Community Noise Information Report
Cranford

28th March – 27th September 2019

November 2021

Introduction

At the request of local residents, Heathrow Airport Ltd installed a temporary noise monitor on the grounds of Cranford Primary School between 28th March and 27th September 2019. This report presents an analysis of airport's operations and the noise data during the first six months of the monitor's deployment.

This report is structured using a template developed by Anderson Acoustics Ltd working with members of the Heathrow Community Noise Forum's (HCNF) Working Group for Monitoring & Verification. It is set out as follows:

- **Section 2 – Key Findings** are presented.
- **Section 3 – Background & Methodology** provides an overview of how the airport operates, where aircraft fly near Cranford, noise terminology and how the data (both operations and noise) have been analysed.
- **Section 4 – Flight track data** presents analysis of the flight tracks and operations above Cranford, including routes, proximity, spatial distribution, height and aircraft types. As flight track data have been collected for many years in the airport's noise and track-keeping (NTK) system, analysis has compared the noise monitoring period with the equivalent six-month period in 2015.
- **Section 5 – Noise Monitor Data** presents an analysis of aircraft noise events and overall community noise levels as measured by the noise monitor. In the absence of previous monitoring at this location, the noise data are analysed for the monitoring period only.
- **Section 6 – Noise Modelling** presents noise levels derived from noise modelling. Aircraft noise models have been generated for easterly and westerly days for the summer periods of both 2013 and 2017 using the AEDT modelling software. Previous reports have been based on Heathrow's verified noise model using INM. This software has been superseded by AEDT.
- **Section 7 – Appendices** presents large-scale versions of the noise modelling results, and provides information on how sound is described, how aircraft noise is measured, and how different sound levels relate to human perception.

It should be noted that this report is intended to describe noise exposure rather than the impact of that exposure, which is subject to individual circumstances. The report describes exposure and differences therein (as applicable) of aircraft using a variety of both operations and noise related metrics.

Whilst this report is considered to present a comprehensive set of analyses, it is not intended to be exhaustive. Should this report prompt any questions or comments, these should be addressed to the HCNF for consideration.

Key Findings

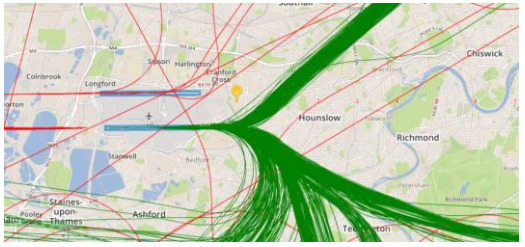
Operations and the community	Noise levels in the community based on measurement at the Cranford monitor	Difference in community noise levels between 2013 and 2017 based on noise modelling
The noise monitor in Cranford is located close to the arrival path to the northern runway on westerly operations and approximately 1km north of departures from the southern runway on easterly operations.	Aircraft noise events recorded at the Cranford monitor are roughly split between arrivals to the northern runway on westerly operations and departures from the southern runway on easterly operations. The remaining events are generally from westerly arrivals to the southern runway.	On westerly operations, there was a decrease in average daytime noise levels of up to 1dB, with the number of events exceeding 65dB decreasing by up to 25 per day.
There has been no significant change to the number of aircraft passing close to Cranford in the period between 2015 and 2019 on both easterly and westerly operations.	Typically, 369 aircraft noise events were recorded on a full day of westerly operations at an average L_{Amax} of 69dB. On easterly operations, there were 608 events per day with an average L_{Amax} of 71dB.	The average level during the night period on westerly operations decreased in 2017 compared to 2013 by up to 1dB, while the number of events exceeding 60dB increased by an average of up to 2 per night.
On both easterly and westerly operations, there was, on average, no significant change in the number of daily movements through the gate between 2015 and 2019. There were only small changes to the distribution of movements throughout the day on easterly and westerly operations.	On westerly arrivals to the northern runway, the B747 is the loudest aircraft type at an L_{Amax} of 75dB, while the A320 family comprise the quietest aircraft types. On easterly departures, the A330 and B747 are loudest at 77dB, while, in addition to the A320 family, the A350 and B787 are the quietest types.	On easterly operations, there was a decrease in average modelled daytime noise level $L_{Aeq,16hr}$ of up to 2dB between 2013 and 2017; however, the modelling indicates an increase of up to 50 daytime N65 events.
There was not a significant change in the altitude of the aircraft above Cranford on westerly arrivals (since all aircraft will be on the ILS) or on easterly departures.	On westerly operations, the first events occur at 04:30, while the busiest hour occurs between 06:00 and 07:00, after which there were typically between 15 and 25 events per hour. On easterly operations, the first events occur after 06:00 with 24-44 events per daytime hour.	There was a decrease in average night-time aircraft noise on easterly operations of up to 3dB and a decrease in N60 of up to six from 2013 to 2017.
During the period between 2015 and 2019, there has been a significant increase in the proportion of large twin engine aircraft operating into Heathrow. The most significant change in terms of individual aircraft type, has been the increased use of the B787.	Before 07:00 on westerly operations, the vast majority of events are recorded from large twin or quad engine aircraft while the last three hours of the days are predominantly small twin-engine aircraft. On easterly operations, noise events are predominantly from small twin engine aircraft during the first two hours of operation between 06:00 and 08:00 and larger aircraft after 22:00.	
The distribution of flights across the day is broadly similar in 2015 and 2019 on both easterly and westerly operations. On westerly operations, there was a slight decrease in movements between 14:00 and 15:00, whilst on easterly operations there was a slight increase in movements between 06:00 and 07:00.	The daytime $L_{Aeq,16hr}$ (from all noise sources) was 57 and 61dB on westerly and easterly operations respectively, while the night $L_{Aeq,8hr}$ was 53dB in both modes of operation. Average hourly levels during westerly arrivals were typically 6dB higher when using the northern runway compared to the southern.	

