THE QUEEN'S AWARDS FOR ENTERPRISE 2009

HELIOS

Heathrow Hub:
Runway Concept Safety Assessment

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Introduction

This study carried out an independent initial safety assessment to give guidance on the feasibility of the Heathrow Hub runway concept from an aviation safety risk-based perspective.

Background to study

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.

Purpose of this study

This study provides an independent initial safety assessment of the Heathrow Hub runway concept.

It investigates the aviation related safety issues arising from the introduction of the new concept, focusing on the dual "in-line" runways which form a unique part of the Heathrow Hub concept. Brainstorming was carried out with aviation experts to determine potential risks and mitigations.

The study also sought to address safety concerns that have been raised with regards to the Heathrow Hub concept.

Scope of the study

The concept for Heathrow Hub is not yet described at a detailed enough level to conduct a safety assessment in line with full regulatory requirements (e.g. the UK CAA 4-part Safety Case). It is not appropriate at present to investigate detailed risk outcomes (severity, likelihood) or set quantitative requirements.

Therefore, this initial safety assessment on the feasibility of the concept took the following approach:

- Identify the unique aspects of the Heathrow Hub concept, compared to today's operations.
- Use operational expertise to assess hazards arising from these changes.
- Assess the impact of the hazards, relative to today's situation.
- Identify any additional mitigations (defences).

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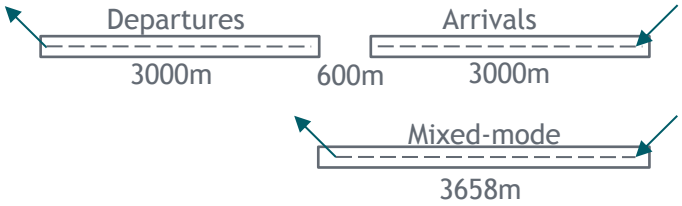
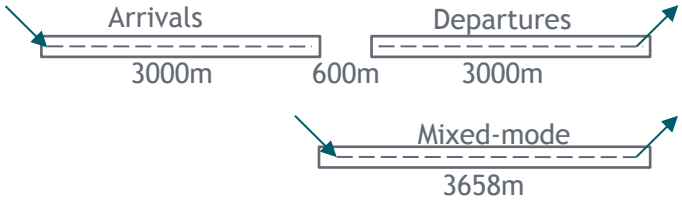
Description of predominant runway modes concept

In updated proposal (the focus of this safety study), three runways are envisaged. As per today, direction of operation and exact runway use is determined by wind direction/speed, environmental constraints (e.g. noise) and capacity or performance limitations.

← Westerly Operations ←



→ Easterly Operations →



Operational modes

The concept assumes three runways operate independently, assuming some form of runway monitoring between the parallel arrivals.

The diagrams above provide an overview of the runway operations during peak throughput, there are a number of noise respite options detailed on the following page.

The current control tower has sufficient line-of-sight to the west end of the new runways.

Impact of runway length

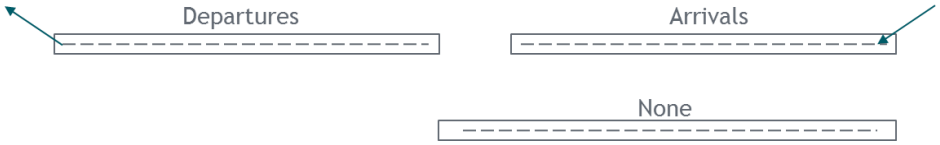
The nominal length of the northern runway will be decreased from the current 3.6km to 3km, but noting the existing southern runway is available at 3.6km.

An assessment of the take-off and landing requirements of various aircraft was undertaken for the Heathrow Hub submission. It found the reduction in the runway length should not impact the operations of the vast majority of aircraft currently operating out of Heathrow.

Noise relief operational modes

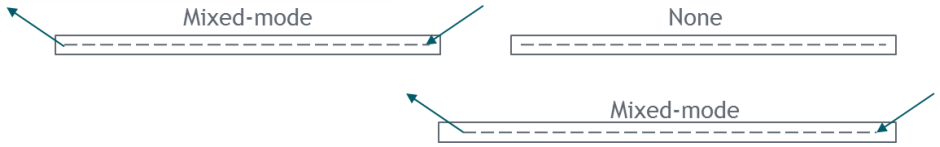
The Heathrow Hub operational concept foresees use of various noise respite options to reduce noise over central and west London, particularly in early mornings and late evenings. The noise profile would be moved 3.6km to the west, meaning aircraft are higher for longer over urban areas.

Southern relief



By stopping operations on the southern runway for periods through the day residents below the flight path can be provided some noise respite.

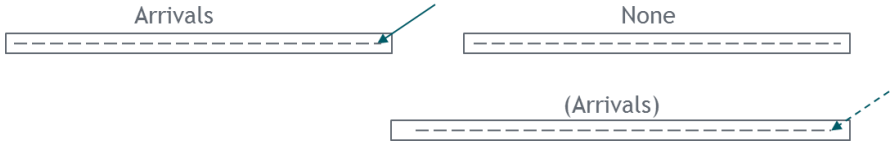
Northern relief



Relief can be provided to those under the approach path of the northern runway by using the extended northern runway in mixed-mode. This allows aircraft to remain higher over urban areas thus reducing noise.

Deep landings

In the early mornings and at night the extended section of the northern runway can be used for the majority of landings. Moving the noise profile for most arriving aircraft during this period 3.6km to the west.



Due to the mix of traffic there may need to be a small number of arrivals on the southern runway during this early morning period. This is expected to be substantially fewer than the arrivals at present.

Independent parallel runway operations

Landing runways are "dependent" according to ICAO criteria*. Use of technological surveillance solutions could enable independent operations. This is not unique to the Heathrow Hub concept, and could be enabled with the current runway configuration.

Runway separations

Parallel runways spaced by more than 1,525m are able to operate independently, meaning that there is no constraint on the timing of take-offs and landings between the runways.

