:** Scenario 2: Late OEI baulked landing

# Claim 2.2: One engine inoperative (OEI) operations will remain clear of obstacles (cont.)

This section considers what happens if an OEI aircraft fails to follow the correct missed approach procedure. An OEI arriving aircraft on a missed approach could come in close proximity with a departing aircraft if the following events all occurred:

- The arriving aircraft has an unannounced or late engine failure at or after the missed approach point.
- The aircraft then executes a late baulked landing commencing from touch down at the end of the TDZ.
- The arriving aircraft does not follow the RNAV missed approach procedure and continues straight over the departure runway either through autopilot failure or flight crew missing the turn (if flying manually).
- The arrivals controller fails to detect the aircraft going around and/or fails to activate the missed approach alarm and/or does not intervene to ensure the initial turn occurs and/or the pilot does not comply with any instructions given.
- The departing aircraft is given a take-off clearance after the arriving aircraft has started its missed approach, or the clearance was given earlier and the crew takes some time to commence the take-off roll. (In the most challenging scenario, there are over 30 seconds between the latest start of the baulked landing and the start of the take-off roll for the departure aircraft.)
- The departure controller does not cancel the departure clearance before the departure reaches take-off decision speed, or the pilot does not comply with the clearance.
- The departing aircrew fail to see or ignore the aircraft on the missed approach (which would be overhead/in-front at the time that it started its take-off roll),

A missed approach alarm is already operated in the Heathrow tower. It provides a warning (e.g. at Northolt and in terminal control) when a missed approach is underway.

As a mitigation, this alarm should be retained and used to advise the departure controller when a missed approach is underway. The two controllers will also sit side by side to aid coordination. This creates a dependency between the two runways which is similar to the current arrangement between Heathrow and Northolt. (Aircraft cannot depart from Northolt when the missed approach alarm is activated).

As a fall-back mitigation, the two runways could be operated in a dependent mode, whereby take-off clearances are only given to aircraft when arrivals are not in a situation where they may execute a missed approach. However, the chain of events described here are not dissimilar to those which could occur today at a busy single runway (as is the case when Heathrow currently has to revert to single runway operation) and therefore the operation is expected to be achievable without this additional mitigation.

# Claim 2.3: Missed approach procedures will be flyable and in compliance with ICAO

## Diverging missed approach and departure tracks

ICAO Doc 9643 Manual on simultaneous operations on parallel or near-parallel instrument runways (SOIR) requires that:

"*the missed approach track for one approach diverges by at least 30 degrees from the missed approach track of the adjacent approach*"

It is conservatively assumed that this requirement should apply between departure tracks and also missed approaches. The missed approaches therefore all have a straight ahead climb followed by a turn as shown in Figure 14.

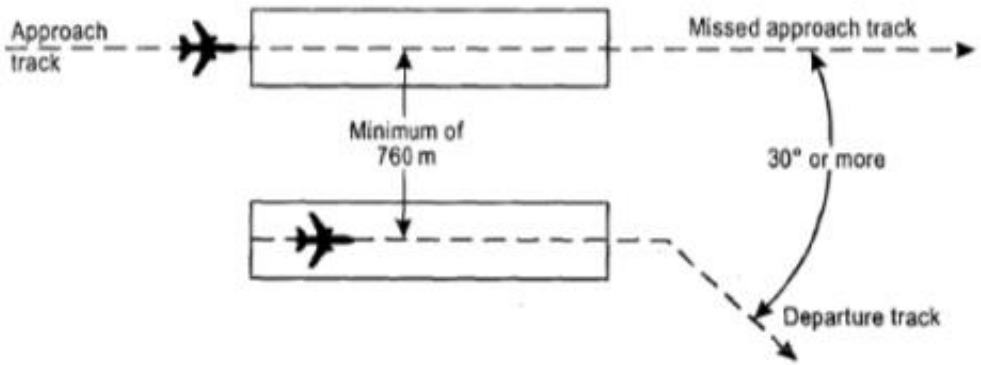



**Figure 14:** ICAO SOIR requirements for missed approaches

# Claim 2.3: Missed approach procedures will be flyable and in compliance with ICAO (cont.)

## Missed approach objective and aims

The objective of the missed approach procedure for the inline runways is to provide a safe, flyable procedure that ensures safe separation from other aircraft on the ground and in the air.

To this end, and following the study workshops, the aim has been to:

i) Ensure that the aircraft going around turns away from any aircraft (static or mobile) that may be on the inline runway ahead.

ii) Ensure that the turn can be conducted safely in a OEI situation.

To meet these aims a procedure has been proposed that allows the aircraft going-around to initiate a turn prior to the threshold of the inline runway. Furthermore, it has been proposed to code the missed approach as an RNAV procedure to increase likelihood of compliance with the turn. Finally, the start of the turn has been established at a point by which all aircraft, including those with OEI, will have reached 500ft at which point safe manoeuvring is allowed (by flight deck procedures and ICAO).

## RNAV missed approach guidance

To help provide predictability in go-arounds, to reduce the likelihood of aircraft failing to turn on the missed approach and to improve cockpit workload during the missed approach, the procedure is proposed to be coded as a full RNAV missed approach. This will allow aircraft equipped with TOGA to LNAV or TOGA to NAV capability to automatically initiate RNAV missed approach guidance when TOGA (take-off go around) is initiated.

There will be nothing to prevent the missed approach being flown manually – this is necessary in the event of a late baulked landing where the FMS may have already de-selected the missed approach procedure assuming the aircraft had landed. However, it is desirable for the go-around track to be flown by the aircraft allowing the crew to focus on compliance with level restrictions.

Upon initiating the missed approach the aircraft will climb following the runway centreline until it reaches a waypoint signifying a turn. This waypoint will be located in the area in between the inline runways in order to guarantee that any OEI aircraft will be able to have reached 500ft.

# Claim 2.3: Missed approach procedures will be flyable and in compliance with ICAO (cont.)

## Turning at 500ft

In most cases a missed approach will have climbed above 1000ft by the time that it reaches the turn initiation waypoint. However, there may in a small set of circumstances be a need for the missed approach turn to be initiated at a height of 500ft agl (above ground level) – namely from a baulked landing or with OEI. This possibility has been considered from an ATM, flight deck and procedure design perspective. There is no reason preventing aircraft turning at 500ft; it is fully compatible with ICAO and UK requirements.

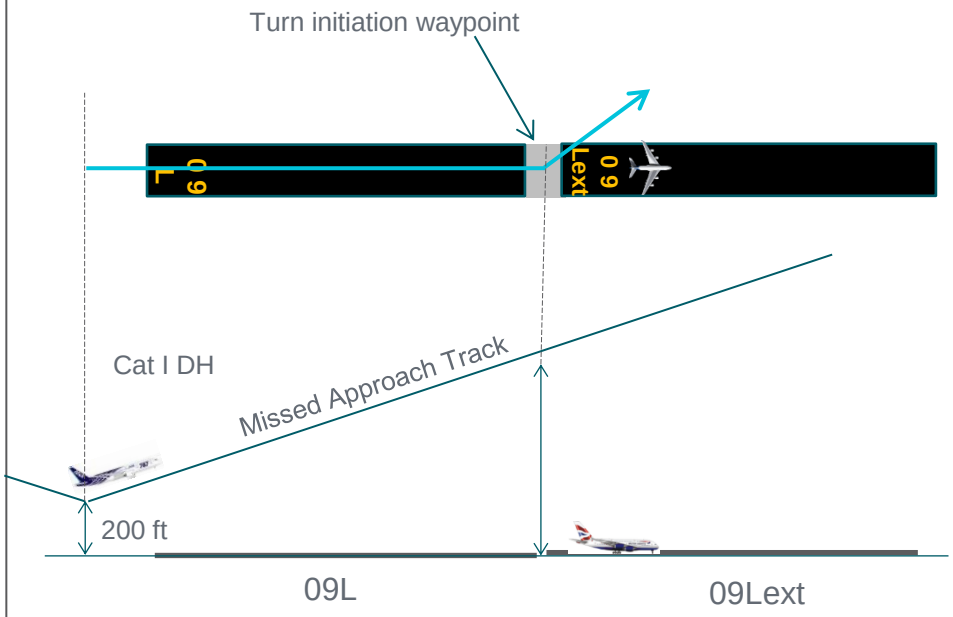



**Figure 15:** Missed approach turn initiation waypoint

# Claim 2.4: Missed approach procedures will take account of Northolt airfield

## Interactions with Northolt

Traffic into and out of Northolt follow clearly defined routes designed to provide separation from Heathrow traffic. Departures turn north at 700ft and approach control keeps arrivals low once they have been handed over by the Heathrow Director. It may be beneficial for RNP arrivals and departures to be implemented at Northolt to provide further confidence to ATC as to the routing of traffic.