Understanding how wind direction affects aircraft operations

Wind direction and operating direction

- The direction aircraft land and take-off from Heathrow depends on the direction of the wind. For safety reasons, aircraft take-off and land into the wind.
- When the wind blows from the west, aircraft arrive from the east, over central London, and take-off to the west. This is called westerly operations. Conversely, when the wind blows from the east, aircraft arrive from the west over Berkshire and take-off to the east. This is called easterly operations.
- The figures below show flight tracks for a typical day of easterly and westerly operations. Arrivals are shown in red, departures green. The position of the noise monitor is indicated by the yellow pin drop.

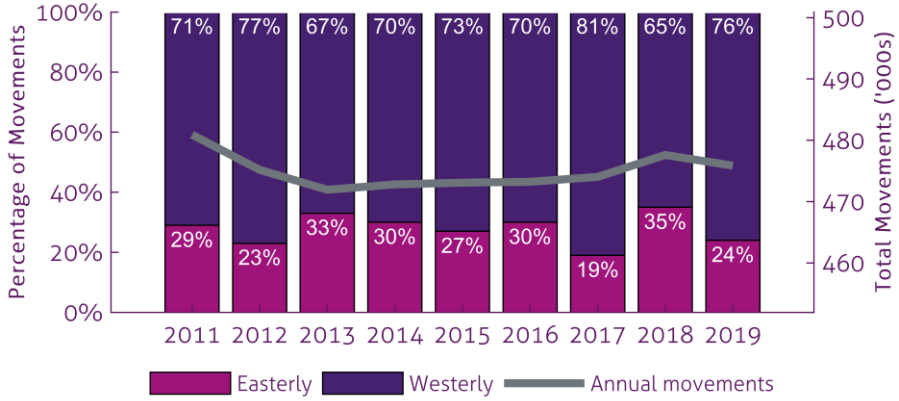
Flight tracks on a westerly day (29th January 2020)



Flight tracks on an easterly day (23rd January 2020)

The proportion of easterly/westerly operations

- Around Heathrow, the prevailing wind direction is from the west.
- Heathrow also operates what is known as the 'westerly preference'. Aircraft will continue to operate in a westerly direction until there are tail winds consistently of 5 knots or more. This was implemented to protect more densely populated areas to the east of the airport.
- As a result, the airport is typically on westerly operations for about 70-75% of the year.
- The figure below presents the **annual** proportion of easterly and westerly operations for the last 9 full years.