Heathrow's runways are spaced by less than this, which means that there are some additional constraints when they are used for simultaneous arrivals. The additional constraints can reduce the landing rate when mitigations are not applied.

Independent departures on parallel runways

Provided the SIDs are strategically de-conflicted it is expected that independent departures on the parallel runways should be possible. Where aircraft need to join the same SID after take-off this can be managed at the operational level.

Safety of independent arrivals

The safety of independent arrivals to runways spaced less than 1,525m is subject to additional mitigations being applied, designated through international standards on the basis of extensive safety studies. The addition of a Precision Runway Monitor (PRM), a technical surveillance solution enabling more precise surveillance of the aircraft on the approach and alerts in case of deviation, would enable the runways to be operated "independently".

With this mitigation in place, it is expected that Heathrow runways could be operated to an acceptable level of safety in an independent manner.

*ICAO Docs 4444 and 9643 discuss runway spacing, ie the distance between centrelines

Airspace concepts

Various airspace designs are possible under the Heathrow Hub concept.

Possible approach routes

The diagram below shows possible approach paths for westerly operations. These include:

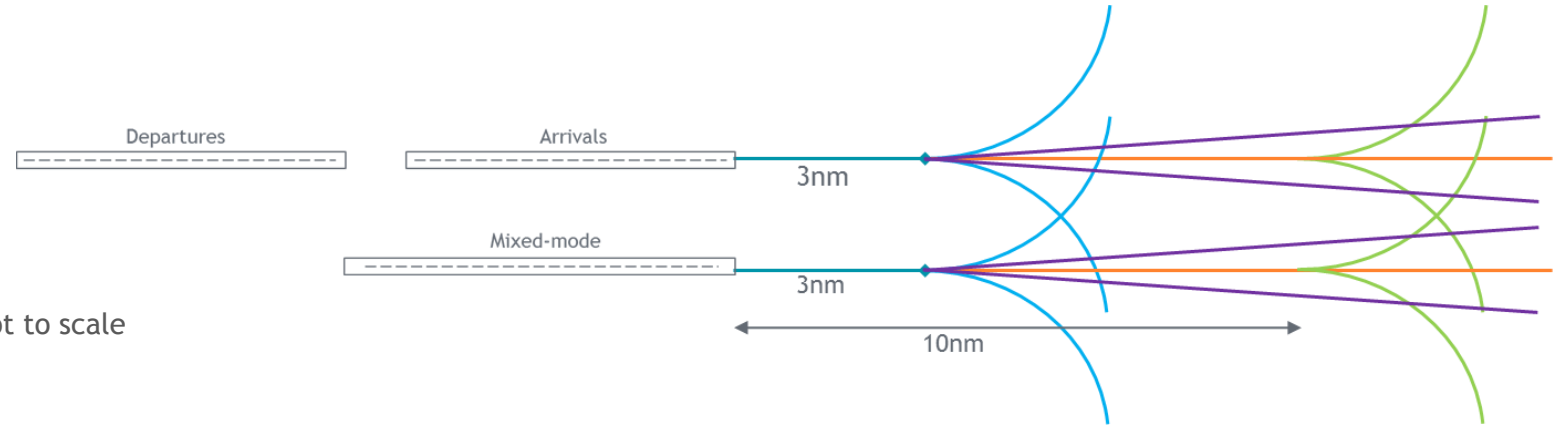
- Curved approach to 3NM and 10NM
- Straight approaches
- Offset centrelines

These airspace designs could be used to shorten routes and reduce fuel burn and/or as noise mitigation measures.

Safety considerations

For some operational modes e.g. deep landings the staggered nature of the runways implies that the design of the approach and departure routes will need to be tailored for this possibility. Whilst these airspace designs are supported by the Heathrow Hub concept, they are neither necessary for its implementation nor unique to its design.

As with any runway concept, the airspace design for Heathrow Hub will need to take account of the increased movements, whilst ensuring safety levels are maintained.



Not to scale

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Safety benefits

The proposed Heathrow Hub concept may deliver a number of safety improvements, reducing risk for the busy operation.

Reduction in runway congestion

- Greater runway capacity will allow a reduced number of aircraft to use each runway per hour than at present, this may result in:
  - Increased separations between aircraft which are either taking off or landing
  - Reduced controller workload
  - Improved resilience to disruption and delay

Ultra long runway in emergency

- If an aircraft mechanical failure were detected prior to landing, the entire length of a 6.6km runway could be cleared of other operations and utilised.

Reduced complexity of ground movements

- The in-line runways have the potential to reduce the complexity of ground movements, resulting in fewer runway crossings and thus a lower probability of runway incursions.

Go-around procedures – nominal case

Almost all go-arounds are flown with all engines operative. From initial assessment of the Heathrow Hub concept, nominal go-around procedures would not present an unacceptable safety risk as per international norms, with sufficient aircraft separations maintained.

Go-around procedures

If the flight crew judge it to be unsafe for an aircraft to land (due to an obstruction on the runway, floating, etc.), a pilot can abort the landing, pull-up, and provide full thrust to the engines to climb away. This is known as a go-around, and is a Standard Operating Procedure. At present at Heathrow, once the aircraft has reached 500', it will turn perpendicular to the centre-line of the runway and climb away.

550 go-arounds were flown at Heathrow in 2010, often due to late vacation of the runway by the preceding aircraft.

Nominal go-around

The vast majority of go-arounds are flown with all engines operative. The nominal case is wheels down in the middle of the touchdown zone.