There is coordination between Heathrow tower, approach control and Northolt tower for Heathrow missed approaches. In the event of a missed approach at Heathrow an alarm sounds in Northolt tower and the controller there is required to hold departures. This dependency is expected to continue and is expected to remain manageable. It is further expected that the alarm may also be extended to the controller handling departures from Heathrow in order that they can be aware of missed approaches and if necessary intervene to separate Heathrow and Northolt traffic.

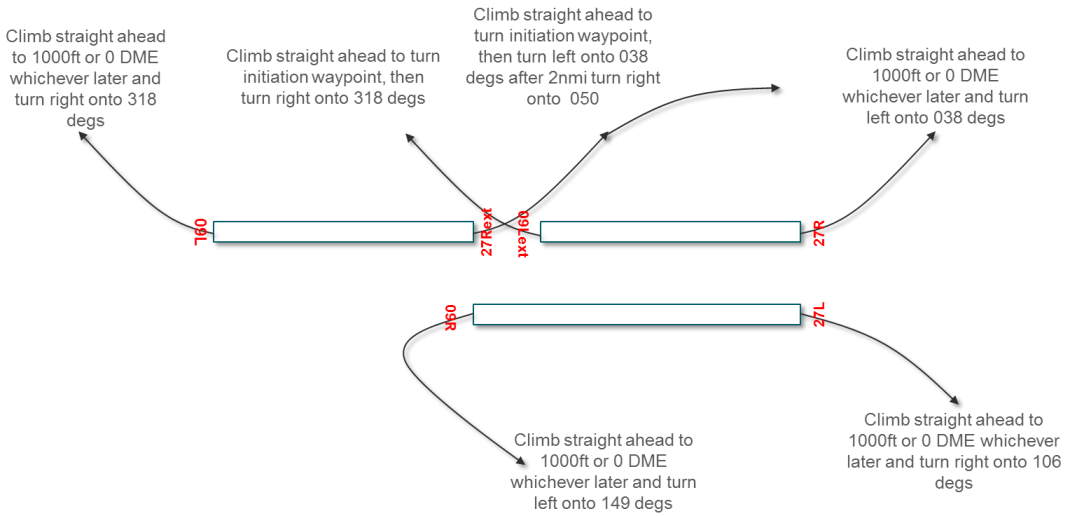
When operating on westerlies, missed approaches from the 27 runways have the potential to interact with Northolt departures (and missed approaches). There is no change to the present situation expected in this situation – the 27R missed approach is the same.

When operating on easterlies, missed approaches from the 09 runways have the potential to interact with Northolt arrivals. The missed approach for 09Lext is no different to the present. The missed approach for 09L would potentially result in smaller separation than present from inbound routes to Northolt. As a consequence a second turn has been inserted into this procedure to ensure separation is preserved by design whilst also accepting that the existing ATM procedures for coordination during a missed approach will also apply and that the controller in the approach control centre may choose to intervene depending upon the traffic situation.

# Claim 2.4: Missed approach procedures will take account of Northolt airfield (cont)

## Indicative missed approach procedures

Figure 16 shows the indicative missed approach procedures, where those to 09L and 27R are to be coded as RNAV missed approaches with a turn commencing at a fixed waypoint by which all aircraft are expected to achieve 500ft agl. Also shown is the relationship between the 09L missed approach and Northolt arrivals.



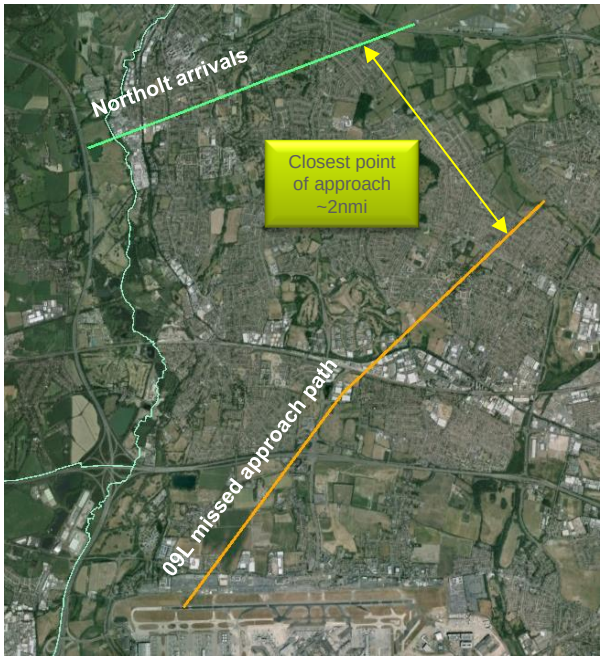




**Figure 16:** Proposed missed approach procedures and proximity to Northolt

# Claim 2.5: Public Safety Zones (PSZs) will be protected

PSZs are areas around runways where developments are controlled. The PSZs for the new runway will need to be calculated using a risk-based calculation, but an illustration of the possible $10^{-4}$ and $10^{-5}$ contours is provided in Figure 17 to show the likely area affected to the west of the airport. Both contours are approximated as triangles from the airport boundary. The figure shows the likely PSZs will be in low-density areas of development.

When operating the inline runways, normal PSZs do not apply to the central area. This is because there are no landings or departures over the adjacent inline runway. Aircraft would only overfly the central area when executing a missed approach or baulked landing and they would anyway be turning away from the runway. A risk based analysis would need to reflect this. The inline runway concept may therefore not be adequately covered by existing the PSZ policy which may need to be updated prior to the concept introduction.

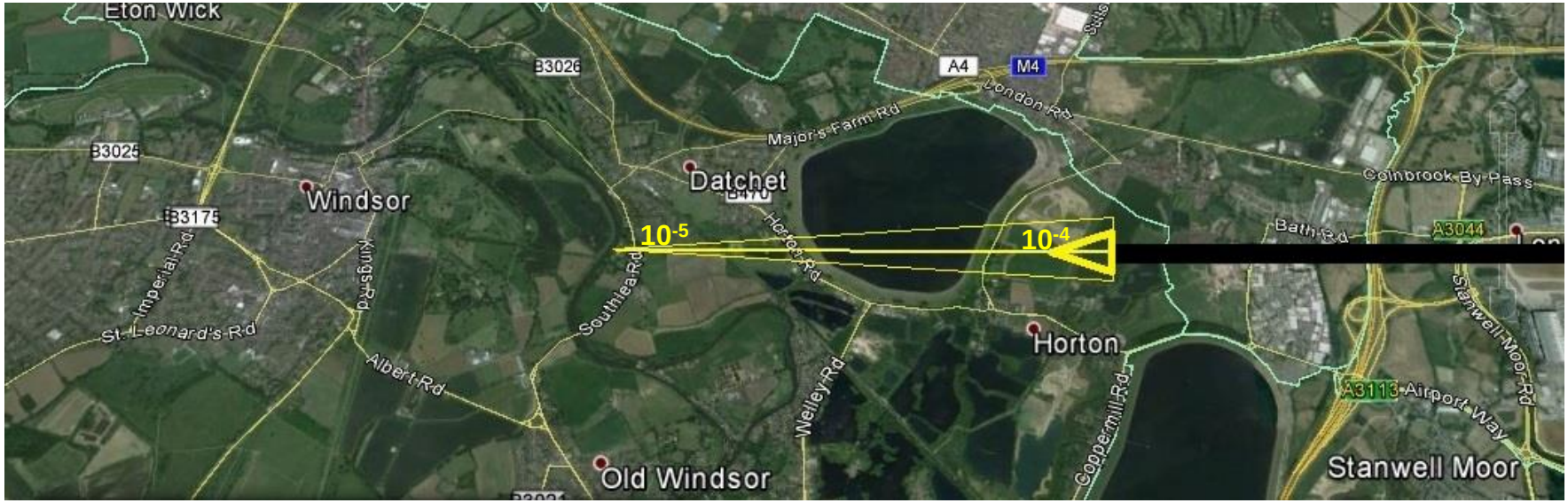



**Figure 17:** Illustrative PSZ for new runway

# Claim 2.6: Changes to ILS positioning will not introduce disruptions to arrivals

ILS will remain the mandatory approach aid, as assumed for the 2023 baseline operation. The complete repositioning of ILS antennas associated with the inline runways requires confirmation that there is no adverse impact on ILS arrivals to these runways. The positioning of the ILS antennas in the RESAs is suitable to support ILS-based arrivals.