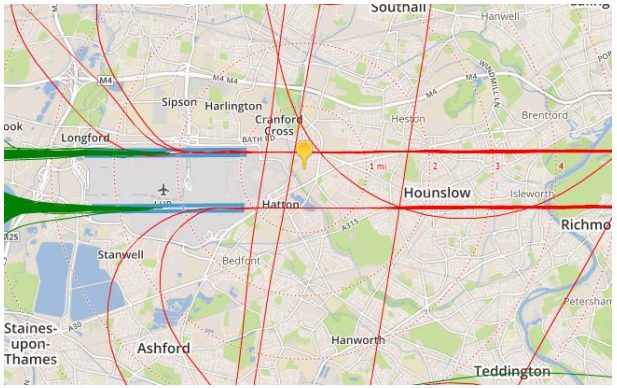


Note: Further information about operations at Heathrow can be found at https://www.heathrow.com/company/local-community/noise/operations

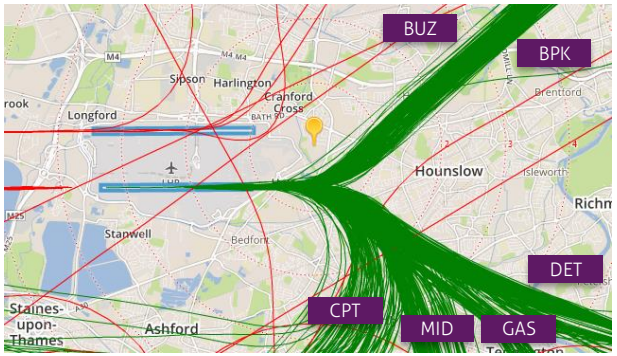
Understanding where aircraft fly near to Cranford

- The images to the right presents a typical day of westerly operations and easterly operations with arrival tracks shown in red and departures in green.
- Aircraft departing the airport follow one of six pre-defined Noise Preferential Routes (NPRs) on both easterly and westerly operations. The choice of route is typically based upon the destination of the flight and is not selected by Heathrow.
- Cranford is predominantly overflown by westerly arrivals to the northern runway. The noise monitor is positioned approximately 400m south of the northern arrival path and 1km north of the southern arrival path on westerly operations. On easterly operations, aircraft following the BPK and BUZ departure routes are generally a minimum of 650m from the noise monitor.
- A system of runway alternation is in place at Heathrow, in order to provide respite to residents living under the arrival paths on westerly operations. For one week, Heathrow uses one runway for landings and the other for take-offs, then switches over at 3pm. The following week, the pattern is reversed, such that what was done in the evening during the previous week, Heathrow does in the morning and vice versa. This is so that communities get respite from planes in the morning one week and in the evening the next.
- Due to the historic Cranford Agreement very few aircraft depart from the northern runway whilst on easterly operations.

Arrival and departure tracks on westerly operations



Arrival and departure tracks on easterly operations



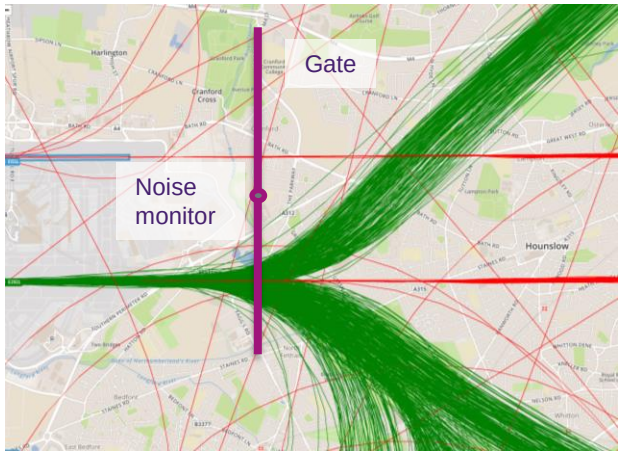
Understanding operational and gate data

Operational data

- The following operational data were provided for the period between 28th March and 27th September 2019 and the same period for the four previous years:
  - Easterly/westerly movements - % of movements in easterly/westerly direction
  - Daily logs - Number of flights operating from Heathrow per day by runway used
  - Heathrow flight-by-flight data - Aircraft type, departure route, runway

Gate analysis

- To investigate the heights, distribution and concentration of aircraft, the Noise and Track Keeping (NTK) system's "gate analysis" function was used to provide data on where aircraft have flown relative to the noise monitor.
- A single gate 4km wide to capture both arrival paths on westerly operations and all departures on easterly operations, was drawn over Cranford centred on the temporary noise monitor.