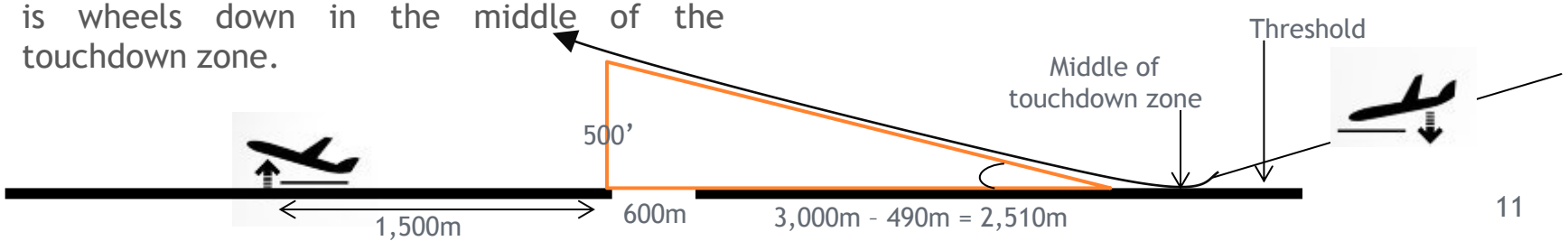
Aircraft separations

The main hazard was assessed to be separation against the aircraft on the in-line departure runway. The worst case would be when an aircraft is taking off at the same time, and becomes airborne early (e.g. 1500m from the departure runway threshold).

For a nominal go around, the aircraft would have a vertical separation of 500' and a minimum horizontal separation as shown below, assuming climb gradients of 6% and 10%.

NB: Detail on the calculation follows on subsequent slides

Climb gradient	Separation (m)
6%	2070
10% (1500'/minute)	3080



Go-around procedures - engine-out (1)

If an engine failure occurs during flight or approach, it is expected that the departure runway would be cleared, as the controller would have time to act. In the very rare event that an engine failure occurs after decision height, sufficient separation between aircraft would still be maintained.

Go-around procedures

The small minority of cases of engine-out go-arounds were considered. These constitute the worst credible scenario for aircraft separation purposes, since the aircraft going around will not climb as rapidly with one engine out.

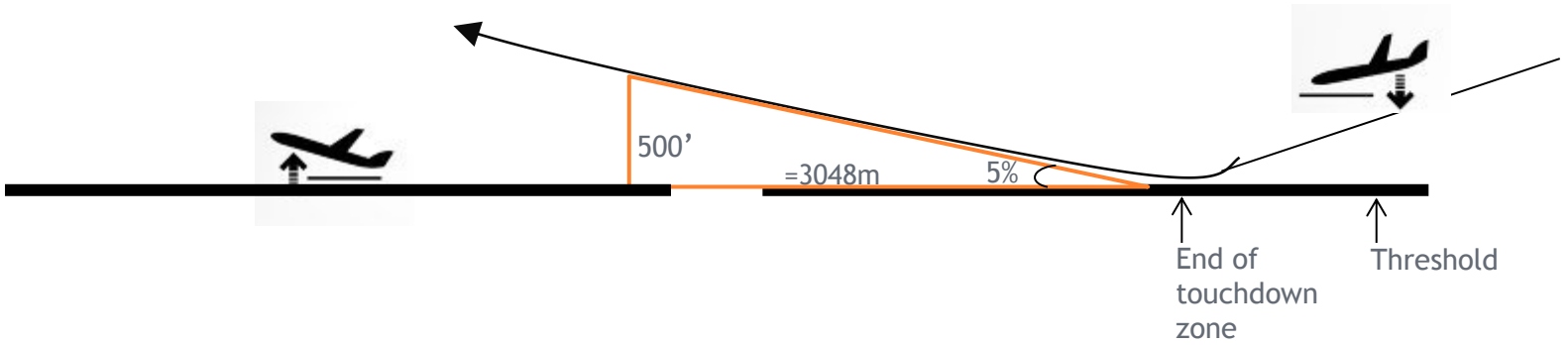
Engine failure in approaching aircraft

If an engine failure were to occur prior to Decision Height, the approaching aircraft would declare this to Air Traffic Control which could clear the take-off runway providing the whole length of 6.6km to land. If necessary, the flight crew would initiate an early missed approach, with no safety risk.

Late engine failure in approaching aircraft

In the very rare cases where an aircraft lost an engine after the Decision Height (e.g. 250', approximately 30 seconds prior to landing, such that the take-off runway could not be cleared, the aircraft operating into Heathrow could still achieve a climb rate of 5% with one engine inoperative in a go-around.

Note that a 2.4% climb rate is the minimum required by regulations when operating with maximum take-off weight; the landing aircraft will be much lighter, and thus more able to climb.



Go-around procedures - engine-out (2)

The highly unlikely scenario of late engine-out and go-around, with an aircraft on the departure runway, as discussed on the previous slide, would still result in a horizontal separation of approximately 1.1km.

Worst credible case

Following the discussion on the previous page, the worst credible case for reduction of aircraft separations is considered. It is assumed that an aircraft executing a go-around procedure only turns once it reaches an altitude of 500'. The worst credible scenario is as follows:

- A landing aircraft with its wheels down at the end of the touchdown zone, decides to execute a go-around and applies full power and climb at a rate of 5% (this is achievable by all the aircraft currently operating out of Heathrow).
- An aircraft is taking off and becomes airborne at 1500m from the start of the take-off runway.
- This occurs on the in-line runway.

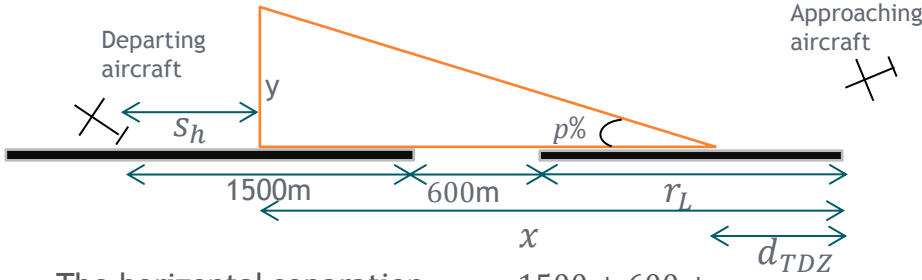
The result is that the aircraft would have a separation of 1130m.