Antennas must be positioned far enough away to avoid damage from jet-blast or vehicle obstruction affecting ILS operability for arrivals on the adjacent inline runway.

Note that this is the claim for ILS effects on arrivals. Potential issues (and risk reducing expert judgement) directly associated with runway, ground and departure operations are addressed within other sections (claims) of the safety argument in this document. Arrivals could be affected where ILS equipment was damage or inoperable and thus the ILS was unavailable to arriving aircraft.

It is assumed that the associated building works (eg the ILS antennas installations) will not infringe protected areas.

All runways are expected to be equipped with Category III ILS equipment that provides the necessary signal accuracy to achieve SOIR performance on all runway ends. It will also mean all aircraft and runway modes can be accommodated in low visibility conditions.

It is assumed that vehicles will be prevented from entering the RESA between the runways.

### Risk arising from jet blast

A key risk arising from jet blast is damage to the ILS localiser antennas in the central area of the inline runways, thereby preventing ILS arrivals.

The FAA requires 600ft (182m) to be provided between engine output and other surface elements such as ILS localisers.

As can be seen under Claim 3, more than 300m is provided between the ILS antennas and the closest point at which the take-off roll starts. Suitable antennas will be required that can withstand jet blast at this range, but it is not expected to be a challenge since some existing Heathrow ILS antennas are at a similar distance from the start of the take-off roll.

# Claim 2.7: Changes to runway positioning and modes will take account of Human Factors aspects

The human performance aspects associated with pilots on approach to the inline runways need to be considered. For example, the pilot perception of the standard length runway on approach to 27R compared with the perception of a longer runway with 27Rext in the distance. Likewise, for example, the perception of the threshold to 27Rext compared with the perception of a deep landing on a long runway whilst approaching 'over' 27R.

Mitigations to the risk of perception error must be resilient to all operating environment conditions, such as sun glare, penetrating low cloud, etc. Where mitigations rely on flight deck indications and tools (eg CAT III operations in poor visibility mitigates perception risk in low cloud risk), such mitigations need to be validated.

Human perception of inline runways has been considered, particularly focusing on the lighting considerations required in combination with other runway infrastructure (eg ILS antennas not interfering with lighting and vice versa).

To prevent confusion with lighting solutions the non-operating runway lights will always be switched off and the operating runway lights always switched on. This will prevent the possibility of a pilot being mis-led by lighting associated with the other inline runway.

A significant mitigation to pilot confusion is also the fact that an aircraft landing on the furthest inline runway will be over the nearer runway by the time it reaches the CAT I decision height. So the pilot would not see the landing threshold of the nearer runway at this point.

It is assumed that the building works associated with the phases of Heathrow Hub transition will be within the protected areas, including appropriate scheduling of lighting installations.

## Runway mode changes

During the day, the modes of runway operation will change as respite is provided or in response to changing weather conditions.

The approaches to the inline runways could potentially cause confusion to pilots if there were multiple approach paths available at the same time or the extended runway were to create the perception of a long runway.

Therefore, ILS and lighting systems will be controlled such that only one approach path will be enabled at any one time.

# Claim 2.8: New runway modes and changed threshold positions will not affect independent parallel arrivals

The independent parallel arrival procedures are not expected to be altered significantly by the Heathrow Hub concept. However, there would be some changes in the areas of:

- Handling break-outs on the parallel approach with increasing movements;
- Staggered 27L/27Rext thresholds during early and northern respite modes (westerly);
- Staggered 09Lext/09R thresholds during early and northern respite modes (easterly);
- Staggered 09L/09R thresholds during peak flow mode (easterly).

## Increased flow rates onto approaches

The most significant change would be a change in the design of the RNP transitions to accommodate an increasing volume of traffic over the years. The exact configuration will require further assessment, but at this stage no new risks have been identified which prevent the concept.

Fast time simulations suggest that it is possible to maintain an arrivals throughput in line with the forecast. However, the arrival rate to the airport will also depend on airspace changes applied under the London Airspace Management Programme (LAMP).

The exact airspace design and traffic flows will require further simulation to ensure controller workload is appropriate, given the expected changes introduced by LAMP.

# Claim 2.9: Break-outs on parallel approaches will be handled in compliance with ICAO

ICAO Doc 4444 PANS-ATM and Doc 9643 Manual on Simultaneous Operations of Parallel or Near-Parallel Instrument Runways (SOIR) specifies the use of a No Transgression Zone (NTZ) when operating independent parallel approaches into runways closer than 1525m. The minimum width of the NTZ is 610m.

An aircraft established on the ILS localiser course is considered to be separated from an aircraft on the adjacent parallel runway ILS localiser course, provided neither aircraft penetrates the NTZ. See Figure 18.

(*Note: for staggered thresholds, the NTZ may not be required from a regulatory perspective, but may still be applied to ensure safety margins*)

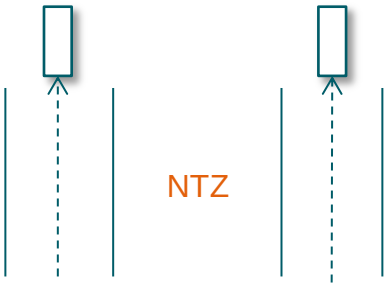



**Figure 18:** No Transgression Zone

If an aircraft penetrates the NTZ, the aircraft on the parallel approach will “break-out” from its approach by turning at least 30 degrees away from the centre-line.

The break-outs could occur at any point along the final approach, meaning the airspace must be designed to cope with 30 degree turns to the north and south of the final approach paths. This is already assumed in the baseline airspace design in 2023.

Controller workload simulations will be required to ensure that the number of aircraft being broken out can be managed safely but there is no evidence that the number of “break-outs” will be unmanageable. ATCOs are assumed to be supported with automated alerting in case of NTZ infringement.

Where the NTZ infringement occurs on short finals, coordination will be required between the APP or TWR controller handling the approaching aircraft, and the TWR controller on the departing runways, to ensure adequate separation is maintained. For the specific case of Northolt, Missed Approach paths will be used to ensure safe separations as per Claim 2.4.

# Claim 2.10: There will be no significant wake turbulence risk when approaching staggered runways

The runway configurations for the concept result in three new relationships between the two approach paths, as shown in Figure 19.

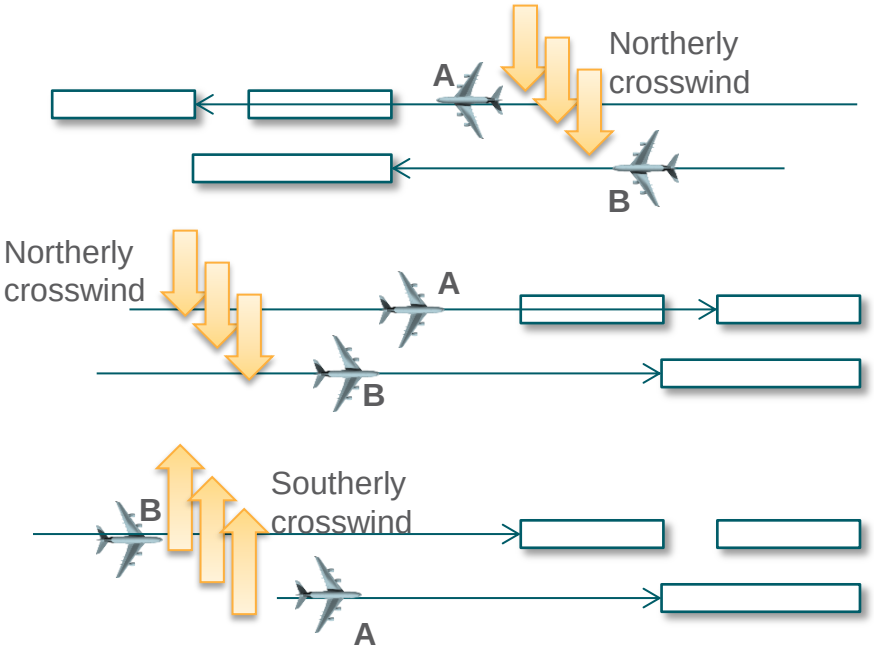



**Figure 19:** 'Staggered' runway arrival modes and wake turbulence

An aircraft on approach to the further runway threshold – aircraft A in the Figure – will be higher at an equivalent point (latitude), by up to 600ft (worst case in the first and third examples).