This figure shows the position of the gate relative to both westerly arrivals (red) and easterly departures (green)

- The gate is 12,000ft high to capture all movements through the gate and perpendicular to the arrival paths.
- The height and position of each aircraft passing through the gate were extracted from ANOMS, Heathrow's NTK system. The following data were extracted:
  - Aircraft deviation from the centre of the gate
  - Aircraft height at gate
  - Time that the aircraft entered the gate
  - Departure route flown – 'standard instrument departure route' (SID)
  - Aircraft type
  - Runway used

Can the data be trusted?

- Through the Heathrow Community Noise Forum (HCNF), an independent study was carried out, investigating the accuracy of flight track data of Heathrow NTK systems.

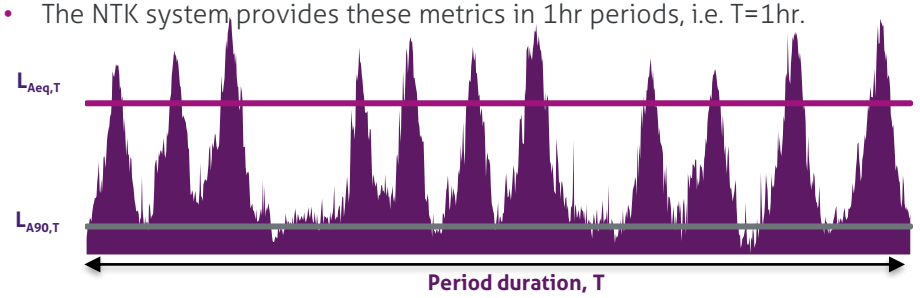
Understanding measured noise data

Measured noise data:

- A Bruel & Kjaer 3639-A, Type 1 integrating sound level meter was set to measure total ambient and background noise levels over hour periods in addition to individual noise events, which, where possible, are linked to aircraft operations.
- Measured data is passed into Heathrow's NTK system without modification – no data have been excluded due to adverse weather conditions.
- For this report, noise data have been provided by Heathrow for the period 28th March – 27th September 2019. Note that a historical comparison is not available since the noise monitor was not installed at this location in previous years.

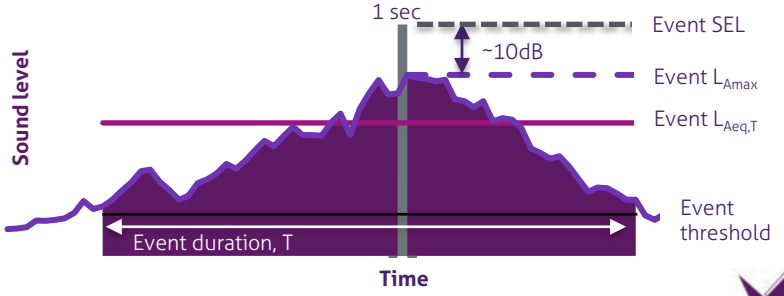
Ambient and background noise levels:

- The figure below illustrates how sound levels can vary over a time period T where aircraft events are experienced. The following metrics are typically used to describe the overall noise environment – $L_{Aeq,T}$ and $L_{A90,T}$. These are described as follows:
  - $L_{Aeq,T}$ – the total ambient sound level across period T from all sources
  - $L_{A90,T}$ – the 'background' sound level exceeded for 90% of the time across period T from all sources
- The NTK system provides these metrics in 1hr periods, i.e. T=1hr.



Noise events:

- When the measured noise level exceeds a pre-determined threshold, a noise event is recorded.
- For ALL noise events, three descriptors are provided:
  - L_{Amax} – the maximum A-weighted sound pressure level during the event
  - SEL (sound exposure level or singe event level) - the sound level of a one second burst of steady sound level that contains the same A-weighted sound energy as the whole event; and
  - Duration – the length of time (T) in seconds that the event exceeds the event detection threshold set on the sound level meter. The threshold is set dependent on local background noise conditions and can vary between monitor locations.
- For noise events linked to an aircraft operation the following data is also provided:
  - Aircraft type
  - Runway
  - Route
  - Position at time of L_{Amax}
  - Position at point of closest approach
- The figure below illustrates the sound metrics associated with an aircraft noise event. The difference between L_{Amax} and SEL is typically around 10dB.