Calculations

The calculations were carried out as follows:

$$x = d_{TDZ} + \frac{100y}{p\%}$$

Let, $d_{TDZ} = 920\text{m}$, $y = 500' = 152\text{m}$, $p\% = 5\%$.
Therefore $x = 3970\text{m}$



The horizontal separation, $s_h = 1500 + 600 + r_L - x$

For the short landing runway, $r_L = 3000\text{m}$ therefore $s_h = 1130\text{m}$

At this stage, best estimates appear to show no unacceptable risk arising from the concept.

Note: a full Collision Risk Model may need to be developed for this concept.

Go-around procedures – engine-out (3)

An initial analysis against current operations at aerodromes with single runways and very closely spaced parallel runways shows that the Heathrow Hub concept is not likely to operate with higher risk than these examples. Note that a full Collision Risk Model would need to be developed.

Existing operations and risk

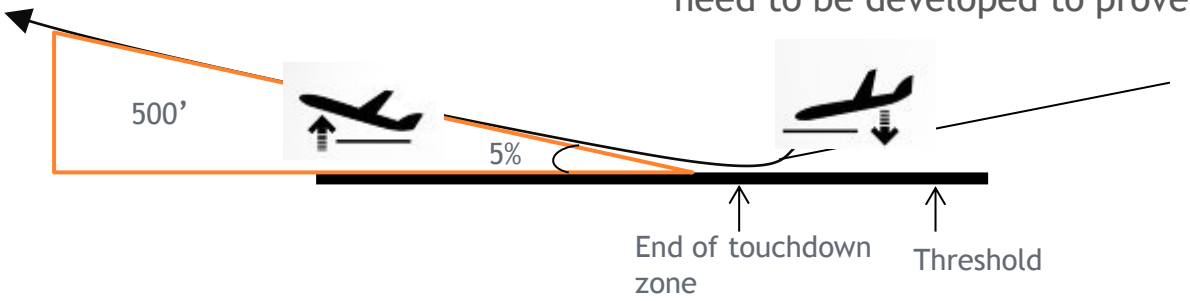
Single runway operations: Arriving and departing aircraft are interleaved on the runway. During busy times, a common scenario is to have a departing aircraft just leaving the ground as the arriving aircraft crosses the threshold.

Very closely spaced parallel runways: At aerodromes with very close runways, operational procedures may require the landing aircraft to be "wheels down" before the departing aircraft is released, but this is not always the case.

Comparison against Heathrow Hub concept

The presence of a departing aircraft ahead of the landing aircraft can be seen in each example. The difference comes in the distance between the aircraft (>> in the Heathrow Hub concept) and the timing of the aircraft arriving over the threshold versus the aircraft starting its take-off roll (<< in the Heathrow Hub concept, as the runways are fully independent).

The 1.1km worst credible case shown on previous slides is estimated to be commensurate with minimum distances reached on a single runway, assuming late go-around and a slow take-off aircraft ahead (see diagram). A full Collision Risk Model may need to be developed to prove this.



Balked landing surface

The balked landing surface is an obstacle clearance surface (for go-arounds). It is not expected that this will cause particular issues for the Heathrow Hub concept.

Definition

A balked landing surface is the obstacle clearance (limitation) surface which is an inclined plane at an angle of 3.33% climb above the horizontal [13], measured from 1800m after the threshold of the arrival runway for a Code 4 runway. No fixed obstacles can impinge upon this area.

Clearance over take-off aircraft tailfin

Whilst not strictly covered by current balked landing surface regulations, we can apply the principles of balked landing surfaces to the new "obstacle" created by the departing aircraft on the in-line runway.

An A380 tailfin is 25m in height. This height would be reached 400m before the end of the landing runway, leaving 1km to gain extra height as an additional safety margin. The balked landing surface at the start of the departure runway is 50m above the ground i.e. the tailfin would be substantially lower than the maximum height allowable.

Conclusion

The balked landing surface, and the specific issue of an aircraft's tailfin on the in-line departure runway, was not considered to be a significant hazard in the Heathrow Hub concept, since the concept will meet existing minimum clearance requirements.

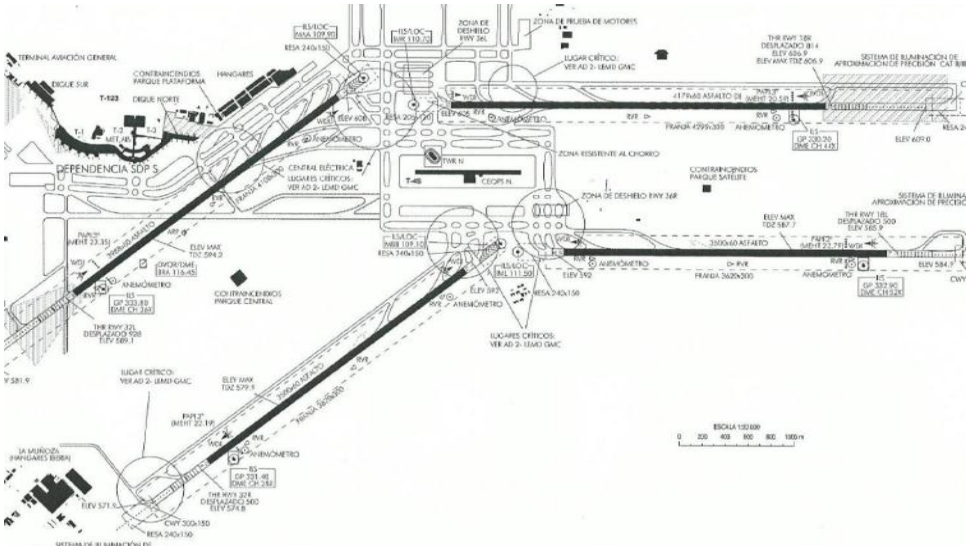
It is noted that the minimum certification requirements for twin engine (one engine inoperative) aircraft may only require 2.4% climb gradient, but that all modern aircraft achieve more than this in practice.

Balked landing surface (2)

A comparison with Madrid Barajas (LEMD) can be made. Similar risks are seen as in the Heathrow Hub concept, with departing traffic sitting on the threshold potentially conflicting with arrivals traffic going around. These have been mitigated to the satisfaction of the Spanish authorities.

