Corporate Communications
External Information Services

8 September 2015
EIR Reference: E0002461

Dear XXXX

I am writing in respect of your recent request of 5 September 2015 for the release of information held by the Civil Aviation Authority (CAA).

Your request:

Under the Environmental Information Regulations, please can you provide an electronic copy of the report "London Heathrow Operational Freedoms Trial: Effect on noise" that was produced by ERCD and included as Annex J of the report

http://www.heathrow.com/file_source/HeathrowNoise/Static/Operational-Freedoms-Final-Report-Heathrow.pdf

Unfortunately the Operational Freedoms page of the Heathrow website no longer appears to exist and I have been unable to find the ERCD report in their search engine or get a response from the website webmaster.

Our response:

Having considered your request in line with the provisions of the Environmental Information Regulations 2004, we have attached a copy of the report.

If you are not satisfied with how we have dealt with your request in the first instance you should approach the CAA in writing at:-

Caroline Chalk
Head of External Information Services
Civil Aviation Authority
Aviation House
Gatwick Airport South
Gatwick
RH6 0YR

caroline.chalk@caa.co.uk

The CAA has a formal internal review process for dealing with appeals or complaints in connection with requests under the Environmental Information Regulations. The key steps in this process are set in the attachment.

Should you remain dissatisfied with the outcome you have a right to appeal against the decision by contacting the Information Commissioner at:-

Information Commissioner's Office
FOI/EIR Complaints Resolution
Wycliffe House
Water Lane
Wilmslow
SK9 5AF
www.ico.gov.uk/complaints.aspx

If you wish to request further information from the CAA, please use the form on the CAA website at http://www.caa.co.uk/application.aspx?catid=286&pagetype=65&appid=24.

Yours sincerely

Mark Stevens
External Response Manager

- The original case to which the appeal or complaint relates is identified and the case file is made available;
- The appeal or complaint is allocated to an Appeal Manager, the appeal is acknowledged and the details of the Appeal Manager are provided to the applicant;
- The Appeal Manager reviews the case to understand the nature of the appeal or complaint, reviews the actions and decisions taken in connection with the original case and takes account of any new information that may have been received. This will typically require contact with those persons involved in the original case and consultation with the CAA Legal Department;
- The Appeal Manager concludes the review and, after consultation with those involved with the case, and with the CAA Legal Department, agrees on the course of action to be taken;
- The Appeal Manager prepares the necessary response and collates any information to be provided to the applicant;
- The response and any necessary information is sent to the applicant, together with information about further rights of appeal to the Information Commissioners Office, including full contact details.

Annex J

London Heathrow Operational Freedoms Trial: Effect on noise

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The authors of this report are employed by the Civil Aviation Authority. The work reported herein was carried out on behalf of Heathrow Airport Limited through a contract agreed on the 21 August 2012.

Population data used in this report are based on 2001 Census data (updated in 2012) supplied by CACI Information Services.

Contents

Glossary of Terms

A-weighting	A frequency weighting that is applied to the electrical signal within a noise-measuring instrument as a way of simulating the way the human ear responds to a range of acoustic frequencies.
AIP	Aeronautical Information Publication (UK Air Pilot).
ANCON	The UK aircraft noise contour model.
ATMs	Air Transport Movement. Either a takeoff or a landing by an aircraft performing a passenger or cargo revenue flight.
BST	British Summer Time
dB	Decibel units describing sound level or changes of sound level. It is used in this report to define differences measured on the dBA scale.
dBA	dBA is used denote the levels of noise measured on an A-weighted decibel scale.
Delay	Is the time lost through an aircraft holding in queues while it is waiting to safely access infrastructure and/or airspace. These queues take various forms, including airborne holding stacks, taxiway queues and being held on stand awaiting clearance from air traffic control (ATC).
DfT	Department for Transport
ERCD	Environmental Research and Consultancy Department
GMT	Greenwich Mean Time
HAL	Heathrow Airport Limited
kt	Knot (nautical mile per hour)
Leq	The equivalent continuous sound level, normally measured on an A-weighted decibel scale.
Lmax	The maximum A-weighted sound pressure level of an aircraft noise event.
MTOW	Maximum take-off weight
NATS	Previously know as National Air Traffic Services Ltd. NATS provides air traffic control services at several major UK airports, including Heathrow.
NPR	Noise Preferential Route.
Punctuality	Is the difference between the planned off- or on-blocks time as defined in the schedule and the actual off- or on-blocks time.
SEAT	South East Airports Taskforce.
SEL	The Sound Exposure Level generated by a single aircraft at the

measurement point, measured in dBA. This accounts for the duration of the sound as well as its intensity.

TEAM Tactically Enhanced Arrivals Measures. The procedure of landing aircraft on the runway designated for departing aircraft – a dual arrival runway operation applied after 07:00 hours. TEAM is triggered when severe inbound congestion occurs, or is anticipated to occur, involving delays of 20 minutes or more.

TEAM* The same as TEAM, except that for TEAM* the threshold trigger is reduced to 10 minutes delay; or the headwind on approach to Heathrow is forecast to be greater than 20 knots at 3000 feet; or the arrival or departure flight schedule is anticipated to run later than 30 minutes or 30% of flights are running outside of the 15-minute punctuality target.

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1. Scope

1.1 Context

1.1.1 The Operational Freedoms Trial has been conducted in three distinct parts over two phases. Phase 1 occurred during winter 2011/12, and Phase 2 was separated into two parts: the summer 2012 season and winter 2012/13 season.

1.1.2 This report assesses the effect on noise of the trial measures, considering both phases of the trial. ERCD has previously reported on the noise effects of Phase 1[1] and Phase 2 summer season[2], the results and findings of which are reproduced in this report.

1.2 Assessment cases

1.2.1 The trial measures applied in the Phase 1 trial are listed below. Please refer to the main report for detailed descriptions of the trial measures.

- Landing westerly arrivals on the designated departure runway (reactive) (TEAM*)
- Landing westerly arrivals on the designated departure runway (proactive)
- Departing aircraft on the designated landing runway (TED)

1.2.2 The trial measures applied in the Phase 2 trial are listed below. Again, please refer to the main report for detailed descriptions of the trial measures.

- Landing aircraft on the designated departure runway (reactive), westerly operations only
- Re-directing (early vectoring) departing aircraft (reactive) on 27L MID, 27R MID, 09R DVR and 09R TANGO in segregated mode
- Arrivals on the designated departures runway re. Airbus A380 (proactive, abbreviated to A380 in this report)
- Landing small and light wake vortex category aircraft on the designated departures runway (proactive, abbreviated to Small/Light in this report)
- Use of the southern runway for Terminal 4 arrivals (proactive, abbreviated to Terminal 4 in this report)

1.2.3 The trial measures were applied between 07:00 and the last departure of the day.

1.2.4 Insufficient data was gathered during Phase 1 to assess proactive arrival measures separately from reactive arrivals measures, from a noise perspective. Similarly the infrequent application of TED during the Phase 1 trial meant that there was insufficient data on which to adequately assess the effects of TED.

1.2.5 The Phase 1 assessment therefore focused on the use of TEAM* (after 07:00) on westerly arrivals and its effects on noise and respite under the westerly arrival flight paths.

[1] Heathrow Phase 1 report, Appendix 14: London Heathrow Operational Freedoms Phase 1 Trial: Effect on noise
[2] Heathrow Phase 2 Summer report, Annex G: London Heathrow Operational Freedoms Phase 2 Trial, Summer Season: Effect on noise

1.2.6 During Phase 2, the proactive tests were applied for three periods: the first between 16 July and 15 August 2012; the second from 1 to 31 October 2012; and the third from 1 to 28 February 2013.

1.2.7 Early vectoring of departing aircraft in dual departure runway mode (i.e. allowing aircraft to depart from the runway designated for arriving aircraft; *tactically enhanced departures*) was proposed for Phase 2 of the trial. It was later decided not to take this forward in the trial.

1.2.8 Landing in-bound aircraft without holding between 05:30 and 06:00 in return for a reduction in flights between 04:30-05:00 was also proposed for Phase 2 of the trial. It was later found that it was not possible to implement this measure during the trial for operational reasons.

1.2.9 The trial measures for both phases of the trial, where applicable, as listed in paragraph 1.2.2 are addressed in sections 2 to 4 of this report

1.3 Trial and baseline periods

1.3.1 The Phase 1 trial comprised the 121 day period 1 November 2011 - 29 February 2012 inclusive (hereafter referred to as the *Phase 1 trial period*). During this period, there were 81 days of 100% westerly operations, 27 days of 100% easterly operations, and 13 days where there was a mixture of westerly and easterly operations.

1.3.2 The Phase 2 trial summer season comprised the 119 day period 1 July - 27 October 2012 inclusive (hereafter referred to as the *Phase 2 summer trial period*). During this period, there were 87 days of 100% westerly operations, 16 days of 100% easterly operations, and 16 days where there was a mixture of westerly and easterly operations.

1.3.3 The Phase 2 trial winter season comprised the 124 day period 28 October 2012 - 28 February 2013 inclusive (hereafter referred to as the *Phase 2 winter trial period*). During this period, there were 80 days of 100% westerly operations, 29 days of 100% easterly operations, and 15 days where there was a mixture of westerly and easterly operations.

1.3.4 HAL proposed that the Phase 1 trial period (Nov 2011-Feb 2012) be compared against the three preceding winter periods:

- November 2008 - February 2009
- November 2009 - February 2010
- November 2010 - February 2011

1.3.5 For the analysis of the Phase 2 summer season, we used a baseline comprising the following three preceding summer periods from 1 July to 27 October (or to the date the clocks change from BST to GMT if that occurs first).

- 1 July - 24 October 2009 (inclusive, 116 days)
- 1 July - 12 September 2010 (inclusive, 74 days, reduced period due to runway closure)
- 1 July - 27 October 2011 (inclusive, 119 days)

1.3.6 Maintenance works to taxiways caused the closure of the northern runway for six weeks from 13 September 2010 during which time normal runway alternation was suspended. The period from 13 September 2010 onwards has therefore been excluded from the Phase 2 summer baseline.

1.3.7 For the analysis of the Phase 2 winter season, we used a baseline comprising the following three preceding winter periods from 28 October (or to the date the clocks change from BST to GMT if that occurs after 28 October) to 28 February inclusive.

- 28 October 2008 – 28 February 2009 (inclusive, 124 days)
- 28 October 2009 – 28 February 2010 (inclusive, 124 days)
- 28 October 2010 – 28 February 2011 (inclusive, 124 days)

1.3.8 Note that the 2011-12 winter period could not be used for the baseline as the Phase 1 trial occurred during this time. Where a trial measure was active for only part of the trial period, e.g. the TEAM* reactive freedom, equivalent periods were selected from the above winter periods to form the baseline against which to assess the effect of the measure. The various trial and baseline periods are summarised below.

2. Landing aircraft on the designated departure runway

2.1 Daily average number of out-of-alternation arrivals

2.1.1 During the trial, Heathrow Airport closely monitored and reported the usage of the freedom to land aircraft on the designated departure runway (reactive freedom). This freedom is hereafter referred to as TEAM* in lieu of the fact that this built on an existing freedom. Monitoring of landings on the departure runway during the baseline periods was not carried out to the same level of detail, such that there is no reliable way of distinguishing flights where the previously used TEAM measure was applied from other out-of-alternation flights[3].

2.1.2 Secondly, the TEAM* trigger has a lower threshold than the previously used TEAM, i.e. anticipated arrival delay of 10 minutes compared with 20 minutes for TEAM. During the trial period, if TEAM* had not been introduced, TEAM would have occurred whenever the 20 minute threshold[4] was met. However, the application of TEAM* altered how delays would build up each day so there is no way of identifying which of the out-of-alternation arrivals would have occurred due to TEAM.

2.1.3 In light of the above, we can reasonably assume that the factors contributing to de-alternation for reasons other than TEAM* (i.e. due to TEAM and for safety/emergency reasons) have remained constant throughout the baseline and trial periods.

2.1.4 Whilst there is no means of retrospectively identifying causes of out-of-alternation arrivals in the baseline periods, we can measurably exclude certain occasions when the published alternation timetable is not adhered to. A specific occasion occurs when high winds from the south preclude the use of runway 27R for arrivals for safety reasons. This may result in the designated landing runway being swapped from that which is published in the landing runway alternation programme. ERCD's analysis excluded out-of-alternation arrivals in the baseline and trial periods which occurred under such conditions, as although aircraft landed out of alternation according to the published schedule, only one landing runway remained in use. We did not wish the results to be affected by these relatively high numbers of out-of-alternation operations which arose due to neither TEAM or TEAM*. In their own analysis, Heathrow considered all out-of-alternation westerly arrivals, including those which occurred under such conditions. Both approaches are acceptable but result in different numbers of out-of-alternation arrivals.

2.1.5 We have established the daily average numbers of out-of-alternation westerly arrivals for the baseline and trial periods. These were calculated for each period by summing all out-of-alternation westerly arrivals between 07:00 and 23:00 hours and dividing by the number of days for which there were more than one out-of-alternation westerly arrival.

2.1.6 The results of our analyses for each part of the trial are presented in **Tables 1 to 3**. The difference in numbers of arrivals between the baseline and the trial period is

[3] I.e. those that operated out of alternation for safety/emergency reasons, e.g. times when one runway was unavailable due to maintenance, obstruction or snow and ice.

[4] Assuming all other triggers were also met

therefore attributable to TEAM*. The average number of daily westerly arrivals (total) and the % of these that were out of alternation have also been presented to put the numbers of out-of-alternation arrivals into context.

Table 1: Average number of daily de-alternated westerly arrivals, Phase 1

Period	Number of de-alternated westerly arrivals (0700-2300)
Nov 2008-Feb 2009	10.5
Nov 2009-Feb 2010	8.0
Nov 2010-Feb 2011	15.3
Average baseline	11.5
Nov 2011-Feb 2012 (Phase 1 Trial)	22.4
TEAM* (Trial – Baseline)	10.9

Table 2: Average number of daily westerly arrivals, Phase 2 summer season

Period	Out-of-alternation	Total	% out-of alternation
1 July - 24 October 2009	8.8	589	1.5
1 July - 12 September 2010	8.3	612	1.4
1 July - 27 October 2011	15.5	615	2.5
Baseline (average of previous periods)	11.4	605	1.9
Trial (Phase 2 summer period)	21.3	607	3.5
TEAM* (Trial – Baseline)	9.9	-	-

Table 3: Average number of daily westerly arrivals, Phase 2 winter season

Period	Out-of-alternation	Total	% out-of alternation
28 October - 31 December 2008	10.4	576	1.8
28 October - 31 December 2009	8.6	560	1.5
28 October - 31 December 2010	15.1	559	2.7
Baseline (average of previous periods)	11.2	559	2.0
Trial (Phase 2 winter period)	8.5	551	1.5
TEAM* (Trial - Baseline)	-2.7	-	-

2.1.7 The analysis shows that:

- during the Phase 1 trial period, there was a near doubling of out-of-alternation westerly arrivals, and that there was a daily average of 10.9 TEAM* arrivals;
- during the Phase 2 summer trial period, the number of out-of-alternation westerly arrivals was nearly double that in the baseline, and that there was a daily average of 9.9 TEAM* arrivals; and
- during the Phase 2 winter trial period, the number of out-of-alternation westerly arrivals was lower than that of the baseline. This suggests that the number of TEAM* and weather-related out-of-alternation arrivals during the Phase 2 winter

trial period was lower than the weather-related out-of-alternation arrivals during the baseline.

2.1.8 The result for the Phase 2 winter trial period is not too unsurprising. We are aware that part of the way into the period a decision was made by the airport to focus on departure punctuality. Use of TEAM* was therefore limited to occasions when departure delay was neither present nor predicted, and its use was reduced significantly.

2.1.9 Following publication of the Phase 2 summer season report, stakeholders raised a concern that the higher number of daily out-of-alternation arrivals in 2011 compared with 2010 and 2009 was an aberration which may have affected the assessment of the number of TEAM* arrivals.

2.1.10 In response we have extended the Phase 2 summer season baseline assessment to include 2008 and 2007 for which there were 9.2 and 5.7 average daily out-of-alternation arrivals respectively. This results in a baseline number of 10.1, which when compared with the trial number of 21.3, gives 11.2 daily TEAM* arrivals. This is 1.3 greater than previously assessed (9.9), and 0.3 greater than the number of TEAM* arrivals calculated in Phase 1 (10.9).

2.1.11 For completeness, we have also extended the Phase 2 winter season baseline assessment to include 2007 for which there were 12.1 daily out-of-alternation arrivals. This results in a baseline number of 11.6, which when compared with the trial number of 8.5, gives -3.1 daily TEAM* arrivals. This is 0.4 lower than assessed using the standard 3-year baseline approach (-2.7).

2.1.12 We considered that including 2007 and 2008 in the baseline did not have a material effect on the analysis.

2.1.13 For consistency across the analyses for each part, no adjustment has been made to account for the proactive freedom arrivals which landed on the designated departure runway during the trial period (these are addressed separately in section 4). This therefore constitutes an assessment of the worst-case.

2.2 Noise energy analysis of out-of-alternation westerly arrivals

2.2.1 Although the primary effect of de-alternation is the disturbance and reduction of respite caused by the number of out-of-alternation westerly arrivals, the overall noise level may also have changed as a result of any changes in the respective fleet mix. To investigate this, the average noise energy for the baseline and trial period out-of-alternation fleet mixes was calculated.

2.2.2 This was done for each of the periods by first multiplying the number of out-of-alternation arrivals[5] of each aircraft type by the antilog of the aircraft's certificated approach noise level. These results were summed to give the overall energy for the period, and then divided by the number of out-of-alternation movements to give the energy of an average out-of-alternation arrival.

2.2.3 The results of our analyses for each part of the trial are presented **in Tables 1 to 3**. The difference in numbers of arrivals between the baseline and the trial period is

[5] Between 07:00 and 23:00 hours

therefore attributable to TEAM*. The average number of daily westerly arrivals (total) and the % of these that were out of alternation have also been presented to put the numbers of out-of-alternation arrivals into context.

2.2.4 The results of our analyses for each part of the trial are presented in **Tables 4 to 6** for the baseline (including a breakdown for each of the historical periods) and trial period separately. These have been converted to linear values (since the 'antilog' operation converts the sound levels to energy) and then normalised to 100 for the Baseline for each part of the trial.

Table 4: Average noise energy for out-of-alternation westerly arrivals Phase 1

Period	Noise energy
November 2008 - February 2009	100
November 2009 - February 2010	107
November 2010 - February 2011	94
Average baseline	100
Trial (Phase 1 period, 2011/12)	98

Table 5: Average noise energy for out-of-alternation westerly arrivals Phase 2 summer season

Period	Noise energy
1 July - 24 October 2009	110
1 July - 12 September 2010	100
1 July - 27 October 2011	90
Baseline (average of previous periods)	100
Trial (Phase 2 summer period, 2012)	99

Table 6: Average noise energy for out-of-alternation westerly arrivals Phase 2 winter season

Period	Noise energy
28th October-31st December 2008	96
28th October-31st December 2009	106
28th October-31st December 2010	98
Baseline (average of previous periods)	100
Trial (Phase 2 winter period, 2012)	101

2.2.5 The results show -2% to +1% changes in noise energy associated with the out-of-alternation westerly arrivals during the trial periods compared with the baselines. This is the equivalent to changes of less than 0.1 dB in noise level, confirming that the mix of out-of-alternation aircraft, in noise terms, was not significantly different during each of the trial periods to that of the respective baselines.

2.3 Statistical descriptors

2.3.1 The analysis presented in section 2.1 shows the average number of out-of-alternation westerly arrivals (after 07:00) for the trial period. A series of statistical analyses have been undertaken to identify how these flights were distributed temporally throughout the average day.

Distribution of numbers of daily out-of-alternation westerly arrivals

2.3.2 The range and spread of the numbers of daily out-of-alternation westerly arrivals was calculated in Phase 2 and is illustrated in the histograms in **Charts 1 to 2** below. This analysis considers only days for which there were more than one out-of-alternation westerly arrival.

Chart 1: Numbers of daily out-of-alternation westerly arrivals Phase 2 summer season

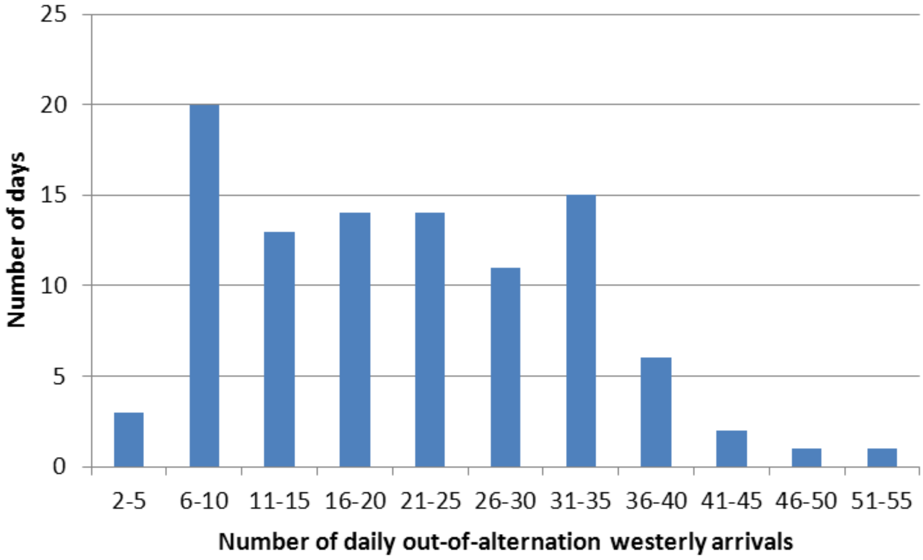
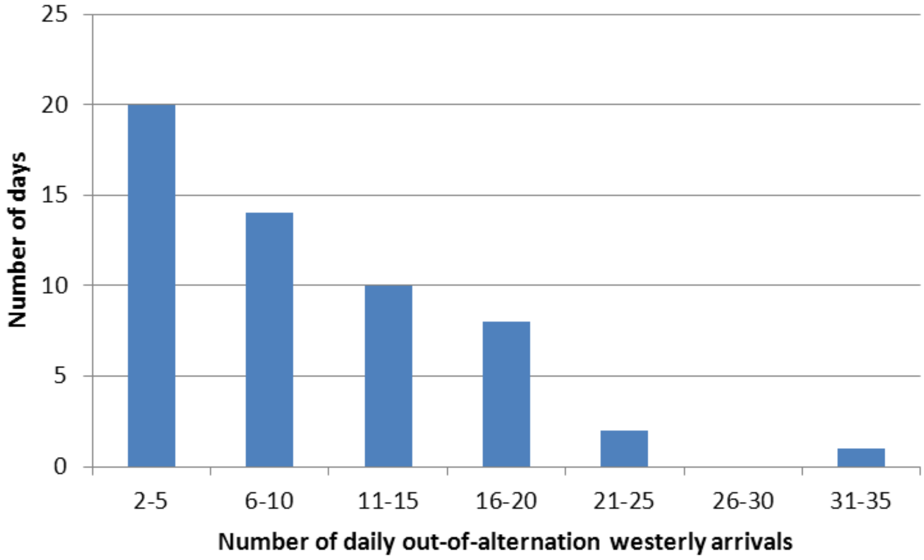


Chart 2: Numbers of daily out-of-alternation westerly arrivals Phase 2 winter season



2.3.3 In the Phase 2 summer season, on any given day there were up to 53 out-of-alternation westerly arrivals. For the majority of days, there were from 6 to 35 out-of-alternation westerly arrivals with the mean falling in the range of 21-25 out-of-alternation westerly arrivals. On 17 days there were no out-of-alternation westerly arrivals[6], and on two days, there was one out-of-alternation westerly arrival. These were not included in the average (section 2.1) and therefore not shown in the chart.

2.3.4 In the Phase 2 winter season, on any given day there were up to 35 out-of-alternation westerly arrivals. For the majority of days, there were up to 20 out-of-alternation westerly arrivals with the mean falling in the range of 6-10 out-of-alternation westerly arrivals. On three days there were no out-of-alternation westerly arrivals, and there were no days where there was only one out-of-alternation westerly arrival. These were not included in the average (section 2.1) and therefore not shown in the chart.

Average time between out-of-alternation westerly arrivals

2.3.5 **Tables 7 to 9** show the average time between out-of-alternation westerly arrivals. The average time could be expressed as the 16 hours (07:00-23:00) divided by the average number of out-of-alternation arrivals within a 16-hour day. However, that ignores that the first out-of-alternation arrival may be some time after 07:00 and the last may be some time before 23:00. The parameter was therefore calculated as the time between the first and last out-of-alternation westerly arrival divided by the number of out-of-alternation westerly arrivals within each 16-hour day. These daily averages were then averaged for each day of the trial when there were out-of-alternation westerly arrivals[7].

Table 7: Average time between out-of-alternation westerly arrivals Phase 1

Period	Average time (minutes)
Baseline	42
Trial	33

Table 8: Average time between out-of-alternation westerly arrivals Phase 2 summer season

Period	Average time (minutes)
Baseline	51
Trial	35

Table 9: Average time between out-of-alternation westerly arrivals Phase 2 winter season

Period	Average time (minutes)
Baseline	53
Trial	50

2.3.6 Despite the number of out-of-alternation arrivals approximately doubling for the Phase 1 and Phase 2 summer season trial periods compared to the respective baselines (see Tables 1 and 2), the average time between out-of-alternation arrivals has neither stayed constant, nor halved. This indicates that out-of-alternation

[6] Of which 16 days were 100% easterly operation
[7] Including days when there was a mixture of easterly and westerly operation

arrivals during the trial period:

- did not occur twice as frequently over the same average number of hours as in the baseline; and
- did not occur at the same frequency but over twice the average number of hours; but
- did occur at a higher frequency and over a greater number of hours in the trial compared with the baseline.

2.3.7 The average time between out-of-alternation westerly arrivals is similar for each of the baseline periods. Although there is a corresponding similarity between the results for the Phase 1 and Phase 2 summer trial periods, the Phase 2 winter season period shows the average time between out-of-alternation westerly arrivals to be closer to baseline values. This reflects the relatively low usage of TEAM* during this part of the trial.

Average number of hours with no out-of-alternation westerly arrivals

2.3.8 Here, for each day, the number of hours between 07:00 and the first out-of-alternation arrival, and the number of hours between the last out-of-alternation arrival and 23:00 are summed. These are then added together for all days when there were out-of-alternation westerly arrivals, and divided by this same number of days to obtain the average. The results are presented below in **Tables 10 to 12**.

Table 10: Average number of hours with no out-of-alternation westerly arrivals
Phase 1

Period	Average number of (decimal) hours
Baseline	9.5
Trial	5.7

Table 11: Average number of hours with no out-of-alternation westerly arrivals
Phase 2 summer season

Period	Average number of (decimal) hours
Baseline	9.1
Trial	5.4

Table 12: Average number of hours with no out-of-alternation westerly arrivals
Phase 2 winter season

Period	Average number of (decimal) hours
Baseline	10.0
Trial	9.4

2.3.9 Despite a near doubling of the number of out-of-alternation westerly arrivals during the Phase 1 and Phase 2 summer season trial periods compared with their respective baselines, the number of hours without de-alternation has not quite halved, confirming that TEAM* is not used twice of often, but when it is used, it is used slightly more intensively than TEAM.

2.3.10 In the Phase 2 winter season, it is clear from the results that the reduced use of TEAM* has led to an average number of hours with no out-of-alternation westerly arrivals that is much closer to the baseline value than for the other parts of the trial.

Average maximum time between out-of-alternation westerly arrivals

2.3.11 The (weighted) average maximum time between out-of-alternation westerly arrivals for the baseline and trial periods are given in **Tables 13 to 15**. The maximum time between any two out-of-alternation westerly arrivals was identified for each day that there were at least two such arrivals. These results were multiplied by the number of out-of-alternation westerly arrivals which occurred on each respective day, the products summed, then that total divided by the sum of the out-of-alternation westerly arrivals for the days where there were at least two such arrivals.

Table 13: Average maximum time between out-of-alternation westerly arrivals
Phase 1

Period	Average maximum time (minutes)
Previous 3 winters	220
Winter 2011-2012	209

Table 14: Average maximum time between out-of-alternation westerly arrivals
Phase 2 summer season

Period	Average maximum time (minutes)
Baseline	295
Trial	238

Table 15: Average maximum time between out-of-alternation westerly arrivals
Phase 2 winter season

Period	Average maximum time (minutes)
Baseline	223
Trial	193

2.3.12 These results show that in all parts of the trial, there were periods of time when out-of-alternation arrivals did not occur. In each case, the average maximum time was lower in the trial than the baseline periods, due to the higher number of out-of-alternation arrivals and/or the different approach taken towards arrivals management by NATS.

2.3.13 The highest maximum times were found for the Phase 2 summer season, and the lowest were found for the Phase 2 winter season. This suggests that even though there were fewer TEAM* arrivals during the Phase 2 winter season, the out-of-alternation westerly arrivals were kept reasonably close together as oppose to being spread across the 8-hour respite period.

2.4 Noise contours

2.4.1 For the analysis of the Phase 1 trial, a comprehensive assessment of the noise effects of TEAM* was undertaken which included: plotting 8-hour and 1-hour L_{eq} noise contours, and 8-hour N70 and TA70 noise contours for the baseline and trial period; plotting contours showing the difference between baseline and trial scenarios for the above metrics; and calculation of areas and populations exposed to different levels of the metrics.

2.4.2 This assessment is included in Appendix 1. In summary, the changes in noise exposure resulting from the increase in de-alternated westerly arrivals were analysed using the Leq noise exposure index for both the 8-hour alternation period and 1-hour 'maximum-use' of TEAM* scenarios. The analysis found:

- A near doubling in out-of-alternation arrivals leads to an increase in Leq noise exposure of almost 3 dB, but almost no decrease in Leq noise exposure. This occurs because the number of flights de-alternated from the designated landing runway is very small compared with the total number of flights on the designated landing runway (1.6% approx.).
- In terms of geographical location, the effects of de-alternation are greatest very close to the airport (immediately east of the airport) where the benefits of alternation are greatest. The effects of de-alternation then become less apparent further away from the airport, particularly beyond approximately 15 km, due to the benefits of alternation diminishing as the differences in noise level between the two flight paths reduce.

2.4.3 A number of additional analyses were undertaken using supplemental noise metrics, including number of events above 70 dBA Lmax (N70) and time above 70 dBA Lmax (TA70). In summary:

- The N70 analysis showed that the Phase 1 trial increase in de-alternation resulted in between one and five more noise events exceeding 70 dBA per 8-hour respite period, but with a corresponding reduction during the 8-hour non-respite period. This reduction is low in proportion to the number of noise events which occur during the 8-hour non-respite period. However the corresponding increase in noise events during the alternation respite period is higher in proportion to the number of noise events which occur during this period.
- The TA70 analysis showed that the Phase 1 trial increase in de-alternation resulted in between 0.5 and 2 minutes more noise exposure above 70 dBA Lmax per 8-hour respite period, but with a corresponding reduction during the 8-hour non-respite period. Similarly as for the number of events, the 0.5 to 2 minute reduction in noise exposure above 70 dBA during the non-respite period is small compared with the overall noise exposure during this period. The corresponding increase during the alternation respite period is again higher in proportion to the noise exposure during this period.

- The variation in number of events and time of exposure above 70 dBA Lmax is due to some of the noise events for the quieter aircraft not exceeding 70 dBA Lmax further out from the airport.

2.4.4 In the Phase 2 summer season, there was a daily average of 9.9 TEAM* arrivals which is 9% lower than that for Phase 1 when there were 10.9 TEAM* arrivals. Because of the similarity in the usage of TEAM* between the two periods, repeating the full assessment for the Phase 2 summer season would give similar results as for Phase 1. As this would not provide any useful new information, there is insufficient justification for carrying out the full analysis for the Phase 2 summer season.

2.4.5 In the Phase 2 winter season, the daily average number of TEAM* arrivals was slightly lower than that of the baseline. Given this marginal change from the baseline, there is insufficient justification for carrying out the full analysis for the Phase 2 winter season.

2.4.6 Referring to sections 2.1.9 and 2.1.12 the number of TEAM* movements in the Phase 2 trial periods has been recalculated on the basis of a baseline incorporating the previous five years. This recalculation resulted in 0.3 more out-of-alternation arrivals in the Phase 2 summer season than the Phase 1 season. This increase would result in an increase in noise level associated with the out-of-alternation arrivals of less than 1 dB, which being less than the threshold of perception (3 dB), we have not reproduced the noise contours.

3. Early-vectored departures

3.1 Daily average number of early-vectored departures

3.1.1 The early-vectored departures freedom was not used during Phase 1, but it was used during certain parts of Phase 2 of the trial. For these times, Heathrow Airport recorded which departures were vectored early, and whether these departures were vectored for the trial or for other reasons, such as for the avoidance of bad weather. Monitoring of early-vectored departures during the baseline periods was not carried out to the same level of detail, so there is no reliable way of identifying the precise number of weather-related early-vectored departures which occurred during the baseline period.

3.1.2 It is reasonable to assume that the number of weather-related early vectors is independent of the Operational Freedoms Trial. Therefore, for the numerical analysis we have established a baseline comprising only the weather-vectored departures identified during the trial period.

3.1.3 The total numbers of early-vectored departures between 07:00 and 23:00 for each relevant SID and for both the baseline and trial are presented in **Table 16** for the summer season, and **Table 17** for the winter season. The numbers of operational freedom (OF) early-vectored departures have been extracted from this data and also presented.

3.1.4 Westerly runway alternation generally halves[8] the number of hours for which the north and south runways are designated for departure operations, compared with easterly operations which are not subject to runway alternation. Therefore, to enable useful comparisons to be made between easterly and westerly operations, the data for 27L MID and 27R MID have been combined and described as 27 MID.

Table 16: Numbers of early-vectored departures
Phase 2 summer season

Period	Early-vectored departures			
	09R DVR	27L MID	27R MID	27 MID
Baseline (weather only)	14	52	30	82
Trial (weather & OF)	895	1930	2398	4328
OF early-vectored only	881	1878	2368	4246

Table 17: Numbers of early-vectored departures
Phase 2 winter season

Period	Early-vectored departures			
	09RDVR	27LMID	27RMID	27MID
Baseline (weather only)	0	10	16	26
Trial (weather & OF)	283	1410	1240	2650
OF early-vectored only	283	1400	1224	2624

[8] Applies when considering 100% westerly or easterly days

3.1.5 The data shows that there were many more (one to two orders of magnitude) operational freedom early-vectored departures than weather-vectored departures during the trial periods. It also shows that there were many more westerly than easterly early-vectored departures due to there having been a predominance of days of westerly operation during the trial.

3.1.6 Comparing the Phase 2 summer and winter seasons, there were significantly more weather and OF early vectored departures during the summer season than the winter season.

3.1.7 The daily average numbers of early-vectored departures for each relevant SID for the baseline and trial are presented in **Table 18** for the Phase 2 summer season, and in **Table 19** for the Phase 2 winter season. The averages for each SID are based on the total number of days for which there was at least one early-vectored departure on the given SID (also presented).

Table 18: Average number of daily early-vectored departures Phase 2 summer season

Period	Early-vectored departures			
	09R DVR	**27L MID**	**27R MID**	**27 MID**
Baseline (weather only)	0.7	0.7	0.4	0.9
Trial (weather & OF)	44.8	26.1	31.1	48.1
OF early-vectored only	44.1	25.4	30.8	47.2
Number of days with early-vectored departures	20	74	77	90

Table 19: Average number of daily early-vectored departures Phase 2 winter season

Period	Early-vectored departures			
	09R DVR	**27L MID**	**27R MID**	**27 MID**
Baseline (weather only)	0.0	0.2	0.4	0.4
Trial (weather & OF)	35.4	32.8	28.2	43.4
OF early-vectored only	35.4	32.6	27.8	43.0
Number of days with early-vectored departures	8	43	44	61

3.1.8 As easterly departures occur on 09R, without alternation to 09L, as occurs for 27L and 27R, the results for the runway 27 SIDs are therefore lower than those for 09R DVR. When the data relating to 27L and 27R MID are combined, it can be seen that on an average day, there are more early-vectored departures on westerly operation than on easterly operation.

3.1.9 Table 18 shows that during the Phase 2 summer season, use of the Early-Vectored Departures operational freedom increased the daily average number of early-vectored departures on 09R DVR and 27 MID by 44.1 and 47.2 departures respectively. During the trial, the average number of daily operational freedom early-vectored departures comprised 98% of all early-vectored departures for both easterly and westerly operations.

3.1.10 Table 19 shows that during the Phase 2 winter season, use of the Early-Vectored Departures operational freedom increased the daily average number of early-vectored departures on 09R DVR and 27 MID by 35.4 and 43.0 departures respectively. During the trial, the average number of daily operational freedom early-vectored departures comprised 99% of all early-vectored departures for both easterly and westerly operations.

3.1.11 The September monthly report produced by Heathrow Airport refers to operational freedoms being applied to the TANGO SID. This is a planned route, rather than a vector heading, which is being used for the same purpose as the vector headings within Phase 2 of the trial.

3.1.12 During the summer season, on 5 September, 19 departures used the TANGO SID. These departures occurred during the period of almost nine hours between 08:00 and 16:52. Since only 19 departures occurred on TANGO, and because these only occurred on one day, no further numerical analysis has been undertaken on this.

3.1.13 During the winter season, 23 departures used the TANGO SID over three days: eight on 5 November, six on 26 November 2012, and nine on 25 January 2013. Again, as departures on TANGO were few and occurred on only three days of the trial, no further numerical analysis has been undertaken on this.

3.2 Noise energy analysis of early-vectored departures

3.2.1 The primary noise effect of early-vectored departures is a shift of ground track for some aircraft, thus redistributing aircraft noise so that some people experience more noise (and others, less) than they otherwise would. We have addressed this effect, in part, by identifying how many more aircraft have been early-vectored off track during the trial due to the operational freedom, than were otherwise vectored for weather avoidance (section 3.1 above).

3.2.2 The overall noise level may also have changed, however, as a result of any changes in the fleet mix of operational freedom early-vectored departures compared with the weather-vectored departures. To investigate this, the average noise energy for the fleet mixes for both categories for each SID could be calculated using an equivalent methodology as that for the out-of-alternation arrivals energy analysis.

3.2.3 However, Tables 16 to 19 show that there were comparatively low numbers of weather-vectored departures. This is too low to be able to obtain a statistically robust average noise energy, therefore the results would have limited validity. We have therefore not presented an energy analysis for early-vectored departures, instead addressing noise energy through the preparation of noise contours (see sections 3.4 and 3.5).

3.3 Statistical descriptors

3.3.1 The core analyses presented in section 3.1 established the average numbers of operational freedom early-vectored departures which occurred during the trial periods. A series of statistical analyses have been undertaken to identify how the numbers of these flights varied from day to day, and how these flights were distributed temporally throughout the average day.

Distribution of numbers of daily operational freedom early-vectored departures

3.3.2 The distribution of the numbers of daily early-vectored departures during the Phase 2 summer season is illustrated in the histograms in **Charts 3 to 6**. Data is presented for all early vectors (weather-related and operational freedom early vectors) and for the operational freedom early vectors only.