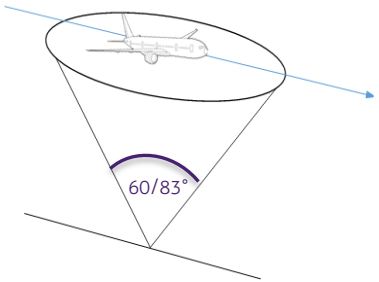
Analysing noise levels from aircraft in this area.

To undertake analysis of measured aircraft noise events, two perspectives are considered.

- Firstly, noise in the community. Aircraft overhead will generally have a higher noise level than those further away. However, noise from aircraft further away still contributes to the noise environment. So when describing noise from aircraft in an area, all aircraft noise events should be considered.
- Secondly, if considering relative noise levels of aircraft, it is best practice to restrict analysis to aircraft deemed 'overhead' to enable like-for-like comparison. This ensures that flights that are quieter purely as a result of being further away do not artificially reduce the analysed noise levels from that aircraft type.

There is no consensus as to what constitutes an overhead flight. In February 2017 the CAA published guidance (CAP 1498) recommending the use of an imaginary cone over the receiver with an apex of 60 or 83 degrees. This is illustrated in the figure below.

Flights are considered overhead if the aircraft pass within cone above the noise monitor

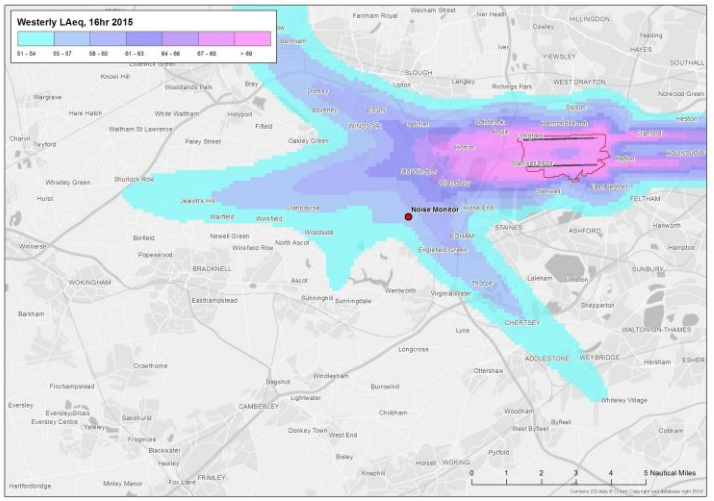


This community information report will, where applicable, present results for overhead flights determined by CAA guidance (based on 83 degree cone) as well as all registered aircraft noise events.

Noise Modelling

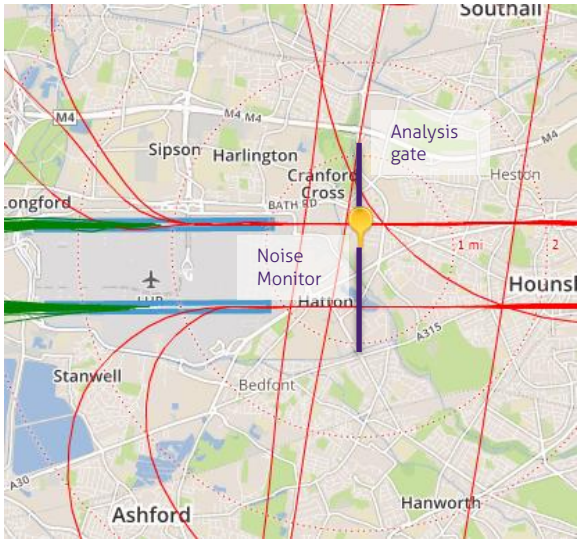
- Aircraft noise modelling has been used to provide an understanding of differences in the noise environment between 2013 and 2017 over the wider geographic area.
- Differences in daytime and night-time levels for an **average day and night of easterly and westerly operations** across the summer periods of 2013 and 2017 have been derived using the Heathrow AEDT model.