Description

Since 2006, Madrid Barajas airport (LEMD) operates independent arrivals and departures, with the departing runway thresholds approximately 800m along the extended centre-line from the arrivals runways.



Risks

The unique risks arise from go-arounds or runway excursions from the arrival runways impacting the departure runways.

These are mitigated by

- the 800m separation between the runways
- specified taxi routings ensuring appropriate clearance at the arrival runway end (in case of go-around) e.g. for balked landing surfaces
- RESAs in line with ICAO guidance (240m) supplemented by EMAS (Enhanced Movement Arrestor Systems) as appropriate

The risks and mitigations are described in more detail in the separate appendix prepared by Gates Aviation [15]

Further work needs to be done to understand the mitigations surrounding arrivals on 18R going around and potentially conflicting with departures on 14L.

Runway End Safety Area (RESA)

The proposed concept envisages an area at the end of the runway which is twice the recommended length of a Runway End Safety Area, this is considered to provide sufficient safety to the operations of both runways.

Definition

A Runway End Safety Area (RESA) is defined by ICAO Annex 14 as "*An area symmetrical about the extended runway centre line and adjacent to the end of the strip primarily intended to reduce the risk of damage to an aeroplane undershooting or overrunning the runway*".

Recommended length

The ICAO recommended practice for code 4 runways (i.e. runways of the type at Heathrow) is for a 240m RESA as measured from the end of the runway strip (60m beyond runway threshold). The minimum requirement is 90m RESA beyond the runway strip.

The Heathrow Hub concept proposes a safety area of 600m before the in-line runway begins. There is an even greater distance before any "obstacle" (aircraft) would be present on the runway.

The proposed safety area of 600m has been chosen to substantially exceed the RESA requirements and recommendations from the UK CAA and ICAO. The length can be increased further if a full collision risk model suggests this is necessary.

Runway excursions - Over-runs (1)

Over-runs past the Runway End Safety Area do not have a higher probability in the Heathrow Hub concept than for any other runway. RESAs are used as mitigations for overruns. Known risks of over-runs for arrivals can be mitigated using the long runway at Heathrow Hub.

Side excursions

The risk to an aircraft veering off the side of the runway is not substantively different in the Heathrow Hub concept to existing operations. No new risks exist.

Over-runs

An over-run occurs when an aircraft, for whatever reason, fails to stop within the designated runway area. This has been initially noted by commenters to be of greater concern for the Heathrow Hub concept due to the active take-off runway in front of the landing runway.

Runway End Safety Areas (RESAs), usually 300m long, are used at airports to mitigate the risk of over-runs. Beyond the RESA distance, there are usually significant obstacles or public areas (train lines, car parks etc). The Heathrow Hub concept includes a safety zone of 600m between the in-line runways.

Risk analysis for Heathrow Hub

The analysis can break down into two parts:

- The risk arising from the over-running aircraft not stopping safely
- The risk arising from the in-line departing aircraft being an “obstacle”

There is no reason why a higher probability of over-runs should exist for the Heathrow Hub concept.

The severity of the risk arising from the over-run is therefore the key concern.

Benefits of the long runway

As long as the risk of an over-run is identified early (e.g. in excessively wet conditions, or due to known failures on the aircraft), the runway can be cleared of departing aircraft, and the risk arising from the over-running aircraft not stopping safely can be hugely mitigated by the total length of the extended runway (6,600m).

Runway excursions - Over-runs (2)

In comparison to existing airport operations, the severity of the risk arising from an aircraft at approximately 800m from the end of the landing runway can be estimated to be similar.

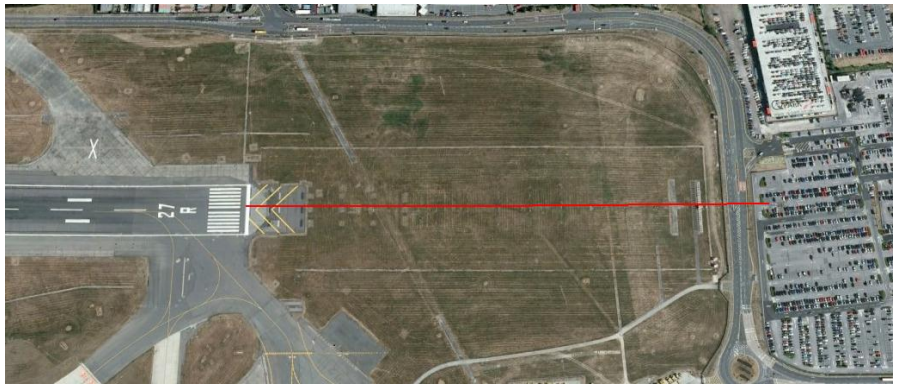
Comparisons

In order to assess the tolerable severity of the risk of the in-line runways concept, a relative approach can be taken with reference to existing airports:

- Luton airport: 420m from end of runway 26 threshold is the middle of the A1081
- JFK runway 04R*: 190m from end of threshold there is a river, 340m a 3 lane road
- Madrid airport: 800m from end of runway 18L to line up point of aircraft waiting clearance to enter runway 14L – note that EMAS is used within the RESAs – see separate appendix [15] for more information
- Heathrow (currently): 500m past end of runway 09L is the Northern Perimeter Road followed by a car park, 540m after threshold of runway 09R is the A30.

*JFK runway 04R has an EMAS arrestor system in place due to the short safety area.

420m after the runway threshold at Luton airport



500m after the runway threshold at Heathrow airport (present day)

Runway excursions - Over-runs (3)

It is estimated that at any airport with the proposed traffic numbers, on average one over-run of >300m past the landing runway end will occur every 57 years. The probability of an over-run colliding with an aircraft ~800m past the landing runway end is much smaller.

Statistics

There were 120 runway excursion accidents during landings between 1998 and 2007. [11]

Landing over-run accidents occur at a rate of approximately 0.5 per million flights worldwide. [10] [14] This rate of overruns appears to be decreasing over time.