Chart 3: Numbers of daily early-vectored departures on 09R DVR Phase 2 summer season

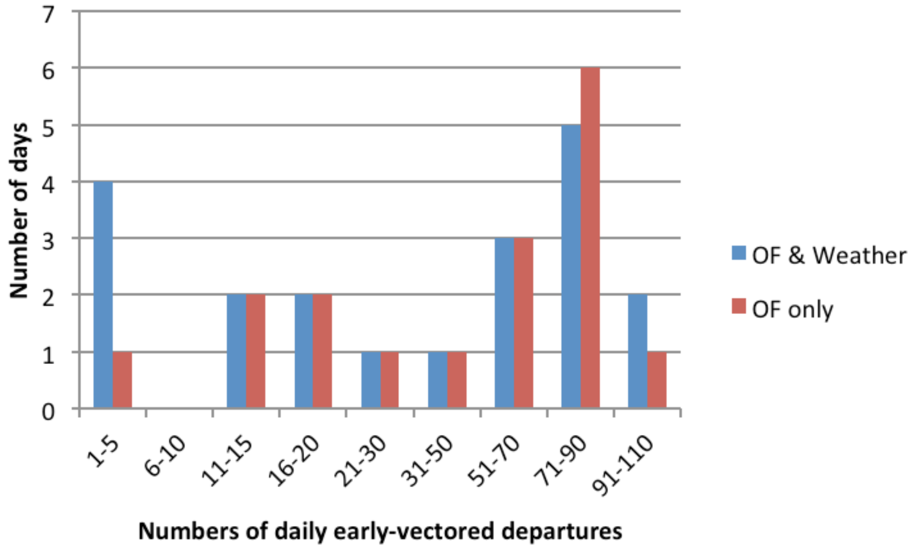


Chart 4: Numbers of daily early-vectored departures on 27L MID Phase 2 summer season

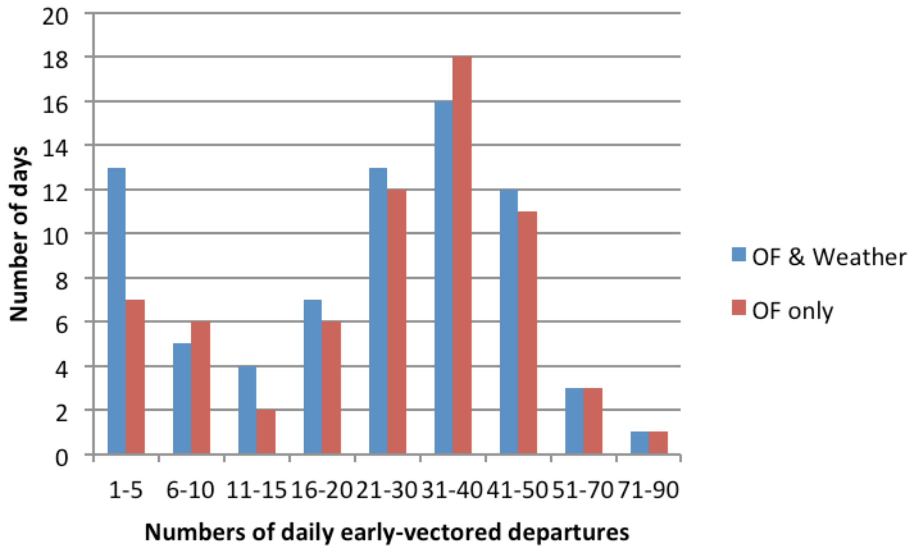


Chart 5: Numbers of daily early-vectored departures on 27R MID Phase 2 summer season

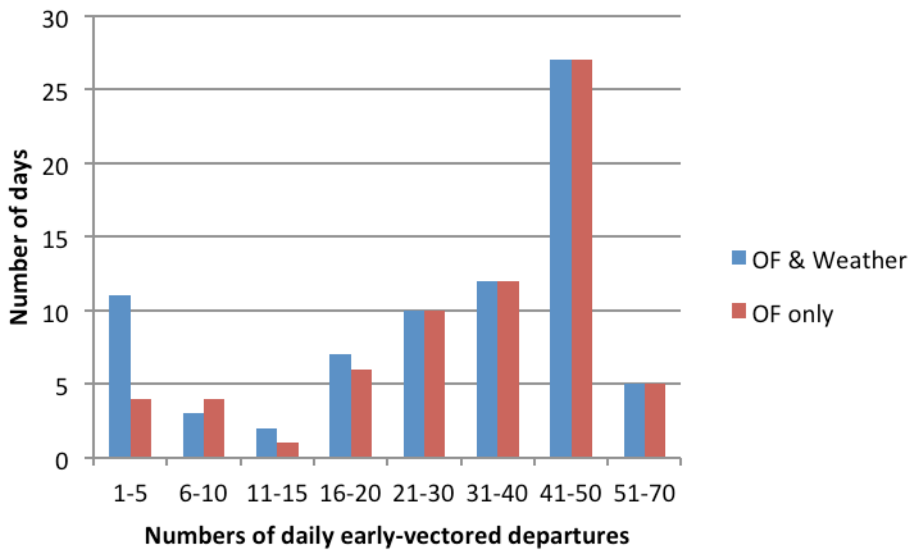
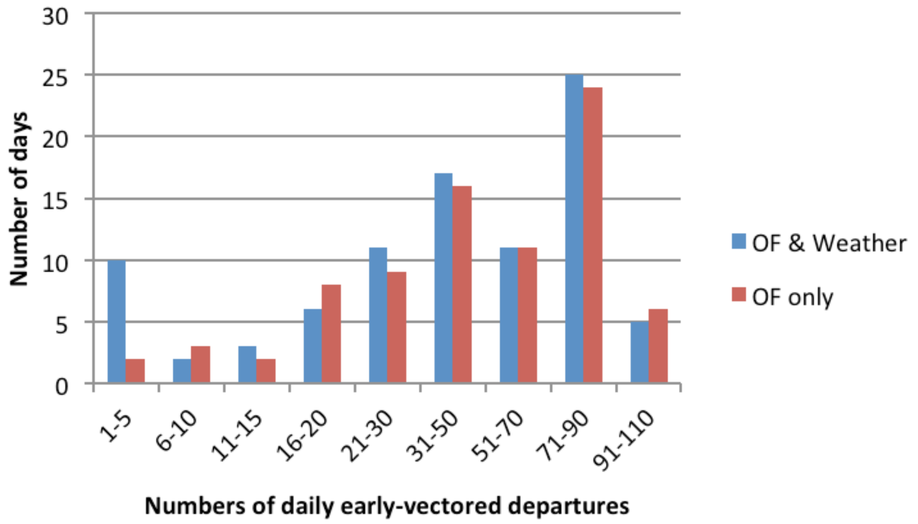


Chart 6: Numbers of daily early-vectored departures on 27 MID Phase 2 summer season



3.3.3 These charts show a large range in the numbers of daily early-vectored departures during the summer season. For each SID, there is a noticeable peak in the numbers of days for which there were between one and five OF & Weather early-vectored departures. These are predominantly weather-vectored departures, not operational freedom early vectors. Of the days when the early-vectored departures freedom was available[9], there were four easterly days, and 17 westerly days, when there were no operational freedom early-vectored departures.

[9] On the basis of 18% easterly operations during the trial period, see main report – 'Heathrow Operational Freedoms Trial - Phase 2, End-of-season report, summer 2012'

3.3.4 For 09R DVR, the modal range of numbers of daily early-vectored departures was 71-90. For over half the days during the trial when there were early-vectored departures on 09R DVR there were from 51 to 90 such departures. For 27 MID, the modal range of numbers of daily early-vectored departures was also 71-90.

3.3.5 For 27L MID, there was a noticeable peak in the range of 31-41 departures, and for 27R MID, the peak was in the range 41-50 departures and was more pronounced than for 27L MID.

3.3.6 The distribution of the numbers of daily early-vectored departures during the Phase 2 winter season is illustrated in the histograms in **Charts 7 to 10**. Again, data is presented for all early vectors (weather-related and operational freedom vectors) and for the operational freedom vectors only.

Chart 7: Numbers of daily early-vectored departures on 09R DVR Phase 2 winter season

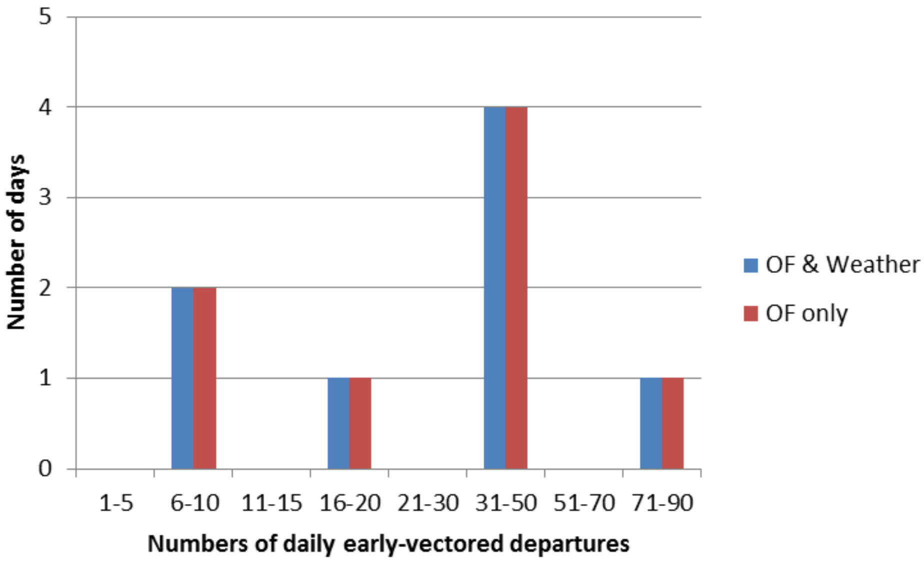


Chart 8: Numbers of daily early-vectored departures on 27L MID Phase 2 winter season

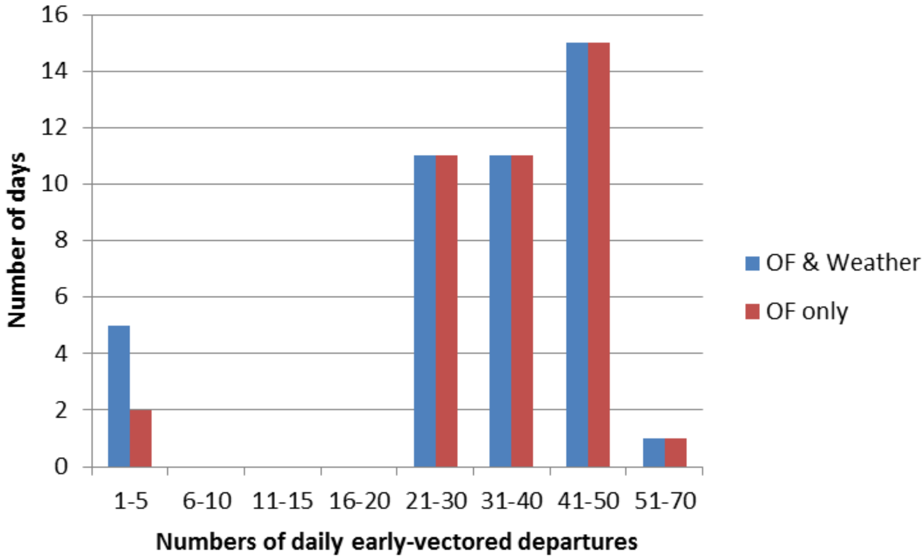


Chart 9: Numbers of daily early-vectored departures on 27R MID Phase 2 winter season

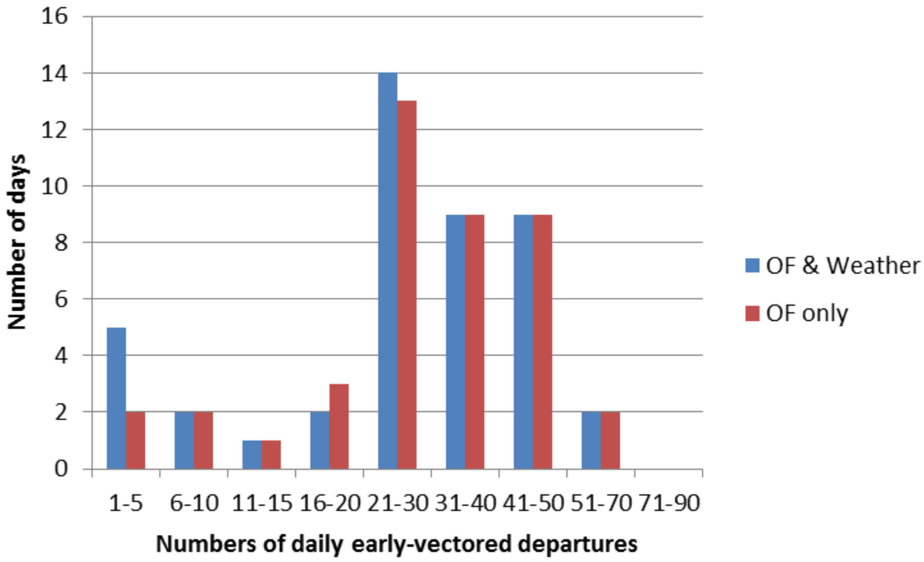
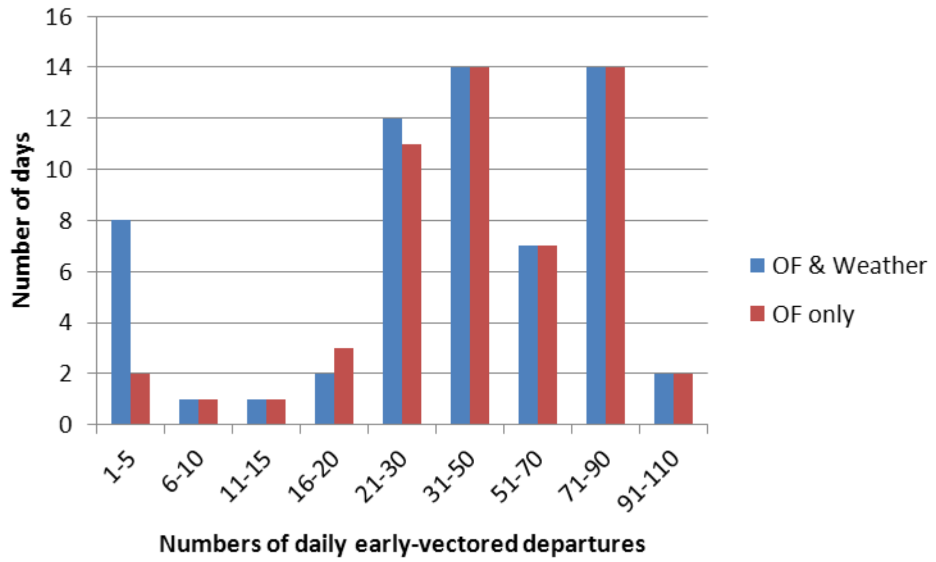


Chart 10: Numbers of daily early-vectored departures on 27 MID Phase 2 winter season



3.3.7 These charts show a large range in the numbers of daily early-vectored departures during the winter season, as for the summer season. The analysis shows, however, that within this range, the distribution of the numbers of daily early-vectored departures is different.

3.3.8 Of the days when the early-vectored departures freedom was available during the winter season (28 Oct 2012-31 Jan 2013 with 14 Easterly days and 67 Westerly days), there were 10 easterly days, 14 westerly days, and six Mixed days when there were no operational freedom early-vectored departures.

3.3.9 For 09R DVR, early-vectored departures occurred on only eight days, four of which had between 31-50 such departures. For 27 MID, the modal ranges of numbers of daily early-vectored departures were 31-50 and 71-90.

3.3.10 For 27L MID, there were noticeable peaks in the ranges of 1-5 and 41-50 departures. For about a third of the days for which there were early-vectored departures on 27L MID, there were up to only five such departures. For 27R MID, there was a single peak in the range 21-30 departures.

Average time between early-vectored departures

3.3.11 **Tables 20 and 21** show the average times between early-vectored departures. These have been calculated in a similar way to that described in section 2.3.5. Data is presented for all early vectors (weather and operational freedom vectors) and for the operational freedom vectors only. Because of the small number of weather-vectored departures, less than one per day on average, it is not appropriate or statistically robust to perform this analysis on the weather-vectored departures only. The data has been included in the tables for interest, however.

Table 20: Average time between early-vectored departures Phase 2 summer season

Period	Average time (minutes)			
	09R DVR	**27L MID**	**27R MID**	**27 MID**
Weather only	2.5	29.3	22.9	30.4
All early vectors	8.5	10.1	8.8	10.1
OF vectors only	8.5	9.5	8.6	9.8

Table 21: Average time between early-vectored departures Phase 2 winter season

Period	Average time (minutes)			
	09R DVR	**27L MID**	**27R MID**	**27 MID**
Weather only	n/a	15.2	15.6	15.5
All early vectors	8.4	9.1	9.2	9.6
OF vectors only	8.4	9.0	8.9	6.2

3.3.12 The average time between early-vectored departures was around eight to ten minutes for the summer season, and around six to nine minutes for the winter season. One may expect that the average time between early-vectored departures would be lower for all early vectors than for weather or OF vectors only. However, the lowest average times were measured for OF vectors only which shows that the freedom was switched on for discrete periods rather than being used on a flight-by-flight basis throughout the day.

Average number of hours with no early-vectored departures

3.3.13 Here, for each day, the number of hours between 07:00 and the first early-vectored departure, and the number of hours between the last early-vectored departure and 23:00 are summed. These are then added together for all the days when there was at least one early-vectored departure for that SID (see Tables 18 and 19), and divided by that same number of days. The results are presented below for the Phase 2 summer and winter seasons. The data has been included for weather-vectored departures only, again for information in light of the lack of statistical validity.

Table 22: Average number of hours with no early-vectored departures Phase 2 summer season

Period	Average number of hours			
	09R DVR	**27L MID**	**27R MID**	**27 MID**
Weather only	15.9	12.3	15.9	12.7
All early vectors	8.9	11.3	11.0	7.3
OF vectors only	8.7	11.4	11.0	7.4

Table 23: Average number of hours with no early-vectored departures
Phase 2 winter season

Period	Average number of hours			
	09R DVR	27L MID	27R MID	27 MID
Weather only	16.0	15.2	15.2	15.2
All early vectors	11.1	11.0	11.7	9.1
OF vectors only	11.1	10.7	11.6	11.1

3.3.14 For the Phase 2 summer season, the number of hours without early-vectored departures was around 2.5 to 3 hours more for 27L MID and 27R MID than for 09R DVR. This is because westerly runway alternation generally halves the number of hours for which the north and south runways are designated for departure operations (for 100% westerly or easterly days). There were fewer hours in an average westerly day with no early-vectored departures than on an average easterly day. This is probably due to the fact that early vectoring was available on a different SID for westerly and easterly operations.

3.3.15 For the Phase 2 winter season, it can be seen that the lower number of early-vectored departures has generally led to an increase in the average number of hours with no such departures compared with the summer season.

Average number of one-hour periods during which there was at least one early-vectored departure

3.3.16 To understand when in a day early-vectored departures occur, for each day and each SID, the number of one-hour periods during which there was at least one early-vectored departure was calculated. These were then added together for all the days when there was at least one early-vectored departure for that respective SID, and divided by that same number of days. The data has been included for weather-vectored departures only, again for information in light of the lack of statistical validity. The results are presented in **Tables 24 and 25** below.

Table 24: Average number of one-hour periods with
at least one early-vectored departure
Phase 2 summer season

Period	Average number of one-hour periods			
	09R DVR	27L MID	27R MID	27 MID
Weather only	1.2	1.8	1.4	1.9
All early vectors	7.3	4.9	5.3	8.4
OF vectors only	7.9	5.2	5.7	9.0

Table 25: Average number of one-hour periods with at least one early-vectored departure Phase 2 winter season

Period	Average number of one-hour periods			
	09R DVR	27L MID	27R MID	27 MID
Weather only	0.0	2.0	1.4	1.6
All early vectors	5.6	5.9	5.0	7.8
OF vectors only	5.6	6.2	5.2	8.4

3.3.17 The data for Phase 2 summer season shows that operational freedom early-vectored departures on 09R DVR occurred, on average, during nearly eight clock-hour periods. Operational freedom early-vectored departures on 27L MID and 27R MID occurred during just over five, and nearly six clock-hour periods respectively. These latter cases are lower than for 09R DVR owing to westerly runway alternation. There was, on average, one more one-hour period with at least one early-vectored departure on westerly operation than on easterly operation.

3.3.18 There were generally fewer one-our periods with at least one early-vectored departure in the winter than the summer season. The exception is OF vectors on 27L MID where there was one extra clock-hour period with such departures during the winter compared with the summer season.

3.3.19 The averages are lower when weather-vectored departures are included, as these occurred in small numbers on some days where there were no operational freedom early-vectored departures.

3.3.20 **Charts 11 to 14** below illustrate the distribution of the daily numbers of one-hour periods where there was at least one early-vectored departure during the Phase 2 summer season. Data is presented for all early vectors (weather and operational freedom vectors) and for just the operational freedom vectors.

Chart 11: Daily numbers of one-hour periods with at least one early-vectored departure on 09R DVR Phase 2 summer season

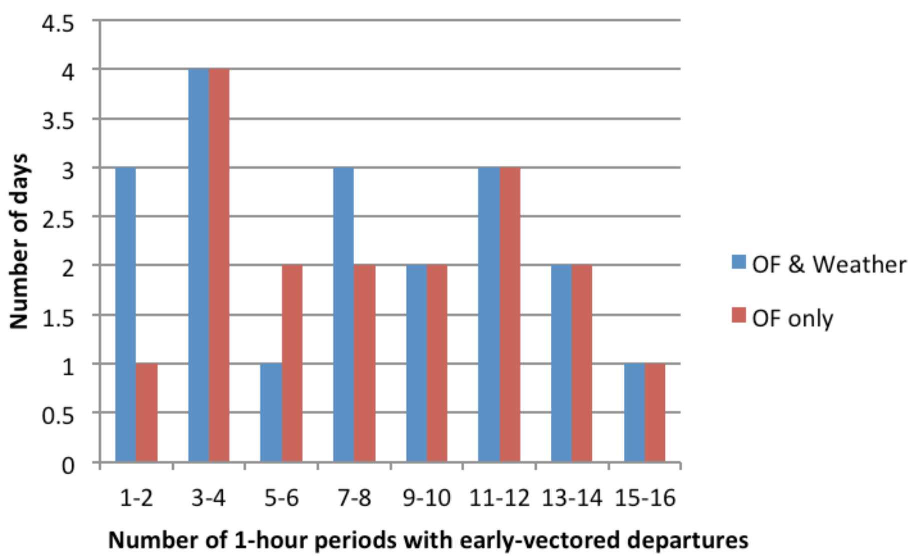


Chart 12: Daily numbers of one-hour periods with at least one early-vectored departure on 27L MID
Phase 2 summer season

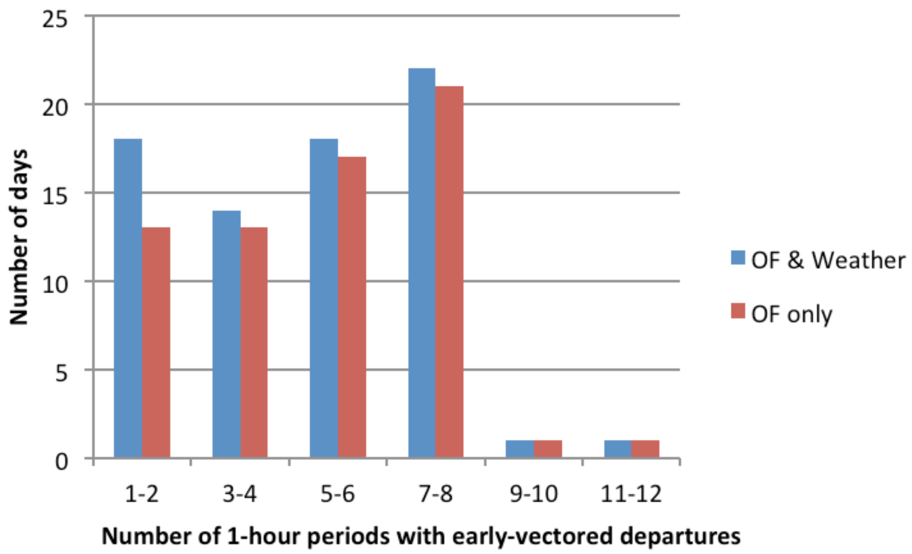


Chart 13: Daily numbers of one-hour periods with at least one early-vectored departure on 27R MID
Phase 2 summer season

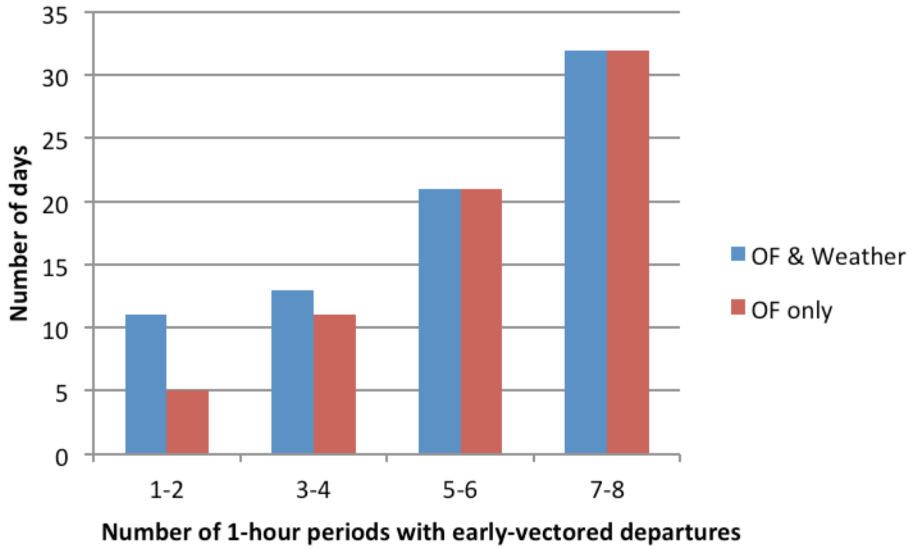
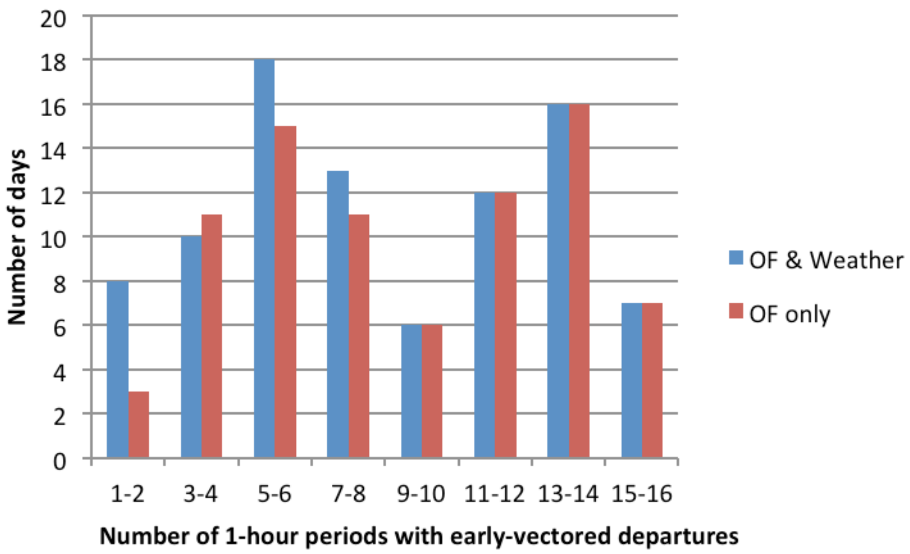


Chart 14: Daily numbers of one-hour periods with at least one early-vectored departure on 27 MID
Phase 2 summer season



3.3.21 Chart 11 shows that on easterly operation, early-vectored departures occurred over almost any number of daytime hours. For westerly operations, early-vectored departures occurred over up to eight hours (with a couple of exceptions on 27L MID); as a consequence of westerly runway alternation. There was a bias towards departures occurring over a larger number of hours.

3.3.22 Chart 14, like Chart 11, indicates that westerly early-vectored departures occurred over any number of daytime hours. Both charts exhibit two peaks, one towards the lower and one towards the upper end of the range. The peaks are more pronounced for Chart 14, presumably due to the larger sample of data.

3.3.23 **Charts 15 to 18** below illustrate the distribution of the daily numbers of one-hour periods where there was at least one early-vectored departure during the Phase 2 winter season. Again, data is presented for all early vectors (weather and operational freedom vectors) and for just the operational freedom vectors.

**Chart 15: Daily numbers of one-hour periods with at least one early-vectored departure on 09R DVR
Phase 2 winter season**

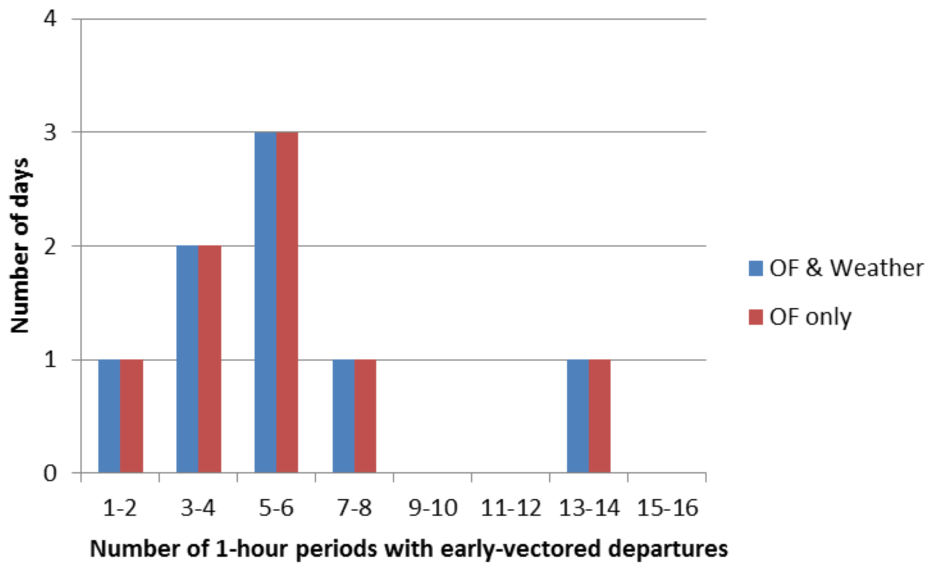


**Chart 16: Daily numbers of one-hour periods with at least one early-vectored departure on 27L MID
Phase 2 winter season**

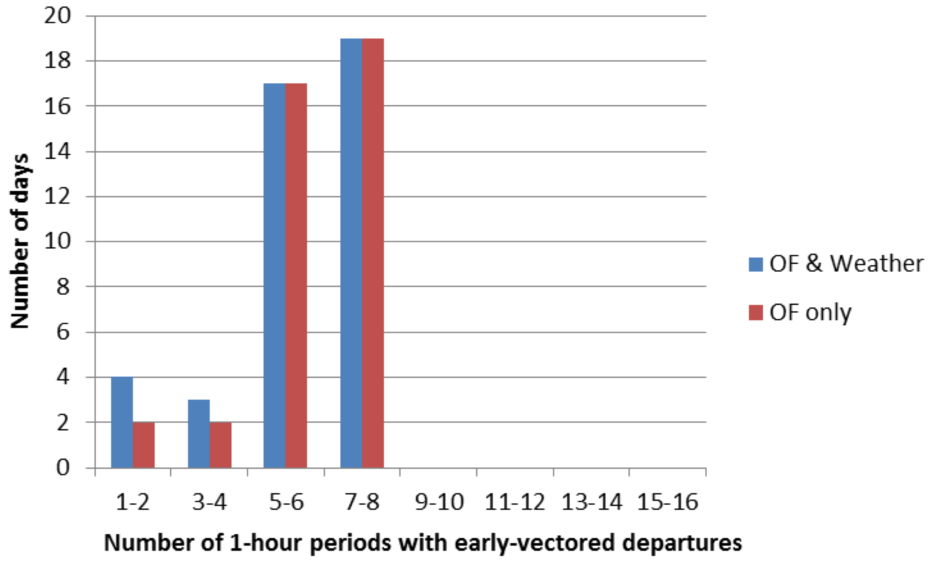


Chart 17: Daily numbers of one-hour periods with at least one early-vectored departure on 27R MID
Phase 2 winter season

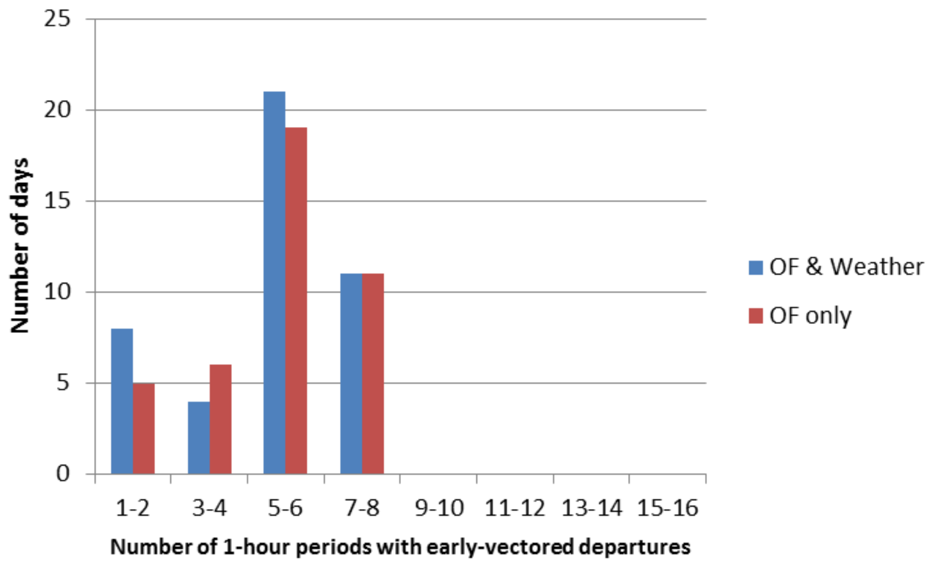
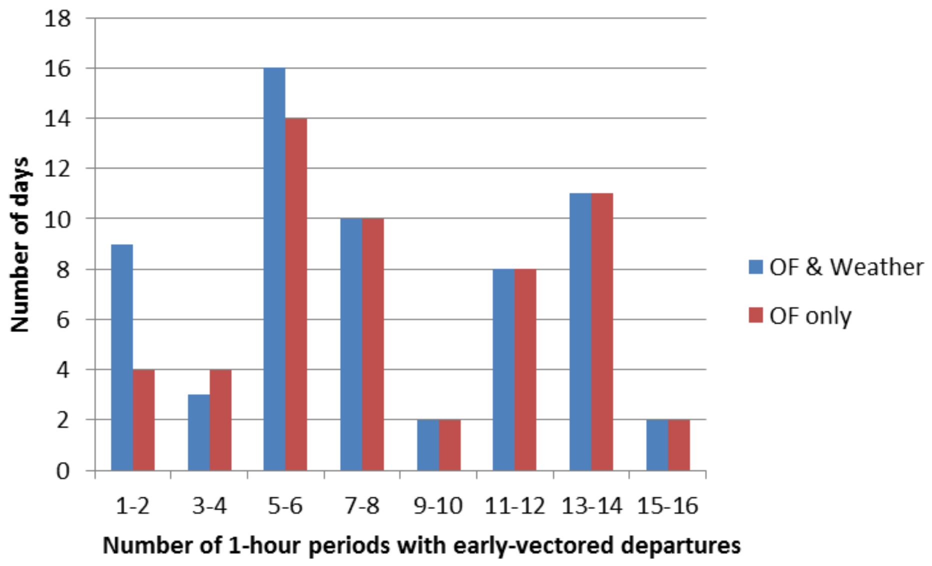


Chart 18: Daily numbers of one-hour periods with at least one early-vectored departure on 27 MID
Phase 2 winter season



3.3.24 Chart 15 shows that on easterly operation, early-vectored departures occurred over 5-6 hours for three out of the eight days for which there were such departures. For westerly operations, Charts 16 and 17 show that early-vectored departures mainly occurred over 5-8 hours as a consequence of westerly runway alternation showing a similar bias towards departures occurring over a larger number of hours as was seen in the summer season data.

3.3.25 Chart 18 indicates that westerly early-vectored departures occurred over any number of daytime hours. Like for easterly operation, there is a peak at 5-6 periods, with an additional less prominent peak at 13-14 periods.

Average number of blocks of consecutive one-hour periods during which there was at least one early-vectored departure

3.3.26 For each day and each SID, the number of blocks of consecutive one-hour periods during which there was at least one early-vectored departure was calculated. These were then added together for all the days when there was at least one early-vectored departure for that respective SID, and divided by that same number of days. The data has been included for weather-vectored departures only, again for information in light of the lack of statistical validity. The results are presented in **Tables 26 and 27** below.

Table 26: Average number of blocks of consecutive one-hour periods with at least one early-vectored departure Phase 2 summer season

Period	Average number of blocks			
	09R DVR	27L MID	27R MID	27 MID
Weather only	1.00	1.46	1.15	1.50
All early vectors	1.21	1.15	1.03	1.30
OF vectors only	1.18	1.08	1.00	1.17

Table 27: Average number of blocks of consecutive one-hour periods with at least one early-vectored departure Phase 2 winter season

Period	Average number of blocks			
	09R DVR	27L MID	27R MID	27 MID
Weather only	0.00	1.00	1.20	1.13
All early vectors	1.13	1.02	1.09	1.10
OF vectors only	1.13	1.03	1.02	1.05

3.3.27 Tables 26 and 27 show that for the vast majority of days, there was only one block of consecutive 1-hour periods with at least one early-vectored departure. In other words, once early-vectoring began, it usually continued with at least one-per-hour until the procedure stops for the day.

3.3.28 On some days there were two blocks, but never three. An intuitive way to interpret the results is that the decimal fraction of the number reveals the number of two-block days per every 100 days (i.e. 1.15 means that in 100 days, 15 days have two blocks of early-vectored departures and 85 days have only one block).

3.3.29 There were broadly the same number of 2-block days on 09R DVR early vectors as on 27 MID during the summer season. There were more 2-block days when weather-vectored departures were taken into account as well as the operational freedom early-vectored departures. During the winter season, there were even fewer 2-block days than during the summer season.

Track density plots

3.3.30 A track density plot illustrates the concentration of flight tracks around an airport. **Figures 1 to 4** are such plots for the Phase 2 summer season trial period. Figures 1 and 2 consider departure operations on 09R DVR, 27L MID and 27R MID only, and illustrate the concentration of operational freedom early-vectored departure tracks and non-operational freedom departure tracks respectively. Figure 3 illustrates the tracks flown by all aircraft departing Heathrow during the trial period, and Figure 4 illustrates all departures except the operational freedom early-vectored departures.

3.3.31 Figures 1 to 4 also present the relevant mean tracks for the standard SID and early-vectored routes.

3.3.32 These figures illustrate the greater number of operational freedom early-vectored departures on 27L MID and 27R MID than on 09R DVR, and give an indication of how the tracks followed by these relate to the non-early-vectored departure tracks.

3.3.33 Since there were fewer early-vectored departures during the winter season, and that they were applied to the same routes as in the summer season, track density plots for the winter season have not been produced.

3.4 L_{eq} noise contours

3.4.1 Since 1990 (Ref 1), $L_{eq,16h}$ (0700-2300) has been the standard noise index used to generate noise contours to depict long-term average noise exposure in the vicinity of airports. For the Phase 1 noise analysis, the effect of TEAM* was assessed by comparing L_{eq} noise contours for the trial and baseline periods.

3.4.2 There was a need to correctly isolate the effects of the Phase 1 trial from the effect of the change in mix of aircraft types that operated during the trial and the baseline periods. The traffic mix was therefore held constant by using the latest available average summer westerly arrival traffic (from summer 2011) and combining this with the average numbers of daily de-alternated westerly arrivals for the baseline and Phase 1 trial periods.

3.4.3 Whilst one could have selected the traffic sample from that during the Phase 1 trial period as the reference traffic mix, there is a long-standing tradition of producing L_{eq} noise exposure contours that represent a summer average day[10]. The summer average day reflects slightly higher traffic numbers during the summer months and also reflects aircraft performance during warmer summer temperatures.

3.4.4 A similar approach has been taken for assessing the effect of early-vectored departures during the Phase 2 summer season. The radar tracks for the operational freedom early-vectored departures were analysed to calculate mean tracks and dispersion parameters for each of the early vector headings. The 2011 summer input data was modified by moving appropriate numbers of aircraft from the mean tracks[11] associated with the 09 RDVR, 27L MID and 27R MID SIDs to the respective early vector tracks. Adjustments were made to account for differences in modal split and daily average movement numbers between the trial and summer 2011 periods.

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[10] An average of the 92-day period from 16 June to 15 September inclusive.
[11] Based on operations from 16th June to 15th September 2011

3.4.5 16-hour L_{eq} noise contours representing the Phase 2 summer season trial were plotted for departure movements only, on all SIDs and early vector headings as appropriate. These are shown in **Figure 5** and the corresponding areas, populations and households are presented in **Table 28** below.

Table 28: Trial 16-hour Leq departure noise contours: areas, populations and households

Noise level (dBA Leq)	Area (km^2)	Population (000s)	Households (000s)
>54	142.4	256.7	103.5
>57	78.3	102.1	40.7
>60	44.1	35.0	14.7
>63	27.3	10.5	4.7
>66	17.1	4.5	2.0
>69	8.3	1.0	0.5
>72	4.6	<0.1	<0.1

3.4.6 Equivalent contours representing the baseline were plotted for summer 2011, see **Figure 6**. The corresponding areas, populations and households are presented in **Table 29** below.

Table 29: Baseline 16-hour Leq departure noise contours: areas, populations and households

Noise level (dBA Leq)	Area (km^2)	Population (000s)	Households (000s)
>54	142.7	256.0	103.4
>57	78.7	102.2	40.8
>60	44.3	35.0	14.7
>63	27.2	10.5	4.7
>66	17.1	4.5	2.0
>69	8.3	1.0	0.4
>72	4.6	<0.1	<0.1

3.4.7 Because the number of weather-vectored departures comprises a small proportion of the total summer departures, it is standard practice when producing summer contours to allocate these movements to the SIDs rather than model them separately. Therefore, the difference between these two contours represents a worst-case effect of the operational freedom early-vectored departures.

3.4.8 The trial and baseline scenarios have been subtracted from each other to portray L_{eq} difference contours. These show changes in 16-hour noise exposure as a result of the operational freedom early-vectored departures. **Figure 7** shows this change in noise exposure above 54 dBA L_{eq}. The corresponding areas, populations and households exposed to specific changes in noise exposure are presented in **Table 30** below.

Table 30: Changes in 16-hour Leq departure noise exposure: areas, populations and households

Noise level (dBA Leq)	Area (km^2)	Population (000s)	Households (000s)
>54	-0.3	0.7	0.1
>57	-0.4	-0.1	-0.1
>60	-0.2	-	-
>63	0.1	-	-
>66	-	-	-
>69	-	0.01	0.01
>72	-	-	-

3.4.9 The trial and baseline contours exhibit slightly different shapes in the lobes to the southeast and southwest. This is due to the repositioning of the early-vectored departures off the standard SIDs. The difference contours show where daytime average noise levels have increased and decreased.

3.4.10 The greatest increase in noise level (where absolute noise levels are 54 dBA $L_{eq,16h}$ or more) is +0.8 dBA as shown by the darkest red shaded area. This occurs beneath the 09R DVR early vector heading. The greatest decrease of -0.6 dBA as shown by the darkest blue shaded area occurs beneath the 09R DVR SID from which the operational freedom early-vectored departures have been redirected.

3.4.11 The data tables show that over 100,000 people are affected by daytime average departure noise at a level of 57 dBA $L_{eq,16h}$. Around 100 fewer people (0.1%) were exposed to at least this level of noise as a result of the operational freedom early-vectored departures.

3.4.12 However, over 250,000 people are affected by daytime average departure noise at a level of 54 dBA $L_{eq,16h}$. Around 700 more people (0.3%) were exposed to at least this level of noise as a result of the operational freedom early-vectored departures. The contour area at this noise level has reduced slightly, so the increase in enclosed population is a result of the trial contour boundary moving to bring in some more densely populated areas and leave out some less densely populated areas.

3.4.13 The numbers of early-vectored departures was considerably lower in the Phase 2 winter season compared with the summer season, so the effect would be proportionally lower. As re-calculating the contours for the winter season would not provide any significantly useful new information, there is insufficient justification for carrying out the full contour analysis for the Phase 2 winter season.

3.5 Noise footprints

3.5.1 SEL (Sound Exposure Level) footprints show the extent of noise energy generated from a single aircraft event, for example, an aircraft either taking off or landing (in contrast to the summing of events in noise exposure). Footprints show a contour of equal SEL values, e.g. a 90 dBA SEL footprint shows the area in which SEL values are greater than (or equal to) 90 dBA. These footprints can be used to identify the relative contribution of different aircraft types, routes and operating procedures on overall noise impact.