Example contours generated by aircraft noise modelling



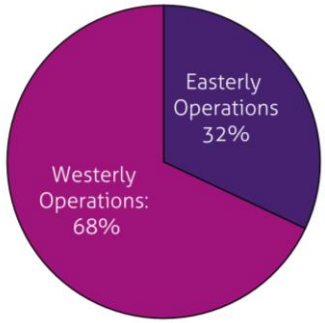
Overview of flight track data – Westerly operations

28th March – 27th September 2019

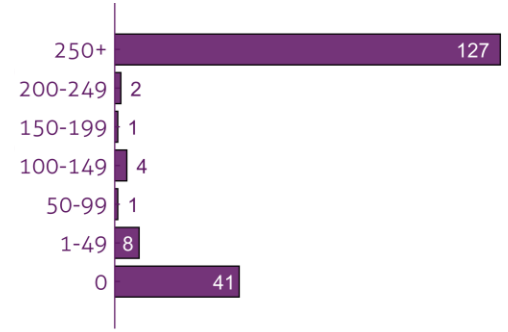


Example day of aircraft tracks in the vicinity of Cranford during westerly operations & the gate position (width 4km)

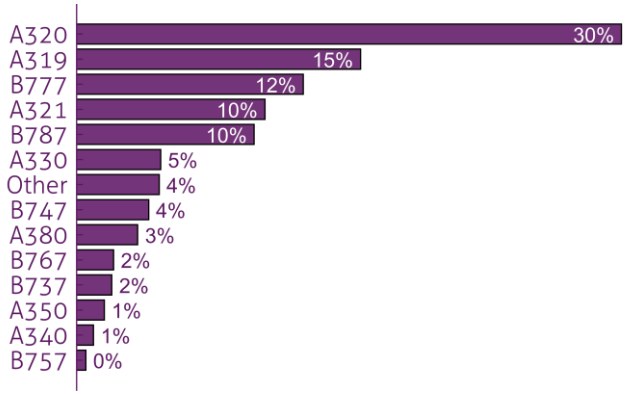
Total 248,164 operations into Heathrow



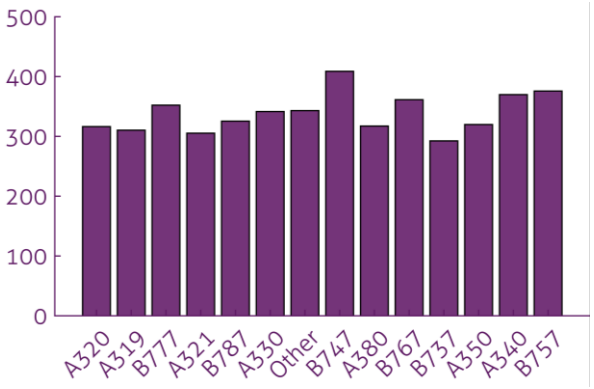
Number of westerly arrivals per day passing through the gate (184 days in total)



Proportion of aircraft types passing through the gate on westerly arrivals



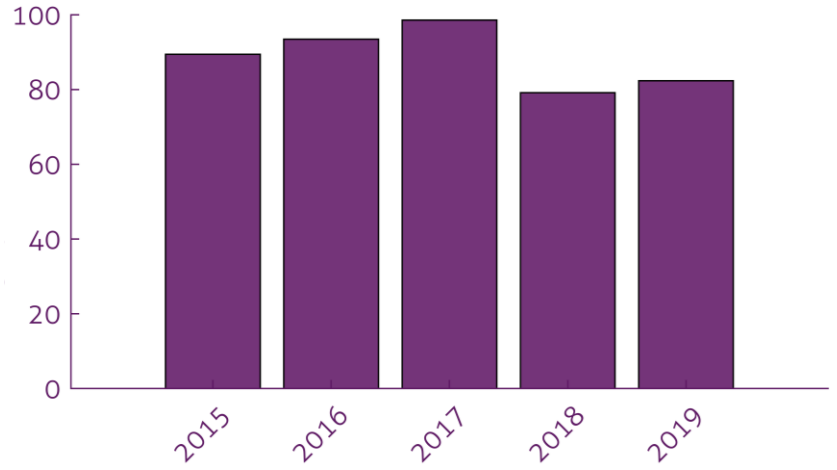
Average height of aircraft as they pass through the gate on westerly arrivals (ft)



Is the number of flights over the area different in 2019 compared to 2015?