Wake vortices will descend, and could be blown to the parallel approach path, where the other aircraft (B) is at a lower point at the equivalent point. Depending on the crosswind and the sink rate of the vortex, it could enter the approach path of aircraft B.

ICAO PANS-ATM only specifies a dependency in runway operations due to wake turbulence when the runways are separated by less than 760m. This is not the case here since the runways have greater separation (over 1000m).

Nevertheless, wake vortex behaviour is not well understood and if wake vortex interactions are a concern then the following mitigations could be applied:

- Putting larger aircraft on the downwind path.
- Making the arrivals dependent in certain wind conditions.

Note that wake vortex interactions are less of a concern for departures since the SIDs are divergent.

# Claim 3

Claim 3: Changes to the baseline 'runways' concept of operations and operating environment can be acceptably safe

# Claim 3: Changes to the baseline 'runways' concept of operations and operating environment due to the Heathrow Hub concept can be acceptably safe

The claim concerns the runway operations in the Heathrow Hub concept.

The key areas associated with the runways element of the concept that were identified are:

- Changes to introduce the inline runways including the interaction with new ground equipment, terminals and taxiways, positioning of runways associated with existing infrastructure and effects of changed runway dimensions
- Effects of the ILS antennas positioning within the RESA between inline runways for aircraft taking-off and touching-down (ie ensuring no physical interaction).

Figure 20 shows the sub-claims for Claim 3.

**Claim 3: Changes to the baseline 'runways' concept of operations and operating environment can be acceptably safe**

| | Sub-claims |
|---|---|
| 3.1 | The central area between the inline runways will contain a suitable RESA and ILS equipment (page 42) |
| 3.2 | Runway entry and exit and taxiway design will be appropriate (page 43) |
| 3.3 | The visual control room will have visibility of the airfield (page 43) |
| 3.4 | Appropriate ATC staff responsibilities will be defined (page 44) |
| 3.5 | Suitable runway lighting will be provided (page 44) |
| 3.6 | The new runway lengths will be sufficient for long-haul departures (page 45) |
| 3.7 | ILS equipment location will not impact aircraft movements (page 46) |

**Figure 20:** Claim 3 and sub-claims

# Claim 3.1: The central area between the inline runways will contain a suitable RESA and ILS equipment

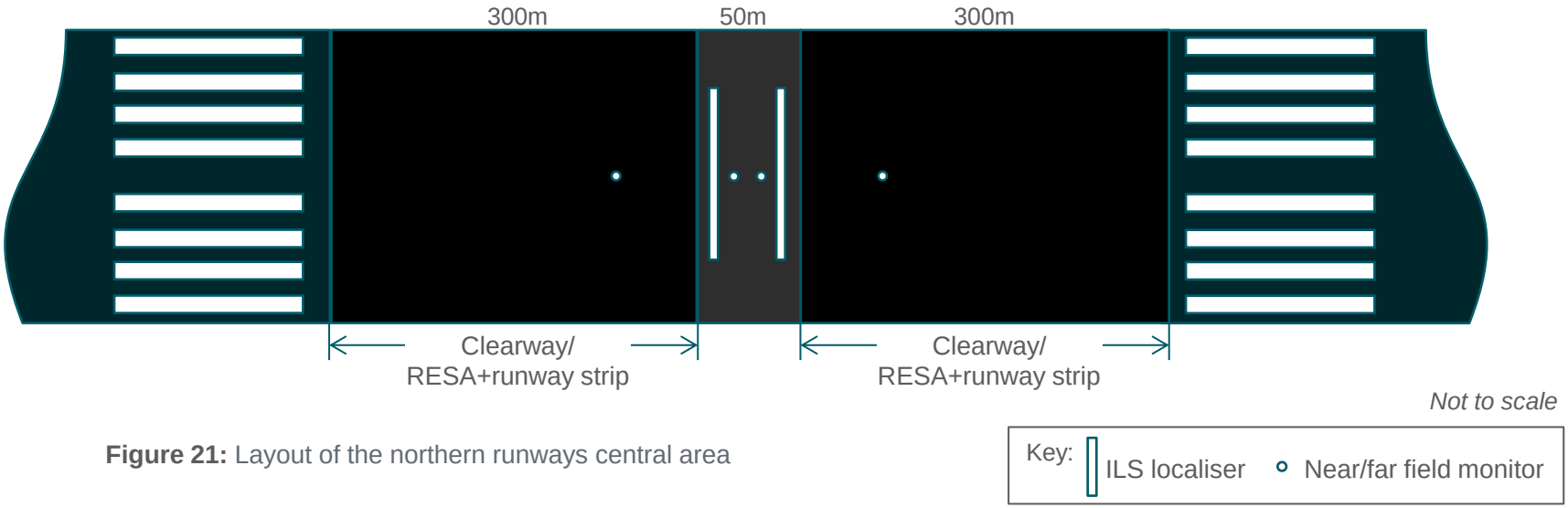



**Figure 21:** Layout of the northern runways central area

RESAs are provided to mitigate the risk of runway excursions (over-runs). The primary mitigation is the application of a RESA to assist the aircraft in stopping prior to significant obstacles (in this case, potentially another aircraft).

The RESAs comply with ICAO recommendations which are that Code 3/4 airports are recommended to be 240m long, following a runway strip of 60m.

Figure 21 shows the central area between the runways.

The runway design shows the distance of the nearest non-frangible object in case of a runway overshoot is 650m (assuming the ILS antennas are frangible in both directions).

As with current procedures, there will be constraints on movements in the ILS critical and sensitive areas to protect the integrity of the ILS signal. Some operational constraints may arise during low visibility procedures, similar to the present situation.

# Claim 3.2: Runway entry and exit and taxiway design will be appropriate
# Claim 3.3: The visual control room will have visibility of the airfield

## 3.2 Runway entry and exit and taxiway design

The runway entry points are at 90 degrees to the runway, to allow maximum situational awareness of the approach path as the departing aircraft lines up.

Rapid Exit Taxiways (RETs) will be designed in line with ICAO recommendations. Some additional RETs (compared to the May 2014 submission) have been added to the masterplan design to allow aircraft to clear the runway at the optimum point. This will also reduce the risk arising from go-arounds, since appropriate placement of RETs is one of the mitigations to aircraft spending too long on the runway (which is a cause of go-arounds).

## 3.3 Visual Control Room (VCR) visibility

The location of the existing VCR has been checked against the position of the new runway to ensure it retains sufficient visibility.

A monorail is proposed linking Terminal 5 and the new Terminal 6 with the central terminals (currently 1, 2 and 3). This monorail may propose a risk to the line-of-sight from the VCR to the southern runway and manoeuvring areas. The monorail design must remove any risk that the line-of-sight is compromised. If necessary, it is understood that the monorail could be made an underground link.

The VCR will need to offer good visibility to the new northern runway. The far end of this is nearly 4500m from the VCR. Additional cameras for remote monitoring may therefore be required.

# Claim 3.4: Appropriate ATC staff responsibilities will be defined
# Claim 3.5: Suitable runway lighting will be provided

## 3.4 ATC staff responsibilities

The extra runway will require a dedicated TWR controller and frequency. This means there will be 3 TWR controllers for the concept instead of 2 for the baseline.