3.5.2 SEL footprints are used to assess airspace change proposals, which affect the distribution of flights at night below 7,000 feet above ground level and within 25 km of a runway. Night is defined here as the period between 23:00 and 07:00 local time. SEL footprints may also be used to illustrate the effects of an airspace change that is relevant to daytime operations. If the noisiest and most frequent aircraft types are different, then footprints should be calculated for both of them at both 90 dBA SEL and 80 dBA SEL.

3.5.3 The change in Leq which results from considering the early-vectored departures is small because of the small number of such departures compared with the total daily departures, i.e. 45-55 early-vectored departures out of around 650 total departures. SEL footprints are useful in highlighting the change in noise level for a given flight.

3.5.4 We have adopted this established methodology[12] to depict the changes in the short-term noise exposure in the vicinity of the airport due to early-vectored departures. We have calculated footprints for the noisiest aircraft type[13] which is permitted to use the freedom and the noisiest type which used any given SID early-vector heading during the trial periods. We have also calculated footprints for the aircraft type which made most frequent use of the freedom on each of the SID early-vector headings.

3.5.5 The following footprints have been calculated and presented in **Figures 8 to 15**. Each figure shows 80 and 90 dBA SEL footprints for the aircraft on the mean track associated with each SID[14], and on the operational freedom early-vector mean tracks for comparison. The mean tracks are also presented.

Footprint figures:

- **Figure 8**: 09R DVR, Airbus A380 RR-engines (noisiest used during the trial and noisiest permitted)
- **Figure 9**: 09R DVR, Airbus A319 IAE V2500 engines (most common)
- **Figure 10**: 27L MID, MD80 (noisiest permitted)
- **Figure 11**: 27L MID, Airbus A330 (noisiest used during the trial)
- **Figure 12**: 27L MID, Airbus A319 IAE V2500 engines (most common)
- **Figure 13**: 27R MID, MD80 (noisiest permitted)
- **Figure 14**: 27R MID, Airbus A330 (noisiest used during the trial)
- **Figure 15**: 27R MID, Airbus A319 IAE V2500 engines (most common)

3.5.6 On 09R DVR, four-engine heavy and super-heavy aircraft (excluding Boeing B747 aircraft) are permitted to be early-vectored under the operational freedom. The A380 is such a four-engine aircraft whose 80 dBA SEL footprint is much larger than that for the MD80 (which has a marginally larger 90 dBA SEL footprint). This is due to the poorer climb performance of the four-engine A380 compared with the MD80. The A380 is therefore more representative of worst-case noise exposure in Richmond and beyond towards central London.

3.5.7 Note that on 20th September, an A340 was erroneously issued with a departure clearance to vector early off the MID SID; it was not permitted to undertake the procedure. The A340 does produce a larger 90 dBA SEL footprint than the A330,

12 Noise assessment methodology defined in CAP725 – CAA Guidance on the Application of the Airspace Change Process

13 In terms of area within the 90 dBA SEL footprint

14 Based on operations from 16th June to 15th September 2011

but as this only occurred once, and in error, we have not presented noise contours representing the operation.

3.5.8 These footprints clearly show the different areas to the east and west of the airport which are affected by departures on the standard SIDs and on the mean early-vectored headings. The greatest differences occur for the 90 dBA footprint for departures on 09R DVR due to the greater earlier separation of the tracks. The greatest differences occur for the 80 dBA footprint for departures on 27R MID where the tracks separate to a greater extent further from the airport.

3.5.9 The differences for SEL levels above 80 dBA are illustrated in the following difference contours. These show the difference in terms of SEL levels between departures on the SID and on the mean operational freedom early-vector mean track.

Difference between SEL footprints:

- **Figure 16**: 09R DVR, Airbus A380 RR-engines
- **Figure 17**: 09R DVR, Airbus A319 IAE V2500 engines
- **Figure 18**: 27L MID, MD80
- **Figure 19**: 27L MID, Airbus A330
- **Figure 20**: 27L MID, Airbus A319 IAE V2500 engines
- **Figure 21**: 27R MID, MD80
- **Figure 22**: 27R MID, Airbus A330
- **Figure 23**: 27R MID, Airbus A319 IAE V2500 engines

3.5.10 The footprint difference plots show geographical locations where SEL noise levels due to individual aircraft departure movements have increased or decreased. In each of the figures, the increases in noise are shown by the darkest red shaded areas, and the greatest decreases are shown by the blue/purple shaded areas.

3.5.11 For the noisiest aircraft types permitted to use each of the freedoms, there were increases in certain geographical areas of up to 7 dBA on 09R DVR for the A380, 6 dBA on 27L MID for the MD80, and 16 dBA on 27R MID again for the MD80. Respective decreases were down to -7 dBA, -6 dBA and -16 dBA. To put this into context, a change of 10 dBA represents a doubling or halving of loudness.

3.5.12 For the noisiest aircraft types used during the trial, there were increases in certain geographical areas of up to 7 dBA on 09R DVR for the A380, 5 dBA on 27L MID for the A330, and 15 dBA on 27R MID again for the A330. Respective decreases were down to -6 dBA, -5 dBA and -14 dBA.

3.5.13 For the most common aircraft type, the Airbus A319, there were increases in certain geographical areas of up to 6 dBA on 09R DVR, 5 dBA on 27L MID and 14 dBA on 27R MID. Respective decreases were down to -6 dBA, -5 dBA and -10 dBA.

3.5.14 The results show that the greatest differences between standard SID and early-vectored departures occur for departures on 27R MID.

3.5.15 Figures 2 and 4 show that in the absence of the early-vectored departure freedom, aircraft already fly a range of tracks. Therefore, the differences in noise level shown in the figures described above refer to the specific cases of an aircraft on the SID mean track and the operational freedom early-vectored mean track. The differences in noise level between aircraft on individual operational freedom early vectors and individual non-operational freedom departures would therefore cover a range of values for a given location on the ground.

4. Proactive freedoms

4.0.1 During Phase 2 of the trial, the airport recorded which departures were proactively directed to land on the designated arrivals runway. Information was also recorded of the reason for the redirection, i.e. which of the three proactive freedoms listed in section 1.1.1 was used.

4.0.2 We undertook an analysis to verify that the proactive freedoms had been correctly recorded. We did this by defining rules based on the criteria for the three freedoms, as defined by the airport, and testing the arrivals which had been flagged against these.

4.0.3 For the Phase 2 summer season, we found that 47 arrivals were recorded as proactive freedoms when the circumstances did not correspond to any of the three freedoms. In these cases, the movements were not included in the analysis. In 12 other cases, the proactive freedom employed was not clearly or explicitly described. We attributed these movements to the freedoms for which the conditions matched, double-counting as a worst-case assumption when considering the freedoms separately. These 12 arrivals were allocated to both the Small/Light and the Terminal 4 freedoms.

4.0.4 For the Phase 2 winter season, we found that 30 arrivals were recorded as proactive freedoms when the circumstances did not correspond to any of the three freedoms. In these cases, the movements were not included in the analysis. All other arrivals recorded as proactive were matched to freedoms where the conditions were correct, double-counting as a worst-case assumption when considering the freedoms separately. 52 such arrivals were double-counted.

4.0.5 The total numbers of each proactive freedom during the Phase 2 summer and winter season trial periods, as used in the analysis, are quantified in **Tables 31 and 32** below. Note that these numbers include the double-counting described above.

Table 31: Summary of proactive freedom allocation Phase 2 summer season

A380	Small/Light	Terminal 4
47	20	316

Table 32: Summary of proactive freedom allocation Phase 2 winter season

A380	Small/Light	Terminal 4
88	16	413

4.0.6 In the same way as for the reactive freedoms, a series of statistical analyses have been undertaken to identify how the numbers of these arrivals varied from day to day, and how these arrivals were distributed temporally throughout an average day. Due to the relatively limited application of the freedoms, no differentiation has been made between proactive arrivals on westerly or easterly operations.

4.1 Daily average number of proactive arrivals

4.1.1 We have calculated the daily average numbers of proactive arrivals for each of the three proactive freedoms. Two averages are provided: the first, an average over the number of days making up the two periods for which the proactive freedoms were applied; and the second, an average over the number of days for which at least one of the respective proactive freedoms occurred. The results are presented in **Tables 33 and 34** below.

Table 33: Average number of daily proactive arrivals
Phase 2 summer season

Average based on:	A380	Small/Light	Terminal 4
No. days freedom permitted	1.2	0.5	8.1
No. days freedom used	2.2	1.5	8.5

Table 34: Average number of daily proactive arrivals
Phase 2 winter season

Average based on:	A380	Small/Light	Terminal 4
No. days freedom permitted	2.8	0.5	12.9
No. days freedom used	3.0	1.5	13.3

4.1.2 The results show that for both the summer and winter seasons, the Terminal 4 proactive freedom was the most frequently used freedom, followed by the A380 freedom. The Small/Light freedom was used the least frequently.

4.2 Noise energy analysis of proactive arrivals

4.2.1 The average noise energy for the fleet mixes which used each of the proactive freedoms during the trial was calculated for westerly arrivals and compared with the fleet mix for all the out-of-alternation arrivals which occurred during the baseline period (see Table 2 of section 2.2). This was done using the same methodology as used for the out-of-alternation arrivals as described in section 2.2.

4.2.2 The results for the baseline and for each of the proactive freedoms are shown in **Tables 35 and 36**. These have been normalised linearly to 100 for the Baseline.

Table 35: Average noise energy for proactive arrivals
Phase 2 summer season

Average based on:	A380	Small/Light	Terminal 4
Baseline	100	100	100
Proactive arrivals	91	29	99

Table 36: Average noise energy for proactive arrivals
Phase 2 winter season

Average based on:	A380	Small/Light	Terminal 4
Baseline	100	100	100
Proactive arrivals	96	25	106

4.2.3 The results show reductions in noise energy associated with the A380 and Small/Light proactive arrival freedoms compared with the baseline out-of-alternation arrivals. These are equivalent to reductions in noise level of around 0.2 – 0.4 dB for the A380, and 5.3 – 5.9 dB for Small/Light, for an average proactive arrival compared with an average baseline out-of-alternation arrival. In other words, the fleet mixes for these two proactive freedoms were less noisy than the TEAM (and therefore TEAM*, see section 2.2) fleet mix.

4.2.4 There was a 1% decrease in noise energy associated with the Terminal 4 proactive arrival freedom for the summer season, which is equivalent to a change of less than 0.1 dB in noise level. For the winter season, there was a 6% increase, equivalent to a 0.2 dB increase in noise level. This highlights that the mix of Terminal 4 proactive arriving aircraft, in noise terms, was broadly similar during the trial period to that of the baseline.

4.3 Distribution of numbers of proactive arrivals

4.3.1 The distributions of the numbers of proactive arrivals across the 39 days for which the proactive freedoms were active during the Phase 2 summer season are illustrated in the histograms in **Charts 19 to 21** below.

Chart 19: Numbers of daily A380 proactive arrivals Phase 2 summer season

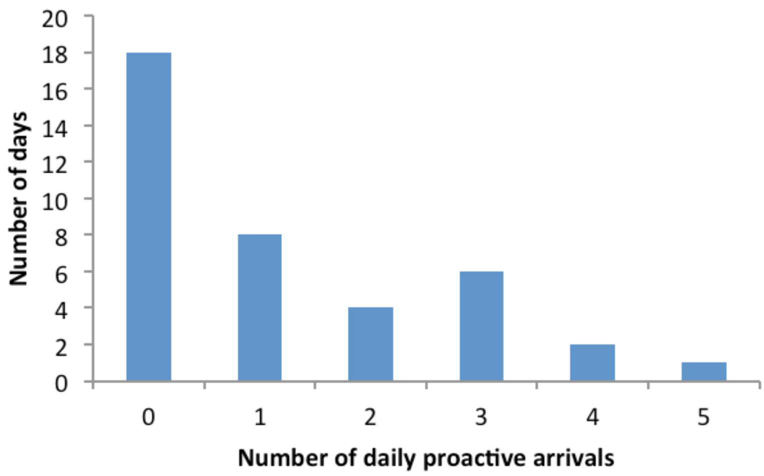


**Chart 20: Numbers of daily Small/Light proactive arrivals
Phase 2 summer season**

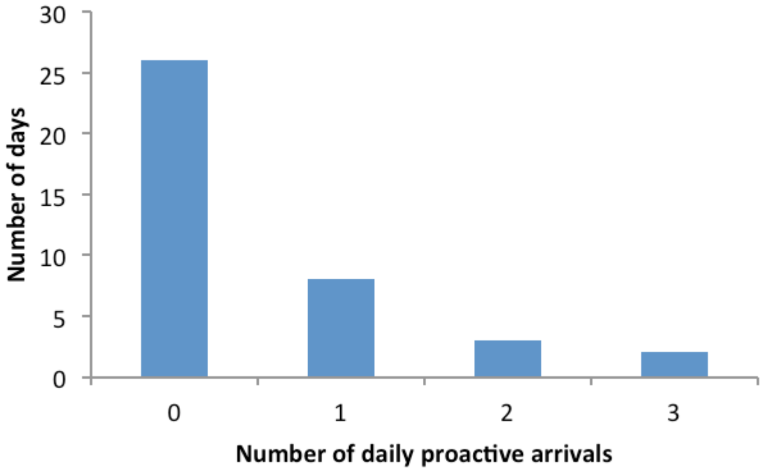
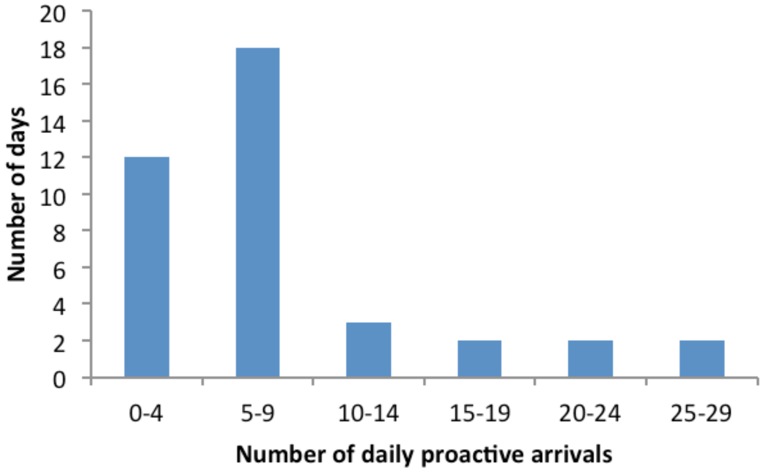


**Chart 21: Numbers of daily Terminal 4 proactive arrivals
Phase 2 summer season**



4.3.2 **Chart 19** shows that there were up to five A380 proactive arrivals on any given day, with the majority of days having zero, one or three proactive arrivals.

4.3.3 **Chart 20** shows that there were up to three Small/Light proactive arrivals on any given day, with the majority of days having zero or one proactive arrivals.

4.3.4 **Chart 21** shows that for the majority of days there were fewer than ten Terminal 4 proactive arrivals. There were up to 28 such arrivals on any given day.

4.3.5 The distributions of the numbers of proactive arrivals across the 32 days for which the proactive freedoms were active during the Phase 2 winter season are illustrated in the histograms in **Charts 22 to 24** below.

Chart 22: Numbers of daily A380 proactive arrivals Phase 2 winter season

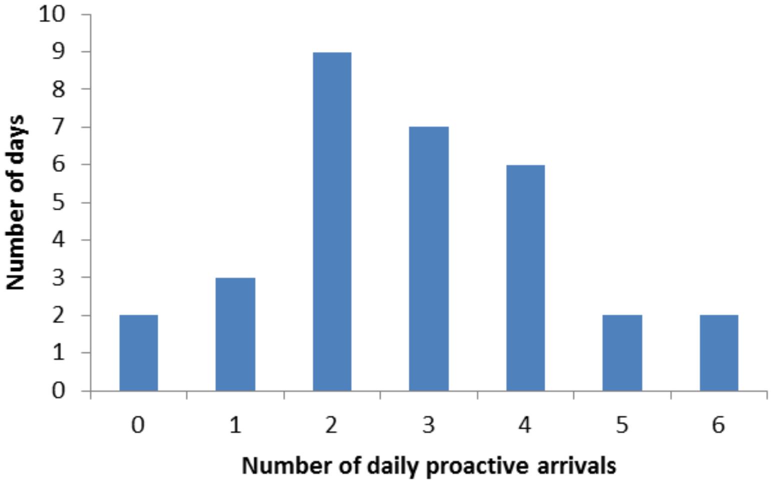


Chart 23: Numbers of daily Small/Light proactive arrivals Phase 2 winter season

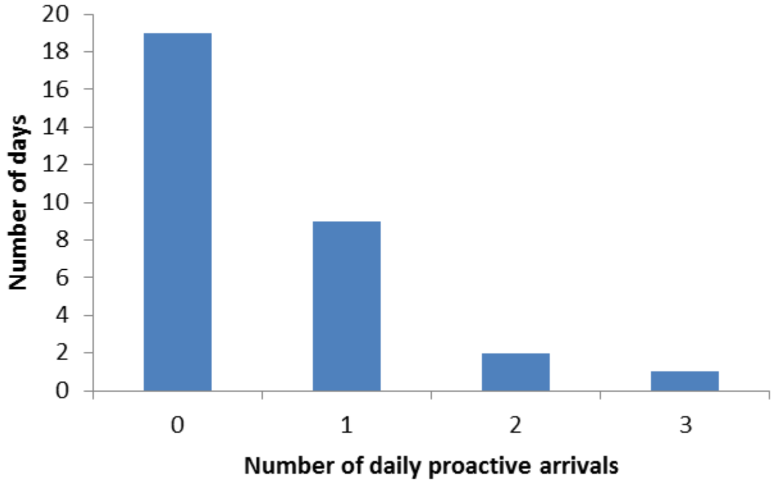
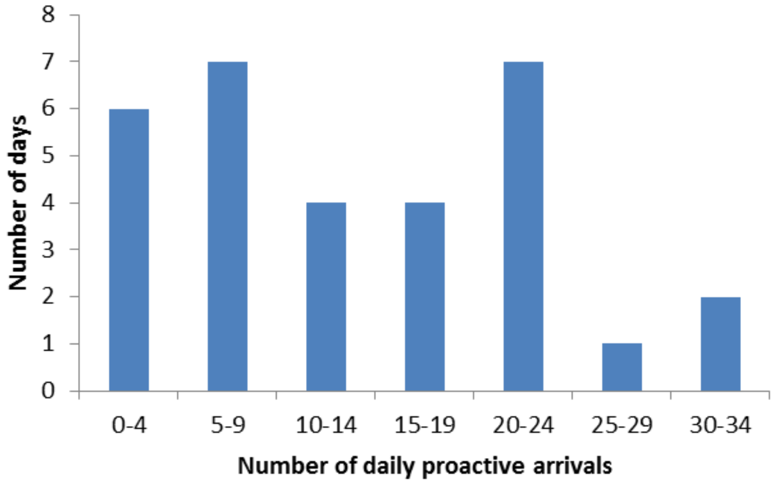


Chart 24: Numbers of daily Terminal 4 proactive arrivals
Phase 2 winter season



4.3.6 **Chart 22** shows that there were up to six A380 proactive arrivals on any given day, with the majority of days having two, three or four proactive arrivals.

4.3.7 **Chart 23** shows that there were up to three Small/Light proactive arrivals on any given day, with the majority of days having zero or one proactive arrivals.

4.3.8 **Chart 24** shows that there was a reasonable spread in the number of T4 proactive arrivals on any given day, with the majority of days having up to ten or 20-24 such arrivals. There were up to 32 such arrivals on any given day.

4.4 Average time between proactive arrivals

4.4.1 **Tables 37 and 38** show the average times between proactive arrivals. These have been calculated in a similar way to that described in section 2.3.5.

Table 37: Average time between proactive arrivals
Phase 2 summer season

Average time (minutes)		
A380	**Small/Light**	**Terminal 4**
54	42	33

Table 38: Average time between proactive arrivals
Phase 2 winter season

Average time (minutes)		
A380	**Small/Light**	**Terminal 4**
114	119	44

4.4.2 Table 37 shows that in the Phase 2 summer season, despite more use having been made of the A380 freedom, the Small/Light freedom was used more intensively. The Terminal 4 freedom was used even more intensively.

4.4.3 Table 38 shows that despite more use having been made of the proactive freedoms in the Phase 2 winter season than in the summer season, their occurrence has been more spread out over an average day.

4.5 Average number of hours with no proactive arrivals

4.5.1 For this indicator, the number of hours between 07:00 and the first proactive arrival, and the number of hours between the last proactive arrival and 23:00 are summed. These are then added together, for each freedom separately, for all the days when there was at least one proactive arrival, and divided by that same number of days. The results are presented in **Tables 39 and 40** below.

Table 39: Average number of hours with no proactive arrivals Phase 2 summer season

Average number of (decimal) hours		
A380	**Small/Light**	**Terminal 4**
13.0	14.1	10.6

Table 40: Average number of hours with no proactive arrivals Phase 2 winter season

Average number of (decimal) hours		
A380	**Small/Light**	**Terminal 4**
9.7	11.4	6.8

4.5.2 The data shown in Table 39 varies as expected considering the average numbers of daily proactive arrivals for each of the freedoms and the average times between proactive arrivals. The lower numbers of hours with no proactive arrivals shown in Table 40 corresponds with the above finding (section 4.4.3) that these operations were more spread out over an average day in the winter seasons compared with the summer season.

4.5.3 Comparing these with the average number of hours with no out-of-alternation westerly arrivals (Tables 11 and 12), each of the individual proactive freedoms left a greater number of daily hours free of arrivals on the designated departures runway than TEAM* (5.4 hours) and even TEAM (9.1 hours), on average during the summer season. During the winter season, the A380 and Small/Light proactive freedoms left comparable numbers of daily hours free to TEAM* (9.4 hours) and TEAM (10.0 hours). The use of the Terminal 4 proactive freedom, by contrast, left fewer hours free.

4.6 Average maximum time (in minutes) between proactive arrivals

4.6.1 The average maximum time between proactive arrivals for the trial period is given in **Tables 41 and 42** below. The maximum time between any two proactive arrivals was identified for each day that there were at least two such arrivals. These results were multiplied by the number of proactive arrivals which occurred on each respective day, the products summed, then that total divided by the sum of the proactive arrivals for the days where there were at least two such arrivals.

Table 41: Average maximum time between proactive arrivals Phase 2 summer season

Average maximum time (minutes)		
A380	**Small/Light**	**Terminal 4**
130	92	116

Table 42: Average maximum time between proactive arrivals Phase 2 winter season

Average maximum time (minutes)		
A380	**Small/Light**	**Terminal 4**
257	205	161

4.6.2 The data in Table 41 supports the observations made previously that during the summer season the Small/Light freedom was used more intensively than the A380 freedom. It also shows that for the times of least intensive use, the Small/Light freedom was used more intensively than the Terminal 4 freedom as well.

4.6.3 Table 42 supports the observation that the proactive arrivals in the winter season appeared to be more spread out throughout the day than in the summer season.

4.6.4 Comparing these with the average maximum time between out-of-alternation westerly arrivals (Tables 14 and 15), it can be seen that (for the Phase 2 summer season) use of the proactive freedoms was generally not spread out over a day to the same extent as for TEAM (295 minutes) and TEAM* (238 minutes).

4.6.5 For the Phase 2 winter season, however, the results were more similar. The maximum intervals between A380 proactive arrivals were greater, on average, than for TEAM (223 minutes) and TEAM* (193 minutes), the maximum intervals between Small/Light freedom were shorter, on average, than for TEAM but greater than for TEAM*, and the maximum intervals between Terminal 4 proactive arrivals were lower, on average, than for either TEAM or TEAM*.

5. Conclusions

5.0.1 This report has considered the effects of the application of landing aircraft on the designated departure runway, early-vectored departures and three different proactive operational freedoms during the three parts of the Operational Freedoms Trial.

5.1 Landing aircraft on the designated departure runway

5.1.1 The analysis shows that there was a near doubling of out-of-alternation westerly arrivals during the Phase 1 and Phase 2 summer trial periods, and that there were daily averages of 10.9 and 9.9 TEAM* arrivals respectively. During the Phase 2 winter trial period, TEAM* was used to a lesser extent and, consequently, the number of out-of-alternation westerly arrivals was lower than that of the baseline.

5.1.2 In response to questions from stakeholders, we tested the effect of extending the Phase 2 summer season and winter season baseline periods to include 2008 and 2007. This did not materially affect the analysis which used baselines comprising the three previous years prior to the respective trial period.

5.1.3 For each part of the trial, the mix of out-of-alternation aircraft, in noise terms, was not significantly different during the trial period to that of the baseline.

5.1.4 During the trial, on any given day there were up to 53 out-of-alternation westerly arrivals. For the majority of days in the summer season, when most use was made of the freedom, there were from 6 to 35 out-of-alternation westerly arrivals. In the winter season, for the majority of days, there were up to 20 out-of-alternation westerly arrivals.

5.1.5 Except for the Phase 2 winter trial period, the out-of-alternation arrivals occurred at a higher frequency and over a greater number of hours compared with the baseline. Additionally, the number of hours with no out-of-alternation westerly arrivals was reduced to about half of the baseline value in the trial periods.

5.1.6 In all parts of the trial, the average maximum time between out-of-alternation arrivals was lower in the trial than the baseline periods, due to the higher number of out-of-alternation arrivals and/or the different approach taken towards arrivals management.

5.1.7 The noise contour analysis of the trial highlighted that:

- a near doubling in out-of-alternation arrivals leads to an increase in Leq noise exposure of almost 3 dB, but almost no decrease in Leq noise exposure.
- the effects of de-alternation are greatest very close to the airport (immediately east of the airport) where the benefits of alternation are greatest. The effects of de-alternation then become less apparent further away from the airport, particularly beyond approximately 15 km.
- the increase in de-alternation resulted in between one and five more noise events exceeding 70 dBA, and between 0.5 and 2 minutes more noise exposure above 70 dBA Lmax, per 8-hour respite period, but with corresponding reductions during the 8-hour non-respite period. These reductions are low in proportion to the number

of noise events/noise exposure during the 8-hour non-respite period. However the corresponding increases during the alternation respite period are higher in proportion to the number of noise events/noise exposure during this period.

5.2 Early-vectored departures

5.2.1 Early-vectored departures occurred during Phase 2 of the trial only. Greater use of this freedom was made during the summer season than the winter season.

5.2.2 There were many more operational freedom early-vectored departures than weather-vectored departures during the trial. There were also many more westerly than easterly early-vectored departures due to there having been a predominance of days of westerly operation during the trial.

5.2.3 There was a large range in the numbers of daily early-vectored departures, with average numbers of easterly or westerly early-vectored departures between 35 and 47 and maximum values over 100 on some days.

5.2.4 The average time between early-vectored departures was around eight to ten minutes for the summer season, and around six to nine minutes for the winter season.

5.2.5 During the summer season, there were fewer hours in an average westerly day with no early-vectored departures than on an average easterly day. This is probably due to the fact that early vectoring was available on a different SID for westerly and easterly operations. The lower number of early-vectored departures in the winter season generally led to an increase in the average number of hours with no such departures compared with the summer season.

5.2.6 Operational freedom early-vectored departures on 09R DVR occurred, on an average day, during nearly eight clock-hour periods, and on 27 MID they occurred during nine clock-hour periods during the summer season. There were generally fewer one-hour periods with at least one early-vectored departure in the winter than the summer season. For the vast majority of days, once early-vectoring had begun, it continued with at least one such departure per hour until the procedure stopped for the day.

5.2.7 16-hour Leq noise contours representing the summer season trial and baseline were plotted for departure movements only. The differences between these were also calculated and L_{eq} difference contours plotted to show changes in 16-hour noise exposure as a result of the operational freedom early-vectored departures.

5.2.8 The greatest increase in noise level (where absolute noise levels are 54 dBA $L_{eq,16h}$ or more) was +0.8 dBA. This occurred beneath the 09R DVR early vector heading. The greatest decrease of -0.6 dBA occurred beneath the 09R DVR SID from which the operational freedom early-vectored departures have been redirected.

5.2.9 Over 100,000 people are affected by daytime average departure noise at a level of 57 dBA $L_{eq,16h}$. Around 100 fewer people (0.1%) were exposed to at least this level of noise as a result of the operational freedom early-vectored departures.

5.2.10 However, over 250,000 people are affected by daytime average departure noise at a level of 54 dBA $L_{eq,16h}$. Around 700 more people (0.3%) were exposed to at least this level of noise as a result of the operational freedom early-vectored departures.

5.2.11 SEL footprints have been presented for the noisiest and most commonly used aircraft on each of the operational freedom early-vector mean tracks and respective SIDs for comparison. Difference contours have also been plotted which show that the greatest differences between standard SID and early-vectored departures of up to 16 dBA occur for departures on 27R MID. To put this into context, a change of 10 dBA represents a doubling or halving of loudness.

5.3 Proactive freedoms

5.3.1 The noise effects of the proactive freedoms were assessed during Phase 2 of the trial only. During Phase 2, greater use was made of these freedoms during the winter season than the summer season.

5.3.2 The results show that of the proactive freedoms, the Terminal 4 freedom was used most frequently, followed by the A380 freedom, and the Small/Light freedom was used the least frequently.

5.3.3 The analysis found that, compared with the baseline out-of-alternation arrivals, the noise energy of the average arrival associated with the A380 and Small/Light proactive arrival freedoms was lower by up to 0.4 dB and 5.9 dB, respectively. The average Terminal 4 proactive arrival was up to 0.2 dB noisier than the baseline out-of-alternation arrivals.

5.3.4 There were up to six A380 proactive arrivals on any given day, with the majority of days having two, three or four proactive arrivals during the winter season (zero to three in the summer season). There were up to three Small/Light proactive arrivals on any given day, with the majority of days having zero or one proactive arrival. There were relatively few days where the Terminal 4 freedom was not used; for the majority of days there were up to nine Terminal 4 proactive arrivals during the summer season, and up to 24 during the winter season.

5.3.5 In the summer season, despite more use having been made of the A380 freedom than the Small/Light freedom, the latter was used more intensively (but over a shorter period of time). The Terminal 4 freedom was used even more intensively. During the winter season, the Terminal 4 freedom was again used more intensively than either of the other two freedoms.

5.3.6 With more use having been made of the proactive freedoms in the winter season than in the summer season, their occurrence has been more spread out over an average day.

5.3.7 For the summer period, the A380 freedom was used about as intensively as TEAM, and the Terminal 4 freedom was used about as intensively as TEAM*. For the winter season, the A380 and Small/Light freedoms were used less intensively than either TEAM or TEAM*. The Terminal 4 freedom was used more intensively than TEAM and TEAM*.

5.3.8 In the summer season, each of the proactive freedoms left a greater number of hours each day free of out-of-alternation arrivals than TEAM* and even TEAM, on average. During the winter season, the A380 and Small/Light proactive freedoms left comparable numbers of daily hours free to TEAM* and TEAM, but the use of the Terminal 4 proactive freedom, by contrast, left fewer hours free.

5.3.9 For the times of least intensive use in the summer season, the Small/Light freedom was used more intensively than the Terminal 4 freedom. The use of the proactive freedoms was generally not spread out over a day to the same extent as for TEAM and TEAM*. During the winter season, the proactive arrivals appeared to be more spread out throughout the day than in the summer season.

Figure 1: Track density plot for operational freedom early-vectored departures

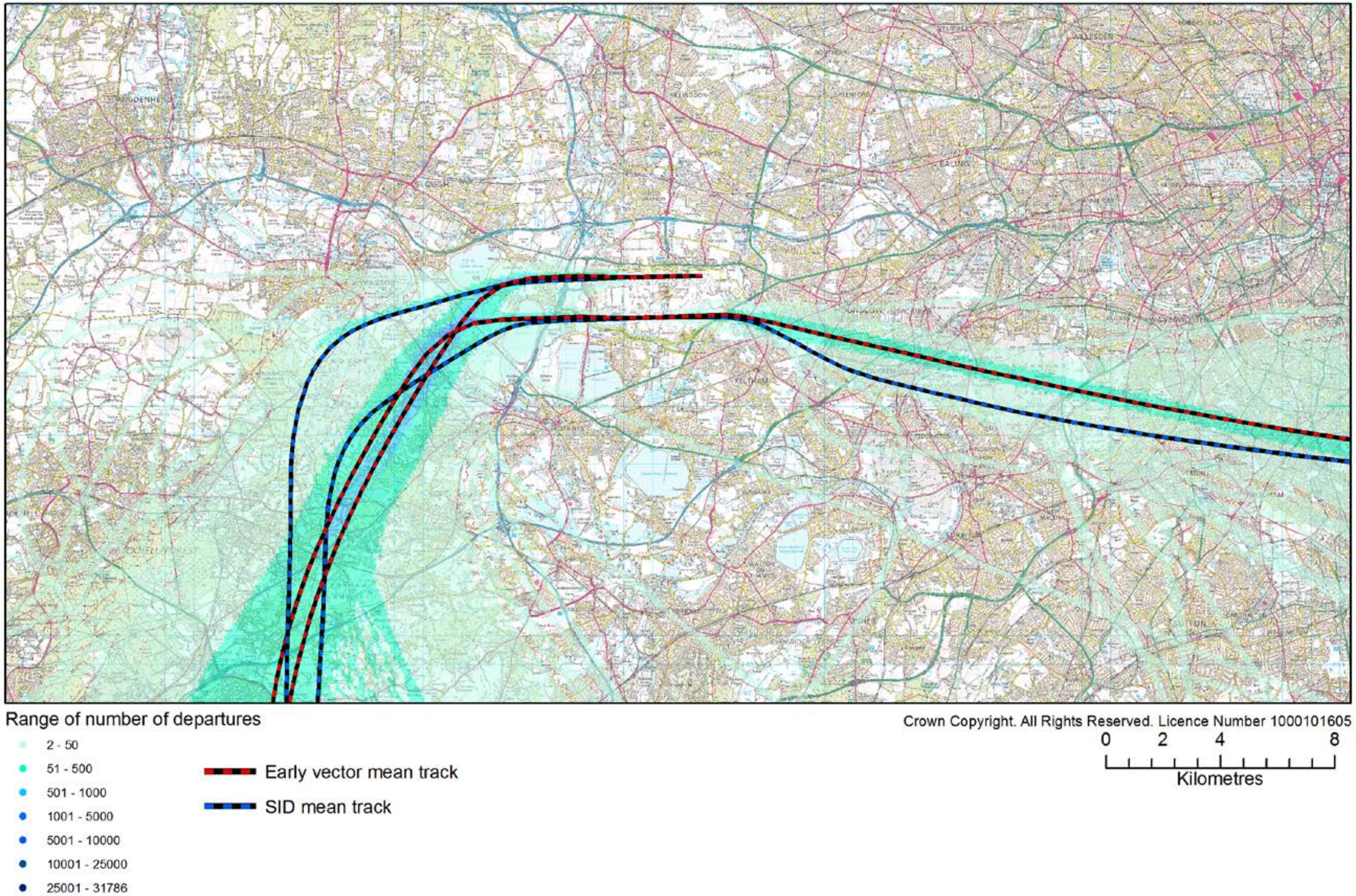


Figure 2: Track density plot for non-operational freedom departures on 09RDVR, 27LMID and 27RMID

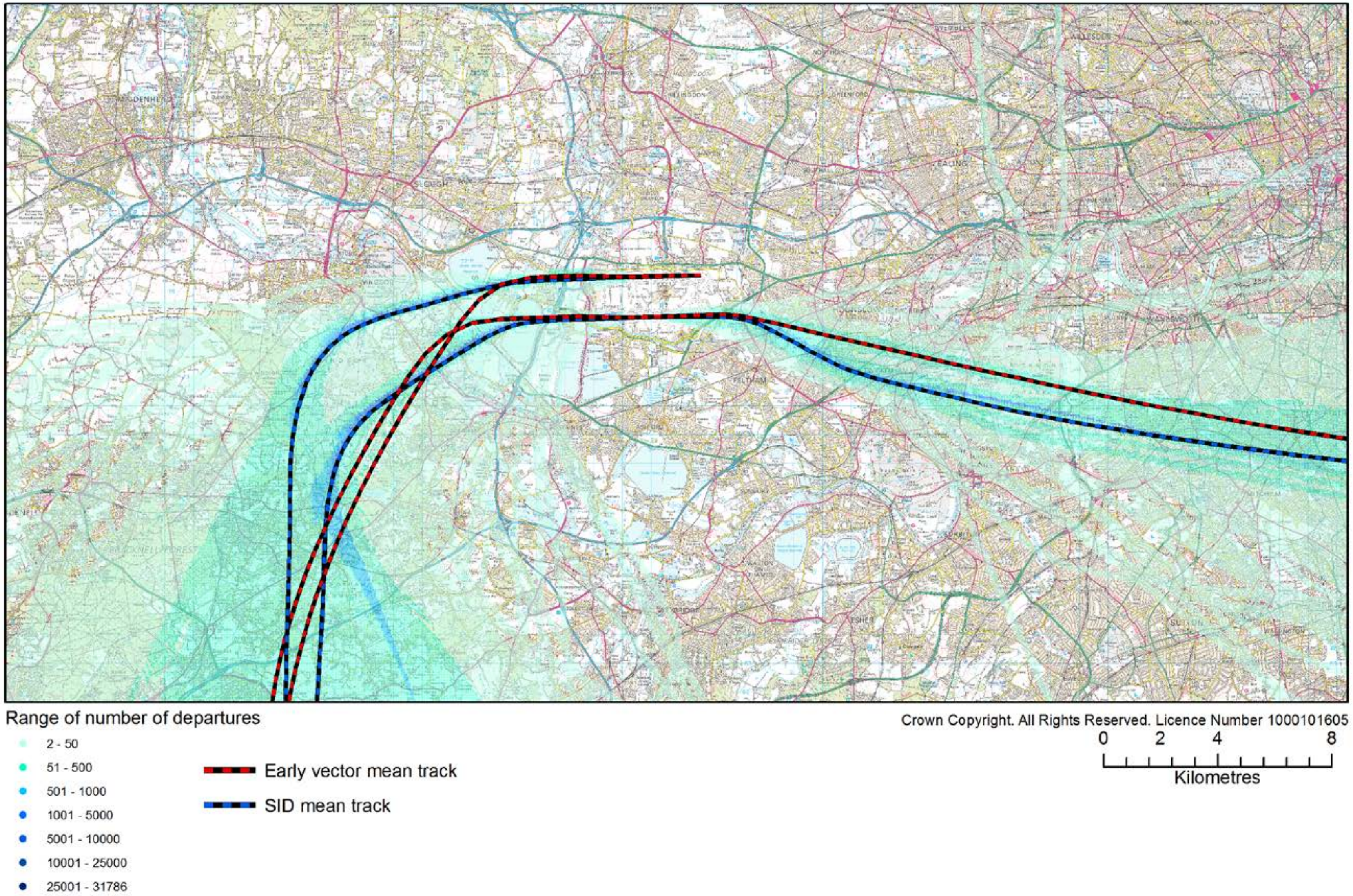


Figure 3: Track density plot for all departures during the trial period

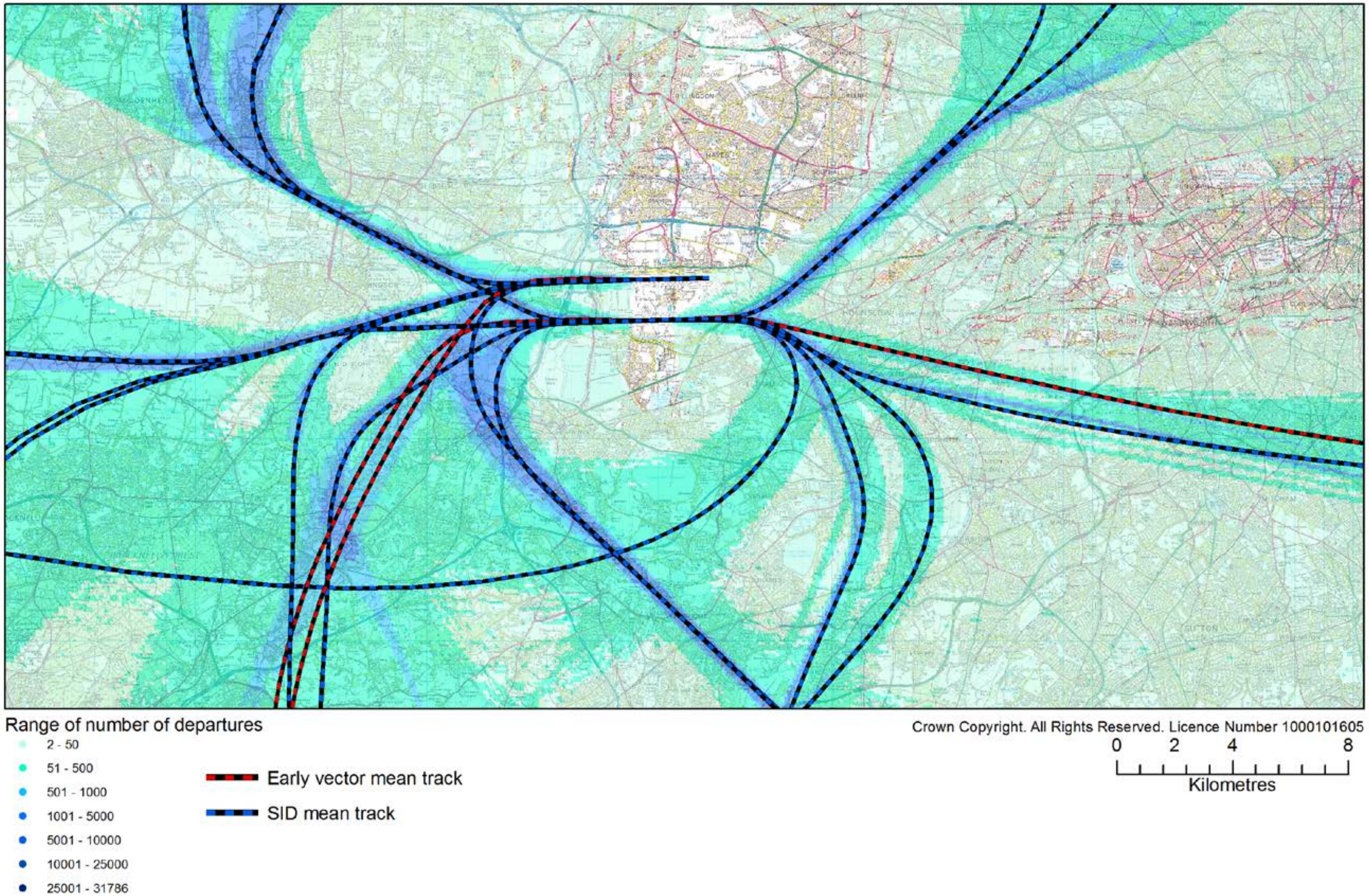


Figure 4: Track density plot for all non-operational freedom departures during the trial period