- The figure to the right shows the total number of arrivals that passed through the analysis gate in the period from 28th March to 27th September from 2015 to 2019.
- Annually, between 79,000 and 99,000 arrivals passed through the gate on westerly operations.
- Year to year changes can be attributed to fluctuations in the proportion of westerly operations (determined by wind direction) and the total number of movements out of Heathrow.
- The table indicates that the proportion of westerly operations in 2015 was 71%, in 2019 68%.
- On a full day of westerly operations:
  - there was a slight decrease in the number of arrivals through the gate in the 2019 period compared to 2015; and
  - a very small proportion of the westerly arrivals passed through the overhead cone and average daily number did not change between years.

Number of aircraft passing through the gate on westerly operations ('000s)



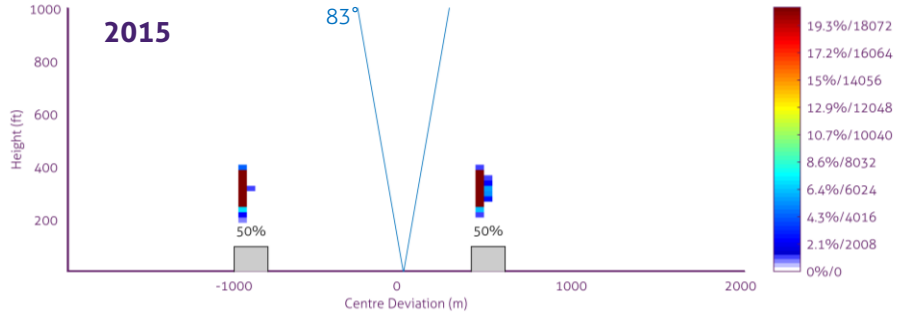
	2015	2019	Difference	Change (%)
Proportion of westerly operations (all Heathrow flights)	71%	68%	-3%	N/A
Average number of westerly arrivals passing through the gate during days of 100% westerly operations	675 (2)*	671 (2) *	-4 (+0)*	-1% (+0%)*

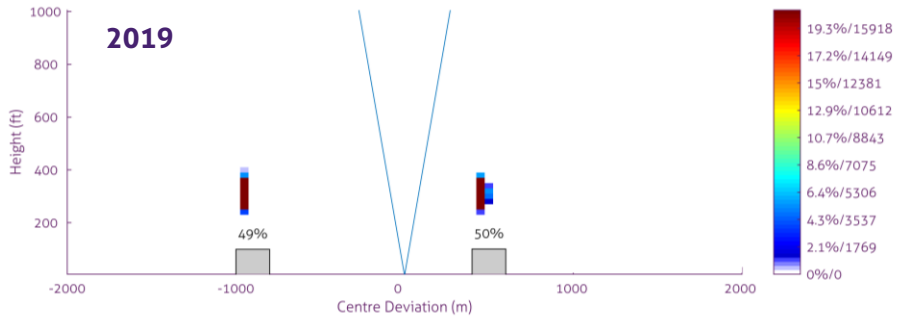
* Figures in parentheses indicate the number of flights passing through the 83 degree overhead cone.

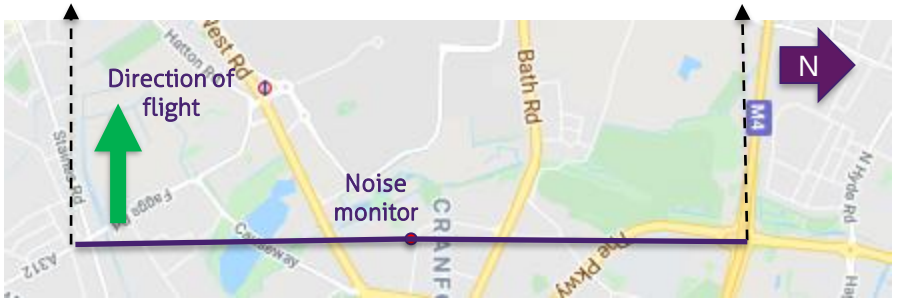
Note: Wherever this section of the report refers to *2019*, it should be noted that this is specifically the measurement period from 28st March to 27th September 2019. Similarly, 2015 specifically refers to the period from 28th March to 27th September 2015.