Good coordination and clear procedures will be necessary between each of the TWR controllers with active runways.

The core tasks of the controllers are likely to remain unchanged for TWR and GND service provision. However, the interaction between the two inline runway controllers will need to be defined since a missed approach to the arrival runway may require aircraft to be held on the departures runway.

A Human Factors assessment will be required as part of the development of the operating procedures for the new controller and other controller interactions.

The VCR currently has limited space to house an additional controller. As noted in Claim 1, it is assumed that the existing light panel operator position will not be required in the baseline. This should create space for the new TWR controller position.

## 3.5 Runway lighting

ILS CAT III lighting will be provided to all runway ends. For the approaches to 09Lext and 27Rext, the lighting will be embedded in the adjacent inline runway.

No constraints have been identified that would prevent the runway lighting implementation.

Analysis of line-of-sight of arriving aircraft has been conducted and shows that the central ILS antennas should not obscure the approach lights.

The end of the touchdown zone (TDZ) may be marked with two pairs of white inset high intensity lights as, for example, London City airport.

# Claim 3.6: The new runway lengths will be sufficient for long-haul departures

The northern runways provide a take-off run available (TORA) of 3000m and a take-off distance available (TODA) of 3300m. It was recognised in the May 2014 submission by Heathrow Hub to the Airport Commission that this could constrain some long-haul departures under specific conditions of aircraft load, range, wind, temperature and precipitation. In this case, these aircraft would expect to depart from the longer (3600m) southern runway or, if they could not, to operate with a limited take-off weight.

Whilst there will be some constrained aircraft, there is no evidence that this will be sufficient to cause operational problems such as taxiway congestion.

In case the number of required-southern departures is large enough to cause operational problems, then several mitigations are possible.

Firstly, a starter extension could be provided for the northern runways. It is anticipated that 50m additional run could be provided with minimal impact. Up to 150m could be provided if the ILS antennas can withstand the jet blast at 150m range (some airports that handle large aircraft already have lower jet blast protection distances). This would increase the TORA to up to 3150m and TODA to 3450m, and would remove any significant operational limitations.

It is unlikely to be required, the northern runways and/or clearways could also be extended to the west. Although this would have a significant financial impact on the project, it would have only limited environmental, operational and safety impacts. The main safety impact would be that the limiting obstacle on the western departures could start to infringe the take-off flight path. This would mean that airlines would have to take account of the obstacle when planning their departures.

Figure 22 shows a possible longer configuration of the northern runways. In this case, the runways have been lengthened by 150m to 3150m and the western end therefore moves west by 300m.

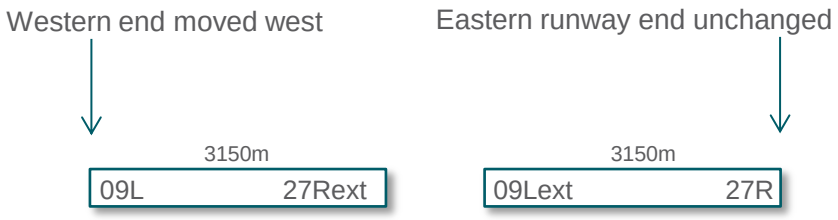



**Figure 22:** Possible longer northern runway configuration

# Claim 3.7: ILS equipment location will not impact aircraft movements

The ILS localiser antennas (and the associated near/far field monitors) will be sited in the central area between the inline runways and it is necessary to ensure that these do not affect operations.

ILS localisers for 09L and 27R will be installed in the central area. Each will be separated from the other by around 40m. Between the localisers will be the Far Field Monitors for 27Rext and 09Lext. The Near Field Monitors for 09L and 27R localisers will be installed in front of the equipment in the RESAs as is currently the case.

The locations of the surface elements and the geometry of the central area is shown in Figure 21.

The siting of the ILS antennas meets international requirements and are outside the RESAs.

The ILS antennas must be protected from jet blast and this is considered in Claim 2.6.

Although not required to comply with international standards, it is recommended that the localisers and monitors are frangible in both directions of potential impact.

# Claim 4

Claim 4: Changes to the baseline ground movements' concept of operations and operating environment can be acceptably safe

# Claim 4: Changes to the baseline ‘ground movements' concept of operations and operating environment due to the Heathrow Hub concept can be acceptably safe

This claim concerns the ground operations introduced by the Heathrow Hub concept. It examines the ability of the taxiways and ground movement operations to support the runway movements expected in 2023 and beyond, taking account of infrastructure between the three runways, as well as the impact of Terminal 4.

The key areas of focus associated with the ground movements element of the concept relate to the changes to baseline operations associated with the functioning of the airport’s ground movements and taxiing in the new configuration.

This claim is supported by simulation modelling with the aim of identifying procedures that can ensure the airport operates without bottlenecks or congestion. Simulations have been conducted that both include and exclude Terminal 4.

Figure 23 shows the sub-claims for Claim 4.

| Claim 4: Changes to the baseline ‘ground movements' concept of operations and operating environment due to the Heathrow Hub concept can be acceptably safe | |
|---|---|
| | **Sub-claims** |
| 4.1 | Terminal 4 southern runway crossings will not cause an undue impact on capacity (page 49) |
| 4.2 | Traffic demand will be accommodated on the ground (page 50-51) |

**Figure 23:** Claim 4 and sub-claims

# Claim 4.1: Terminal 4 southern runway crossings will not cause an undue impact on capacity

It is assumed that Terminal 4 arrivals and departures will plan to operate on the southerly runway where possible, reducing the need for crossing of the active runway.

However, if the ILS is still in operation, as assumed for 2023, then there are occasions where some aircraft will still need to cross the southern runway to depart. This is because operational constraints imposed by the ILS equipment location prevent some large aircraft from departing on the southern runway from the southern entry points. So they must cross to the north side and depart from there, as shown in Figure 24.

In the simulation all runway crossings occur at or near to the threshold at which aircraft will commence their take-off run to avoid crossing at high energy points.

The simulation found that the targeted capacity can be achieved whilst crossing aircraft on the southerly runway without undue impact.

The simulation also considered a scenario where Terminal 4 was closed. In this case, the simulation showed that there could be a shortage of stands in the central area by 2045. To mitigate this, there may need to be a change in turn-around times, overnight parking and/or a slight increase in the number of stands in the central area.

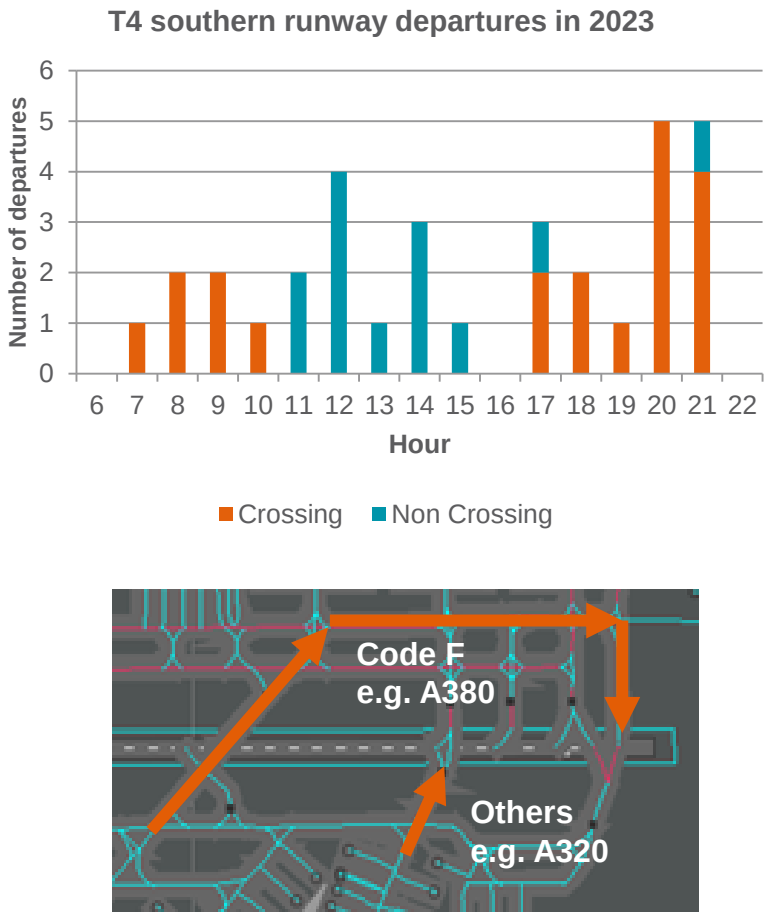



**Figure 24:** Southern runway crossings (2023)

# Claim 4.2 Traffic demand will be accommodated on the ground

The concept assumes that Terminal 4 crossings are as described on page 49 and that taxiing aircraft are kept clear of the taxiways nearest to the runway when runway exits (RET and standard) are in operation. This means the concept can operate to capacity with clear exits available from the runway.