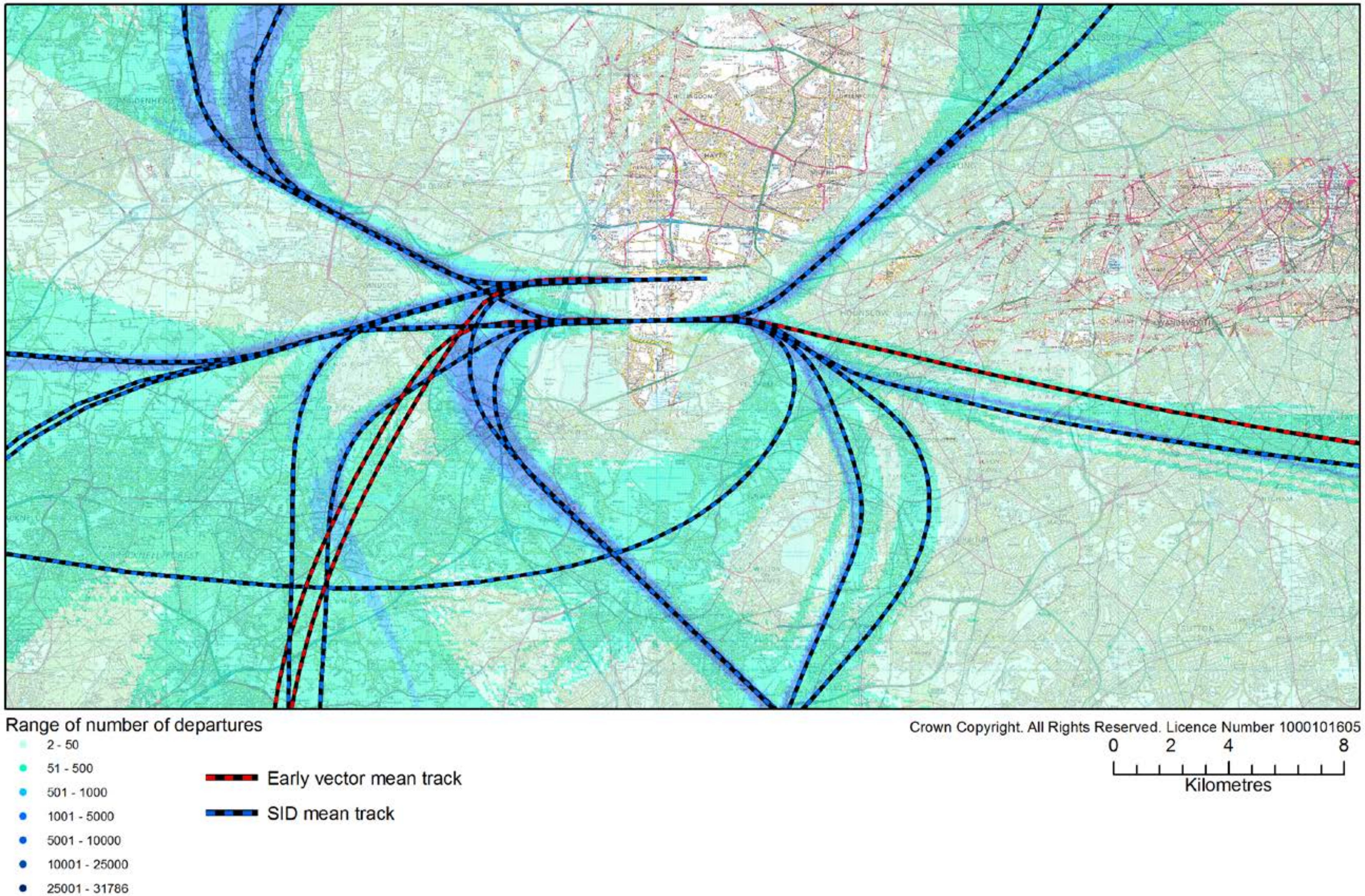
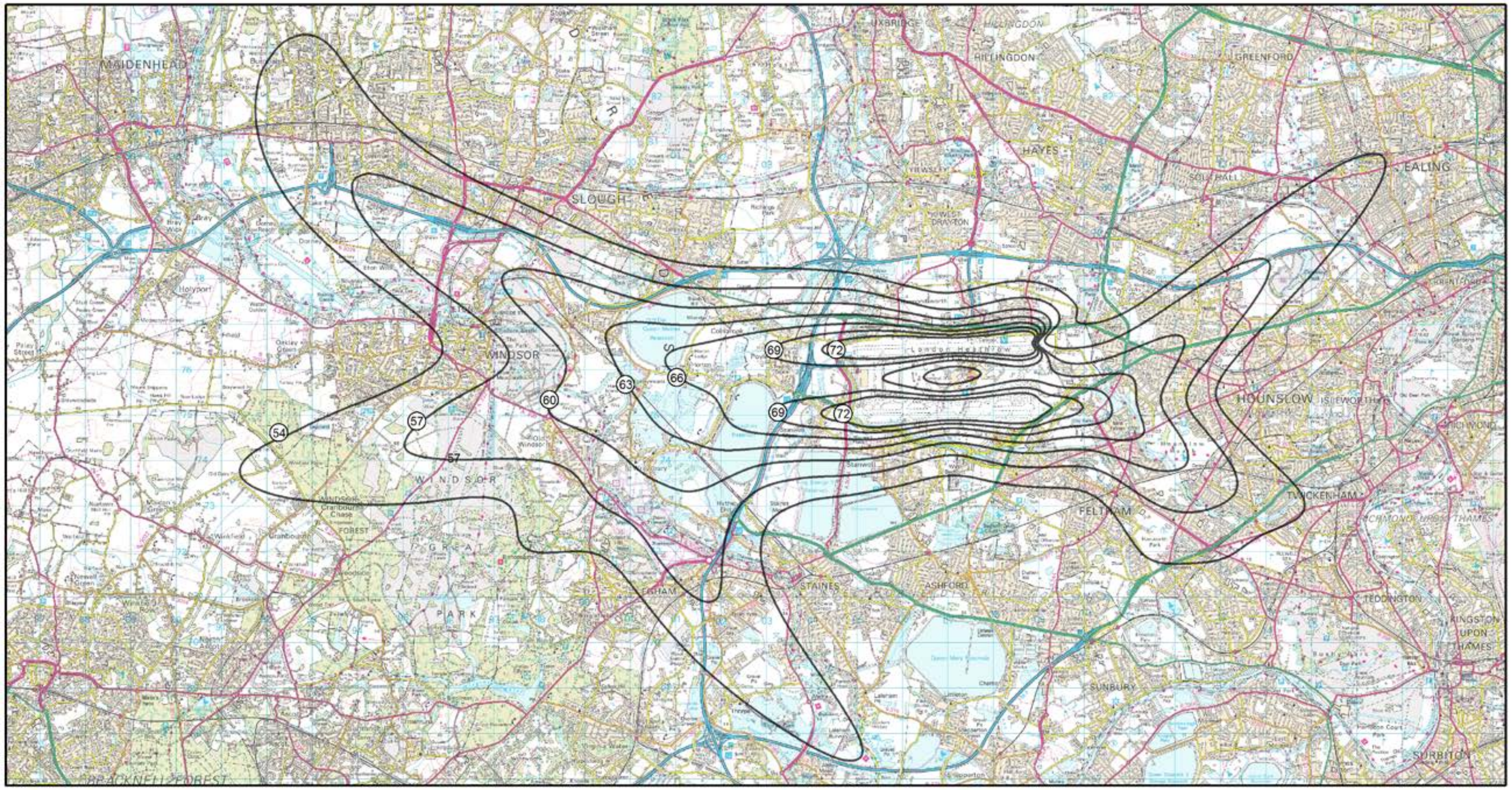


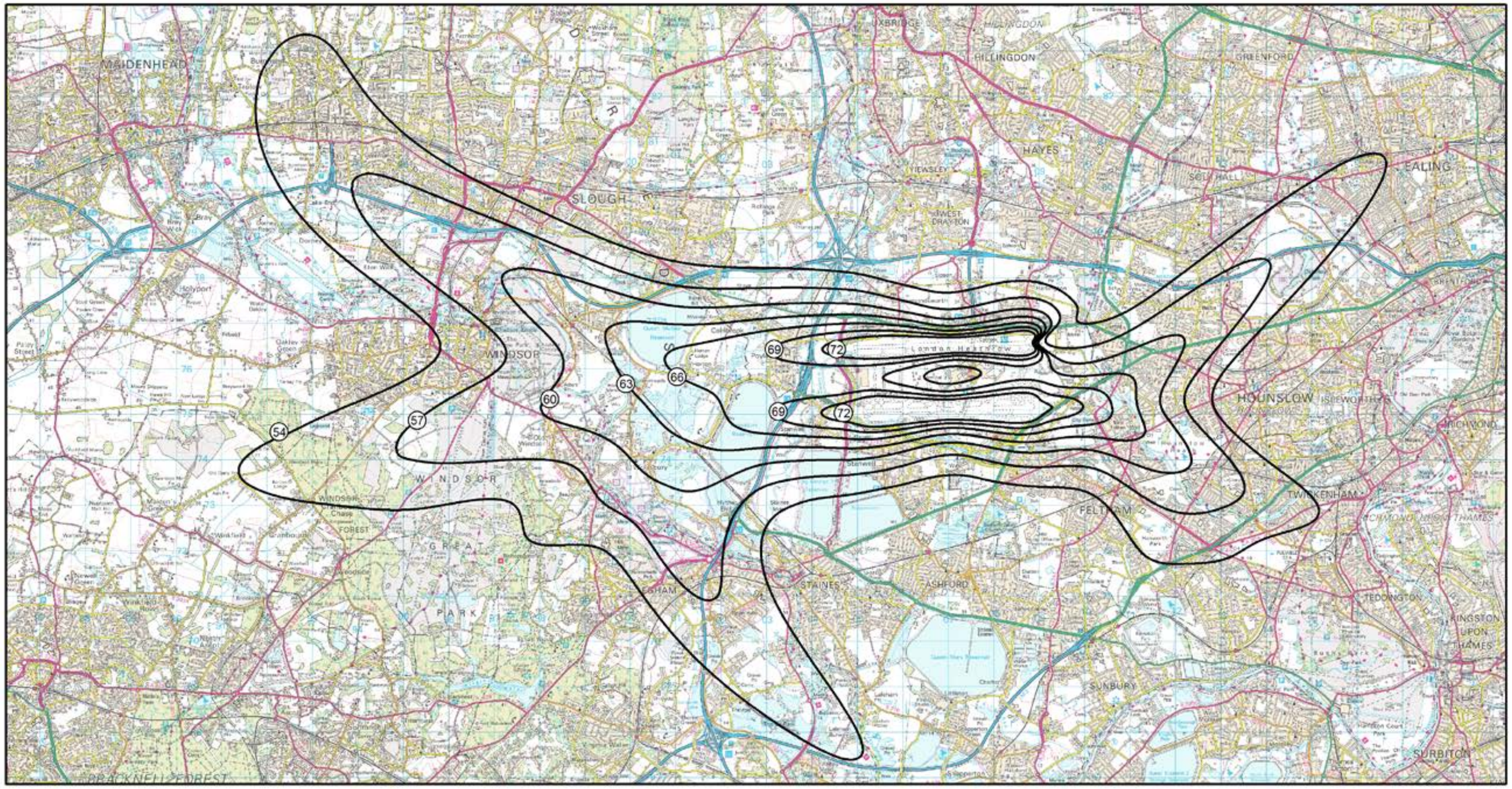
Figure 5: 16-hour Leq noise contours representing departure movements during the trial



0 2.5 5 10

Kilometres

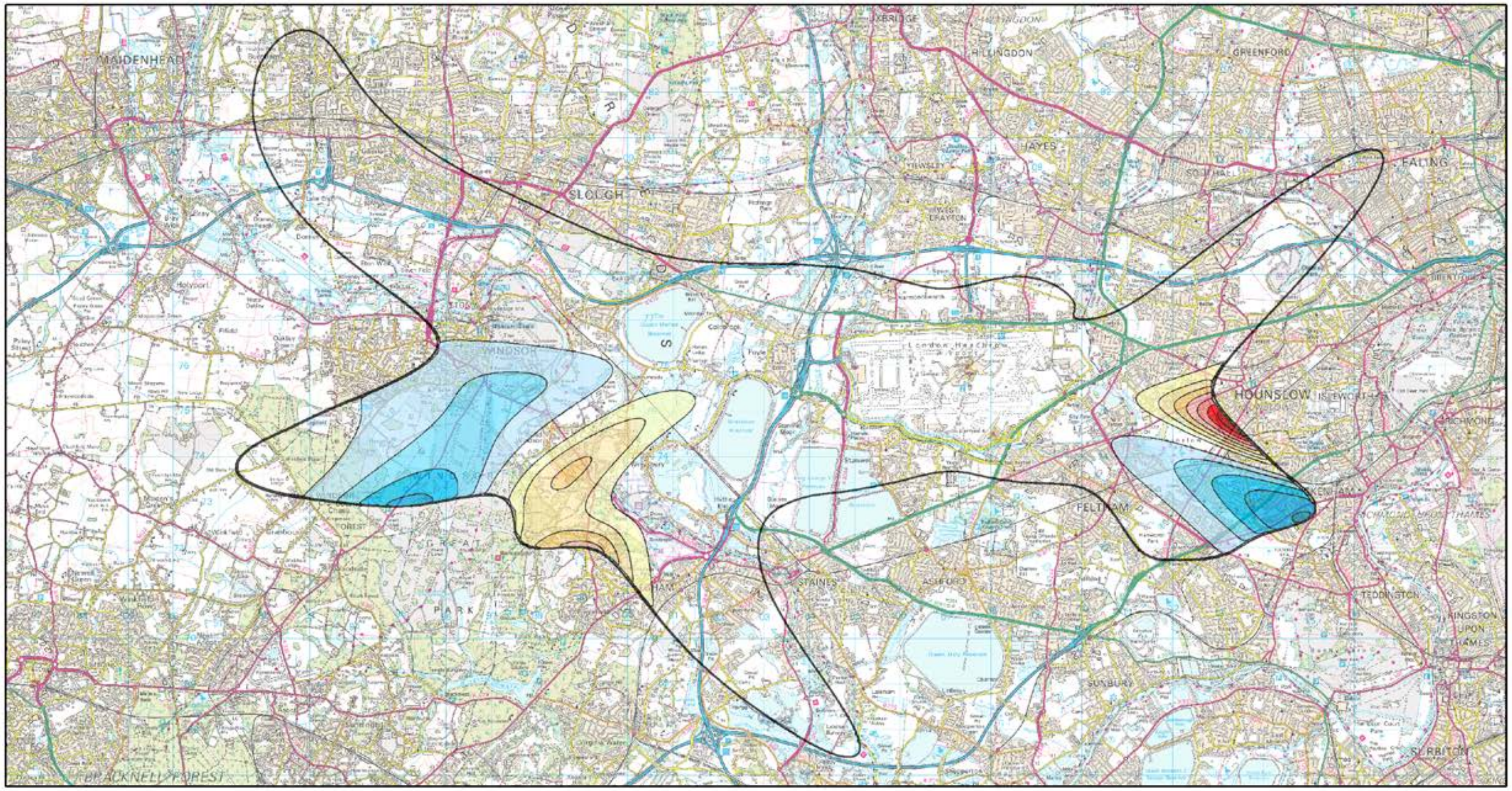
Figure 6: 16-hour Leq noise contours representing departure movements for the baseline



0 2.5 5 10

Kilometres

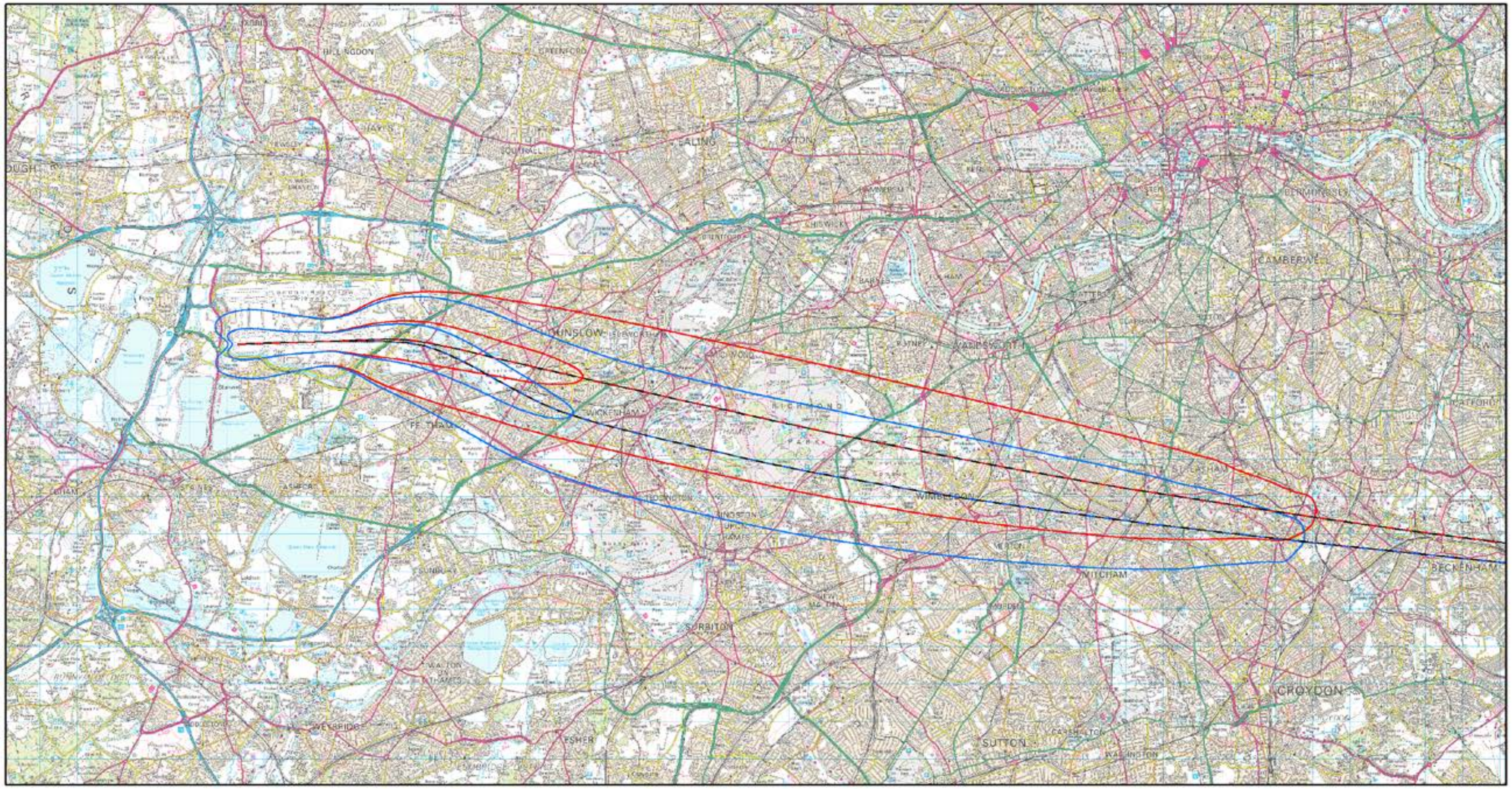
Figure 7: 16-hour difference Leq contours for trial vs baseline



- 0.7 to 0.8dB
- 0.6 to 0.7dB
- 0.5 to 0.6dB
- 0.4 to 0.5dB
- 0.3 to 0.4dB
- 0.2 to 0.3dB
- 0.1 to 0.2dB
- -0.5 to -0.6dB
- -0.4 to -0.5dB
- -0.3 to -0.4dB
- -0.2 to -0.3dB
- -0.1 to -0.2dB
- 54dB Leq contours (baseline and trial)

0 3 6 12
Kilometres

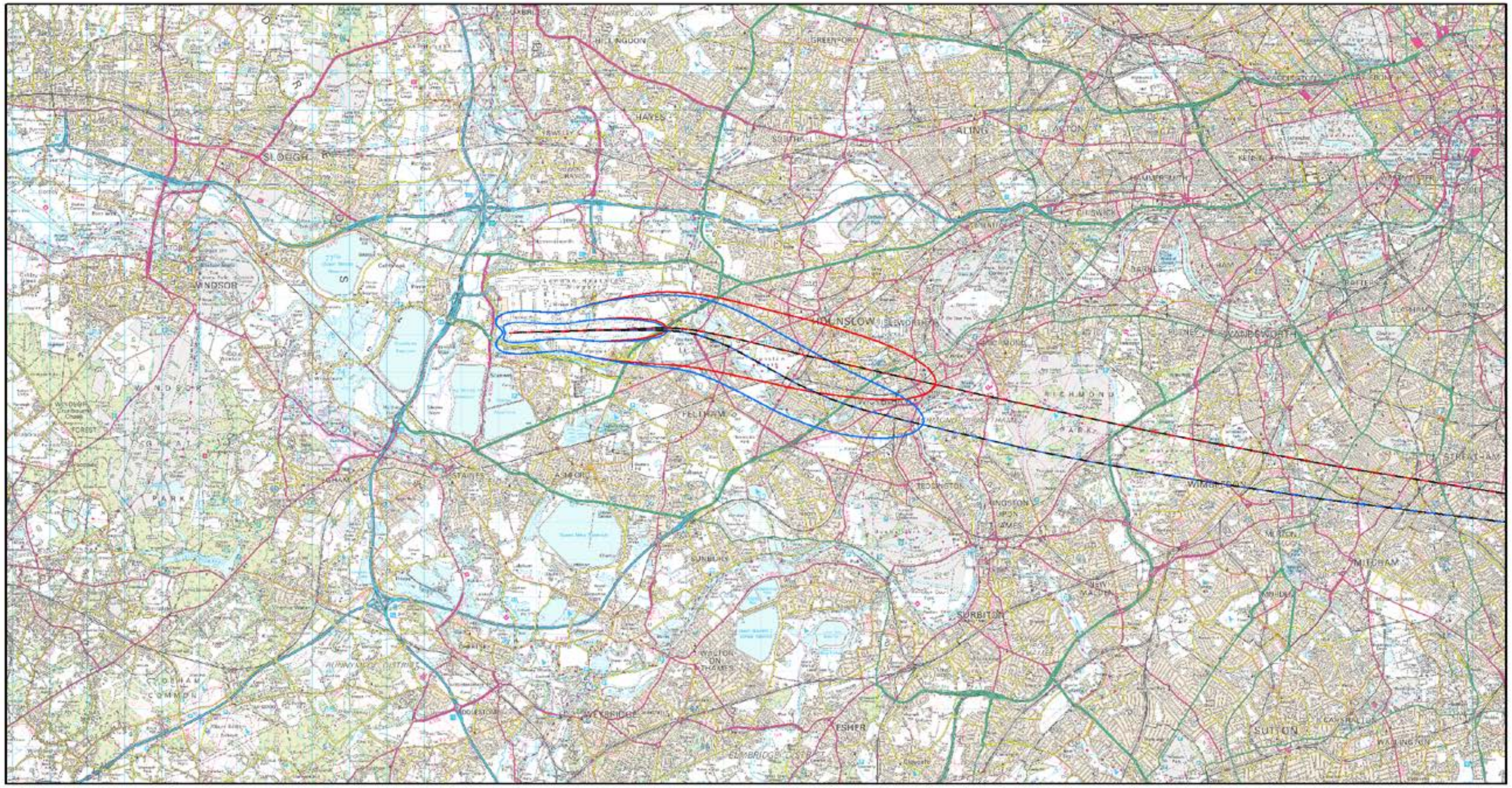
Figure 8: SEL Footprint for 09R DVR, A380 (noisiest used during the trial and noisiest permitted)



0 2 4 8
Kilometres

- Early-vectored departure
- Departure on SID
- Early vector mean track
- SID mean track

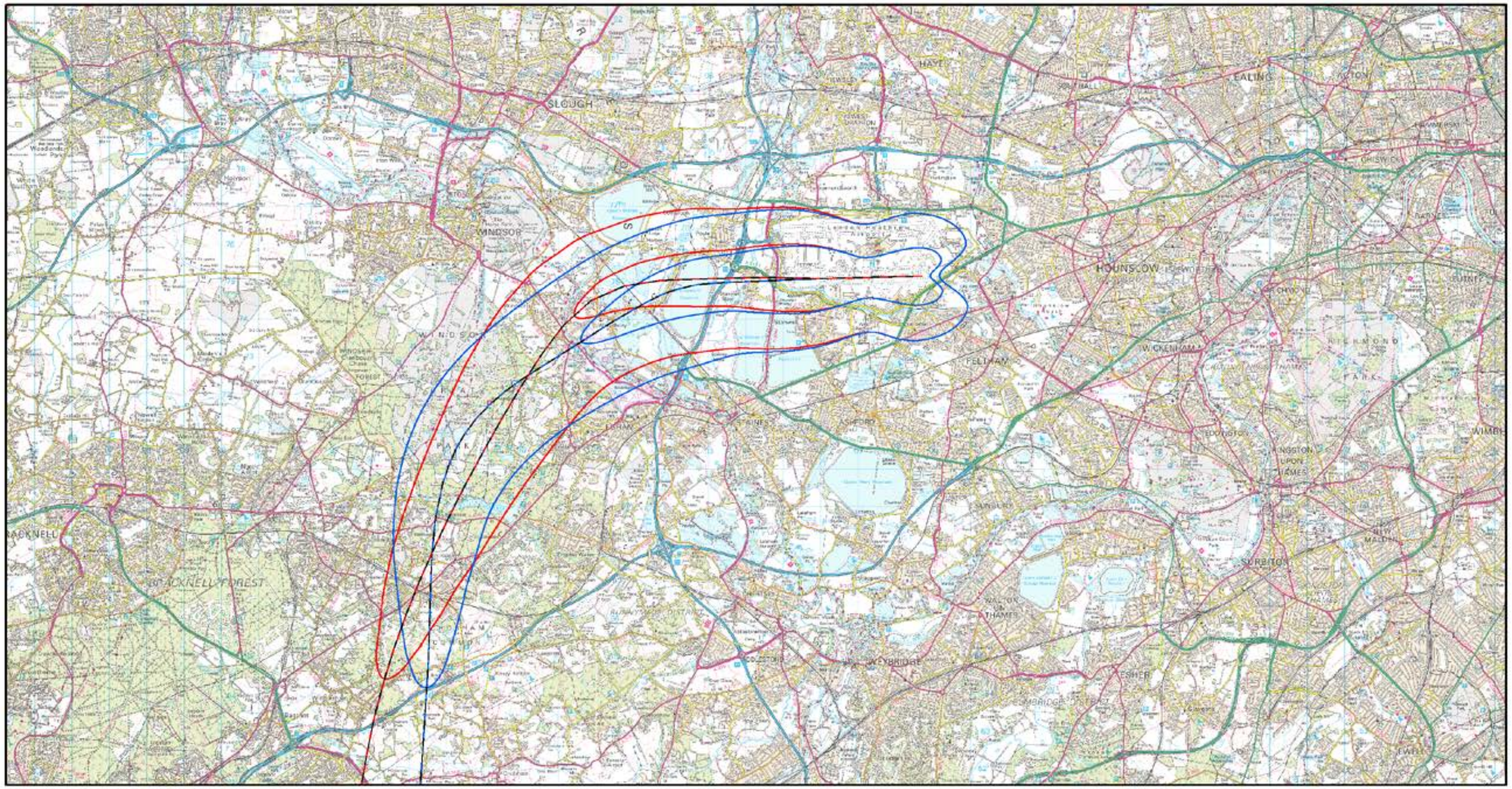
Figure 9: SEL Footprint for 09R DVR, A319 (most common)



0 2 4 8
Kilometres

- Early-vectored departure
- Departure on SID
- Early vector mean track
- SID mean track

Figure 10: SEL Footprint for 27L MID, MD80 (noisiest permitted)



0 2 4 8
Kilometres

- Early-vectored departure
- Departure on SID
- Early vector mean track
- SID mean track

Figure 11: SEL Footprint for 27L MID, A330 (noisiest used during the trial)

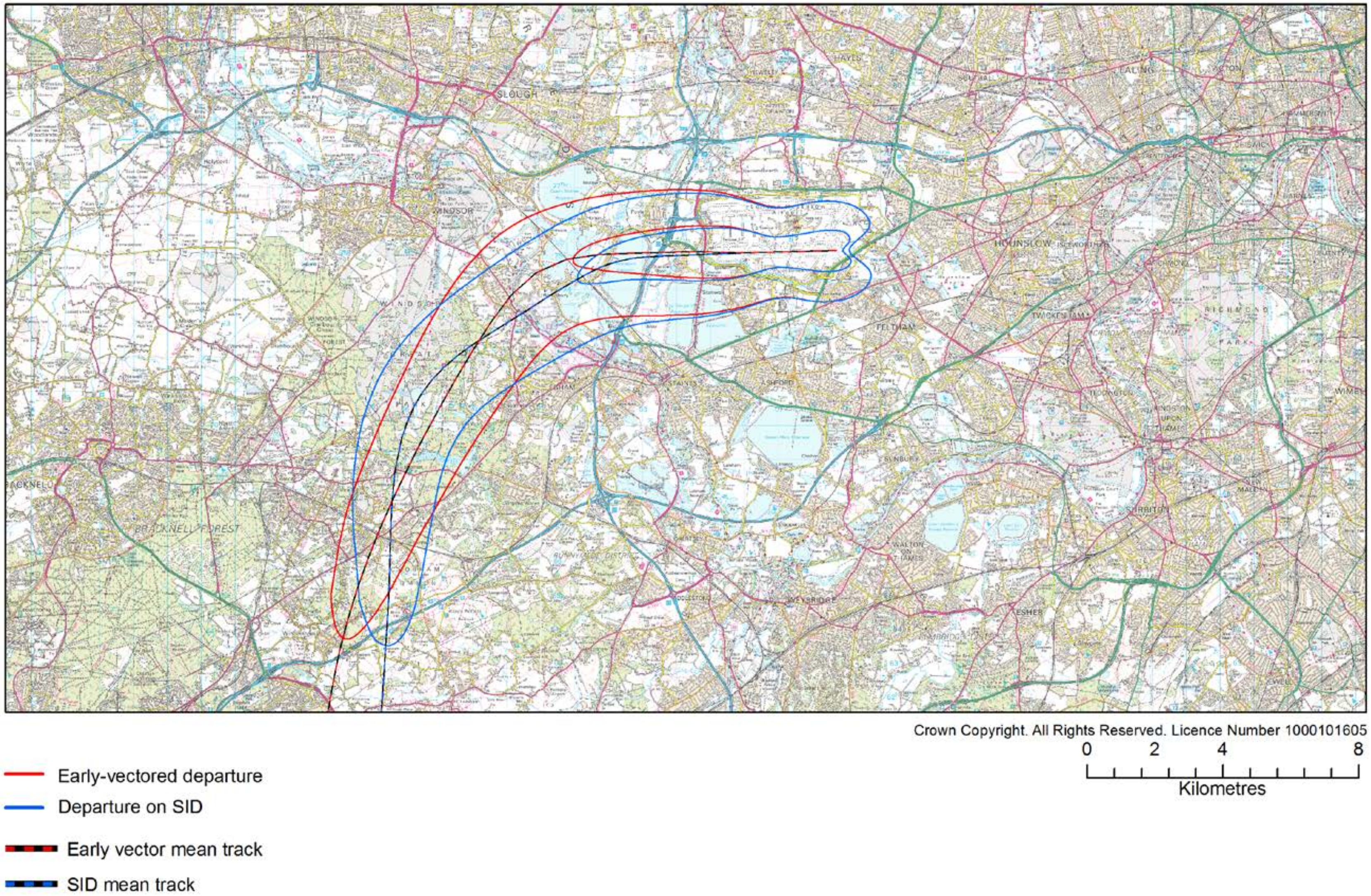


Figure 12: SEL Footprint for 27L MID, A319 (most common)

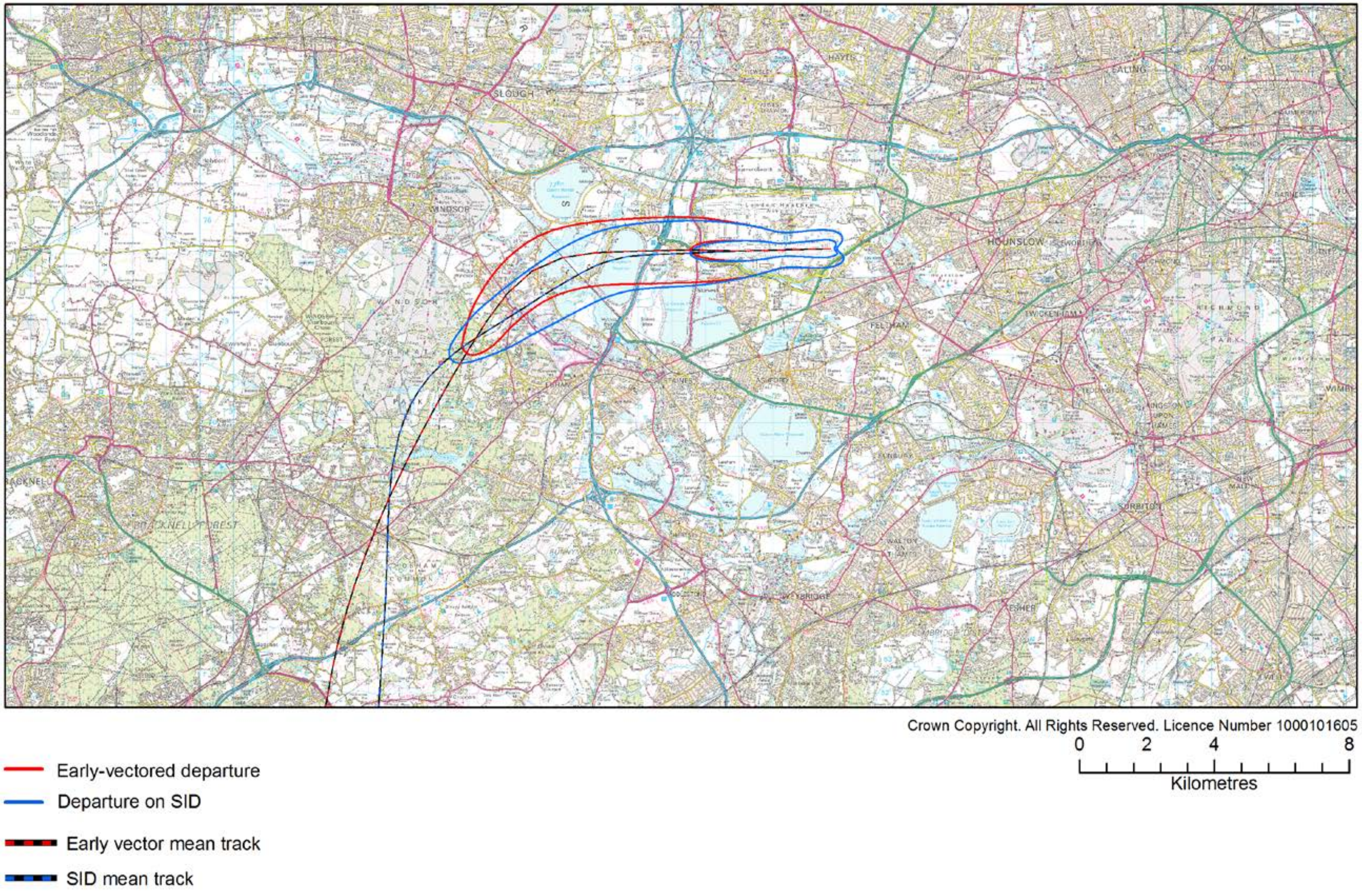
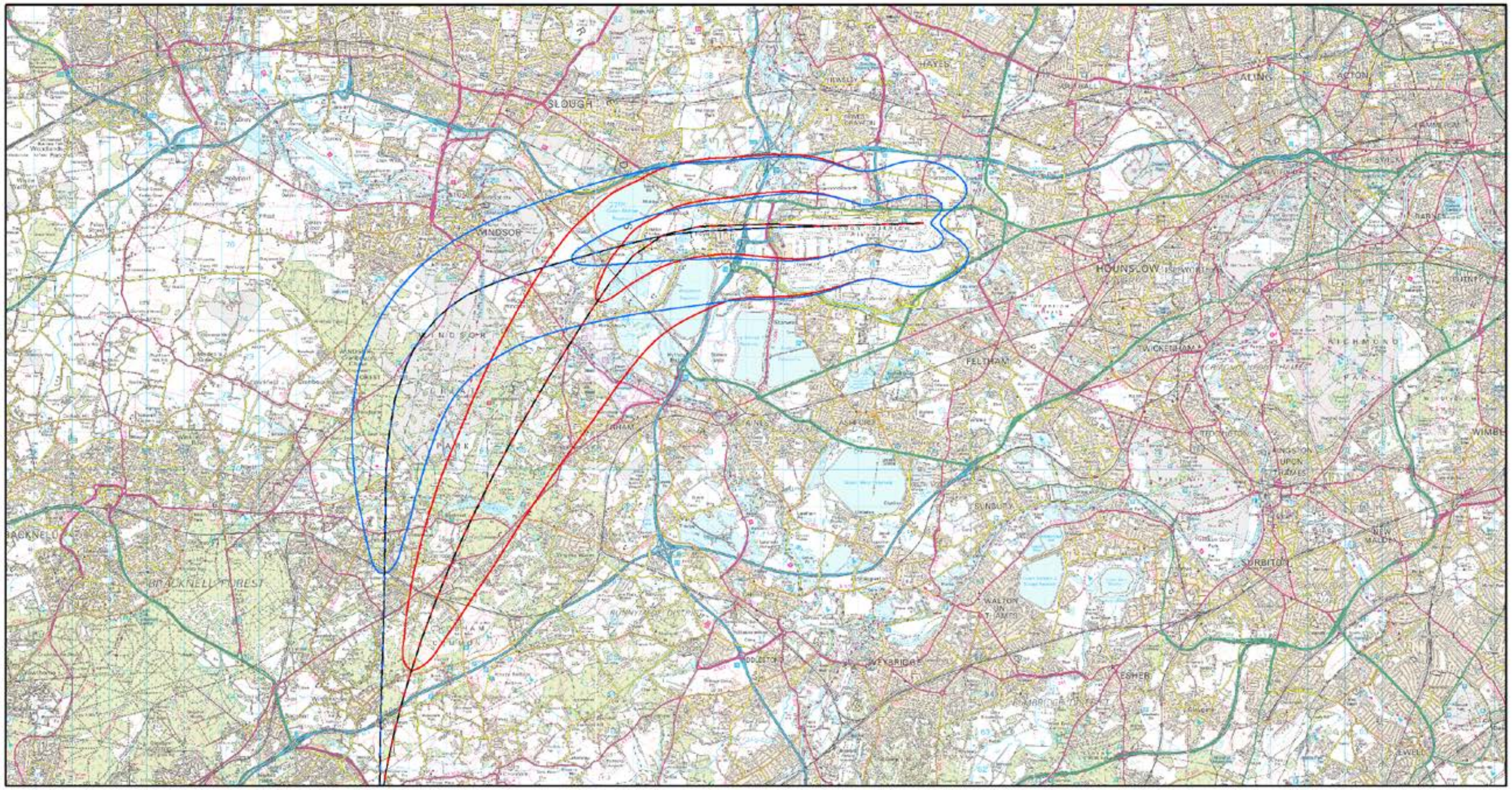


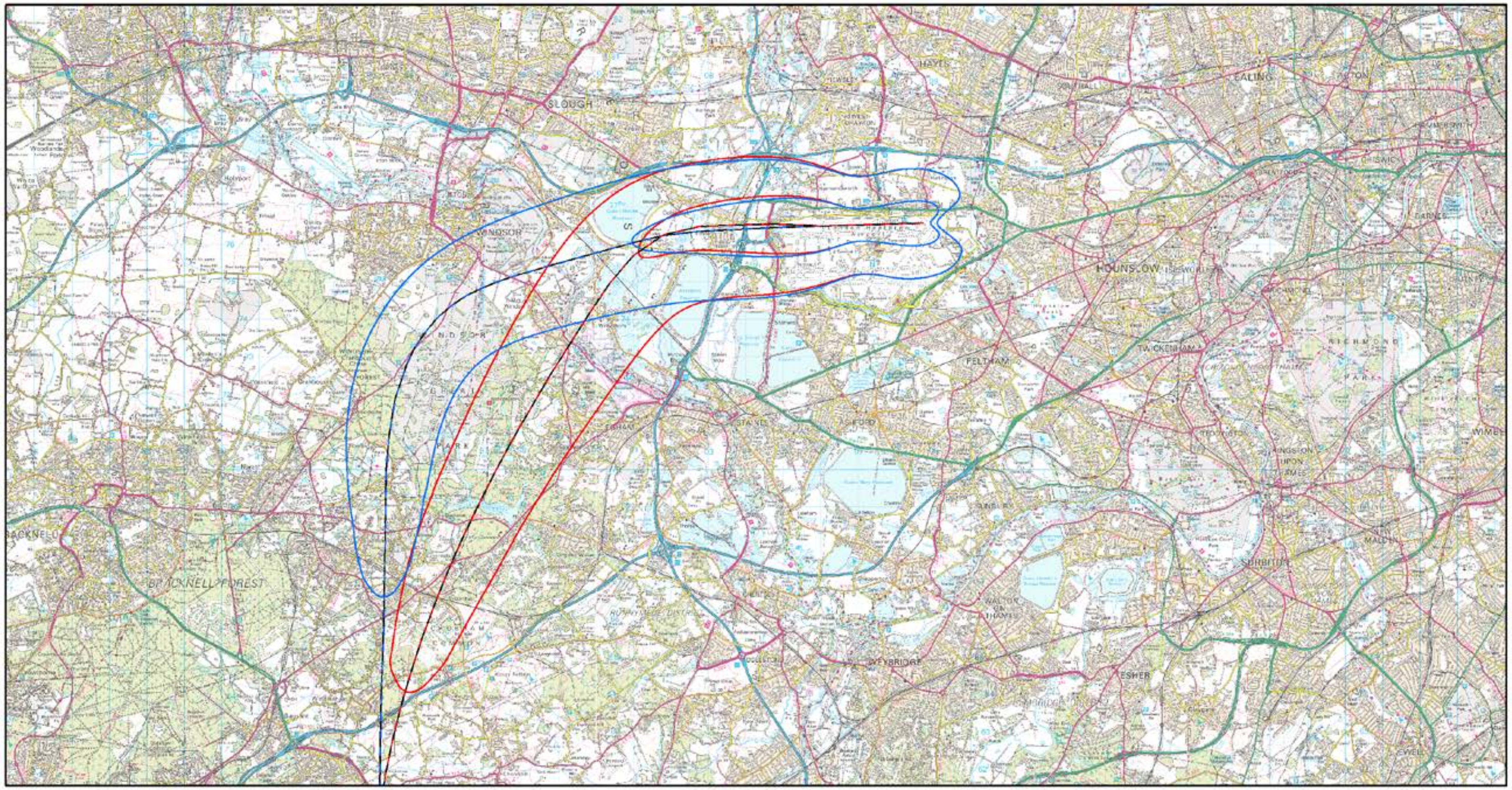
Figure 13: SEL Footprint for 27R MID, MD80 (noisiest permitted)