An FAA study found that 90% of over-runs stop within 1000' (≈305m). [12]

The American FAA undertook several studies which concluded that a safety area of greater than 2000' [610m] offered no worthwhile additional safety benefit and did not justify the costs involved.

Likelihood of overrun for Heathrow Hub

Taking account of the statistics and the proposed traffic levels at Heathrow Hub, we can assess the likelihood of an overrun at Heathrow.

Heathrow Hub anticipates up to 350,000 landings a year. The below calculations estimate the over-run frequency at Heathrow with this level of traffic:

$$\begin{aligned} &\#overruns\ per\ year \\ &= overruns\ per\ flight \times \#flights\ per\ year \\ &= 0.5 \times 10^{-6} \times 350'000 \\ &= 0.175\ overruns\ per\ year \\ &\rightarrow 1\ overrun\ every\ 5.7\ years \end{aligned}$$

$$\begin{aligned} &Approximately\ 90\%\ of\ overruns\ stop\ within\ a\ RESA\ of\ 300m \\ &\therefore 1\ overrun\ can\ be\ expected\ to\ pass\ 300m\ every\ 57\ years \end{aligned}$$

The above calculations make use of averages and apply to any aerodrome with the same aircraft traffic, and not to this concept in particular.

Landing overruns are much less likely when landing using a precision approach. [14]

Runway excursions - Over-runs (4)

For the Heathrow Hub concept, the severity of the over-run is mitigated by the extensive RESA (600m) and the use of operational mitigations when problems are detected early. Note that the presence of a longer runway gives benefits if the possibility of over-run is detected early.

Causal factors

The most important causal factor identified is the runway condition being wet or contaminated with water. The risk of a landing over-run is about 13 times higher on a wet/contaminated runway than on a dry runway. [10]

Operational mitigations could be applied when the runway was assessed as wet/contaminated, with departures not lined up independently of arriving aircraft.

This further reduces the probability of an over-run occurring where an aircraft collides with an aircraft waiting for departure on the in-line runway.

i.e. 1 in 57 years (on average), an over-running aircraft would pass 300m.

Much less than this (on average), an over-running aircraft would pass 600-800m.

Lower again is the probability that operational mitigations would not be applied.

Since the Heathrow Hub concept provides a RESA of 600m, we conclude that it is extremely improbable that an over-run would pass this clearance zone at the same time as a departure aircraft was sitting at the threshold.

Precision approach navigation aids – ILS, GBAS, MLS

Potential hazards were identified around the placement of an ILS localiser at the end of the long runway. Other airports experience similar issues, however, the specific geometries of the Heathrow Hub concept should be investigated in the full safety case.

ILS placement

The concept states that the ILS localiser must be placed at the end of the 6.6km runway stretch rather than the end of a normal length runway (approximately 3.6km). There are two issues potentially unique to this layout: the accuracy obtained from the signal, and the angle of the beam.

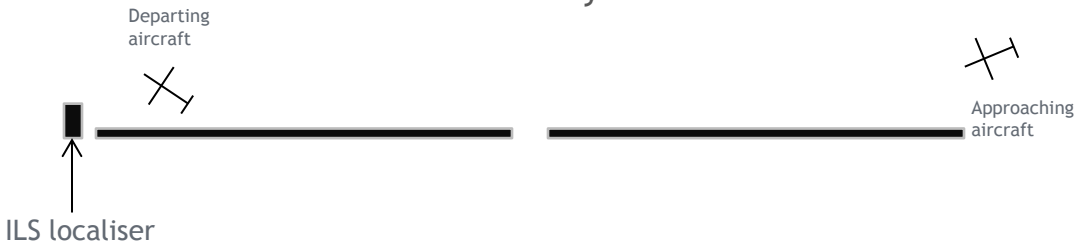
The distance to the ILS localiser may pose some issues which will be assessed in the full safety review, however this situation is not considered unduly constraining from a technical perspective, and it is expected that it will not present a serious obstacle.

Interference

A potential hazard was identified of the take-off aircraft (or aircraft waiting to take-off) interfering more readily with the ILS localiser beam, and thereby disrupting the signal to the landing aircraft. The nominal situation can be compared to single runway airports, where an aircraft may be taking off whilst another aircraft is on approach.

It is recognised that the geometry of the aircraft passing through the localiser beam will be different in this concept (both whilst on the ground and in the air). The interference characteristics of this concept should therefore be considered in greater detail in the full safety case.

Single runway airport



Heathrow Hub concept

Precision approach navigation aids – ILS, GBAS, MLS

The Heathrow Hub concept of navigation aid operations is not substantively different from that currently used at a number of airports.

Low visibility procedures

Operational mitigations using dependent take-off and landings on the in-line runways may be required when low visibility procedures (LVP) are in force, requiring the ILS critical and sensitive areas to be cleared. This is no different to today's situation.

Selection of correct glidepath

Assuming that precision approaches were installed for both northern runways, it will be important that an aircraft selects the correct glidepath and is unable to select the wrong one (i.e. deep landings glide path for normal operations or normal glidepath for a deep landing). To mitigate this risk, the alternative glidepath should be turned off when not in use.

This may be difficult when the runway modes change, such as from deep landing mode to a normal mode (e.g. 0700), since both glidepaths will be active. A short change-over delay may be necessary, with a small loss of slots.

Alternative Navigation Aids

In addition to ILS, the Heathrow Hub concept is able to support other forms of precision approach navigation aids such as GBAS Landing Systems and MLS.

- GBAS (Ground Based Augmentation System) Landing Systems are not currently widely deployed, but on the timescales in which this concept may be implemented GBAS is planned to deliver equivalent performance to ILS Cat III. GBAS gives benefits of curved approaches and off-set thresholds to be defined, giving more variants of the approach to be flown.
- MLS (Microwave Landing System) equipment is already fitted to a proportion of aircraft operating out of Heathrow and could be used instead of or in addition to ILS, dependent on further uptake.

Other assessed hazards (1)

Several other potential hazards were identified by the analysis, but were not judged to pose additional risk due to the unique characteristics of the Heathrow Hub concept.