Figure 25 indicates the potential congestion zones from fast-time simulation. The 'dashed' area relates to the requirement for Code F departures from Terminal 4 to cross the runway to depart from 27L. This will not be required when ILS is replaced as the precision approach and landing aid or if Terminal 4 closes.


**Figure 25:** Potential taxiway congestion zones

Certain changes to the way the taxiway system operates were implemented in the simulations to prevent bottlenecks from appearing. For example, Figure 26 shows changes around the T5 stands and entry to 27Rext in order to avoid queuing. A one-way system was applied to some of the taxiways.

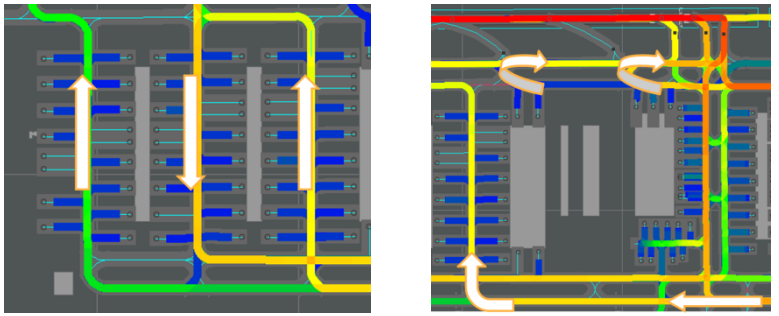


**Figure 26:** Changes to taxiway operations

Appropriate tool support will be required to enable the management of the ground movements, e.g. in terms of planning the optimum taxi routes. In particular, it is important that the departure manager (DMAN) tool takes into consideration the level of queues on the airfield and prevents pushback when congestion is building to prevent significant blockages occurring.

# Claim 4.2 Traffic demand will be accommodated on the ground (cont)

The simulation found that operations were achievable in the 2023 and 2045 scenarios. Average taxi times are shown in Table 3.

However, though during busy periods additional optimisations will be required to mitigate delays. Depending on the optimisations and in periods of disruption, peak periods may need to be lengthened to accommodate all the traffic demand.

In 2045, especially during easterly operations, bottlenecks can be caused by departing aircraft queues. Further optimisation of one way systems and the addition of further taxiway segments or parallel stretches may be needed to address this specific issue.

In addition, the schedule will need to be optimised to better match the available capacity of both the terminals and the available taxiway network. At present, only a limited optimisation of the schedule has been conducted.

Under the current schedule assumptions, there is a potential shortfall in stands during peak periods in 2045. Some further optimisation of the schedule against the stand allocation will be required.

| | 2023 | 2045 |
|---|---|---|
| **Westerly operation** | | |
| Arrivals | 6.5 min | 7.0 min |
| Departures | 11.8 min | 13.8 min |
| **Easterly operation** | | |
| Arrivals | 7.8 min | 7.8 min |
| Departures | 8.5 min | 8.5 min |

**Table 3:** Average taxi times from simulation

# Claim 5

Claim 5: Changes to the baseline 'departures' concept of operations and operating environment due to the Heathrow Hub concept can be acceptably safe

# Claim 5: Changes to the baseline ‘departures' concept of operations and operating environment due to the Heathrow Hub concept can be acceptably safe

This claim concerns the departure operations of the Heathrow Hub concept.

The key areas of focus identified through the workshops are:

- Changes to the SIDs, including assessment of obstacle surfaces and airspace impacts.
- The impact of helicopter operations.
- The impact of (flock of) bird strike risk associated with the western reservoir.
- Changes to runway modes and take-off positions affecting independent parallel departures.
- ATC co-ordination procedures

Figure 27 therefore shows the sub-claims for this claim.

**Claim 5: Changes to the baseline ‘departures' concept of operations and operating environment due to the Heathrow Hub concept can be acceptably safe**

| | Sub-claims |
|---|---|
| 5.1 | SIDs will be protected by ICAO obstacle surfaces (page 54) |
| 5.2 | Suitable SIDs can be designed to interface with the airspace (page 55) |
| 5.3 | Airspace constraints will not unduly impact departures (page 56) |
| 5.4 | Helicopter and other special routes will not impact departures (page 56) |
| 5.5 | Bird strike risk will not impact departures (page 57) |
| 5.6 | Independent parallel departures will be possible with the new runway modes and take-off positions (page 57) |
| 5.7 | ATC co-ordination of departures will be practicable (page 58) |

**Figure 27:** Claim 5 and sub-claims

# Claim 5.1: SIDs will be protected by ICAO obstacle surfaces

As described in Claim 2.1, the key obstacle surfaces have been modelled by URS. The take-off and climb surface (TOCS) starts from 60m after the runway end and has a slope of 2%.

In developing the geometry of the runway, a vertical alignment for the extended runway has been created that allows the 1% Take-Off Flight Path to clear a mobile obstacle on the access track at the Queen Mother Reservoir as shown in Figure 29. This protects the higher TOCS surface. A number of power lines have been identified that will need to be moved underground to protect the obstacle limitation surfaces.

To ensure the TOCS surface is protected, aircraft shall only take-off over an inline runway if it is closed. This is consistent with the proposed runway modes for the new concept.

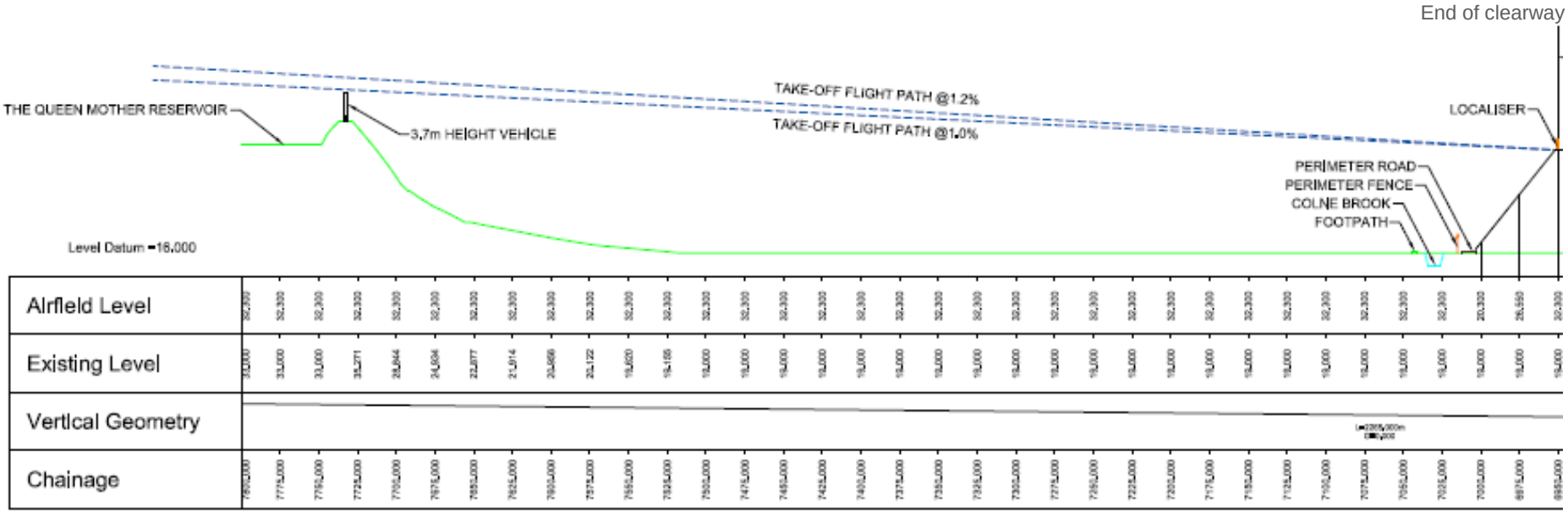



**Figure 29:** Take-off flight path surface

# Claim 5.2: Suitable SIDs can be designed to interface with the airspace

## Allocation of runway by SID

It is anticipated that departing aircraft will generally be allocated to a departure runway on the basis of their selected SID/destination (ie ‘compass’ departures).