0 2 4 8
Kilometres

- Early-vectored departure
- Departure on SID
- Early vector mean track
- SID mean track

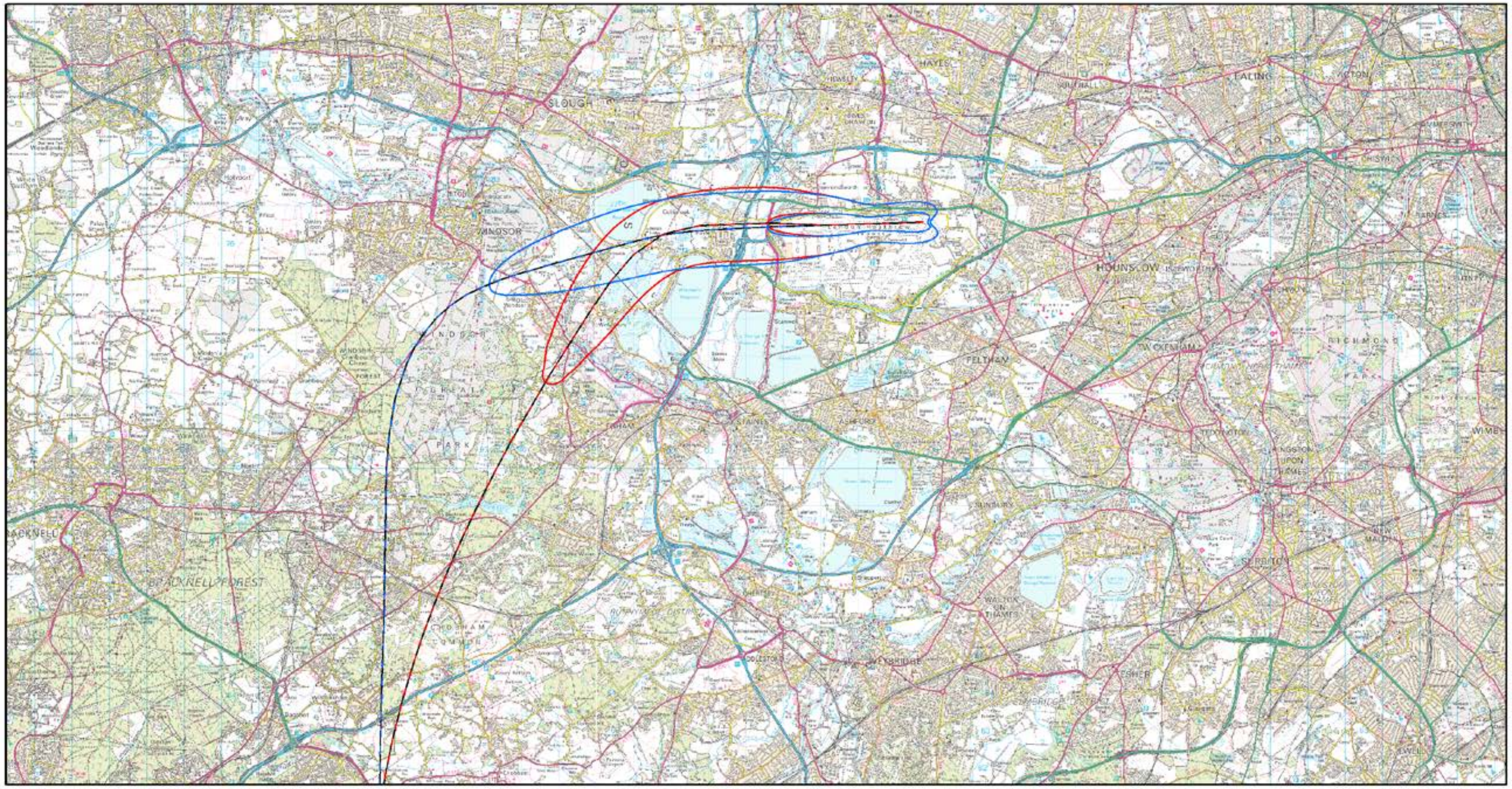
Figure 14: SEL Footprint for 27R MID, A330 (noisiest used during the trial)



0 2 4 8
Kilometres

- Early-vectored departure
- Departure on SID
- Early vector mean track
- SID mean track

Figure 15: SEL Footprint for 27R MID, A319 (most common)



0 2 4 8

Kilometres

- Early-vectored departure
- Departure on SID
- Early vector mean track
- SID mean track

Figure 16: SEL difference, departures on the SID vs early-vectored mean track, 09R DVR, A380

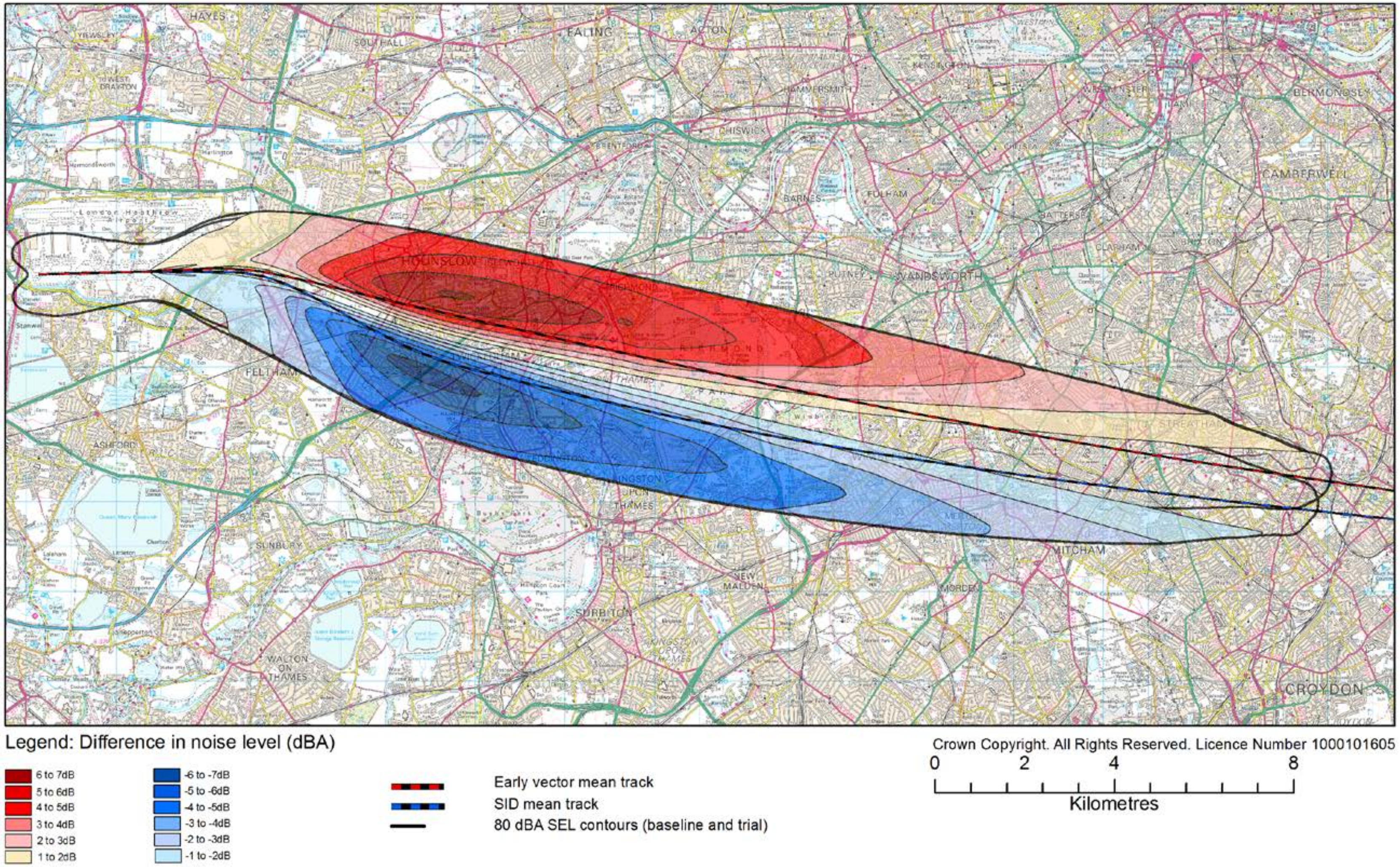


Figure 17: SEL difference, departures on the SID vs early-vectored mean track, 09R DVR, A319

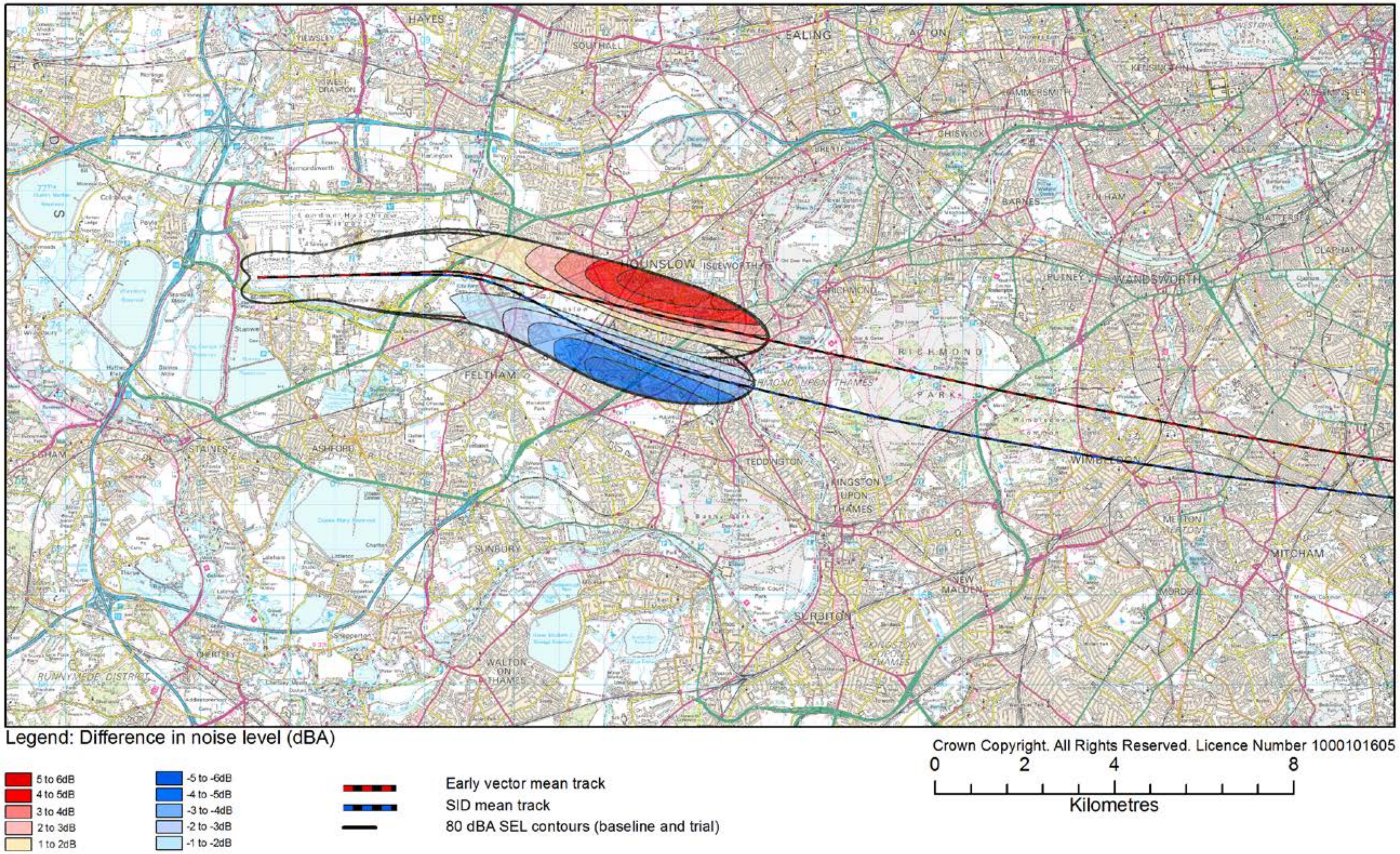


Figure 18: SEL difference, departures on the SID vs early-vectored mean track, 27L MID, MD80

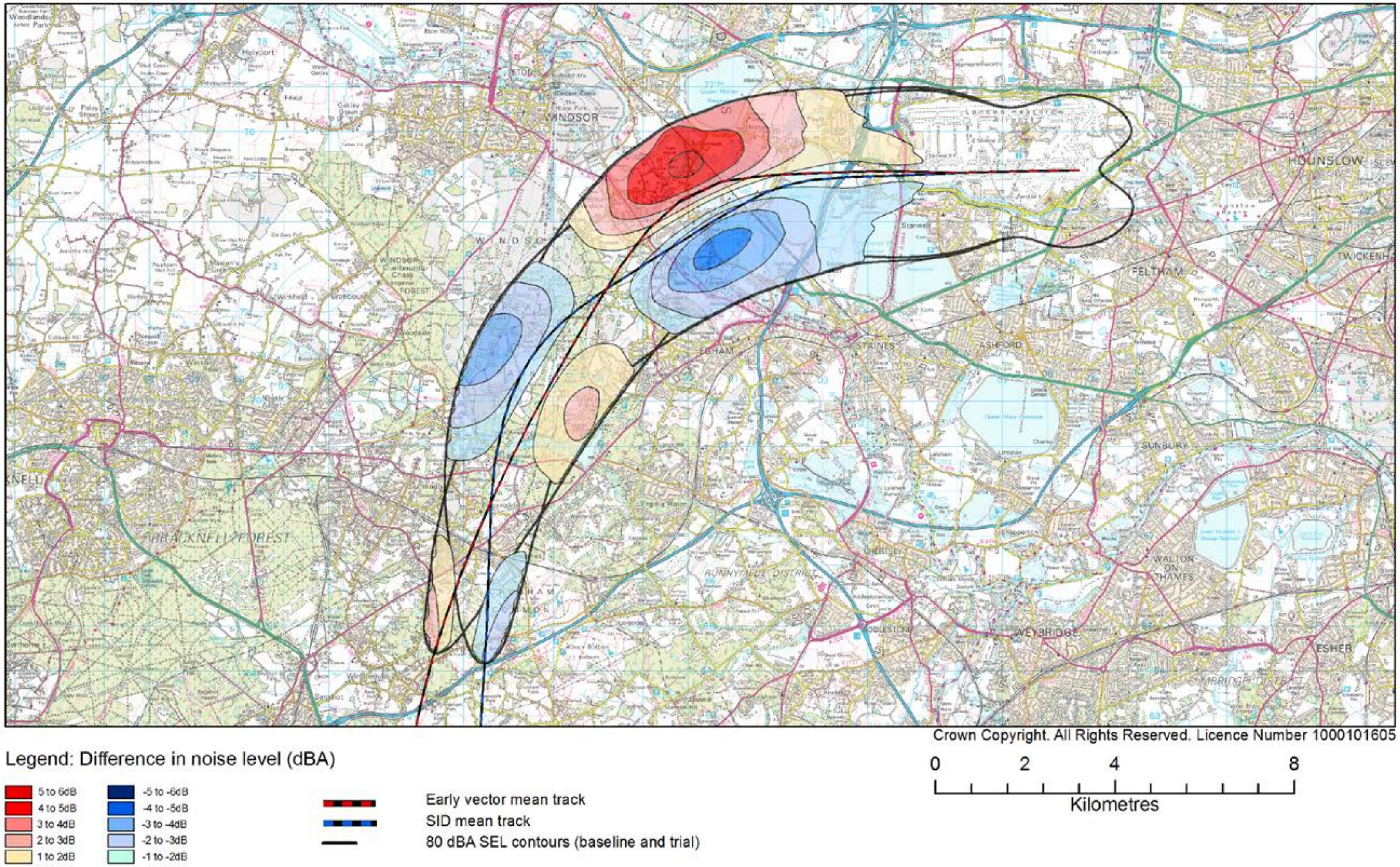


Figure 19: SEL difference, departures on the SID vs early-vectored mean track, 27L MID, A330

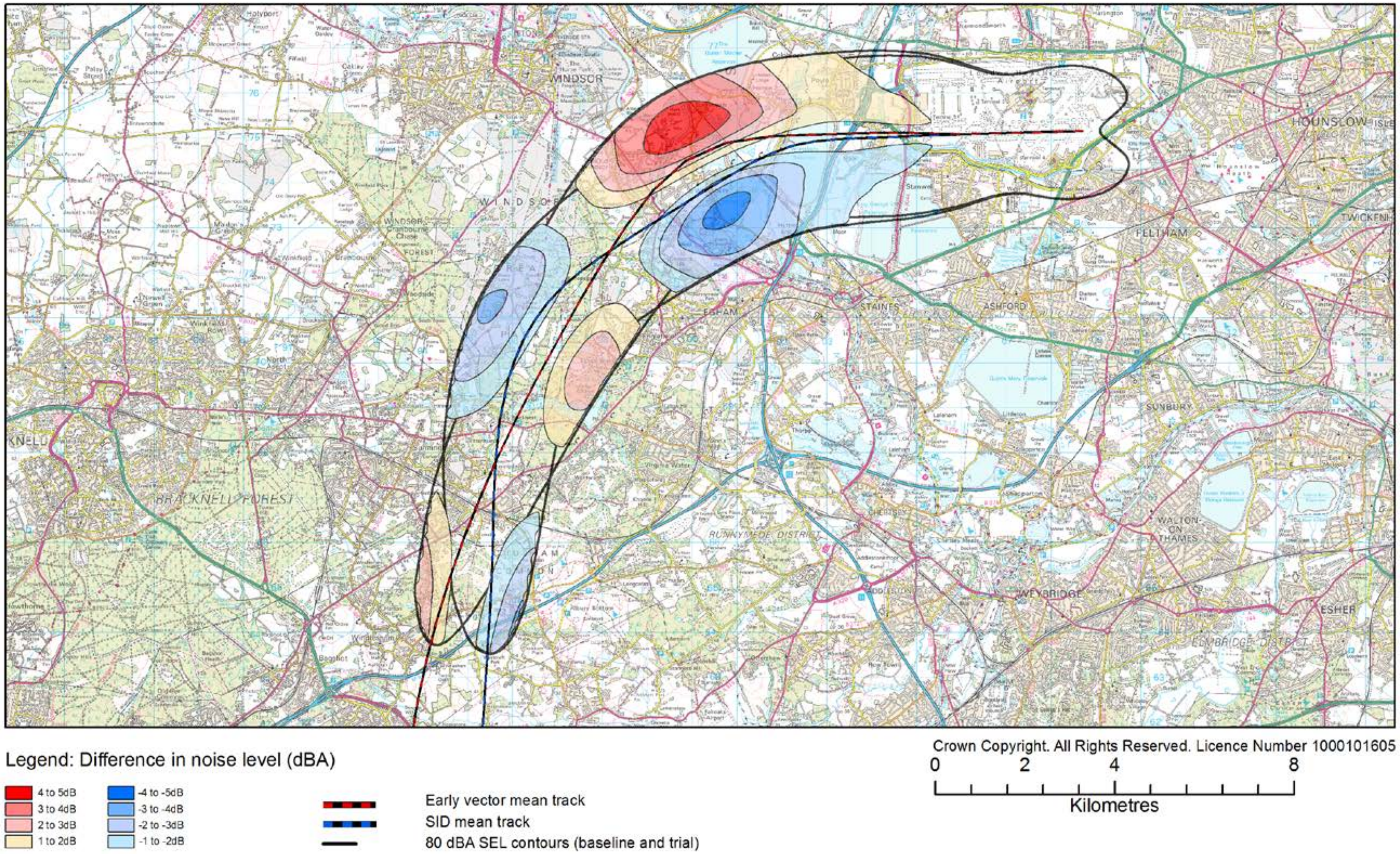
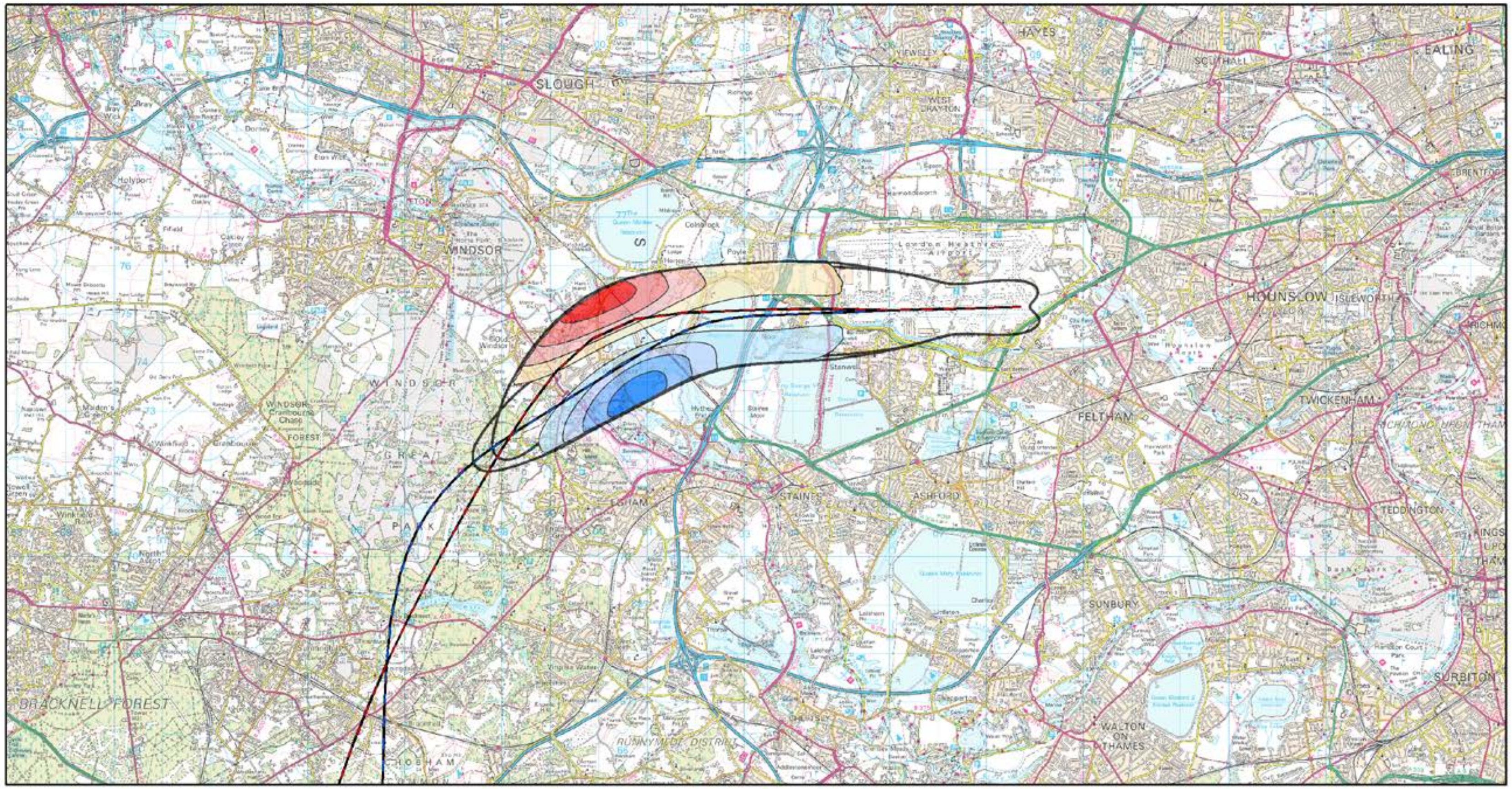


Figure 20: SEL difference, departures on the SID vs early-vectored mean track, 27L MID, A319



Legend: Difference in noise level (dBA)

4 to 5dB	-4 to -5dB	Early vector mean track
3 to 4dB	-3 to -4dB	SID mean track
2 to 3dB	-2 to -3dB	80 dBA SEL contours (baseline and trial)
1 to 2dB	-1 to -2dB	

0 2 4 8
Kilometres

Figure 21: SEL difference, departures on the SID vs early-vectored mean track, 27R MID, MD80

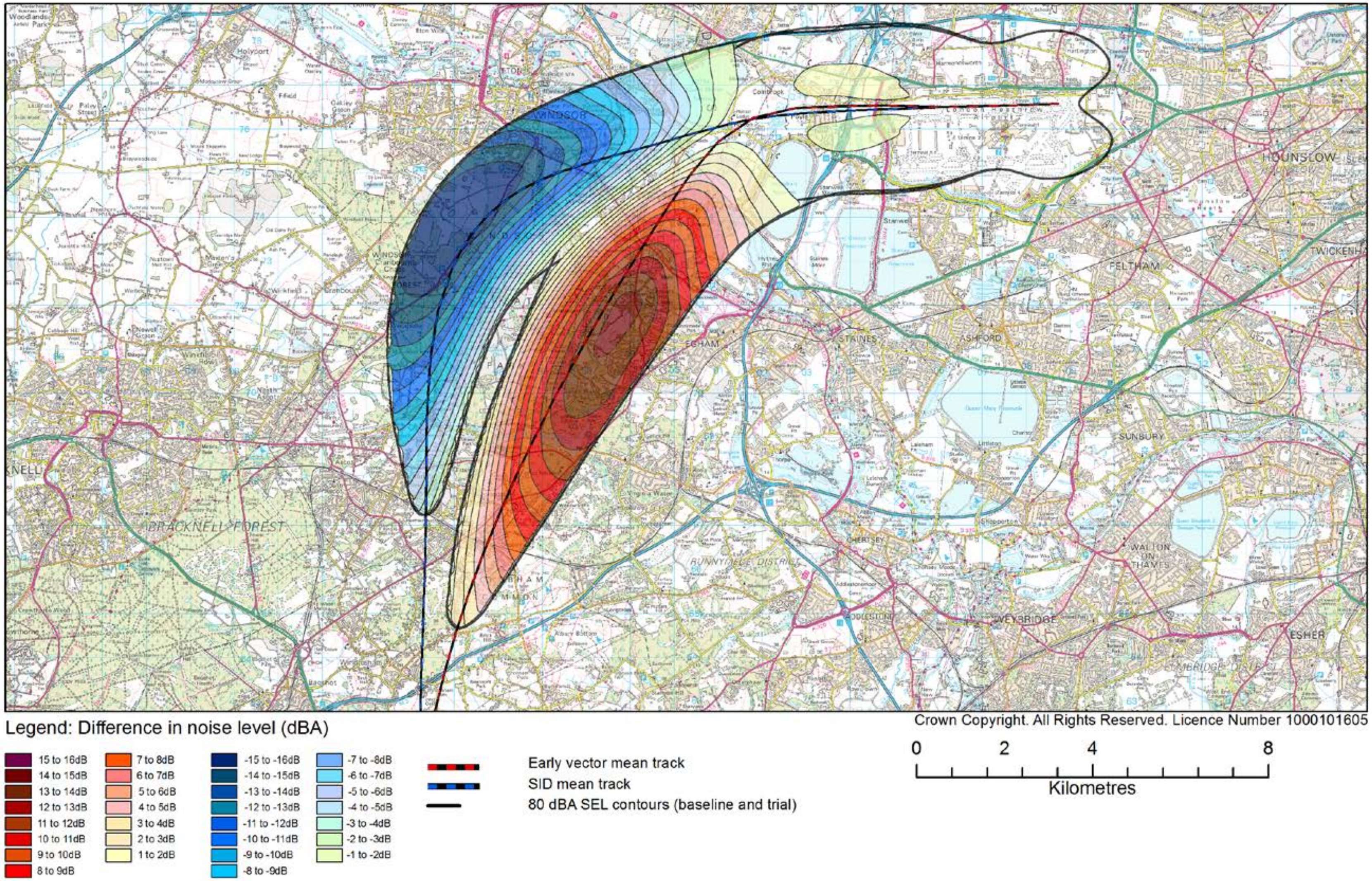


Figure 22: SEL difference, departures on the SID vs early-vectored mean track, 27R MID, A330

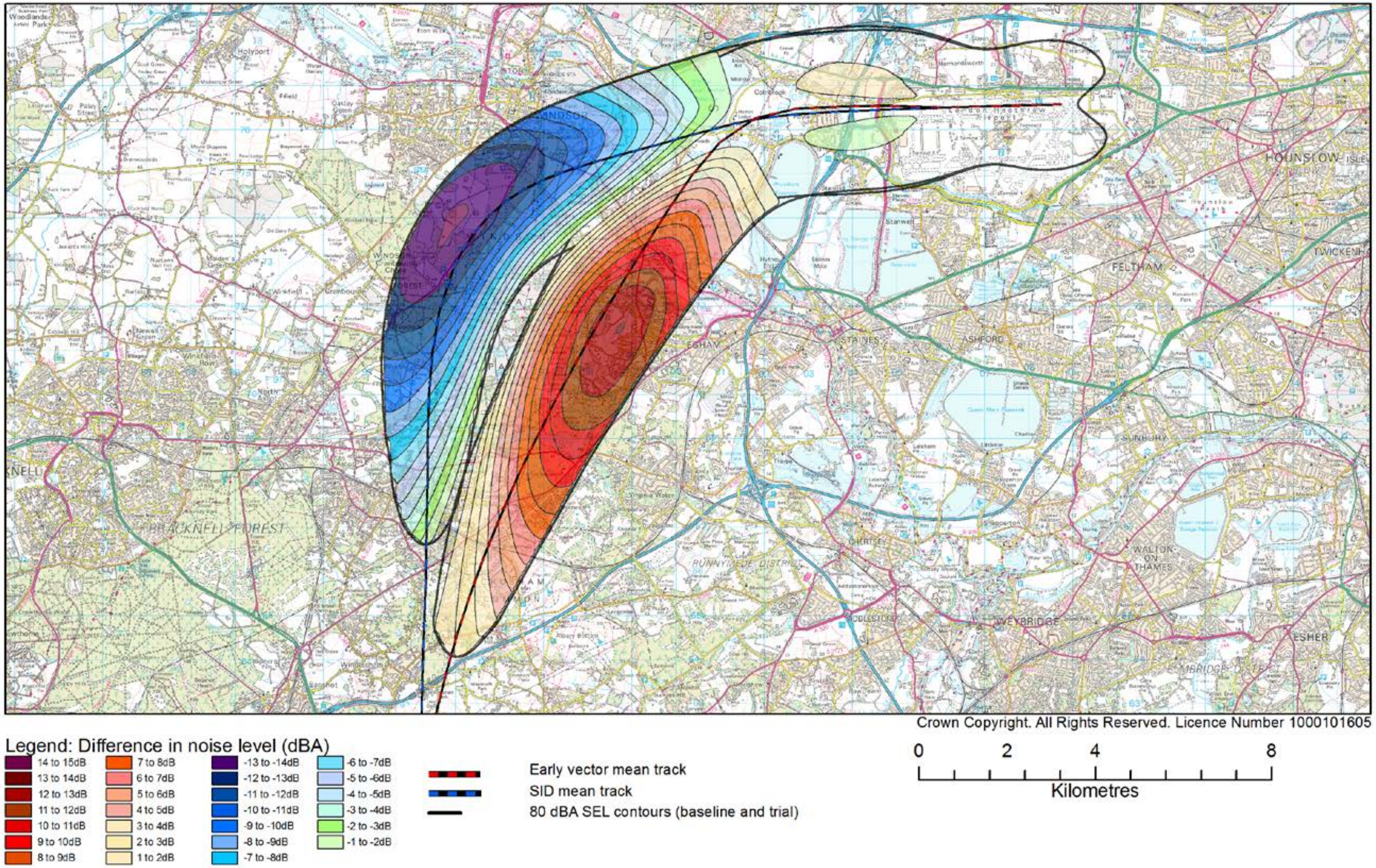
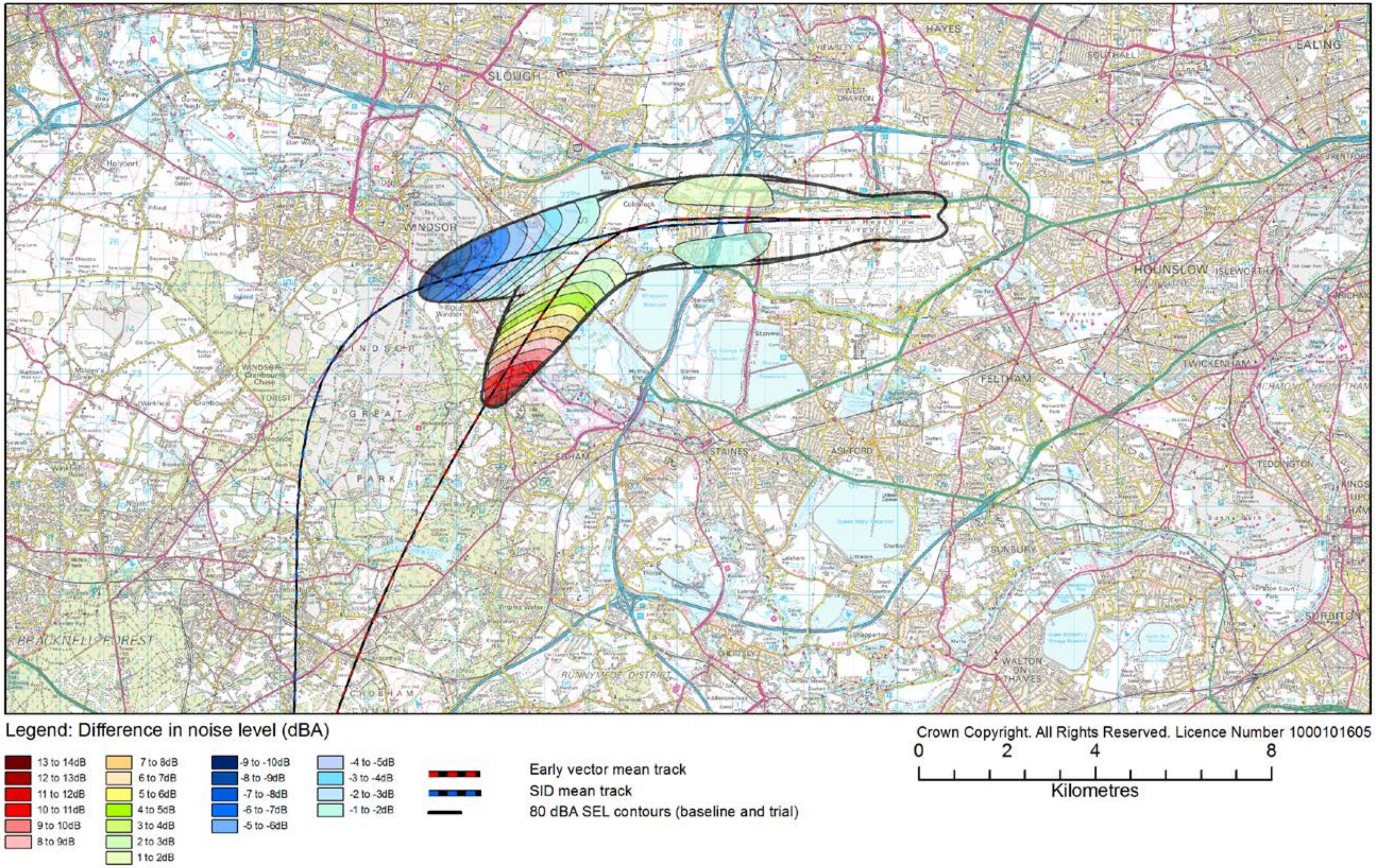


Figure 23: SEL difference, departures on the SID vs early-vectored mean track, 27R MID, A319



Appendix 1

London Heathrow Operational Freedoms Phase 1 Trial: Noise contours for out-of-alternation westerly arrivals

Based on report Phase 1 Trial: Effect on noise
by D P Rhodes, G Cebrian and M Sissons

The authors of this report are employed by the Civil Aviation Authority. The work reported herein was carried out on behalf of BAA (now Heathrow Airport Ltd.) through a contract agreed on the 9th March 2012.

Population data used in this report are based on 2001 Census data (updated in 2011) supplied by CACI Information Services.

Contents

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1 Effects on Noise

1.1 The effects of runway alternation

1.1.1 The two runways at London Heathrow airport are separated by approximately 1,400m (4,600ft). When standing underneath one flight path sound from an aircraft on the other landing flight path must therefore travel a greater distance to reach an individual, reducing the level or intensity of the sound.

1.1.2 At many locations under the westerly arrival flight paths this lateral distance between the two flight paths is considerably greater than the height of the aircraft on the approach path. This means that the sound is emitted from the adjacent flight path at a relatively shallow angle. As a result the path of the sound is influenced by the ground surface, resulting in sound absorption due to atmospheric scattering effects and the influence of the ground surface itself. All three effects combine to further reduce the noise level from the adjacent arrival flight path. Since the effects are related to the physics of sound propagation and therefore independent of the type of aircraft.

1.1.3 **Figure 1** illustrates the peak (Lmax) noise levels for a landing Boeing 747-400 on an overhead flight path and on the adjacent flight path. At 5km from touchdown the difference in noise levels between the two flight paths is 25 dB, at 10km the difference is 15 dB, at 15km the difference is 10 dB. These are significant differences. However, by 29 km from touchdown the difference reduces to 5 dB because differences in sound propagation between the two flight paths progressively reduce as the height of the aircraft on the landing flight path increases. It follows from this that the benefits of runway alternation are greatest closest to landing, but these benefits do diminish with distance from landing.

1.2 Leq 16hr

1.2.1 Since 1990 (Ref 1), Leq 16hr (0700-2300) has been the standard noise index used to generate noise contours to depict long-term average noise exposure in the vicinity of airports. The main input to the noise contour calculation process is the summer daily average movements by aircraft type, flight path and runway.

1.2.2 Runway alternation has been in place at London Heathrow airport since 1972. The system alternates on a weekly and daily basis whilst operating in a westerly direction. One runway is used for westerly landings between 0700 and 1500, whilst the other is used for departures. The designated landing and departure runways then reverse for the second half of the day, between 1500 and 2300. The system then reverses the runway used on a weekly basis, such that on a weekly basis residents are provided with alternating predictable periods of respite in the morning and afternoon/evening periods respectively.

1.2.3 Analysis of historic and phase 1 trial period data shows that the number of de-alternated westerly arrivals is approximately equal within morning and afternoon/evening alternation periods, as is the number of arrivals during these two periods. Thus, during westerly operations the number of aircraft landing on each runway average out over a full 16hr day (0700-2300) and thus the effects of de-alternation of westerly arrivals simply cancel out and will not be apparent in Leq

16hr noise contours. The solution is to produce Leq 8hr noise contours, depicting the noise exposure for each runway alteration period.

1.3 Leq 8hr

1.3.1 Although the noise effects of de-alternated westerly arrivals will cancel out over a 16hr day, de-alternation will affect respite within the two 8hr alternation periods, i.e. the morning period, 0700-1500, and the afternoon/evening period, 1500-2300.

1.3.2 As highlighted in para 1.2.3, the overall number of westerly arrivals and the number of de-alternated arrivals are approximately evenly distributed between the two 8hr alternation periods. Thus the traffic numbers used to illustrate the change in 8hr Leq noise exposure contour can be considered to be the same for both morning and afternoon/evening alternation periods simplifying the number of scenarios to be considered.

1.3.3 The phase 1 trial took place during the winter months. However, the mix of aircraft types that operated during the phase 1 trial and the previous three winters has changed, entirely independently of the trial, reflecting the normal progressive trend towards more modern aircraft types. In order to correctly isolate the effects of increased de-alternation during the trial period, the traffic mix needs to be held constant, whilst calculating the effects solely from increased de-alternation.

1.3.4 Whilst one could select the traffic sample from that during the phase 1 trial period as the reference traffic mix, there is a long-standing tradition of producing noise exposure contours that represent a summer average day. The summer average day reflects slightly higher traffic numbers during the summer months and also reflects aircraft performance during warmer summer temperatures. A summer average normally includes a portion of both westerly and easterly operation. However, since TEAM* is only applied during westerly arrival operations, it is logical to analyse only a westerly summer average day.

1.3.5 The assessment therefore used the latest available 16hr average summer westerly arrival traffic from summer 2011. The historic and phase 1 trial de-alternation values[1] were then combined with this data in order to generate the westerly arrival traffic distribution by runway for an 8hr alternation period as shown in **Table 1**.