Bird strike risk

Bird strike risk is not a particular characteristic of this concept but may need to be assessed with further research at a later stage due to the move towards the existing reservoirs.

Take-off

The risk posed to or by aircraft taking off is unchanged from the present situation, except for incursions by landing aircraft due to over-runs and go-around procedures, as discussed earlier.

Shorter take-off runways potentially increase risk, but the concept allows for runways well within the operational requirements of the existing and near-term fleet. Where a longer runway is required for a particular departure, the southern runway could be used, this issue is considered further in the complexity of ground movements section.

Jet blast

Risk to aircraft on landing runway due to jet blast is likely to be minimal, particularly due the length of the clearance zone between the runways. E.g. jet blast contours expected from the B747-800 aircraft extend to around 450m at 50mph and 680m at 35mph.

It is unlikely that a landing aircraft would be at the far end of the landing runway, such that it would be exactly 600-700m away from the take-off aircraft.

No taxiing aircraft are foreseen in between the runways.

Other assessed hazards (2)

Factors such as public safety zones, control tower visibility, and the impact on other airspace were assessed and are not expected to pose a substantially greater risk than at present (or can be mitigated using existing techniques).

Public Safety Zones (PSZs)

The public safety zones will be displaced to the west and be larger than present (due to the increased number of movements), this is not foreseen to cause substantial issues.

The need for and potential impact of an intermediate PSZ between the in-line runways should be assessed at a later stage.

Distance to runway end from control tower

The estimated distance from the existing control tower to the far end of the West runways is approximately 4.7km, leading to possible hazards in ATC situational awareness at this distance. If this is judged an issue by controllers, additional mitigations could include binoculars, remote cameras, and secondary control towers (as used at Amsterdam Schiphol).

Impact on airspace

Due to the in-line positioning of the runways in this concept, the impact on the airspace should be minimised compared with other concepts. No unique risks were identified. This should be assessed in detail at a later stage.

Staggered mixed-mode runways

Heathrow Hub envisages operating two mixed-mode runways in a staggered configuration (e.g. northern relief scenario). These operations will place demands on the navigation performance of the departing aircraft on the near runway (so as not to lose separation with the landing aircraft on the far runway). A particular issue may be the offset seen by the departing aircraft as the navigation computer picks up a wider set of beacons on departure (e.g. DME/DME). The required and achievable navigation performance of departing aircraft should be considered in more detail in the full safety case.

Other assessed hazards (3)

Runway markings for multiple thresholds and the complexity of ground movements were considered and were not judged to pose a substantially greater risk than at present, and are dealt with successfully at other airports.

Multiple threshold runway markings

Runway markings must be clear to ensure the avoidance of doubt as to which is the target runway and to indicate the correct touchdown zone. The Heathrow Hub concept will also require that the clearance zone between the runways is easily visible.

Multiple runway thresholds will be required to enable landings in both directions, and to allow for deep landings.

The threshold for deep landings could potentially cause confusion, this issue is dealt with in the human factors section.

Multiple runway thresholds are already successfully in use at Frankfurt airport. Unique runway designations must be provided for each runway threshold (i.e. 27R and 27ext).

It is considered that hazards can be mitigated for multiple runway thresholds in the Heathrow Hub concept.

Complexity of ground movements

Due to a small percentage of aircraft potentially requesting a longer departure runway (i.e. the southern runway), there could be an increase in the complexity of ground movements. Furthermore, when runway operational modes change for e.g. noise mitigation purposes there would be an impact on ground movements as today.

Where operational mode changes would be known (i.e. used strategically), it is not thought that undue risk exists.

The tactical request for a longer departure runway may lead to increased complexity and workload for ground controllers. This issue is not unique to Heathrow Hub and many major airports manage with different length runways. In addition the in-line runways may reduce the number of runway crossings needed (and thus reduce the risk of a runway incursion) compared to other concepts.

Other assessed hazards (4)

Wake vortex on staggered arrivals and independent parallel departures were identified as possible hazards, whilst neither issue is expected to be especially serious both will need to be considered in detail in a full safety review.

Wake vortex on staggered arrivals

The Heathrow Hub operational concept does not envisage the need to reduce longitudinal separations due to wake vortex issues compared to current operations or planned enhancements (e.g. RECAT).

Current daily operations at Heathrow also use parallel staggered arrivals (TEAM – Tactically Enhanced Arrivals Mode).

In very limited cases, the use of staggered runways (i.e. one aircraft deep landing) for parallel independent arrivals may have additional issues with wake vortex sinking and drifting due strong northerly winds (such that the wake vortex incurs on the path of the aircraft arriving on the southern runway). It is thought the distance between the runways will mean this risk is extremely minimal; nevertheless, this will be considered in a full safety review.

Independent parallel departures

Heathrow Hub envisages independent departures on parallel runways in both a staggered and non-staggered arrangement. This could cause potential issues surrounding radar separation and lateral separation on aircraft converging on the same SID.

It is expected that mitigations such as strategically deconflicted SIDs using enhanced Performance Based Navigation (RNP-1) and operational procedures (e.g. placing aircraft departing northerly onto the northern runway) will allow these operations in a safe manner. However, departures on independent parallel runways is an issue that needs to be considered in a full safety review.

Runway construction hazards

During construction of the new in-line runway some measures will need to be taken to ensure the continuing safety of operations at Heathrow.

Construction near existing North runway

The proposed safety area between the in-line runways will abut the existing North runway (which will be shortened). Currently at Heathrow, work such as runway resurfacing is carried out at night to reduce the operational impact. It is expected that construction of the closer sections of the new runway will also need to take place at night. Additionally all construction staff for these closer sections will need to be security screened as work will need to be carried out airside.

As construction moves further west it is expected that a groundside area can be created and that the maximum height of works equipment will be sufficiently low to maintain obstacle clearance surfaces and to allow work to continue whilst the existing runway is in use.

Lighting and visual distinction

Both new runway lighting and lights on construction vehicles will have to be carefully controlled to minimise potential confusion whilst the existing North runway is in use. New runway lighting will also be needed on the shortened existing runway.