A small number of aircraft may need to depart from the southerly runway for payload reasons whilst operating to the north (see claim 3.6). Likewise, it may reduce ground congestion to depart some northbound aircraft from Terminal 4 from the southerly runway.

In such situations, the departures on the parallel runway may be paused, temporarily reducing the overall departure rate.

## Proposed SIDs

The SIDs for the new concept are expected to resemble the baseline SIDs, but with a small westward move for the start of the SIDs from 27Rext. Claim 5.3 addresses the impact of that change. The SIDs are expected to be de-conflicted from arrivals and from traffic on adjacent SIDs.

Discussions with the CAA and NATS on the likely departure routes identified no issues that would prevent the SIDs interfacing to airspace.

# Claim 5.3: Airspace constraints will not unduly constrain departures
# Claim 5.4: Helicopter and other special routes will not impact departures

## 5.3 Airspace constraints

Departures from 27Rext may require routes to be designed to minimise the impact of noise on Windsor. Whilst not a specific safety issue, the resultant noise constraints could lead to traffic being concentrated on certain SIDs.

Interactions with Northolt traffic could be increased as traffic level grow, but this may be mitigated partially by the further west positioning of the SIDs off 27Rext. Easterly SIDs are expected to be as per the baseline. Northolt is discussed further in Claim 2.4.

Low level operations in the vicinity of the Heathrow SIDs may be impacted by the SID tracks for 27Rext. In particular, the workshops identified that White Waltham may be constrained, with a need to introduce circuit height (800ft) joining instructions instead of the standard overhead join at 1300ft agl.

## 5.4 Helicopter and other special routes into and over Heathrow

The primary helicopter routes currently overfly the western end of the airfield (west of Terminal 5). It is expected that these will be moved further west, overflying the western end of the extended northerly runway. If necessary, the routes could then dog-leg towards the current waypoint at Stanwell. No new risk has been identified. The easterly routes around the airfield (overhead the Virgin Hangar) are expected to stay as currently flown. At times of peak flow delays should be expected due to the need to transit dual arrival streams.

Overflights (South to North) into Northolt are expected to be unchanged.

# Claim 5.5: Bird strike risk will not impact departures
# Claim 5.6: Independent parallel departures will be possible with the new runway modes and take-off positions

## 5.5 Risk of bird strike

The issue of changes to the bird strike risk was raised in the hazard identification workshops, as the western end of 27Rext is closer to the Queen Mother reservoir with its attendant bird habitats.

Bird strike is an existing hazard since the airport has a number of nearby reservoirs. Nevertheless, the move west will mean that departures are closer to this reservoir which could increase its likelihood. Therefore specialist analysis and mitigation will be required, as the combination of new construction impacting existing habitats, the new height of the runway, and the proximity to the reservoir may all change the overall risk of bird strike.

If necessary, bird control measures may be applied.

## 5.6: Independent parallel departures

The baseline includes independent parallel departures implemented with RNP SIDs. It is assumed that the routes will comply with ICAO Doc 9643 requirements to diverge by 15 degrees after take-off as shown in Figure 30.

The staggered take-off points of the new concept are not expected to limit the departure operations. The SIDs are expected to continue to diverge.

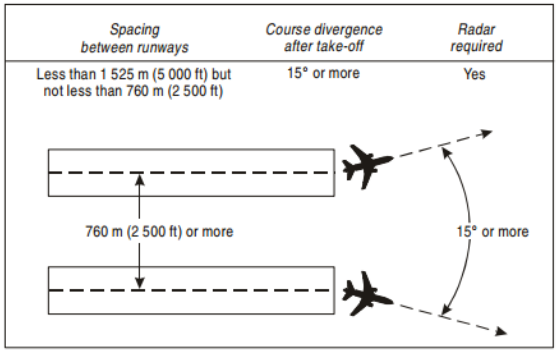



**Figure 30:** Course divergence for independent parallel departures

# Claim 5.7: ATC co-ordination of departures will be practicable

The responsibilities and interactions of the Heathrow Tower air traffic controllers will change due to the introduction of the additional in-line runway and staggered thresholds.

To ensure aircraft are sequenced to the correct runway for the necessary SID, in order to maintain throughput, it is expected that the ATCO will use a departure/surface manager (DMAN/SMAN) tool. There are multiple factors involved in the sequencing decision, hence the need for automated support.

The management of departures against missed approaches on the in-line runway was considered to be an important task for the TWR controllers. This is discussed in Claim 2.1.

## Departures during runway closures

The specific scenario in which runway 09Lext is closed may lead to a situation in which aircraft are departing 09L at the same time as landing on 09R (shown in Figure 31).

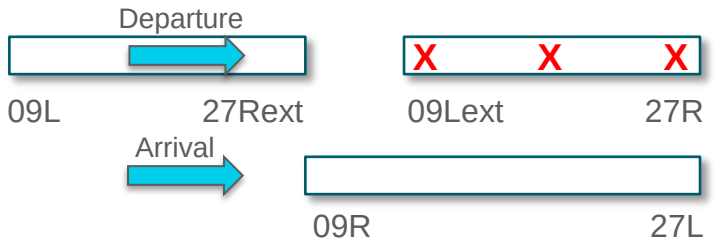



**Figure 31:** Departure vs arrival separation when one runway closed

In this case, existing guidance on parallel operations (ICAO Doc 9643) can be applied, including the application of Missed Approach Procedures for 09R (turn right at 500ft or 0DME) and de-conflicted SIDs (northerly runway departures generally depart along northern SIDs).

# Conclusion

# Conclusion

## Overview

The safety argument considers a claim that “The Heathrow Hub aviation concept can be acceptably safe in principle” (claim 0). This claim is supported by a number of sub-claims that cover:

- the establishment of the baseline 2023 concept (claim 1),
- the assessment of:
  - arrivals operations (claim 2),
  - runway operations (claim 3),
  - ground operations (claim 4),
  - departure operations (claim 5).

These claims are considered in the following pages.

## Scope

The scope of this assessment is the extent of where the Heathrow Hub concept impacts the baseline concept for the aerodrome, ATM and airspace at the time of transition into operation.

## Approach

The approach taken was to assess operations through a number of “scenarios” and to use these to identify hazards and suitable mitigations.

The assessment has:

- included expert assessment in the area of procedure geometry modelling (for missed approach, baulked landings and go-arounds),
- considered the impacts of shorter, independent inline runways and interactions with RESAs, including ILS positioning,
- considered the independent parallel arrivals/ departures and ground infrastructure runway/ taxiway movements, and
- considered ATC/Tower coordination associated with the new runway modes and changes between modes.

# Conclusion

## Claim 1

### Assumptions on the baseline concept of operations and operating environment are identified and will be acceptably safe

The baseline changes have been identified in the discussion in claim 1 in this document and the key assumptions associated with this are:

- The Heathrow Hub concept would commence transition into operations in 2023.
- The Heathrow baseline runway configuration in 2023 will be as per today.

It is assumed that the 2023 Heathrow baseline will be acceptably safe, and that each change introduced for the baseline will be implemented and phased into operation based on an approved safety case and updated unit safety case in accordance with relevant safety management systems.

## Claim 2

### Changes to the baseline 'arrivals' concept of operations and operating environment due to the Heathrow Hub concept can be acceptably safe

This claim is supported if the following assumptions are validated/actions undertaken:

- Building works associated with the phases of concept transition will be within the protected areas.
- To ensure that aircraft either land by the end of the touchdown zone (TDZ) or execute a missed approach/baulked landing, the following mitigations may be required for the inline runways:
  - High intensity lights situated at the end of the TDZ and an instruction in the AIP to pilots that this indicates the latest landing point.
  - An automated system to monitor that arrivals have landed by the end of the TDZ and otherwise to raise an alarm to the controller.
  - The use of stable ILS approaches by default (required to meet SOIR) which will reduce the likelihood of landing long.
  - The use of a speed conformance monitor on the final approach, as assumed in the baseline, which will reduce the likelihood of landings with excessive speed.