Table 1: Distribution of traffic by runway for 8hr Leq noise contour assessment

Period	Runway	Number of westerly arrivals (8hr)
Pre-trial	Designated landing runway	302.9
	Designated departure runway	5.8
Phase 1 trial	Designated landing runway	297.5
	Designated departure runway	11.2

1.3.6 The resulting 8hr Leq contours for pre-trial and phase 1 trial scenarios when the southern runway (27L) is the designated landing runway are presented in **Figures 2 and 3** respectively. The corresponding areas, populations and households are shown in **Tables 2 and 3** respectively.

[1] Data presented in Table 1 of main report (Annex J)

Table 2: Pre-trial 8hr Leq noise contours - areas, populations & households when the southern runway (27L) is the designated landing runway

Noise level (dBA Leq)	Area (km²)	Pop (000s)	Hse (000s)
>54	60.7	409.9	179.1
>57	32.4	173.9	75.7
>60	15.4	73.8	31.2
>63	7.6	29.9	11.7
>66	3.7	14.2	5.6
>69	1.8	3.5	1.3
>72	0.9	0.2	0.1

Table 3: Phase 1 trial 8hr Leq noise contours - areas, populations & households when the southern runway (27L) is the designated landing runway

Noise level (dBA Leq)	Area (km²)	Pop (000s)	Hse (000s)
>54	62.3	415.4	181.2
>57	33.0	175.0	75.8
>60	15.5	73.4	31.0
>63	7.6	29.3	11.5
>66	3.7	13.6	5.4
>69	1.8	3.4	1.2
>72	0.9	0.2	0.1

1.3.7 **Table 4** shows the relative changes between Tables 2 and 3 for the case when the southern runway is the designated landing runway.

Table 4: Changes in 8hr Leq noise exposure due to the increase in de-alternated flights when the southern runway (27L) is the designated landing runway

	Change		
Noise level (dBA Leq)	Area (km²)	Pop (000s)	Hse (000s)
>54	+1.6	+5.5	+2.1
>57	+0.6	+1.1	+0.1
>60	-	-0.4	-0.2
>63	-	-0.6	-0.2
>66	-	-0.6	-0.2
>69	-	-0.1	-0.1
>72	-	-	-

1.3.8 The results in Table 4 show a small increase in size of the 54 and 57 dBA Leq noise contours. Increased de-alternation results in the re-distribution of westerly arrivals across two arrival flight paths. At higher noise exposure levels, closer to the airport, the noise differences between the two flight paths are greater and thus the noise influence from one approach flight path on the other is minimal since the noise exposure is dominated by the nearest flight path. Thus any increase in de-alternation tends to cancel out, in terms of Leq exposure. Further out from the airport, where noise levels from either approach flight path are similar, both flight paths contribute towards the overall noise exposure. Both effects are almost certainly a consequence of Leq being a logarithmic noise unit – where the addition of a much quieter noise event to much louder one results in little change in cumulative noise level, whereas further out the noise levels from the two flight paths become closer in magnitude and thus both influence the cumulative noise level.

1.3.9 The pre-trial and post trial scenarios can also be subtracted from each other to portray Leq difference contours. These show changes in 8hr noise exposure as a result of the increase in de-alternated westerly arrivals. **Figure 4** shows the change in 8hr Leq noise exposure above 54 dBA Leq. The corresponding areas, populations and households exposed to specific changes in noise exposure are shown in **Table 5**.

Table 5: Areas, populations and households exposed to changes in 8hr Leq noise exposure due to increased de-alternation when the southern runway (27L) is the designated landing runway

8hr Leq change (dB)	Area (km^2)	Pop (000s)	Hse (000s)
>+1	3.2	13.9	5.0
>+2	1.6	3.9	1.3
>+3	-	-	-

1.3.10 No areas are exposed to an increase in Leq noise exposure of more than 3 dB. This is not surprising since the number of de-alternated arrivals does not double. Figure 4 shows that areas exposed to increases of +1 and +2 dB Leq respectively are relatively close to the airport. This is where the noise differences between two approach flight paths are greatest and thus the localised effect of increased de-alternation leads to increased noise exposure.

1.3.11 **Figures 5 and 6** and **Tables 6 and 7** show the 8hr Leq noise exposure for the pre-trial and phase 1 trial respectively when the northern runway (27R) is the designated landing runway.

Table 6: Pre-trial 8hr Leq noise contours - areas, populations & households when the northern runway (27R) is the designated landing runway

Noise level (dBA Leq)	Area (km^2)	Pop (000s)	Hse (000s)
>54	60.9	426.5	188.9
>57	32.4	175.6	74.3
>60	15.2	65.2	25.8
>63	7.5	34.8	13.0
>66	3.7	15.1	5.4
>69	1.8	5.5	1.8
>72	0.9	1.8	0.6

Table 7: Phase 1 trial 8hr Leq noise contours - areas, populations & households when the northern runway (27R) is the designated landing runway

Noise level (dBA Leq)	Area (km²)	Pop (000s)	Hse (000s)
>54	62.5	432.8	191.6
>57	33.0	175.7	74.1
>60	15.2	64.6	25.6
>63	7.5	34.4	12.9
>66	3.7	14.6	5.2
>69	1.8	5.3	1.7
>72	0.9	1.8	0.6

1.3.12 **Table 8** shows the relative changes between Tables 6 and 7 for the case when the northern runway is the designated landing runway.

Table 8: Changes in 8hr Leq noise exposure due to the increase in de-alternated flights when the northern runway (27R) is the designated landing runway

	Change		
Noise level (dBA Leq)	Area (km²)	Pop (000s)	Hse (000s)
>54	+1.6	+6.3	+2.7
>57	+0.6	+0.1	-0.2
>60	+0.1	-0.6	-0.2
>63	-	-0.4	-0.1
>66	-	-0.5	-0.2
>69	-	-0.2	-0.1
>72	-	-	-

1.3.13 Despite anticipated differences due to differing population distributions underneath the 27L and 27R arrival flight paths, the results in Tables 6 to 8 for the northern runway (27R) are very similar to those for the southern runway and indicate there are no overall differences in noise exposure whether westerly arriving flights are de-alternated from the southern or northern runways.

1.3.14 As before the pre-trial and phase 1 trial scenarios were ‘subtracted’ from each other to determine the areas, populations and households exposed to change 8hr Leq noise level, these being illustrated in **Figure 7** and **Table 9**.

Table 9: Areas, populations and households exposed to changes in 8hr Leq noise exposure due to increased de-alternation when the northern runway (27R) is the designated landing runway

8hr Leq change (dB)	Area (km²)	Pop (000s)	Hse (000s)
>+1	3.2	12.7	4.9
>+2	1.6	1.4	0.5
>+3	-	-	-

1.3.15 Figure 7 shows very similar effects to Figure 4, albeit for the opposite arrival flight path. Likewise Table 9 shows very effects in terms of population exposure despite expected differences to differing population distributions under the two flight paths.

1.4 Leq 1hr

1.4.1 Section 1.3 highlighted the effects in terms of de-alternated westerly arrivals changing noise exposure within the 8hr alternation periods. Because the measure, TEAM*, that gives rise to de-alternated westerly arrivals may be used for relatively short periods of time to facilitate recovery from delay and disruption, its effects may not be fully captured by calculating noise exposure over a full 8hr alternation period. In this context a 1hr Leq noise exposure calculation may give a clearer illustration of the effects of de-alternation.

1.4.2 However, presenting noise exposure for a 1hr hour average time period would give exactly the same picture as that for 8hr Leq. In the context of short periods the maximum use of de-alternation prior to the trial and during the phase 1 trial is more relevant. In theory the number of flights landed in one hour with the application of TEAM* would be expected to be higher than with TEAM and both higher than without any measure applied. However, the number of aircraft landed in any single hour is much more strongly correlated with characteristics of the aircraft, in particular their wake vortex characteristics that dictate the spacing between successive arriving aircraft. For simplicity, the summer 2011 hourly average traffic has been used to assess both the pre-trial and phase 1 trial 1hr Leq scenarios.

1.4.3 The historic number of de-alternated westerly arrivals was calculated from an average of the hourly maximums from the preceding three winter periods (the same as used for the 8hr Leq analysis). The phase 1 trial hourly maximum was then identified from the trial period. The corresponding arrival numbers by runway for analysis are presented in **Table 10**.

Table 10: Distribution of traffic by runway for 1hr Leq noise contour assessment

Period	Runway	Number of westerly arrivals (1hr)
Pre-trial	Designated landing runway	32.6
	Designated departure runway	6.0
Phase 1 trial	Designated landing runway	25.6
	Designated departure runway	13.0

1.4.4 Table 10 shows that the maximum number of de-alternated arrivals in one hour is only slightly higher than the average over an 16hr entire day. Secondly, over one hour, the phase 1 trial total number of de-alternated arrivals is slightly more than double the pre-trial maximum, whereas over a whole day the phase 1 trial number is slightly less than double the number pre-trial. This reinforces the earlier finding that TEAM* may be used more intensively than TEAM, but it is not used twice as often.

1.4.5 Using the data in Table 10, 1hr Leq noise exposure contours were calculated using the same process as for the 8hr Leq contours. **Figures 8 and 9** show the 1hr Leq noise contours for the pre-trial and phase 1 trial scenarios when the designated landing runway is the southern runway (27L). The corresponding areas, populations and household counts are presented in **Tables 11 and 12.**

Table 11: Pre-trial 1hr Leq noise contours - areas, populations & households when the southern runway (27L) is the designated landing runway

Noise level (dBA Leq)	Area (km²)	Pop (000s)	Hse (000s)
>54	67.6	439.7	191.5
>57	37.4	191.9	81.3
>60	16.1	71.3	29.3
>63	7.6	29.2	11.3
>66	3.7	11.7	4.6
>69	1.8	2.2	0.8
>72	0.9	0.2	0.1

Table 12: Phase 1 trial 1hr Leq noise contours - areas, populations & households when the southern runway (27L) is the designated landing runway

Noise level (dBA Leq)	Area (km²)	Pop (000s)	Hse (000s)
>54	71.5	466.4	203.6
>57	39.2	186.5	78.5
>60	17.2	77.2	30.6
>63	7.7	28.5	10.7
>66	3.7	10.0	3.7
>69	1.8	1.5	0.5
>72	0.9	0.2	0.1

1.4.6 **Table 13** shows the relative changes between Tables 11 and 12 for the case when the southern runway is the designated landing runway.

Table 13: Changes in 1hr Leq noise exposure due to the increase in de-alternated flights when the southern runway (27L) is the designated landing runway

	Change		
Noise level (dBA Leq)	Area (km²)	Pop (000s)	Hse (000s)
>54	+3.9	+26.7	+12.1
>57	+1.8	-5.4	-2.8
>60	+1.0	+5.9	+1.3
>63	+0.1	-0.7	-0.6
>66	-	-1.7	-0.9
>69	-	-0.7	-0.3
>72	-	-	-

1.4.7 Table 13 effectively shows the additional noise exposure in a peak hour from the use of pre-trial TEAM to the use of TEAM*. As expected, the effects within one hour are greater than the effects over eight hours. However, the effects are small and again it is apparent that they are further from the airport at lower noise levels. Closer to airport, the overall effects are neutral.

1.4.8 As in the 8hr Leq analysis, the two 1hr Leq noise exposure scenarios were 'subtracted' to determine areas, populations and households subject to noise increases. **Figure 10** illustrates the areas subject to noise changes when the southern runway (27L) is the designated landing runway. The corresponding areas, populations and households are shown in **Table 14**.

Table 14: Areas, populations and households exposed to changes in 1hr Leq noise exposure due to increased de-alternation when the southern runway (27L) is the designated landing runway

1hr Leq change (dB)	Area (km²)	Pop (000s)	Hse (000s)
<-1	4.8	15.3	6.0
>+1	21.3	111.7	46.6
>+2	13.1	56.1	22.1
>+3	3.5	11.2	3.9

1.4.9 In contrast to the 8hr Leq comparison, a small area is predicted to experience a 1 to 2 dB noise reduction due to the transfer of arrivals from the designated landing runway to the departure runway. This reduction is also dependent on the assumption that the hourly landing rate would not increase significantly, which may not always be the case.

1.4.10 A small area is exposed to noise increases of more than 3 dB. This was expected since the number of de-alternated arrivals is shown to slightly more than double in a peak hour.

1.4.11 Similar analysis was undertaken for when the northern runway (27R) is the designated runway. **Figures 11 and 12** show the 1hr Leq noise exposure contours for the pre-trial and phase 1 trial cases respectively. The corresponding areas, populations and households are shown in **Tables 15 and 16**.

Table 15: Pre-trial 1hr Leq noise contours - areas, populations & households when the northern runway (27R) is the designated landing runway

Noise level (dBA Leq)	Area (km²)	Pop (000s)	Hse (000s)
>54	67.8	456.4	201.4
>57	37.4	190.6	79.3
>60	15.9	68.0	26.9
>63	7.5	31.6	11.8
>66	3.7	12.9	4.6
>69	1.8	4.4	1.4
>72	0.9	1.5	0.5

Table 16: Phase 1 trial 1hr Leq noise contours - areas, populations & households when the northern runway (27R) is the designated landing runway

Noise level (dBA Leq)	Area (km²)	Pop (000s)	Hse (000s)
>54	71.6	469.7	205.9
>57	39.3	192.5	80.4
>60	17.0	72.7	28.2
>63	7.7	31.1	11.6
>66	3.7	9.2	3.2
>69	1.8	2.8	0.9
>72	0.9	0.9	0.3

1.4.12 **Table 17** shows the relative changes between Tables 15 and 16 for the case when the southern runway is the designated landing runway.

Table 17: Changes in 1hr Leq noise exposure due to the increase in de-alternated flights when the northern runway (27R) is the designated landing runway

	Change		
Noise level (dBA Leq)	Area (km²)	Pop (000s)	Hse (000s)
>54	+3.8	+13.3	+4.5
>57	+1.9	+1.9	+1.1
>60	+1.1	+4.7	+1.3
>63	+0.2	-0.5	-0.2
>66	-	-3.7	-1.4
>69	-	-1.6	-0.5
>72	-	-0.6	-0.2

1.4.13 The overall trend, particularly for changes in area, is similar to the 1hr Leq changes when the southern runway is the designated landing runway. However, the increase in population exposed to noise above 54 dBA Leq halves when the northern runway (27R) is the designated runway. This is entirely due to differences in population distribution under the two landing flight paths.

1.4.14 By subtracting the noise exposures calculated for the pre-trial and phase 1 trial cases, the areas exposed to changes in 1hr Leq noise exposure when the northern runway is the designated landing runway was calculated and is shown in **Figure 13**. The corresponding areas, populations and household counts are shown in **Table 18**.

Table 18: Areas, populations and households exposed to changes in 1hr Leq noise exposure due to increased de-alternation when the northern runway (27R) is the designated landing runway

1hr Leq change (dB)	Area (km²)	Pop (000s)	Hse (000s)
<-1	4.7	17.9	6.4
>+1	21.4	113.8	49.2
>+2	13.5	58.8	24.3
>+3	3.6	8.7	3.3

1.4.15 Comparing the results in Table 18 with those in Table 14, the results are very similar, despite the differences in population exposed to more than 54 dBA Leq. This is likely reflected in the fact that the areas exposed to changes in noise exposure are much smaller than the 54 dBA Leq contour and thus reflect different population distributions.

1.4.16 Comparing the 1hr Leq noise exposure changes (Tables 14 and 18) with the 8hr Leq changes (Tables 5 and 9), it is apparent that although effects within a single hour may be more significant than over an 8hr alternation period, the changes in noise exposure remain relatively small and localised to small areas.

1.5 N70

1.5.1 The Leq noise index combines both the noise exposure of each individual noise event and the number of events using the equal noise energy principle. The Leq index is a widely used for all environmental noise analysis including road and rail noise as well as aircraft noise and is recommended by the World Health Organisation (Ref 2).

1.5.2 The N70 index gives the number of peak noise events that exceed a level of 70 dBA. The number of events that exceed a threshold level can be calculated for any threshold level. A level of 70 dBA Lmax was adopted for use in Australia (Ref 3) on the basis that it represented an indoor speech interference level typical of an Australian home. UK homes typically have higher outdoor to indoor sound absorption rates than Australian ones and thus the threshold level of 70 dBA Lmax cannot be considered to have the same significance in the UK as it has been given in Australia. Thus, whilst it cannot be used directly to estimate indoor speech interference in the UK, estimating and portraying changes in the number of noise events that exceed 70 dBA Lmax can potentially give greater insight into the degree of intrusion from time varying noise events.

1.5.3 N70 noise exposure is calculated in virtually the same way as for Leq, except that the peak noise level for each event is calculated rather than the Sound Exposure Level (SEL) normally calculated when estimating Leq. The number of peak noise levels that exceed the threshold level, in this case 70 dBA Lmax is then summed for all the traffic at each location on the ground.

1.5.4 The N70 contours presented here are for the 8hr alternation time period and thus utilise the same traffic distribution as provided in Table 1. **Figures 14 and 15** show the 8hr N70 contours for the pre-trial and phase 1 trial westerly arrivals when the southern runway (27L) was the designated landing runway. The corresponding areas, populations and household counts are shown in **Tables 19 and 20**.

Table 19: Pre-trial 8hr N70 noise contours - areas, populations & households when the southern runway (27L) is the designated landing runway

Number of noise event s above 70 dBA Lmax (-)	Area (km²)	Pop (000s)	Hse (000s)
>5	31.4	152.8	64.6
>10	25.3	125.4	54.4
>20	19.9	97.3	41.5
>50	14.7	67.6	28.5
>100	10.2	42.0	17.2
>200	5.7	21.4	8.4

Table 20: Phase 1 trial 8hr N70 noise contours - areas, populations & households when the southern runway (27L) is the designated landing runway

Number of noise events above 70 dBA Lmax (-)	Area (km²)	Pop (000s)	Hse (000s)
>5	34.5	166.9	70.1
>10	30.5	148.3	62.8
>20	19.8	96.7	41.2
>50	14.7	67.2	28.3
>100	10.1	40.6	16.6
>200	5.7	21.4	8.3

1.5.5 The differences between the two tables are shown in **Table 21**.

Table 21: Changes in 8hr N70 noise exposure due to the increase in de-alternated flights when the southern runway (27L) is the designated landing runway

	Change		
Number of noise events above 70 dBA Lmax (-)	Area (km²)	Pop (000s)	Hse (000s)
>5	+3.1	+14.1	+5.5
>10	+5.2	+22.9	+8.4
>20	-0.1	-0.6	-0.3
>50	-0.1	-0.4	-0.2
>100	-0.2	-1.4	-0.6
>200	-	-	-0.1

1.5.6 Table 21, in particular, highlights exactly the same trend as shown for both 8hr and 1hr Leq, i.e. little or no effect close to the airport and then small increases further away from the airport. Referring back to Table 1, within an 8hr alternation period, only 5.5 flights have been moved from one runway to another as a result of de-alternation due to the use of TEAM*. It may seem contradictory then that the area exposed to more than 10 noise events above 70 dBA Lmax may increase in size, but this could occur for example when increased de-alternation causes the number of events at a location to change from, say, 7 events, to 12 events, effectively moving a location from outside the >10 noise event contour to within it.

1.5.7 It is likely that this effect occurs at low numbers of events because it is representative of exposure further out from the airport, where the noise levels from the two arriving flights paths become similar (cf. Figure 1) and therefore begin to interact, especially in areas between the flight paths. Referring back to Table 21, it states that almost 23,000 more people were exposed to more than 10 noise events above 70 dBA Lmax. However, Table 21 does not tell us how many *more* noise events these people were exposed to, only that they fell into the more than 10 events contour.

1.5.8 In order to understand the change in number of events that people were exposed to, how many people and to what change number, we again need to subtract the two scenarios and generate 'difference N70 contours', as shown in **Figure 16** for the case when the southern runway (27L) is the designated landing runway. Note that because N70 is a linear noise index it now highlights the benefits of moving the flights away from the designated landing runway, as well as the adverse effects of de-alternated arrivals landing on the designated departure runway – the N70 contours are in fact a mirror image of each other, for each area exposed to one less noise event, there is a corresponding area exposed to one more noise event. The corresponding areas, populations and household counts are shown in **Table 22**.

Table 22: Areas, populations and household counts exposed to changes in the number of noise events above 70 dBA Lmax over 8hr, due to increased de-alternation when the southern runway (27L) is the designated landing runway

Change in number of noise events above 70 dBA Lmax (-)	Area (km²)	Pop (000s)	Hse (000s)
5 less	5.1	19.2	7.5
4 less	5.6	21.0	8.2
3 less	6.1	23.3	9.1
2 less	9.0	33.8	13.4
1 less	14.3	64.8	27.4
1 more	14.1	59.3	23.4
2 more	8.8	38.6	14.5
3 more	6.1	28.1	10.4
4 more	5.6	25.1	9.2
5 more	5.2	22.7	8.3

1.5.9 Table 22 gives probably the clearest illustration yet of the effects of de-alternating 5.5 additional arriving aircraft over 8hr. Under the designated landing runway (27L), people are exposed to between 1 to 5 fewer noise events. Under the arriving flight path for 27R (designated departure runway), people are exposed to between 1 to 5 more noise events above 70 dBA Lmax. This now adds context to the statement in para 1.5.7 that 23,000 more people were exposed to more than 10 noise events above 70 dBA Lmax. Whilst this still holds, we know that the *increase* in exposure may be as little as one more noise event, but no more than 5 noise events.

1.5.10 A similar analysis was conducted for when the northern runway (27R) was the designated landing runway. **Figures 17 and 18** show the 8hr N70 contours for the pre-trial and phase 1 cases. The corresponding areas, populations and household counts are shown in **Tables 23 and 24** respectively.

Table 23: Pre-trial 8hr N70 noise contours - areas, populations & households when the northern runway (27R) is the designated landing runway

Number of noise events above 70 dBA Lmax (-)	Area (km²)	Pop (000s)	Hse (000s)
>5	31.0	147.2	60.2
>10	25.1	122.8	50.5
>20	19.6	80.9	32.4
>50	14.4	61.6	24.4
>100	9.9	42.6	16.2
>200	5.8	25.9	9.5

Table 24: Phase 1 trial 8hr N70 noise contours - areas, populations & households when the northern runway (27R) is the designated landing runway

Number of noise events above 70 dBA Lmax (-)	Area (km²)	Pop (000s)	Hse (000s)
>5	34.2	159.7	65.2
>10	30.2	141.9	57.9
>20	19.5	80.7	32.3
>50	14.4	61.0	24.1
>100	9.7	41.4	15.7
>200	5.7	25.6	9.4

1.5.11 The differences between the two tables are shown in **Table 25**.

Table 25: Changes in 8hr N70 noise exposure due to the increase in de-alternated flights when the northern runway (27R) is the designated landing runway

	Change		
Number of noise events above 70 dBA Lmax (-)	Area (km²)	Pop (000s)	Hse (000s)
>5	+3.2	+12.5	+5.0
>10	+5.2	+19.1	+7.4
>20	-0.1	-0.2	-0.1
>50	-0.1	-0.6	-0.3
>100	-0.2	-1.2	-0.5
>200	-	-0.3	-0.1

1.5.12 Again, results for when the northern runway (27R) is the designated landing runway are very similar to those for when the southern runway (27L) is the designated landing runway.

1.5.13 As before, the two scenarios were subtracted to determine what changes in number of events certain areas were exposed to. **Figure 19** shows the changes in 8hr N70 noise exposure for when the northern runway (27R) is the designated landing runway. As expected it represents a mirror image of Figure 15. The corresponding areas, populations and household counts are shown in **Table 26**.

Table 26: Areas, populations and household counts exposed to changes in the number of noise events above 70 dBA Lmax over 8hr, due to increased de-alternation when the northern runway (27R) is the designated landing runway

Change in number of aircraft above 70 dBA Lmax (-)	Area (km²)	Pop (000s)	Hse (000s)
5 less	5.2	22.7	8.3
4 less	5.6	25.1	9.2
3 less	6.1	28.1	10.4
2 less	8.8	38.6	14.5
1 less	14.1	59.3	23.4
1 more	14.3	64.8	27.4
2 more	9.0	33.8	13.4
3 more	6.1	23.3	9.1
4 more	5.6	21.0	8.2
5 more	5.1	19.2	7.5

1.5.14 Likewise, the results in Table 26 are also a mirror image of the results for when the southern runway is the designated landing runway (Table 22).

1.6 TA70

1.6.1 Whilst the N70 noise index attempts to overcome some of criticisms attributed to the Leq index, it is not without its own flaws. The N70 index does not take into account how noisy each event is above 70 dBA Lmax, only whether it is above or more 70 dBA, i.e. equal weighting is given to a noise event at 71 dBA as to one at 100 dBA.

1.6.2 This can be overcome to some extent by calculating the total noise exposure in terms of time when the noise exposure level exceeds a threshold level. Such an index is referred to as a Time Above (a threshold) index. It is common to adopt the same threshold level as for N70, i.e. 70 dBA Lmax, although it has no established meaning, especially in a UK context. TA70 addresses the criticism of N70 because there is generally a high degree of correlation between the duration of a noise event and the peak level of the event, i.e. louder events tend to last longer than quieter events for a given ground location.

1.6.3 TA70 cannot be calculated as readily as Leq and N70 since it requires a representation of the time history of the event to be approximated in order to estimate the time above a threshold level. The internationally recommended methods for calculating noise exposure around airports are what are known as integrated models, i.e. they predict cumulative noise exposure, but do not directly calculate the time history of each individual noise event. The models are therefore required to use theoretical algorithms to define the shape of the time history from which the duration of each event may be estimated.

1.6.4 Since Time Above has been seldom used in the UK, its estimation and validation are not routine practice. Validation of westerly arrival noise event durations highlighted substantial differences between those predicted. Corrections were subsequently made in order to ensure individual aircraft and cumulative durations reflected measured data. It must, however, be acknowledged that estimates of

TA70 cannot be made with same degree of confidence as for, Lmax, SEL, Leq and N70.

1.6.5 As for 8hr Leq and N70 analysis, estimates of the areas, populations and households exposed to certain durations of noise exposure above 70 dBA Lmax were calculated, first for pre-trial and phase 1 trial scenarios where the southern runway (27L) was the designated landing runway and then where the northern runway (27R) was the designated landing runway.

1.6.6 **Figures 20 and 21** show the TA70 contours for the pre-trial and phase 1 trial scenarios when the southern runway was the designated landing runway. The corresponding areas, populations and household counts are shown in **Tables 27 and 28** respectively.

Table 27: Pre-trial 8hr TA70 noise contours - areas, populations & households when the southern runway (27L) is the designated landing runway

Time exposed to noise above 70 dBA Lmax (mins)	Area (km^2)	Pop (000s)	Hse (000s)
0.5	33.9	164.3	68.9
1	29.6	143.4	60.5
2	22.7	110.8	47.7
4	18.3	88.4	37.5
8	14.5	67.4	28.3
16	11.3	48.3	20.0
32	7.4	29.6	11.6
64	4.5	18.4	7.1

Table 28: Phase 1 trial 8hr TA70 noise contours - areas, populations & households when the southern runway (27L) is the designated landing runway

Time exposed to noise above 70 dBA Lmax (mins)	Area (km^2)	Pop (000s)	Hse (000s)
0.5	37.7	179.7	75.5
1	32.7	158.2	66.2
2	27.4	133.4	56.0
4	18.5	88.2	37.4
8	14.4	67.1	28.2
16	11.2	47.5	19.6
32	7.1	28.8	11.3
64	4.5	18.5	7.2

1.6.7 The changes between the two scenarios are shown in **Table 29**.

Table 29: Changes in 8hr TA70 noise exposure due to the increase in de-alternated flights when the southern runway (27L) is the designated landing runway

Change in time exposed to noise above 70 dBA Lmax (mins)	Change		
	Area (km²)	Pop (000s)	Hse (000s)
0.5	+3.8	+15.4	+6.6
1	+3.1	+14.8	+5.7
2	+4.7	+22.6	+8.3
4	+0.2	-0.2	-0.1
8	-0.1	-0.3	-0.1
16	-0.1	-0.8	-0.4
32	-0.2	-0.8	-0.3

1.6.8 The major change highlighted in Table 29 is that increased westerly arrival de-alternation results in 23,000 more people experiencing 2 to 4 minutes of noise exposure above 70 dBA Lmax during an 8hr alternation respite period. It is noted that the figure of 23,000 is the same as the increase in number of people estimated to experience more than 10 noise events above 70 dBA Lmax. The two results are in fact consistent, since landing approach noise events at the relevant locations typically have individual durations of 20-30 seconds. One to five additional de-alternated flights exceeding 70 dBA Lmax would therefore result in an increase of between half to two minutes additional noise exposure.

1.6.9 As with Leq and N70, the locations and number of people exposed to specific changes in TA70 can be estimated by subtracting the two scenarios. **Figure 22** and **Table 30** show difference TA70 contours.

Table 30: Areas, populations and household counts exposed to changes in the time exposed to noise events above 70 dBA Lmax over 8hr, due to increased de-alternation when the southern runway (27L) is the designated landing runway

Change in time exposed to noise above 70 dBA Lmax (mins)	Area (km²)	Pop (000s)	Hse (000s)
-1.5	1.9	10.4	4.2
-1.0	5.0	19.3	7.5
-0.5	8.0	31.1	12.2
+0.5	7.9	36.3	13.6
+1.0	5.0	22.8	8.3
+1.5	1.8	7.0	2.6

1.6.10 The results in Table 30 are almost symmetric, as was the case in Tables 22 and 26, since TA70 is also a linear index. Thus, redistributing flights from one arriving flight path to another results in some people experiencing less time exposed to noise above 70 dBA, but some experiencing more time.

1.6.11 A similar analysis was conducted for the scenarios when the northern runway (27R) is the designated landing runway. **Figures 23 and 24** show the TA70 contours for the pre-trial and phase 1 trial scenarios respectively. The corresponding areas, populations and households counts are shown in **Tables 31 and 32** respectively.

Table 31: Pre-trial 8hr TA70 noise contours - areas, populations & households when the northern runway (27R) is the designated landing runway

Time exposed to noise above 70 dBA Lmax (mins)	Area (km²)	Pop (000s)	Hse (000s)
0.5	33.7	156.8	63.8
1	29.6	136.8	55.6
2	22.4	98.7	40.2
4	18.0	74.9	29.7
8	14.2	61.5	24.3
16	11.0	48.0	18.5
32	7.3	34.5	12.9
64	4.6	20.9	7.6

Table 32: Phase 1 trial 8hr TA70 noise contours - areas, populations & households when the northern runway (27R) is the designated landing runway

Time exposed to noise above 70 dBA Lmax (mins)	Area (km²)	Pop (000s)	Hse (000s)
0.5	37.7	178.1	73.5
1	32.7	149.0	60.5
2	27.0	117.7	47.5
4	18.2	74.8	29.7
8	14.1	61.3	24.2
16	10.9	47.0	18.0
32	7.1	34.1	12.7
64	4.5	20.6	7.5

1.6.12 The change between the two scenarios is shown in **Table 33**.

Table 33: Changes in 8hr TA70 noise exposure due to the increase in de-alternated flights when the northern runway (27R) is the designated landing runway

Time exposed to noise above 70 dBA Lmax (mins)	Change		
	Area (km²)	Pop (000s)	Hse (000s)
0.5	+4.0	+21.3	+9.7
1	+3.0	+12.2	+4.9
2	+4.6	+19.0	+7.3
4	+0.2	-0.1	-
8	-0.1	-0.2	-0.1
16	-0.1	-1.0	-0.5
32	-0.1	-0.4	-0.2

1.6.13 The results shown in Table 33 again show a consistent tend as seen in the earlier results for de-alternation from the southern runway.

1.6.14 The pre-trial and phase 1 trial scenarios were subtracted to identify areas where specific changes in the time of noise exposure above 70 dBA Lmax occur as shown in **Figure 25**. The corresponding areas, populations and household counts are shown in **Table 34**.

Table 34: Areas, populations and household counts exposed to changes in the time exposed to noise events above 70 dBA Lmax over 8hr, due to increased de-alternation when the northern runway (27R) is the designated landing runway

Change in time exposed to noise above 70 dBA Lmax (mins)	Area (km^2)	Pop (000s)	Hse (000s)
-1.5	1.8	7.0	2.6
-1.0	5.0	22.8	8.3
-0.5	7.9	36.3	13.6
+0.5	8.0	31.1	12.2
+1.0	5.0	19.3	7.5
+1.5	1.9	10.4	4.2

1.6.15 As expected the results in Table 34 are a mirror image of those in Table 30.

2 Conclusions

2.1 This report has considered the effects of the application of the TEAM* operational freedom during the phase 1 trial conducted between November 2011 and February 2012. Operational data relating to the landing runway and the designated landing runway in use during westerly arrival operations was analysed for the phase 1 trial period and compared against the same calendar period from the three previous winter seasons.

2.2 The changes in noise exposure resulting from the increase in de-alternated westerly arrivals was analysed using the Leq noise exposure index for both the 8hr alternation period and 1hr ‘maximum-use’ of TEAM* scenarios. The analysis found:

- A near doubling in de-alternated flights leads to an increase in Leq noise exposure of almost 3 dB, but almost no decrease in Leq noise exposure. This occurs because the number of flights de-alternated from the designated landing runway is very small compared with the total number of flights on the designated landing runway (~1.6%).
- In terms of geographical location, the effects of de-alternation are greatest very close to the airport (immediately east of the airport) where the benefits of alternation are greatest. The effects of de-alternation then become less apparent further away from the airport, particularly beyond approximately 15km away, due to the benefits of alternation diminishing as the differences in noise level between two flight paths reduce.

2.3 A number of additional analyses were undertaken using supplemental noise metrics, including number of events above 70 dBA Lmax (N70) and time above 70 dBA Lmax (TA70). In summary:

- N70 analysis showed that the phase 1 trial increase in de-alternation resulted in between one to five more noise events exceeding 70 dBA per 8hr respite period, but with a corresponding reduction during the 8hr non-respite period.
- The TA70 analysis showed that the phase 1 trial increase in de-alternation resulted in between 0.5 to 2 minutes more noise exposure above 70 dBA Lmax per 8hr respite period, but with a corresponding reduction during the 8hr non-respite period.
- The variation in number of events and time of exposure above 70 dBA Lmax is due to some of the noise events for the quieter aircraft not exceeding 70 dBA Lmax further out from the airport.

References

1. Ollerhead JB et al, “The Use of Leq as an Aircraft Noise Index”, DORA Report 9023, JB Ollerhead and JB Critchley, Civil Aviation Authority, September 1990.
2. WHO, “Guidelines for Community Noise”, World Health Organisation, 1999.
3. Southgate et al, “Expanding Ways to Describe and Assess Aircraft Noise”, Department of Transport and Regional Services, Australia, ISBN 0 642 42262 1, March 2000.

Figure 1: B747-400 Lmax noise level for overhead and adjacent landing runway

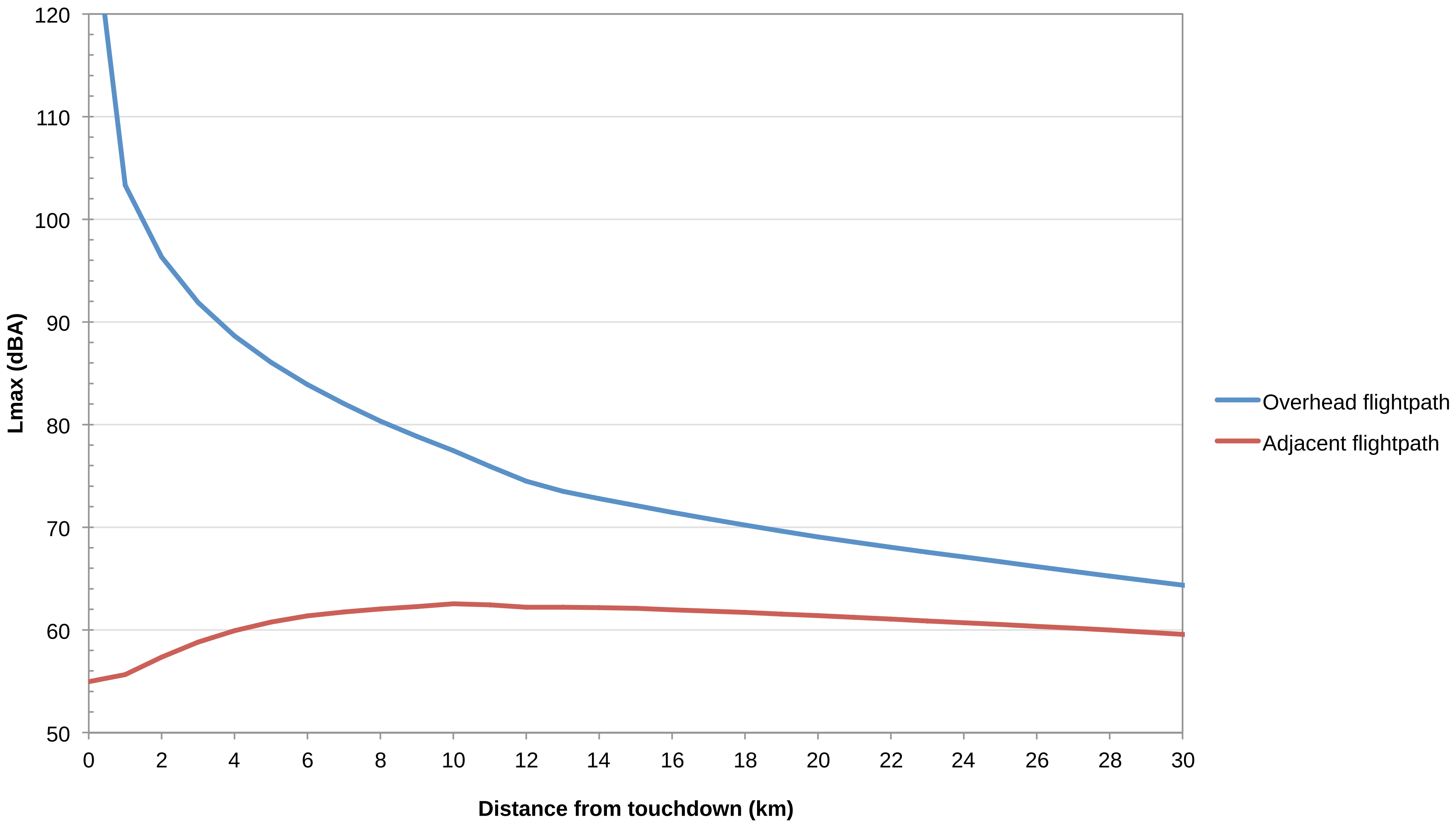
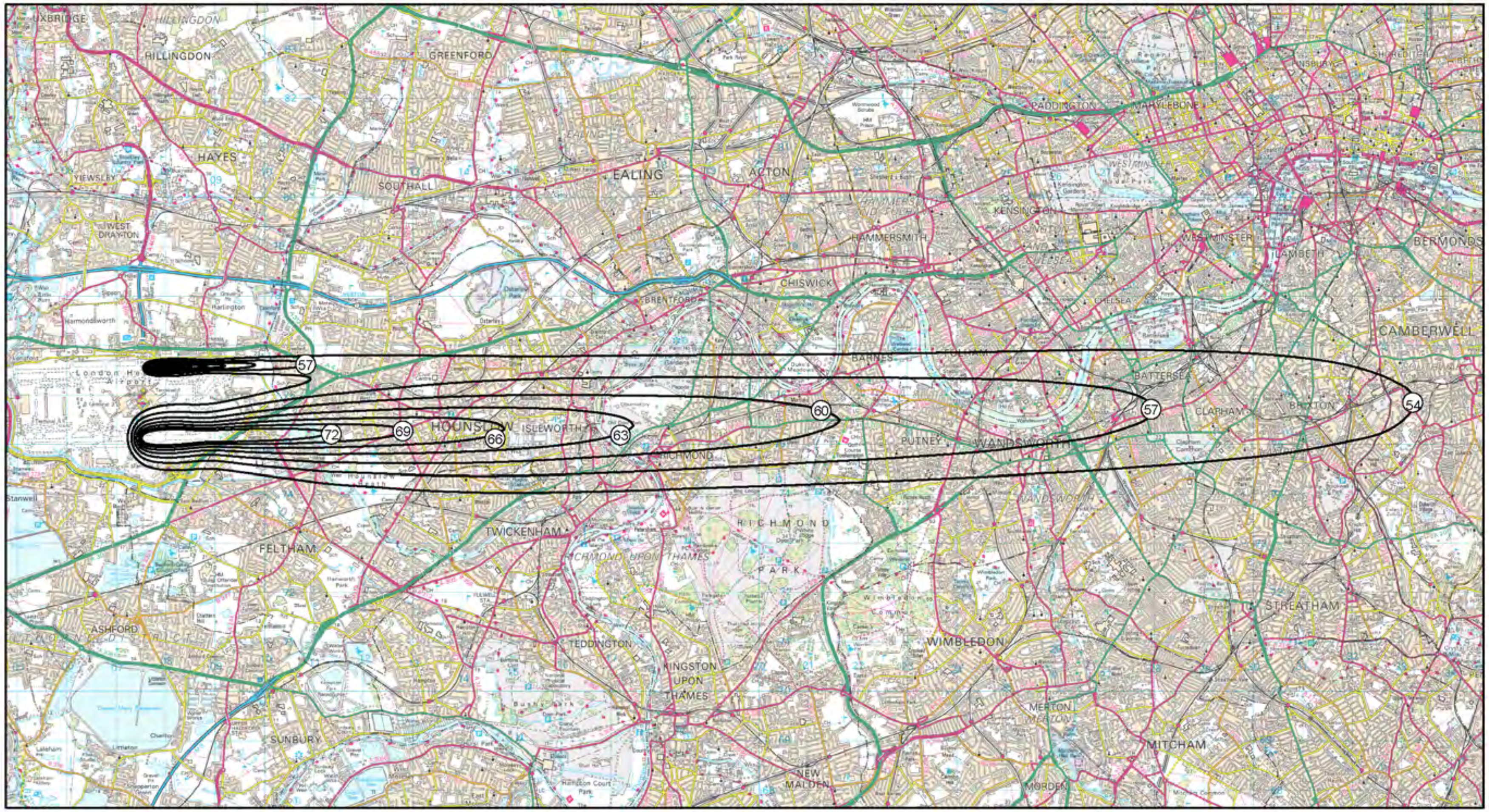