Care will need to be taken that there remains visual distinction between the current operational runway, the safety area, and the new runway throughout construction.

ILS placement

To allow runway surface construction over the area of the existing ILS, the ILS will have to be moved or offset. The placement of an ILS at the end of the 6.6km runway is not likely to be possible during construction due to interference. Other ILS specific issues are discussed on slide 21.

Human Factors

Any new concept will introduce human factors related hazards, such as potential confusion or mis-perception of runways. The unique aspects of the Heathrow Hub concept were assessed, and potential mitigations identified.

Taxiing errors

Identified unique hazards included:

- Taxiing aircraft turns the wrong way onto extended runway in central area and attempts take-off in wrong direction
- Taxiing aircraft selects wrong taxiway and turns onto operational landing runway rather than take-off runway, creating an incursion on an operational landing runway

Both these hazards would be mitigated by appropriate signage, briefings, and critically the use of lead-in lighting to the runways to assist pilots in choosing the correct route. This is no different to current operations.

Deep landing runway incorrectly selected

The hazard of a deep landing runway being incorrectly selected could be mitigated by unique designation of runways and approaches, and the use of clear approach lighting dependent on the approach in use. If runway monitoring was in use, a technical system could also provide an alert if the aircraft was not following the cleared approach.

Perception of longer runway

Hazards around perception (given pilot inexperience with an ultra-long runway) may lead to long landings and over-runs. Pilots may also assume they are able to land long.

Mitigations are the same as currently:

- clear briefing on the use of the runway (including occupancy awareness)
- clear demarcation of the clearance area between runways.

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Additional optional mitigations

It is possible to modify the proposed concept to include longer runways if it were judged to be necessary for operational or safety reasons. This mitigation appears to have the most benefits and the least disadvantages when compared to the other mitigations discussed on following slides.

Longer runways

Longer runways could be considered if the following issues are not seen to be adequately covered by other mitigations:

- The clearance zone (RESA) of 600m is judged to be insufficient
- Length of 3000m take-off or landing runway not sufficient for operational purposes (e.g. operational flexibility and capacity unduly compromised by requiring use of southern runway)
- Aircraft separation during go-arounds not judged to be sufficient, even if aerodrome minimum climb requirements applied.

Balance of safety and flexibility with cost

Longer runways will increase the cost of the scheme, and thus the economic impact will need to be assessed with regard to any improvement in safety and operational flexibility that could be offered.

Offset runway centrelines

Offset centrelines could be considered if the following issues are not seen to be adequately covered by other mitigations:

- Pilot incorrectly selects the deep landing runway at an inappropriate time.
- An over-running aircraft endangering the departure point of the take off runway.

Offset centrelines could allow a clearer distinction between the runways, and reduce the severity of incidents due to over-runs by a landing aircraft. This assumes the over-running aircraft would continue straight on.

Balance of factors

The ability to reduce the severity of overruns will depend on the extent to which the centrelines can be offset. This mitigation may increase complexity of runway markings and may be dependent on the ability to increase the width of the runway obstacle free zones.

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Conclusions

The proposed Heathrow Hub concept, and specifically the unique risks associated with the runway layout, are judged to be within existing risk parameters using a combination of risk probability and comparison against existing situations. More detailed analysis will be required for evidence.

Conclusions

1. The following safety hazards arising from the Heathrow Hub concept were assessed:

- Go-around procedures
- Balked landing surface
- RESAs
- Runway Excursions – Over-runs
- Precision approach navigation aids – ILS, GBAS, MLS
- Runway markings
- Other hazards (bird strikes, risk to/from take-off, PSZs, airspace, control tower distance, wake vortex, departures)
- Human factors

2. The key unique risks identified were the go-around procedures and the over-run into a departing aircraft.

3. Safety benefits were also identified, in particular arising from the use of a long runway in emergency, and better allocation of aircraft across runways and taxiways.

Conclusions

4. The go-around procedures have been shown to not introduce undue risk due to the new runway layout. In nominal go-arounds, an acceptable separation is maintained between aircraft. Even in the worst credible case (with multiple badly timed events), it is thought to be extremely improbable* that the two aircraft would come closer than 1.1km.

5. For the over-run risk, it was assessed to be extremely improbable* that the over-running aircraft could reach the departure runway threshold – far less than 1 in 57 years on average.

» The identified hazards therefore do not present a safety risk that should lead to the exclusion of the Heathrow Hub concept on safety grounds at this stage.

*The term “extremely improbable” refers to the remotest probability allowed under standard aviation safety assessments (e.g. for certification).

Bibliography

This slide provides a list of references used in compiling this initial safety assessment.

1. ICAO Docs 4444 (PANS-ATM) and 9643 (Manual on Simultaneous Operations on Parallel or Near-parallel Runways)
2. Balked landing surface, FAR 23.77
3. Airbus A380 Aircraft Characteristics, Airport and maintenance planning
4. Boeing 747-400/800 Airplane Characteristics of Airport Planning
5. Heathrow Hub submission to UK Airport Commission
6. DfT Circular 01/2010, Control of development in airport public safety zones
7. CAP 637, Visual Aids Handbook, CAA
8. EGLL-London Heathrow textual data, AD 2.EGLL-1, 27 Jun 2013, NATS AIP
9. Analysis of Aircraft Overruns and Undershoots for Runway Safety Areas, ACRP report 3, Transportation Research Board
10. A study of runway excursions from a European Perspective, 23 March 2010, Eurocontrol
11. Runway excursions Part1: A worldwide review of commercial jet aircraft runway excursions, AR-2008-018(1), Australian Transport Safety Bureau
12. DOT/FAA/AOV 90-1, Location of Commercial Aircraft Accidents/Incidents Relative to Runways, July 1990, R.E. David
13. ICAO Doc 9137 Airport Services Manual
14. Running out of runway (Analysis of 35 years of landing overrun accidents), NLR, 2005
15. Gates Aviation – Hazards, constraints and mitigations at LEMD Madrid Barajas