# Conclusion

- Other measures applied at least for the inline runways are assumed to be:
  - The missed approach alarm on the northern runway will be retained and may be automated. It will be used to advise the departure controller when a missed approach is underway. The two controllers will also sit side by side to further aid coordination.
  - Use of a RNAV coded missed approach which will allow aircraft equipped with TOGA to LNAV or TOGA to NAV capability to automatically initiate RNAV missed approach guidance. The MAP will also be flyable manually.
  - The MAP will be coded with a turn initiation at a point at which it can be guaranteed that any aircraft with an engine failure will be able to have reached 500ft. This is expected to be above the central area.
  - Separation will be preserved with traffic operating into Northolt through a second turn in the MAP, whilst also retaining the existing ATM procedures for coordination during a missed approach.

The following assumption will need to be validated regarding the runway positioning and associated lighting:

- Lighting and ILS will be interlocked and controlled such that only one approach path will be enabled at any one time.

The following assumptions will need to be validated and actions undertaken regarding independent parallel arrivals:

- The airspace design and traffic flows will require further simulation to ensure controller workload is appropriate, given the expected airspace changes of NATS' London Airspace Management Programme.
- Controller workload simulations will be required to ensure that the number of aircraft being broken out of a parallel approach can be managed safely.
- ATCOs will be supported with automated alerting in case of NTZ infringement.

# Conclusion

**Claim 3**

**Changes to the baseline 'runways' concept of operations and operating environment due to the Heathrow Hub concept can be acceptably safe**

This claim is supported if the following assumptions are validated/actions undertaken:

- The extra runway will require a dedicated TWR controller and frequency. Good coordination and clear procedures will be necessary between each of the TWR controllers with active runways.
- ILS localiser antennas will be designed to withstand jet blast.
- ILS CAT III lighting will be provided to all runway ends.
- For the approaches to 09Lext and 27Rext, the lighting will be embedded in the adjacent inline runway.
- The end of the touchdown zone (TDZ) will be marked with inset high intensity lights.
- The proposed monorail linking the terminals will be positioned to remove any risk that the line-of-sight is compromised for the VCR.
- Remote cameras will provided if required for the VCR to ensure visibility of the western end of the northern runways.
- An analysis of specific aircraft operations against the provided runway length will be required to identify the number of aircraft that need to depart from the southern runway and apply any identified mitigations if required.

# Conclusion

## Claim 4

**Changes to the baseline 'ground movements' concept of operations and operating environment due to the Heathrow Hub concept can be acceptably safe**

This claim is supported if the following assumptions are validated/actions undertaken:

- The assumptions in this report for the fast-time simulation are validated. (Further simulations will be required if any significant changes are made.)
- The proposed taxiway operations will be modified as proposed to reduce congestion at pinch points.
- Appropriate system support will be provided to aid ground management, eg for taxi route planning.

## Claim 5

**Changes to the baseline 'departures' concept of operations and operating environment due to the Heathrow Hub concept can be acceptably safe**

This claim is supported if the following assumptions are validated/actions undertaken:

- The impact of the staggered arrivals will not materially increase wake turbulence risk. If it a wake vortex risk is identified, then mitigations will need to be applied.
- Procedures may need to be modified at White Waltham airfield to keep traffic separated from the 27Rext SIDs.
- Bird control measures will be taken if required once the impact of the Queen Mother reservoir on bird-strike risk has been assessed.

# Conclusion

## Overall Claim (Claim 0)

For each claim, a number of assumptions and actions to be undertaken have been identified that will, on the basis of the analysis and expert judgement, adequately address the identified risks.

Therefore subject to the assumptions and actions identified in the report, in principle it is claimed and demonstrated that the Heathrow Hub aviation concept can be acceptably safe.

# Workshops

# The following workshops were held to develop the concept and for hazard assessment

## Overview

Several workshops were undertaken with operational, technical and safety experts.

The assumptions on the baseline 2023 Heathrow concept and the changes to baseline assumptions due to the Heathrow Hub concept were identified on 20th June.

The concept of operations assumptions identified on 20th June, along with operational scenarios, were used to facilitate an initial hazard assessment on 25th June

Further validation of the hazard assessment was conducted on 30th June, the output of which provides input to this document.

The workshop attendees are shown in Table 4.

| Name | Role | Meetings attended |
|---|---|---|
| (Capt) Jock Lowe | Technical Director, Heathrow Hub Limited | 30th June |
| (Capt) Bill Brown | Flight Ops Expert (previously Senior Flight Ops, BA) | 25th, 30th June |
| (Capt) Doug Brown | Flight Ops Expert (previously Senior Flight Ops, BA) | 25th, 30th June |
| (Capt) Frank Zubiel | CAA Flight Ops (previously Senior Flight Ops, BA) | 30th June |
| Adam Spink | Heathrow Tower ATCO, NATS Services Limited | 30th June |
| Glen Smith | Safety Assessment Project Manager and Safety Expert, Helios | 20th, 25th, 30th June |
| Nick McFarlane | Ops and Technical Expert, Helios | 20th, 25th June |
| Ben Stanley | Ops, Technical and Safety Expert, Helios | 20th, 25th, 30th June |
| Steve Leighton | Ops, Technical and Safety Expert, Helios | 20th, 25th, 30th June |
| Philip Church | Navigation, Technical and Safety Expert, Helios | 20th, 25th, 30th June |
| Libor Homola | Technical and Safety Support, Helios | 20th, 25th, 30th June |

**Table 4:** Concept and hazard assessment workshop attendees

# Acronyms

# Acronyms

| | |
|---|---|
| 09Lext | Runway 09 Left Extended |
| 27Rext | Runway 27 Right Extended |
| agl | above ground level |
| AIP | Aeronautical Information Publication |
| AMAN | Arrival Manager |
| ATC | Air Traffic Control |
| ATCO | Air Traffic Control Officer |
| ATM | Air Traffic Management |
| ATS | Air Traffic Service |
| APP | Approach |
| CAA | Civil Aviation Authority |
| ConOps | Concept of Operations |
| DA(H) | Decision Altitude (Height) |
| DMAN | Departure Manager |
| EASA | European Aviation Safety Agency |
| FMS | Flight Management System |
| GBAS | Ground Based Augmentation System |
| GMC | Ground Movement Controller |
| GND | Ground |
| HAZID | Hazard Identification |
| ICAO | International Civil Aviation Organization |
| IFR | Instrument Flight Rules |
| IHS | Inner Horizontal Surface |
| ILS | Instrument Landing System |
| LAMP | London Airspace Management Programme |
| MAP | Missed Approach Procedure |
| MDA(H) | Minimum Descent Altitude (Height) |
| MLS | Microwave Landing System |
| NATS | National Air Traffic Services |
| NOZ | Normal Operating Zone |
| NTZ | No Transgression Zone |
| OEI | One Engine Inoperative |
| PANS-ATM | Procedures for Air Navigation Services – ATM |
| PANS-OPS | Procedures for Air Navigation Services – Aircraft Ops |
| PBN | Performance Based Navigation |
| PSZ | Public Safety Zone |
| RESA | Runway End Safety Area |
| RF | Radius to Fix |
| RNAV | Area Navigation |
| RNP | Required Navigation Performance |
| RWY | Runway |
| SMAN | Surface Manager |
| SOIR | Simultaneous operations on parallel or near-parallel instrument runways |
| TBS | Time Based Separation |
| TDZ | Touchdown Zone |
| TOCS | Take-Off Climb Surface |
| TODA | Take-Off Distance Available |
| TOGA | Take-Off / Go Around |
| TORA | Take-Off Run Available |
| TWR | Tower |
| SID | Standard Instrument Departure |
| STAR | Standard Arrival Route |
| VCR | Visual Control Room |
| VCT | Visual Control Tower |