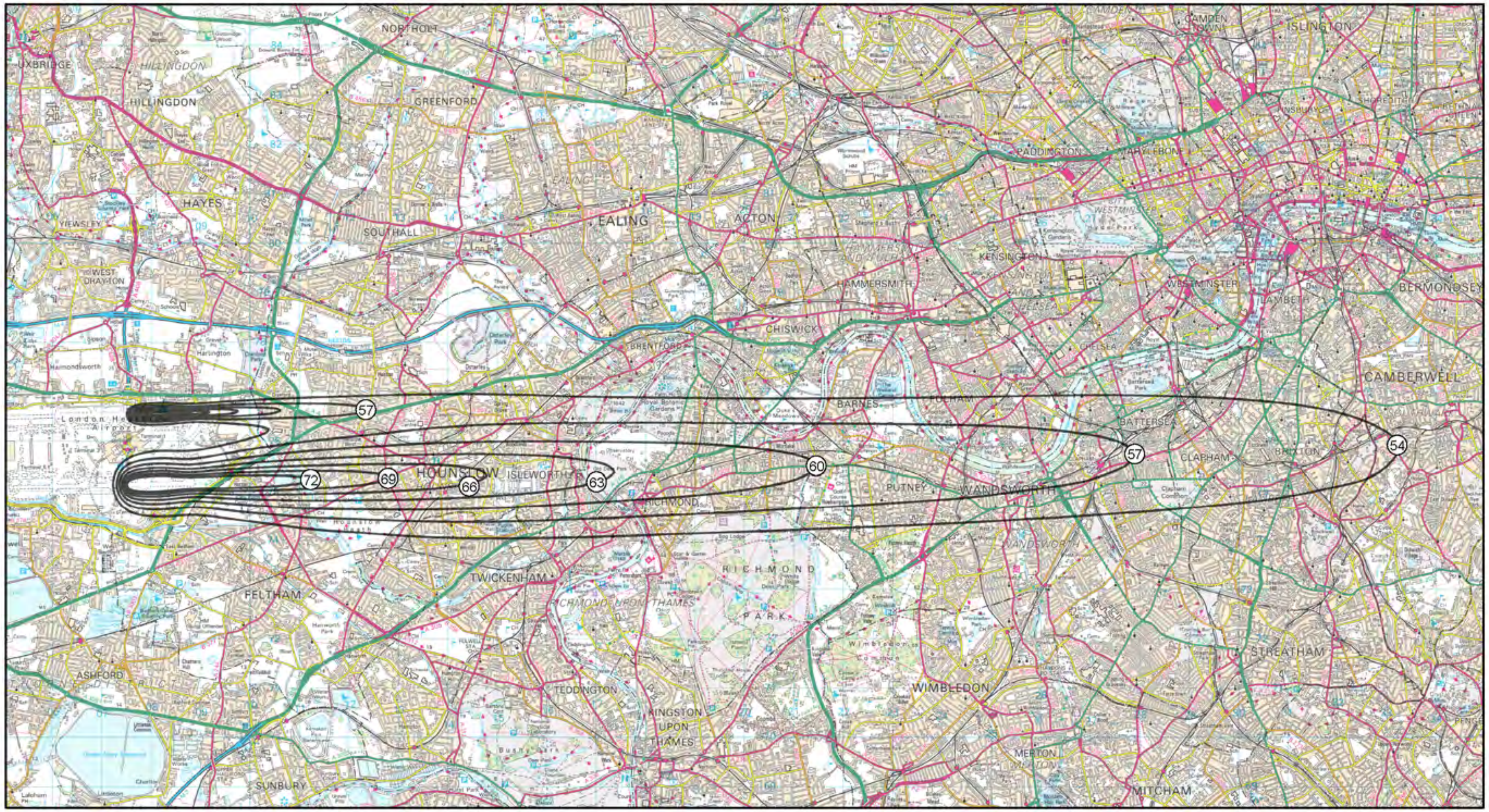
Figure 2: 8hr Leq pre-trial contours when 27L is the designated landing runway



0 2.5 5 10

Kilometres

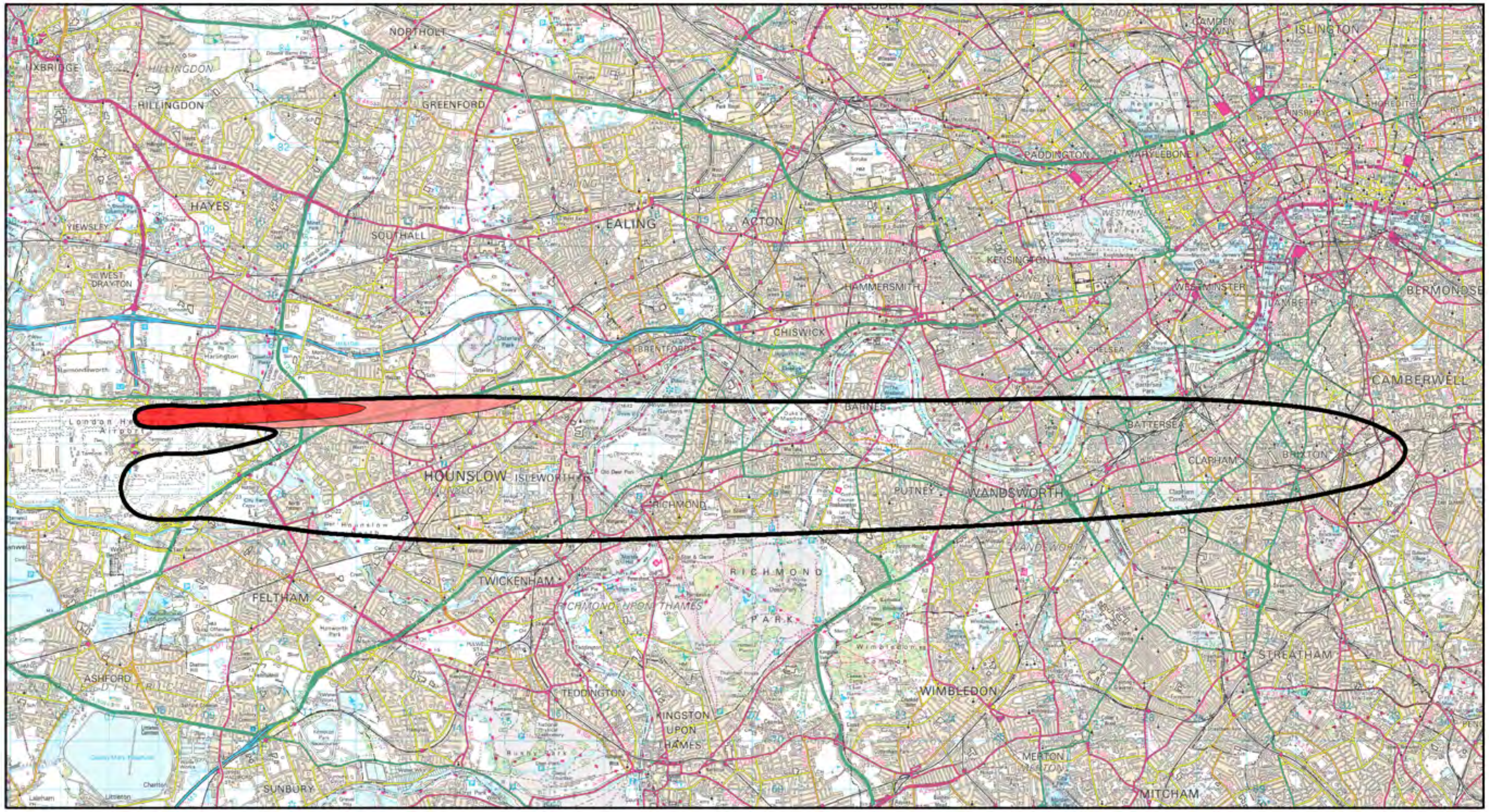
Figure 3: 8hr Leq contours for phase 1 trial when 27L is the designated landing runway



0 2.5 5 10

Kilometres

Figure 4: 8hr difference Leq contours for phase 1 trial vs pre-trial when 27L is the designated landing runway



0 2.5 5 10
Kilometres

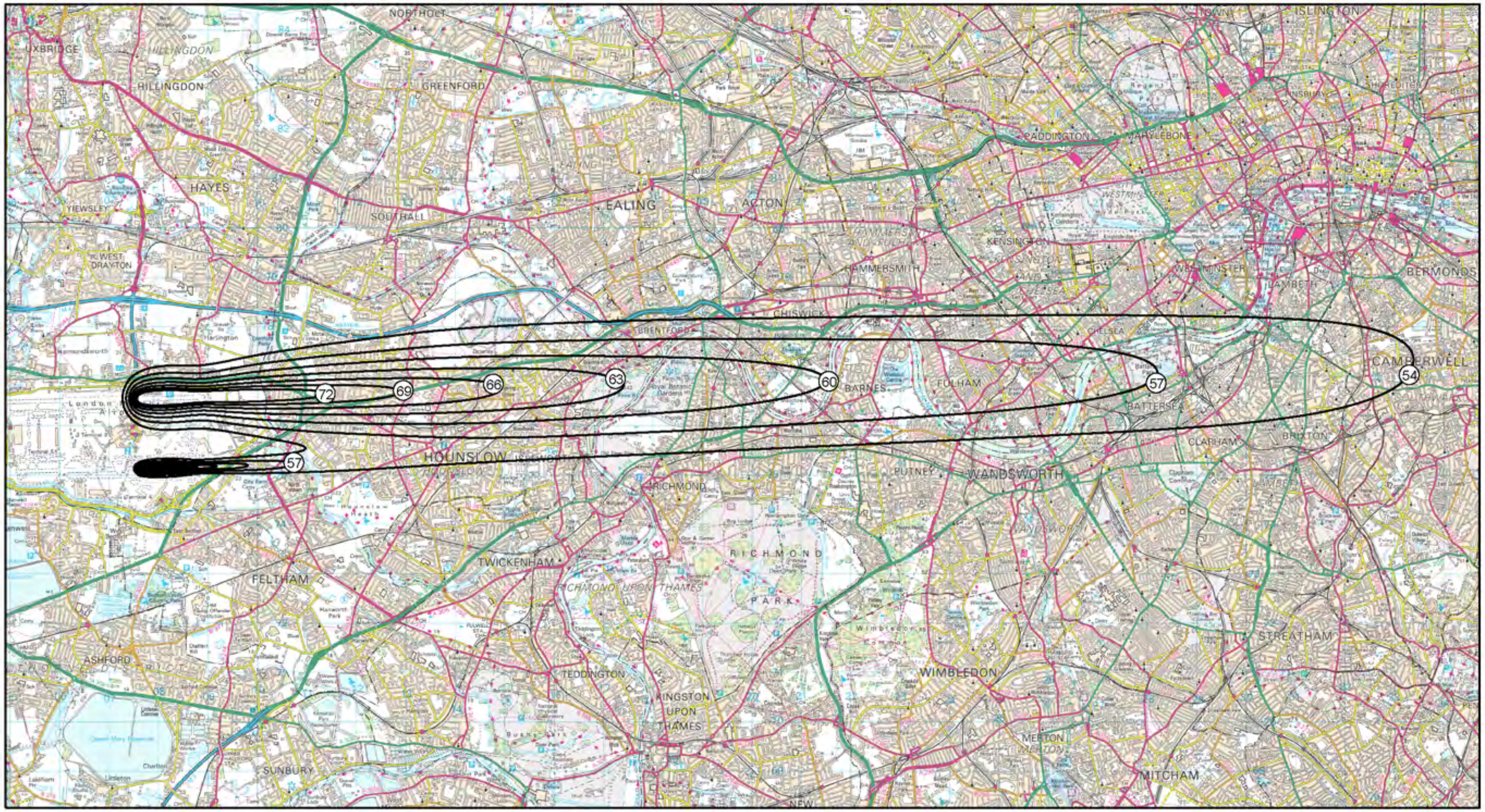
Change in noise exposure:

+1 to +2 dB

+2 to +3 dB

54 dBA Leq contour for trial period

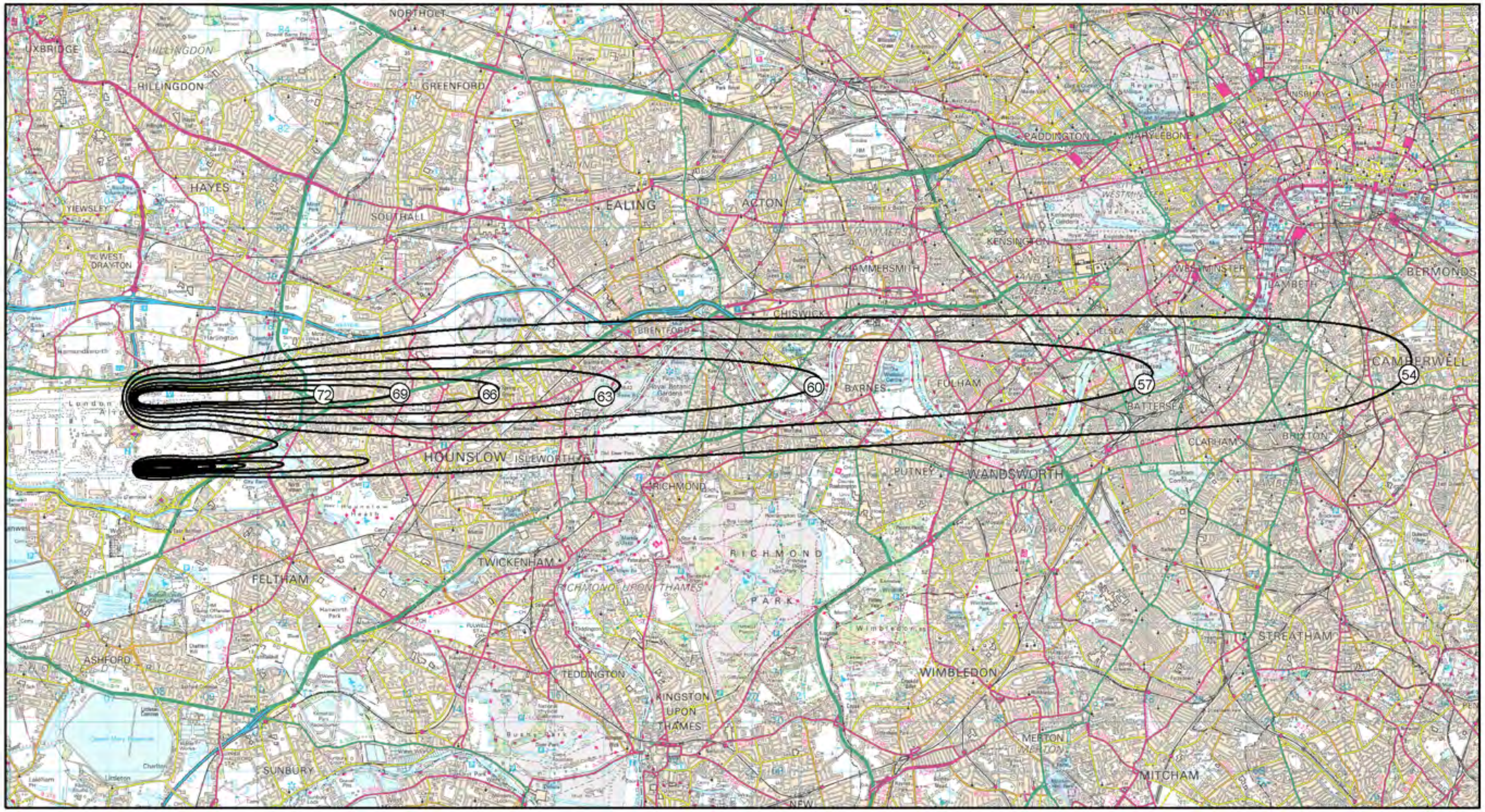
Figure 5: 8hr Leq contours for pre-trial when 27R is the designated landing runway



0 2.5 5 10

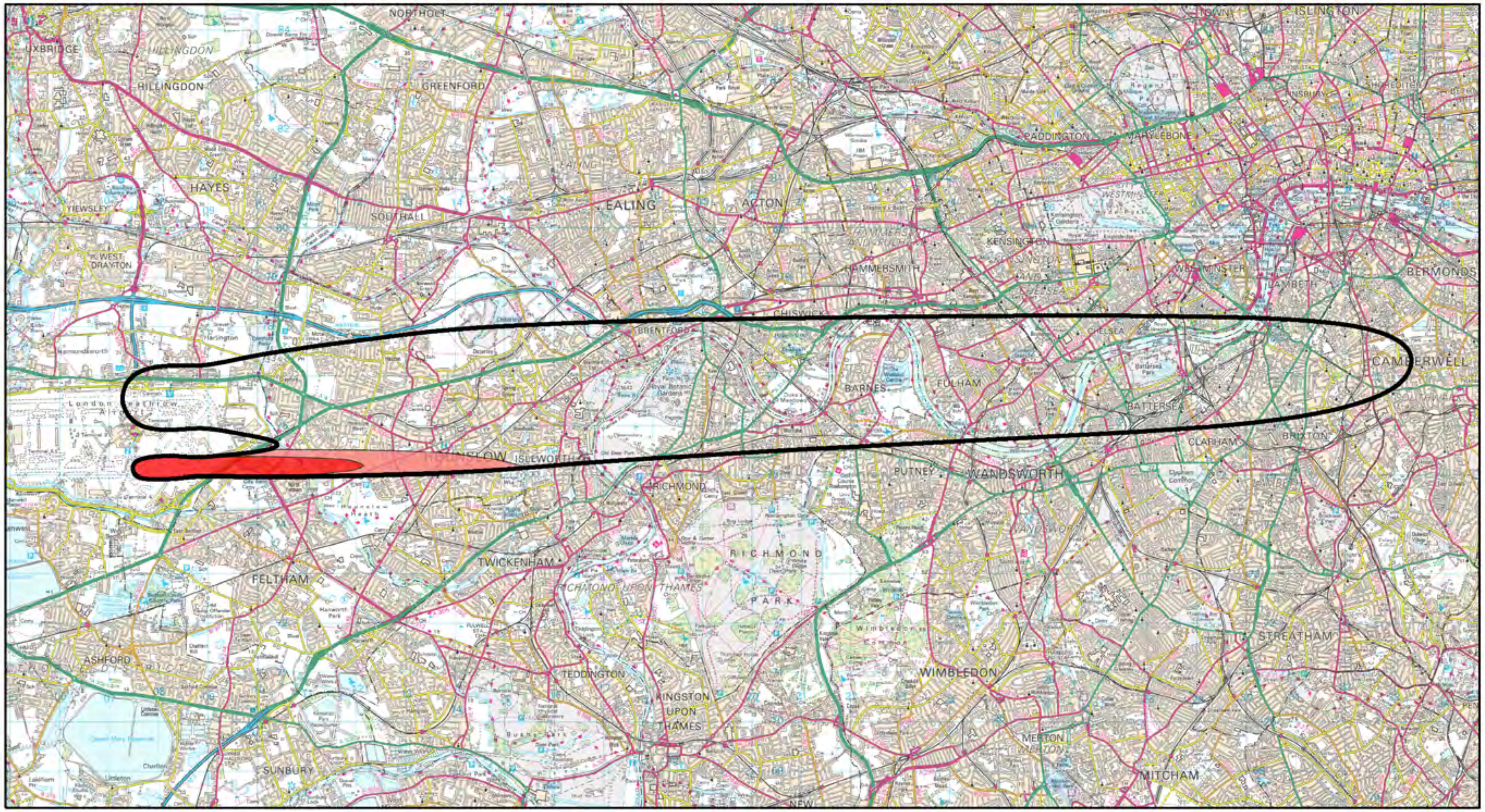
Kilometres

Figure 6: 8hr Leq contours for phase 1 trial when 27R is the designated landing runway



0 2.5 5 10
Kilometres

Figure 7: 8hr difference Leq contours for phase 1 trial vs pre-trial when 27R is the designated landing runway

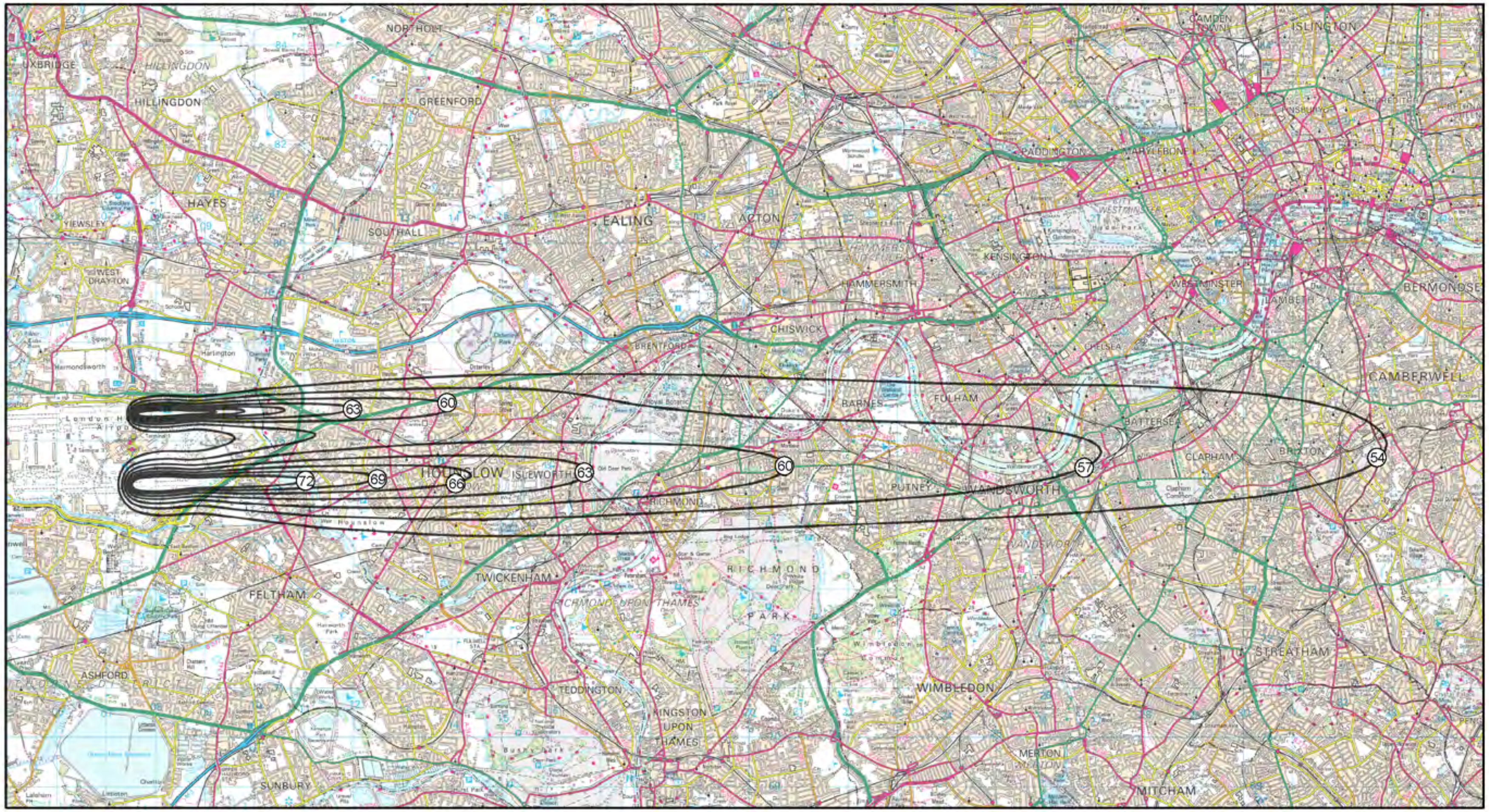


0 2.5 5 10
Kilometres

Change in noise exposure:

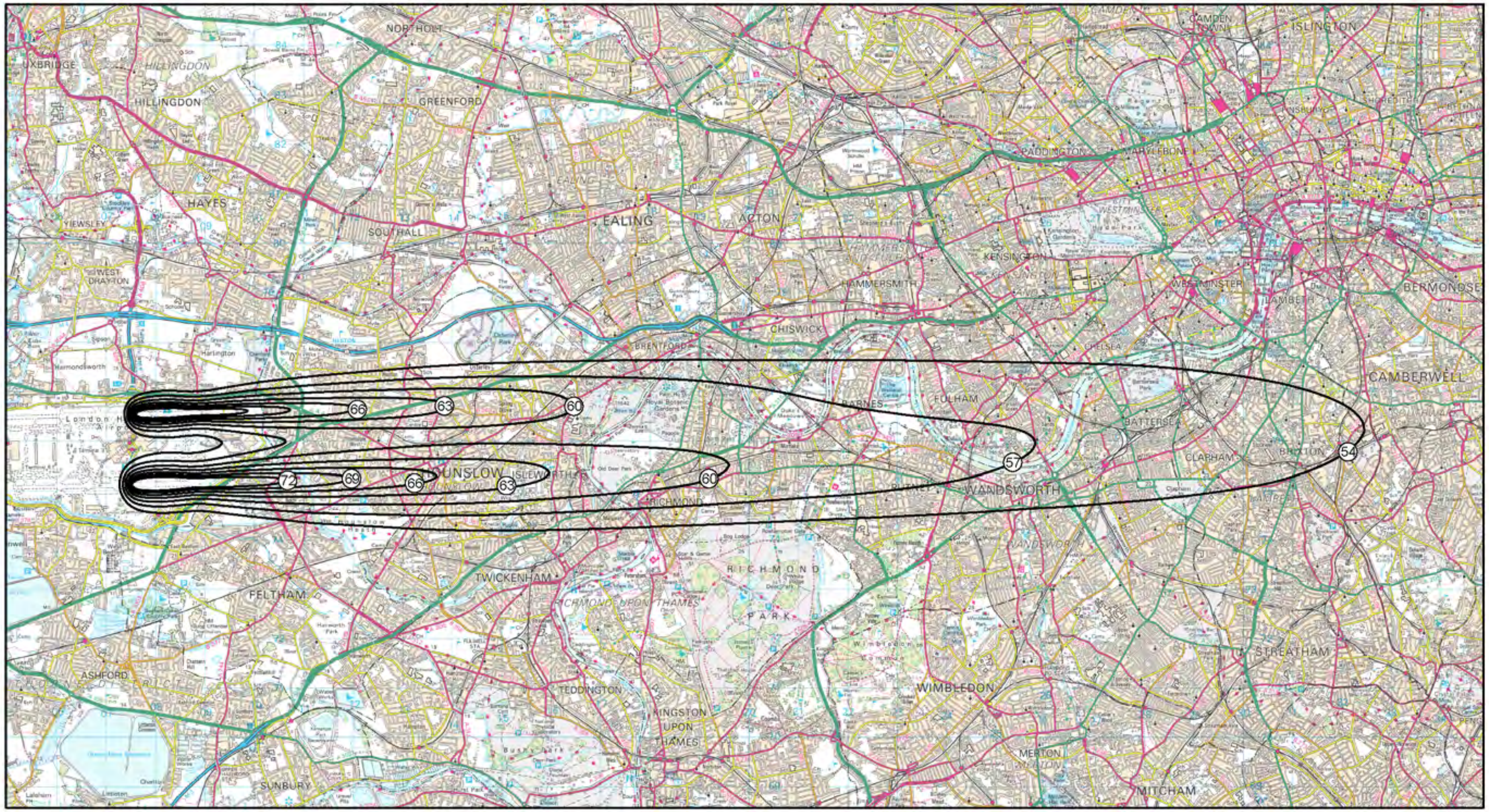
- +1 to +2 dB
- +2 to +3 dB
- 54 dBA Leq contour for trial period

Figure 8: 1hr Leq contours for pre-trial maximum number of de-alternated arrivals when 27L is the designated landing runway



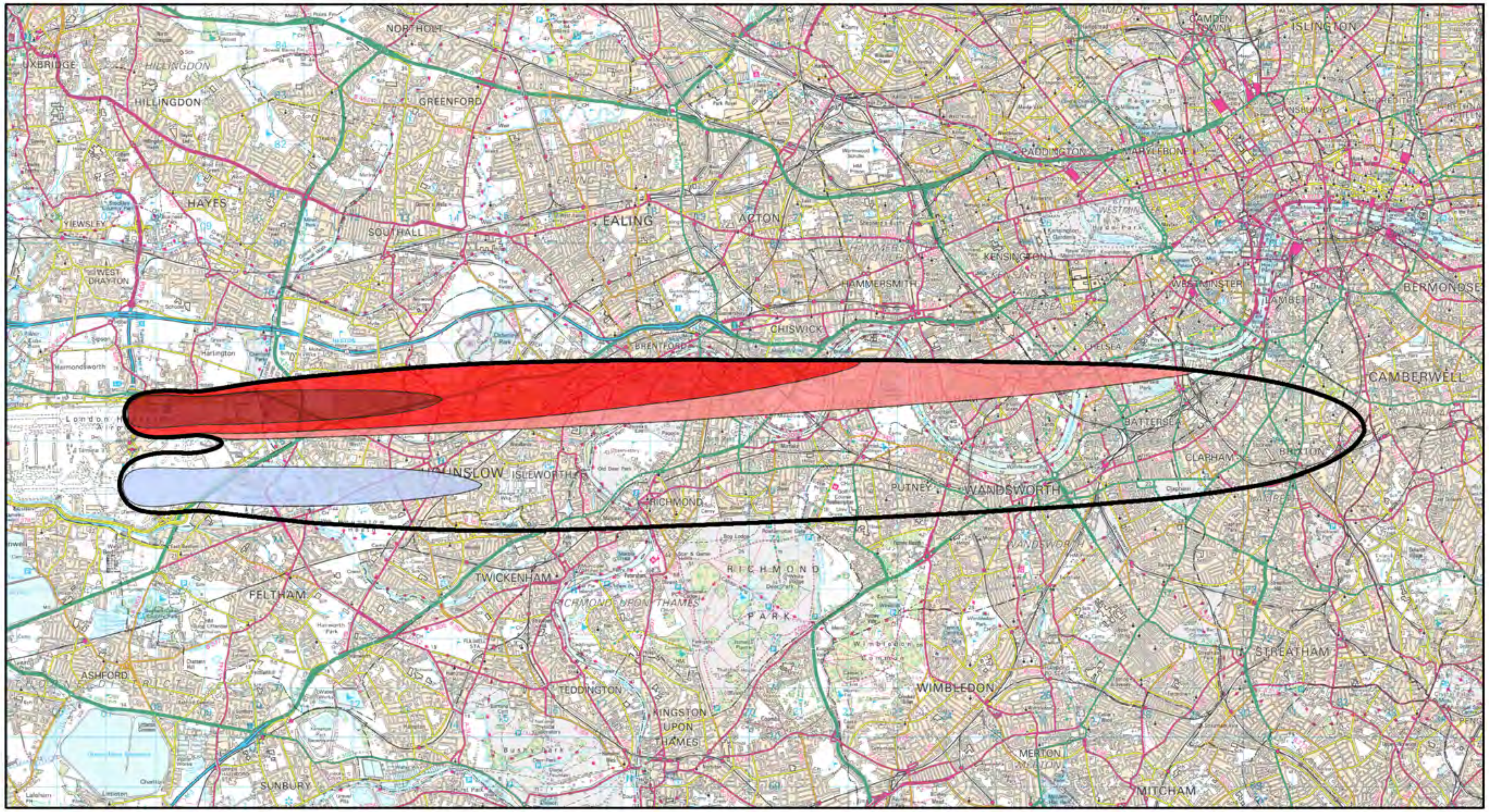
0 2.5 5 10
Kilometres

Figure 9: 1hr Leq contours for phase 1 trial maximum number of de-alternated arrivals when 27L is the designated landing runway



0 2.5 5 10
Kilometres

Figure 10: 1hr difference Leq contours for phase 1 trial vs pre-trial maximum number of de-alternated arrivals when 27L is the designated landing runway

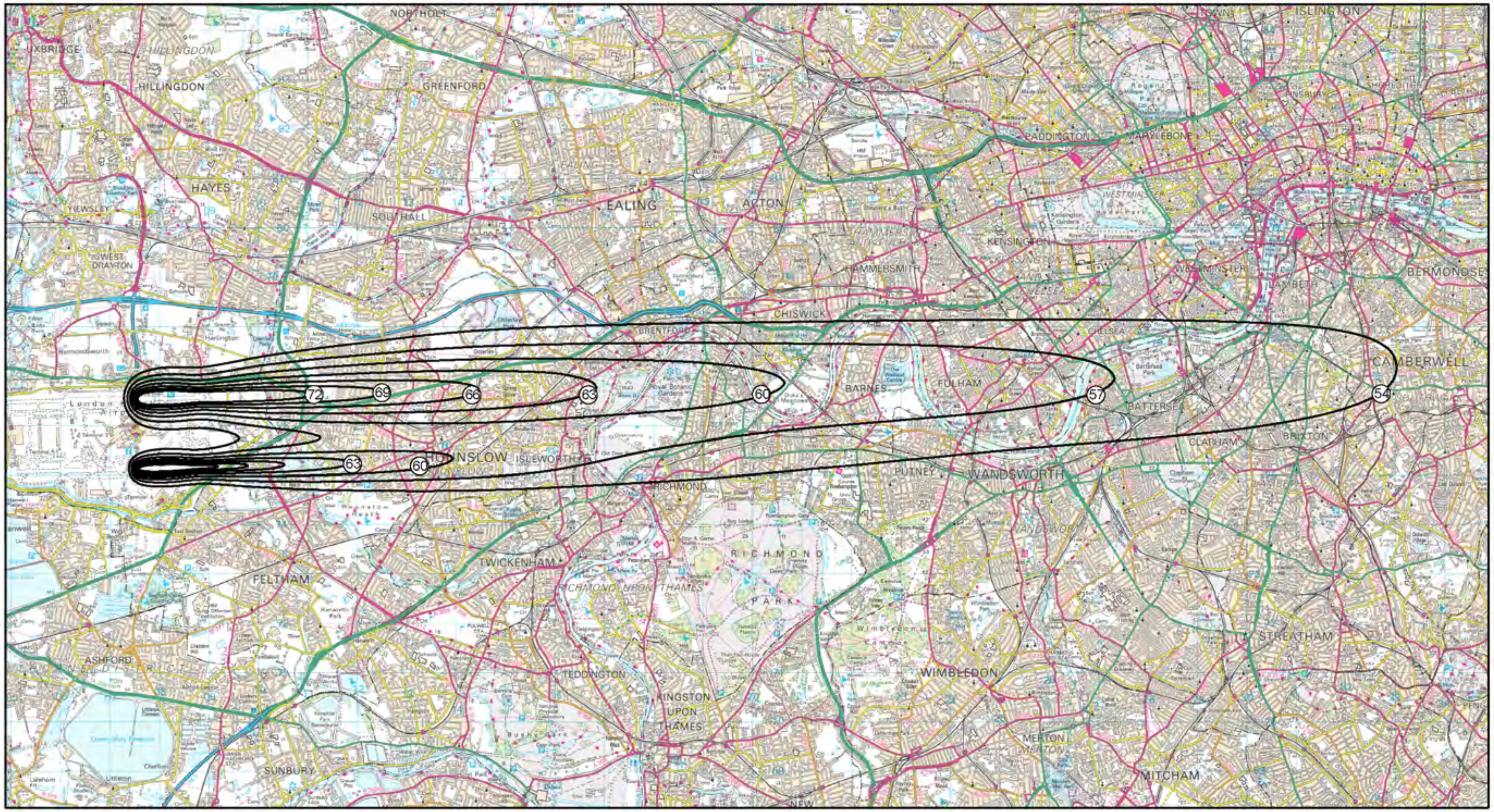


0 2.5 5 10
Kilometres

Change in noise exposure:

- -1 to -2 dB
- +1 to +2 dB
- +2 to +3 dB
- > +3 dB
- 54 dBA Leq contour for trial period

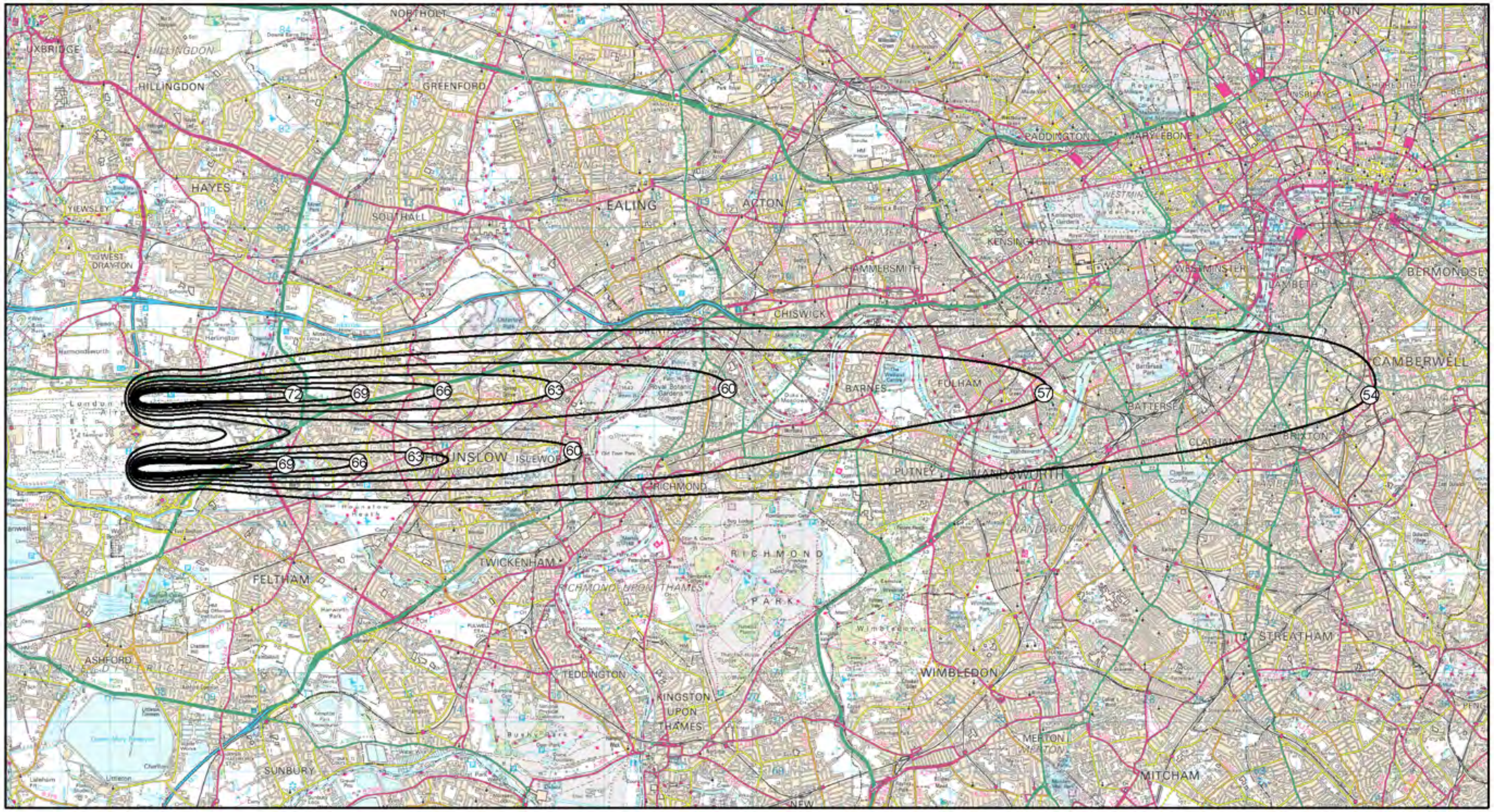
Figure 11: 1hr Leq contours for pre-trial maximum number of de-alternated arrivals when 27R is the designated landing runway



0 2.5 5 10

Kilometres

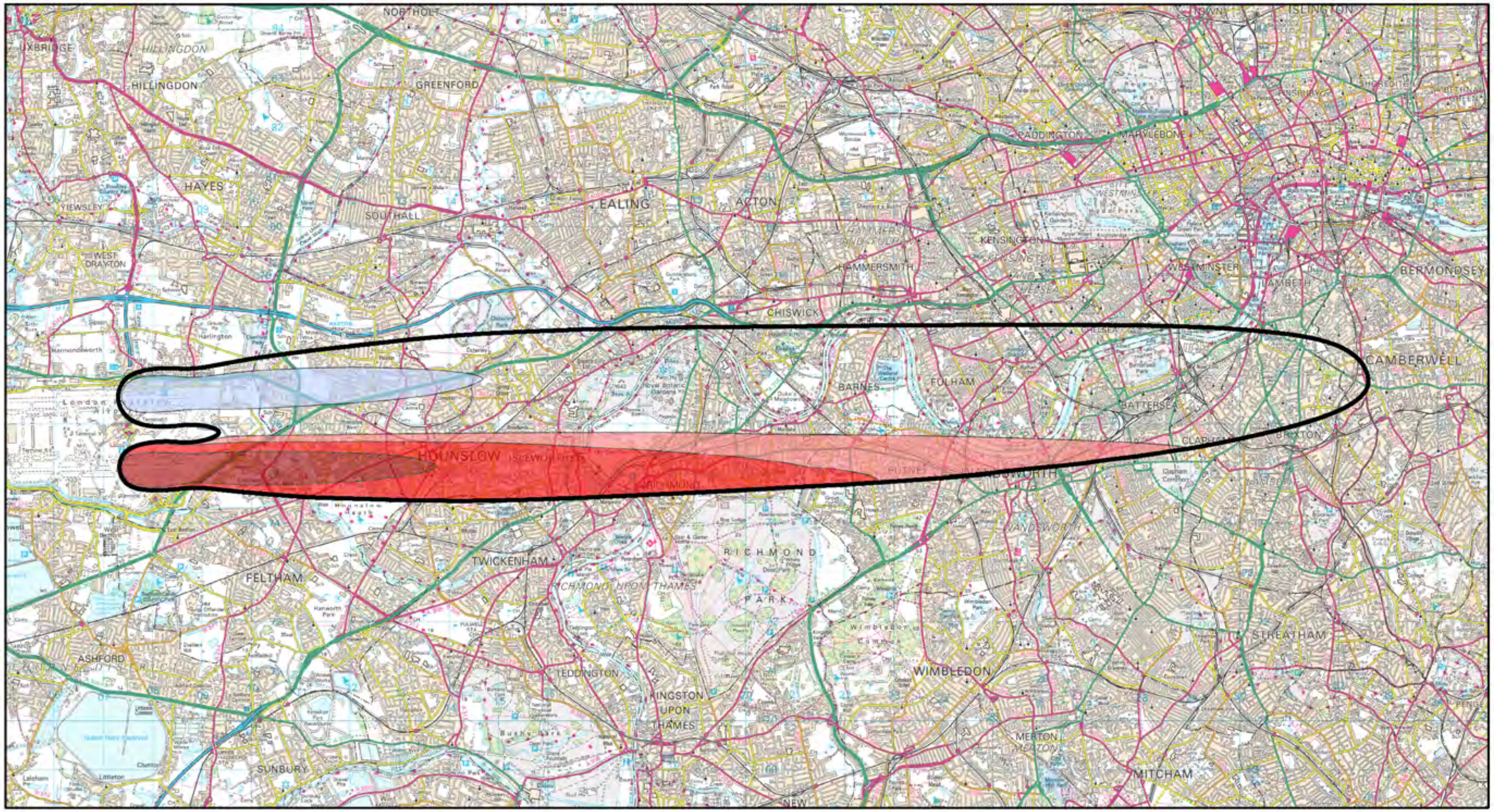
Figure 12: 1hr Leq contours for phase 1 trial maximum number of de-alternated arrivals when 27R is the designated landing runway



0 2.5 5 10

Kilometres

Figure 13: 1hr difference Leq contours for phase 1 trial vs pre-trial maximum number of de-alternated arrivals when 27R is the designated landing runway



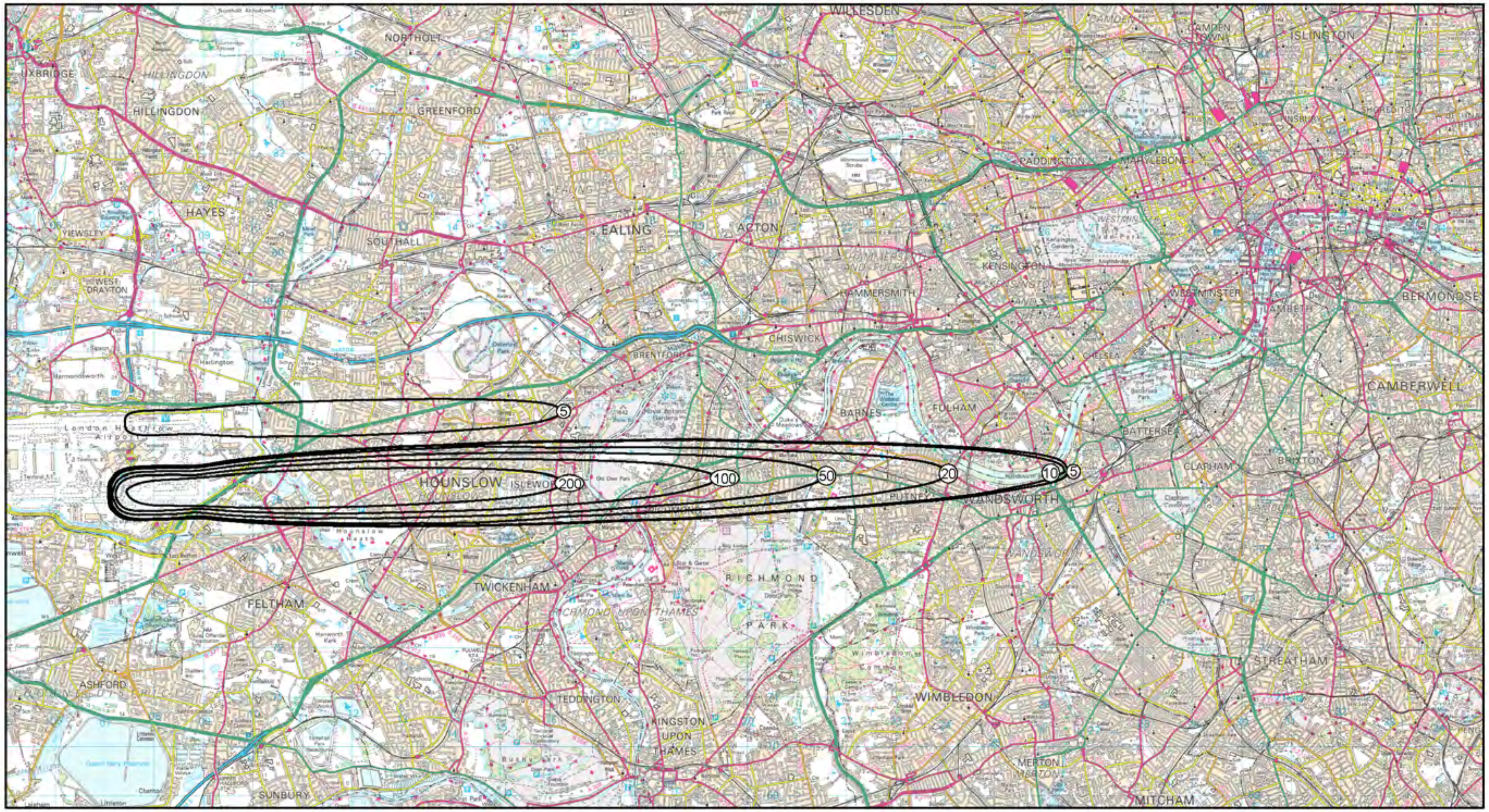
0 2.5 5 10

Kilometres

Change in noise exposure:

- -1 to -2 dB
- +1 to +2 dB
- +2 to +3 dB
- > +3 dB
- 54 dBA Leq contour for trial period

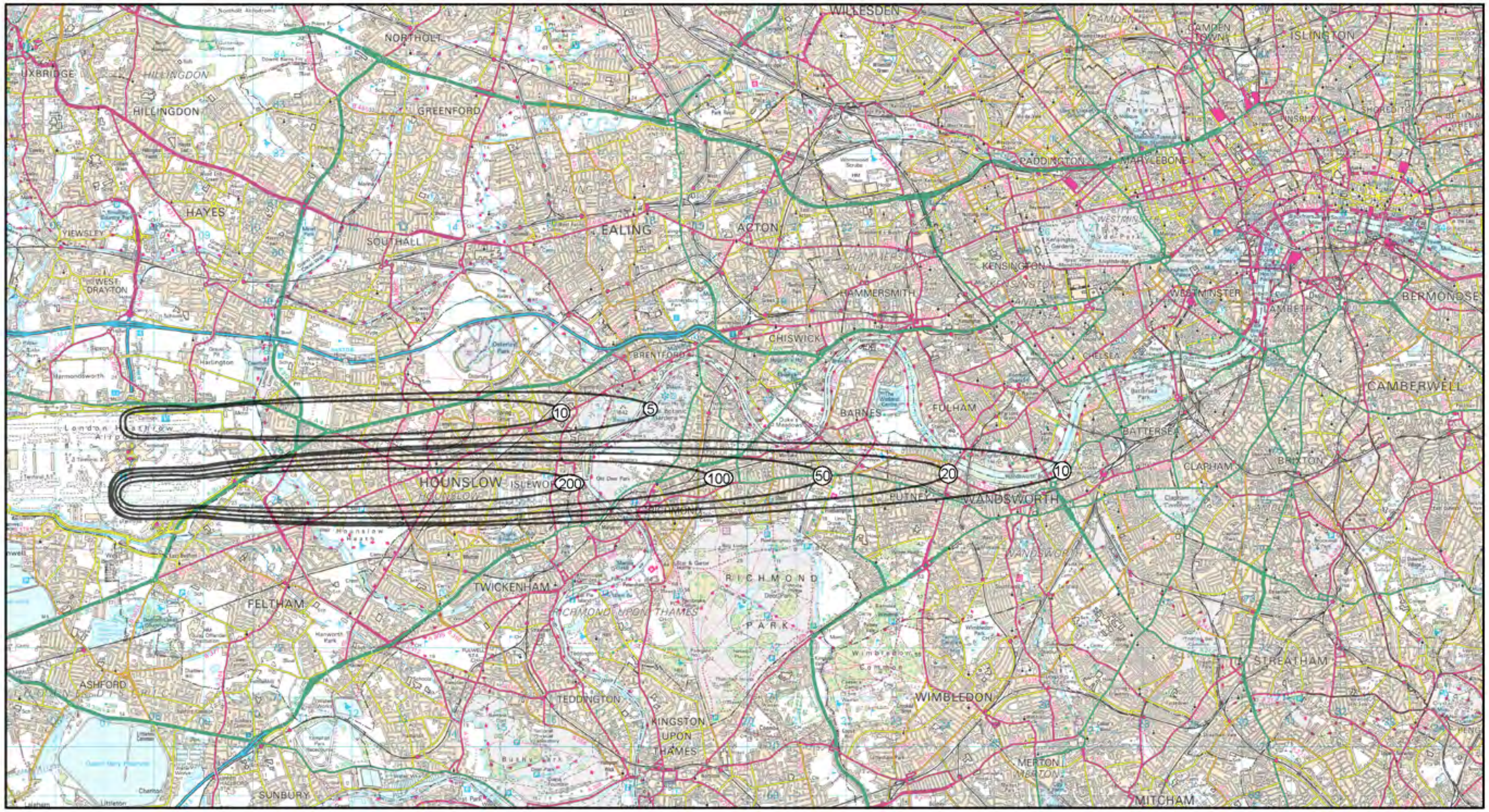
Figure 14: 8hr N70 contours for pre-trial when 27L is the designated landing runway



0 2.5 5 10

Kilometres

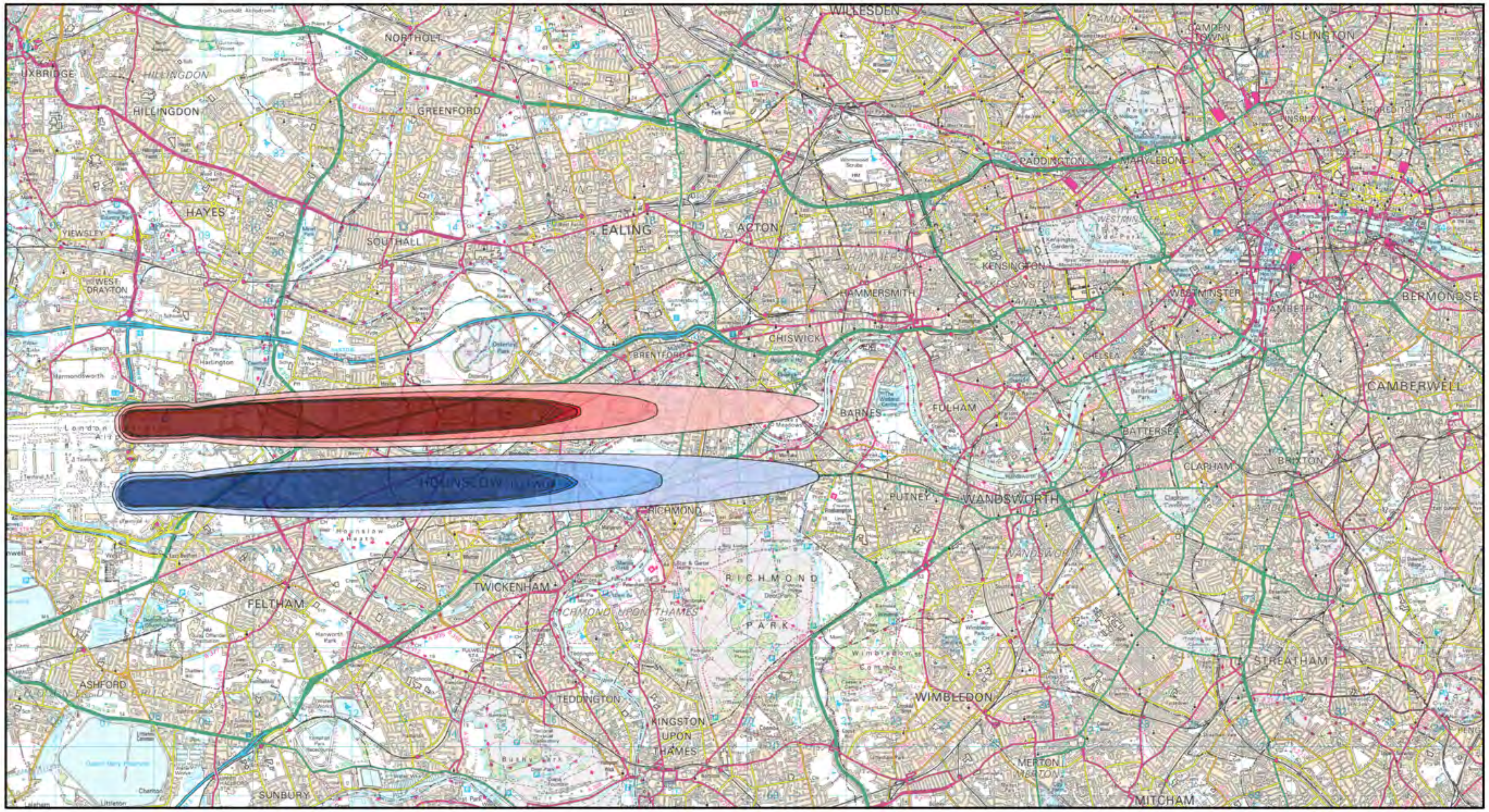
Figure 15: 8hr N70 contours for phase 1 trial when 27L is the designated landing runway



0 2.5 5 10

Kilometres

Figure 16: 8hr difference N70 contours for phase 1 trial vs pre-trial when 27L is the designated landing runway

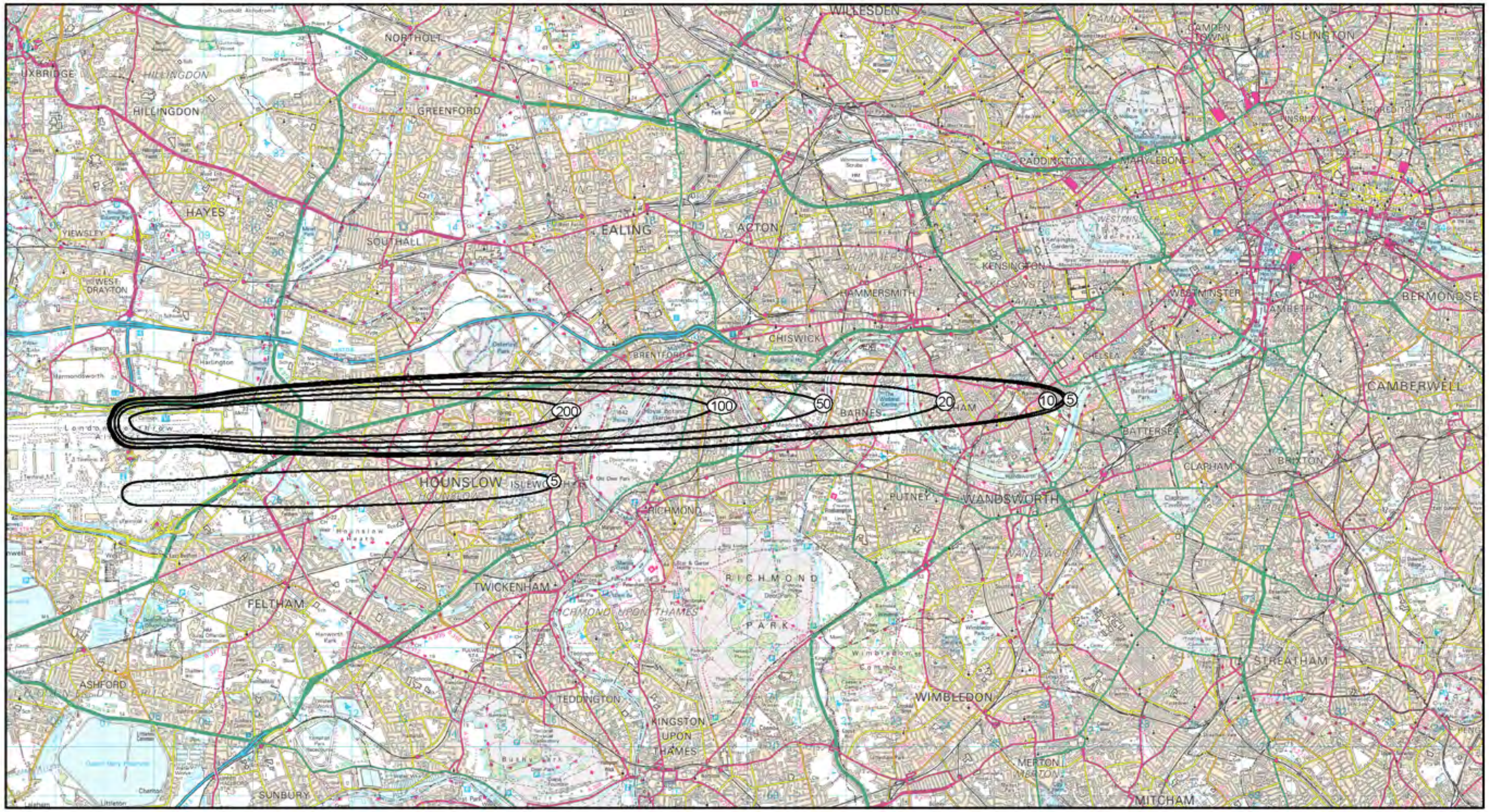


0 2.5 5 10
Kilometres

Change in number of events above 70dBA Lmax:

-1 to -2	+1 to +2
-2 to -3	+2 to +3
-3 to -4	+3 to +4
-4 to -5	+4 to +5
<-5	>+5

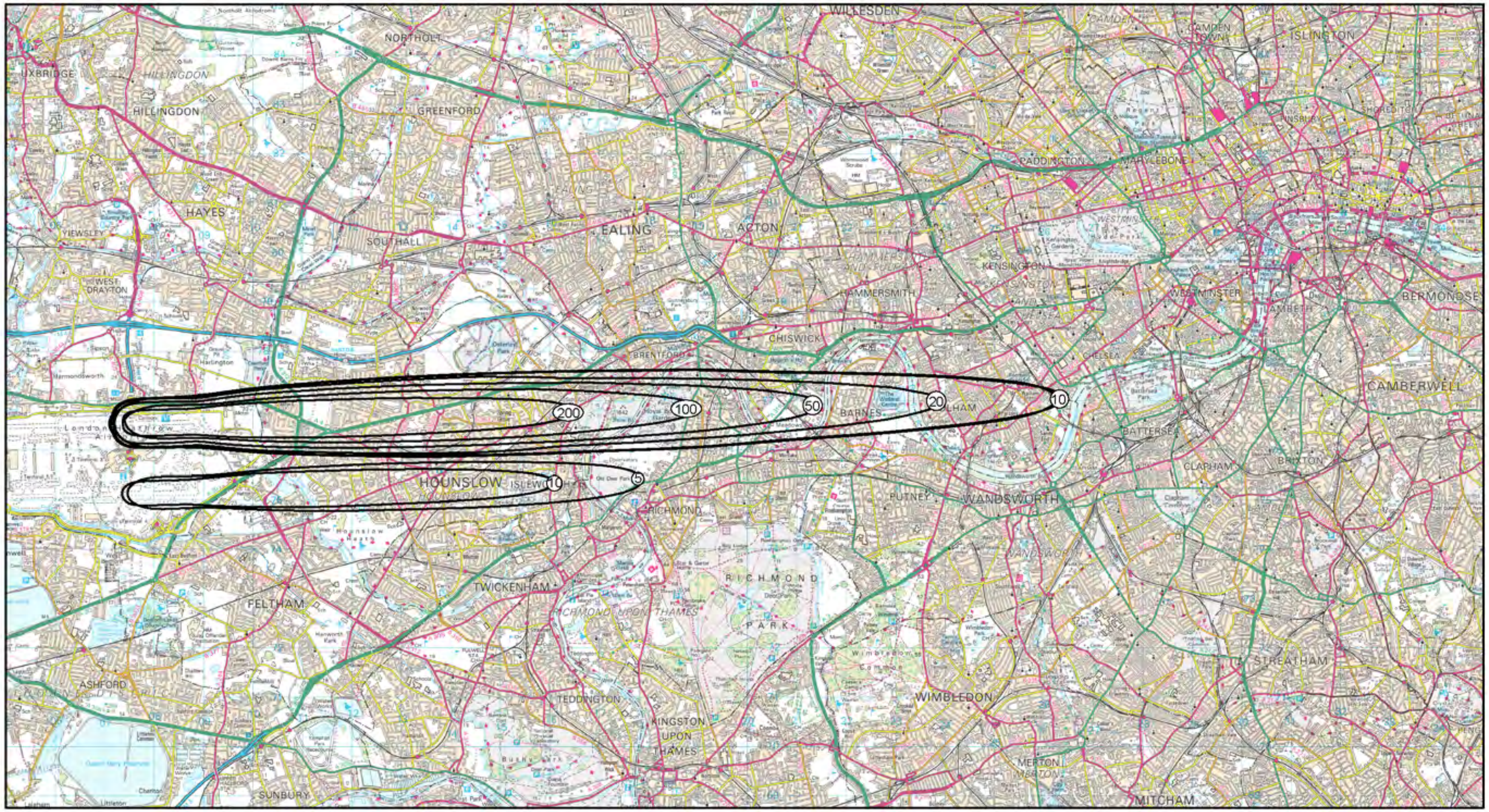
Figure 17: 8hr N70 pre-trial contours when 27R is the designated landing runway



0 2.5 5 10

Kilometres

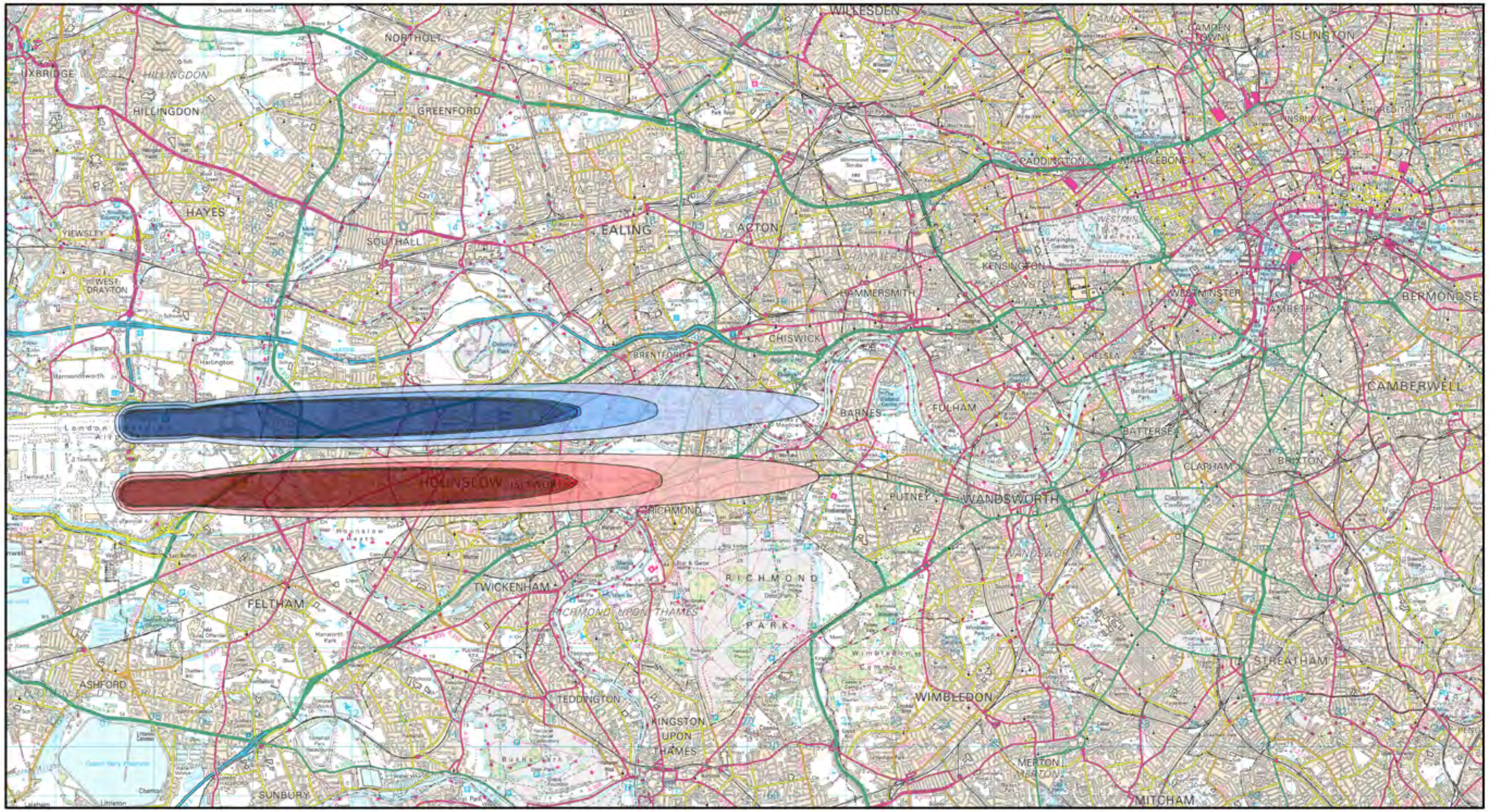
Figure 18: 8hr N70 contours for phase 1 trial when 27R is the designated landing runway



0 2.5 5 10

Kilometres

Figure 19: 8hr difference N70 contours for phase 1 trial vs pre-trial when 27R is the designated landing runway



0 2.5 5 10
Kilometres

Change in number of events above 70dBA Lmax:

- -1 to -2
- -2 to -3
- -3 to -4
- -4 to -5
- <-5
- +1 to +2
- +2 to +3
- +3 to +4
- +4 to +5
- >+5

Figure 20: 8hr TA70 contours for pre-trial when 27L is the designated landing runway

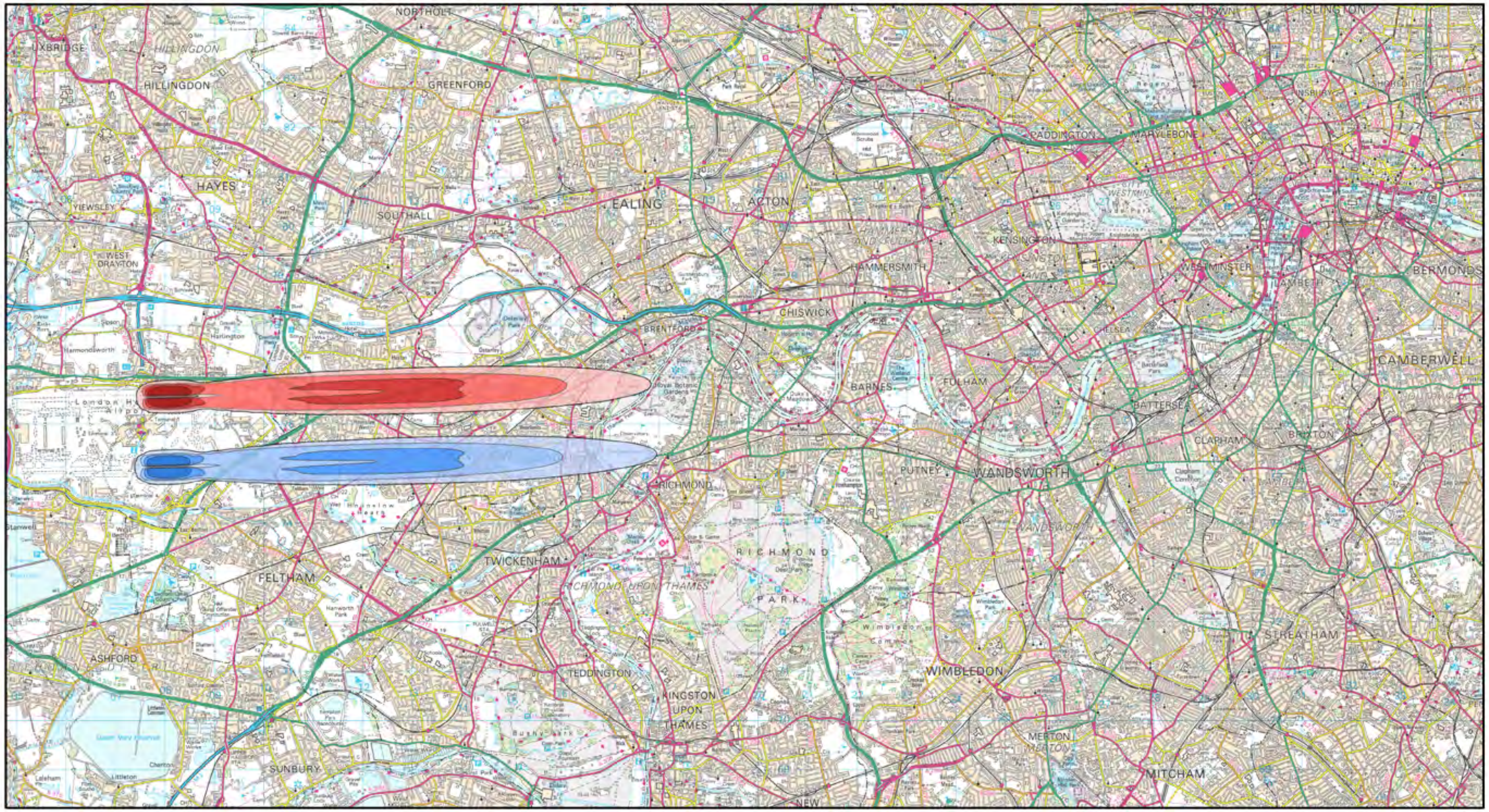
0 2.5 5 10
Kilometres

Figure 21: 8hr TA70 contours for phase 1 trial when 27L is the designated landing runway

0 2.5 5 10

Kilometres

Figure 22: 8hr difference TA70 contours for phase 1 trial vs pre-trial when 27L is the designated landing runway

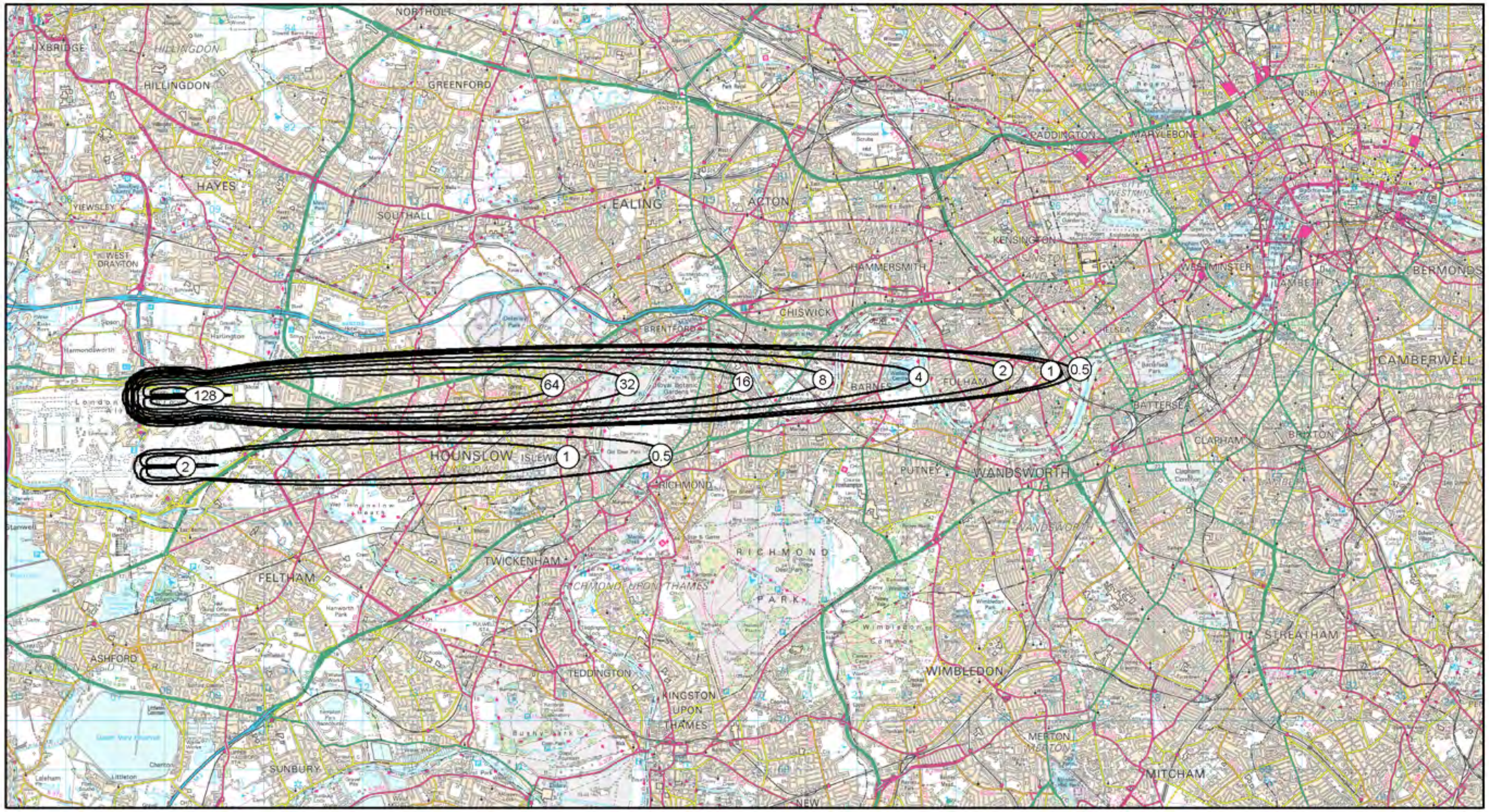


0 2.5 5 10
Kilometres

Time exposure to noise (TA70):

0.5 to 1 minute	-0.5 to -1 minute
1 to 1.5 minutes	-1 to -1.5 minutes
1.5 to 2 minutes	-1.5 to -2 minutes
>2 minutes	<-2 minutes

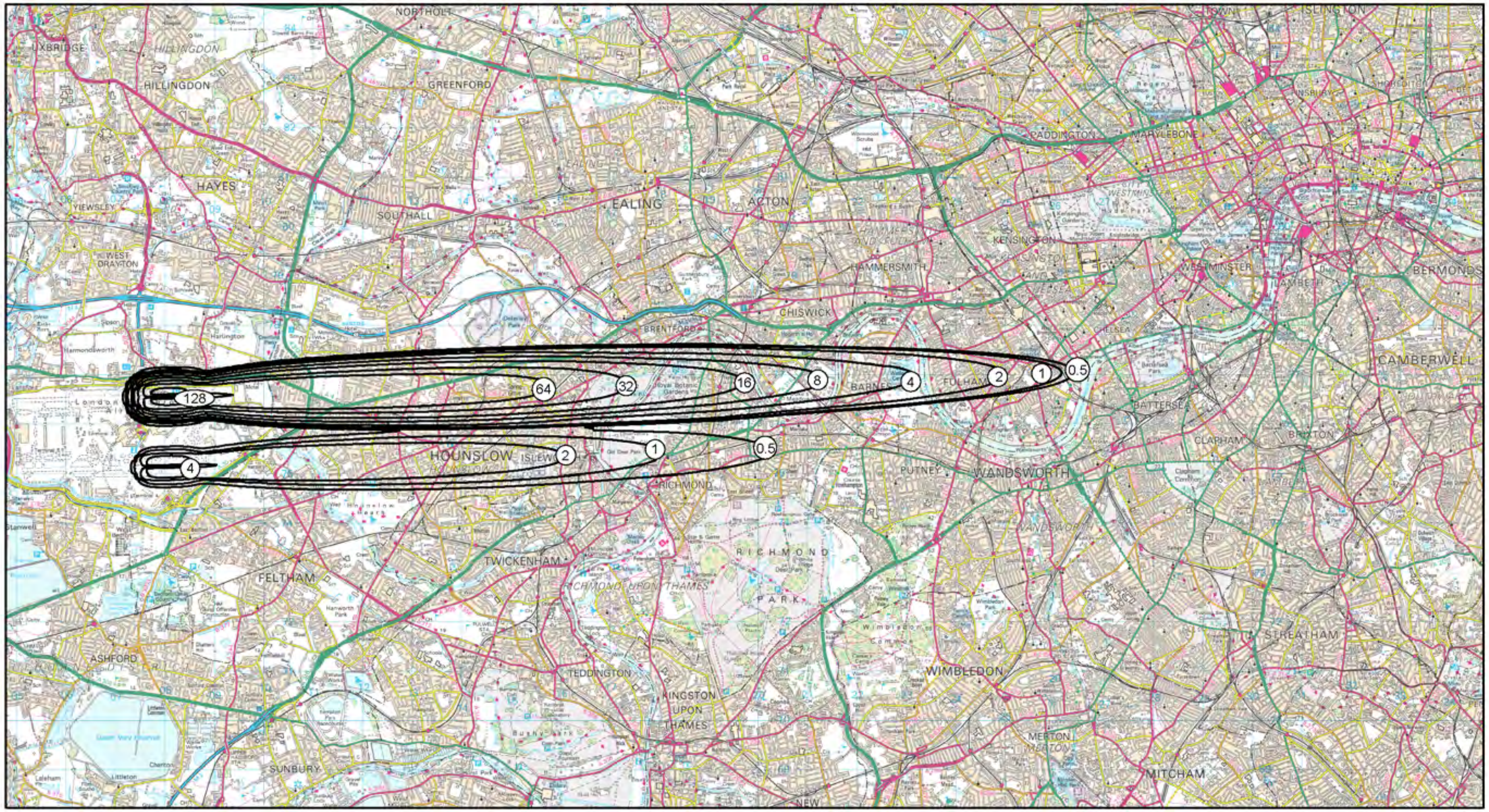
Figure 23: 8hr TA70 contours for pre-trial when 27R is the designated landing runway



0 2.5 5 10

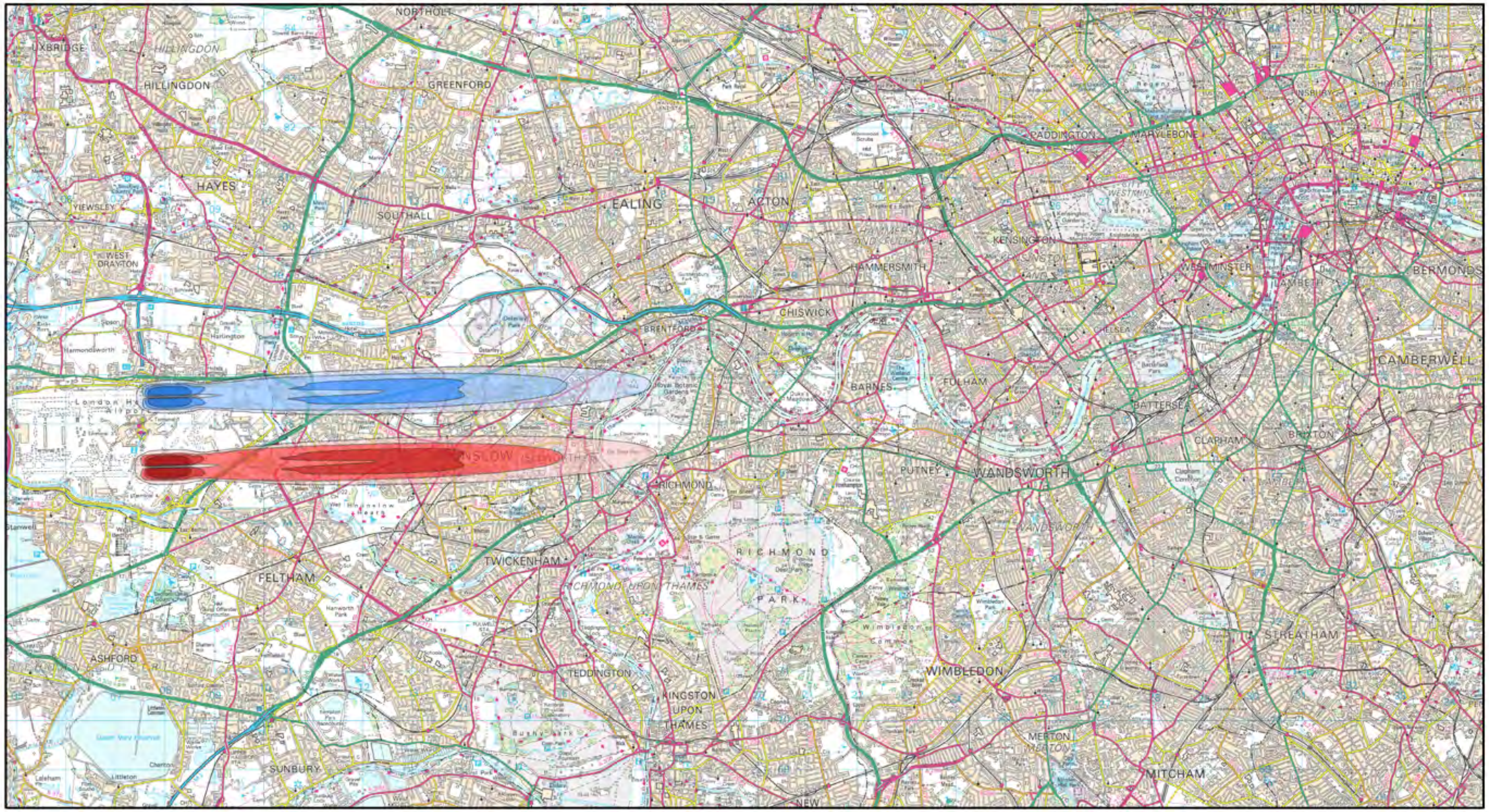
Kilometres

Figure 24: 8hr TA70 contours for phase 1 trial when 27R is the designated landing runway



0 2.5 5 10
Kilometres

Figure 25: 8hr difference TA70 contours for phase 1 trial vs pre-trial when 27R is the designated landing runway



0 2.5 5 10 Kilometres

Time exposure to noise (TA70):

0.5 to 1 minute	-0.5 to -1 minute
1 to 1.5 minutes	-1 to -1.5 minutes
1.5 to 2 minutes	-1.5 to -2 minutes
>2 minutes	<-2 minutes