Is the concentration of westerly arrivals different between 2015 and 2019?

- The figures to the right are "heat maps" showing the 2D concentrations of aircraft as they pass through the westerly gate during the 2015 (the upper figure) and 2019 (the lower figure) monitoring period. Also shown by the grey bars is the concentration at different distances from the centre along the length of the gate.
- The scale has been normalised according to the proportion of movements. In other words, the same colour represents the same proportion of movements in each plot yet may represent a different number of movements.
- The two spots of concentration in the plots relate to each of the arrival paths; the concentration to the right is the arrival path to the northern runway, the concentration to the left is the arrival path to the southern runway.
- Since all aircraft have joined ILS (Instrument Landing System) by Cranford, a system of radio waves that guide the aircraft to the runway, there was no significant change to the position or concentration of the aircraft above the noise monitor.



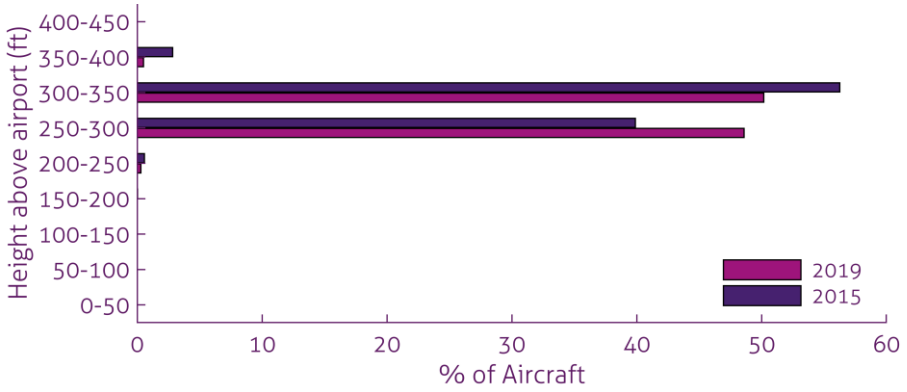


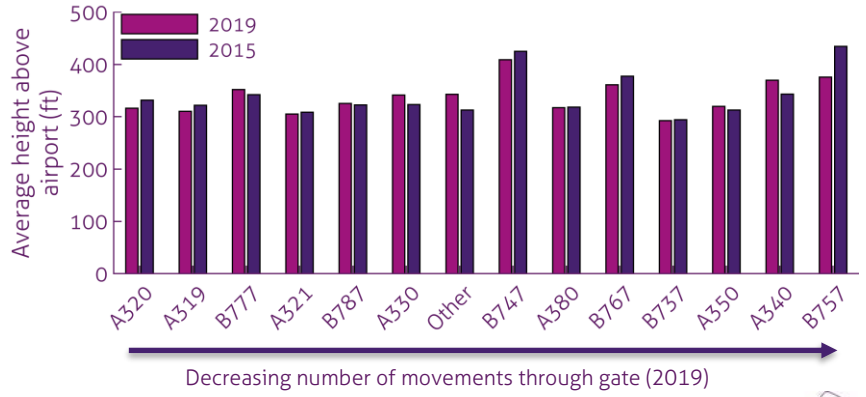


Are aircraft heights different between 2015 and 2019?

- The table to the right presents the average height of aircraft on arrival as they passed through the analysis gate in the 2015 and 2019 periods.
- This indicates that aircraft above Cranford were, on average, the same altitude in the 2019 period compared to 2015.
- The figures present the distribution of aircraft heights through the gate comparing 2015 with 2019 (upper figure) and the average height by aircraft type (lower figure).
- The upper figure shows that the average altitude has not changed between 2015 and 2019 since all aircraft will have joined the final approach by the time they pass over Cranford. However, there has been a slight shift from the number of aircraft passing through the gate at an altitude of 300-400ft to between 250 and 300ft.
- The lower figure shows that there are only slight differences between aircraft types; however, the B747 is a notable outlier at almost 100ft higher, on average, than most other aircraft types.

	2015	2019	Difference
Average height of arrivals passing through the analysis gate	330ft	330ft	No change



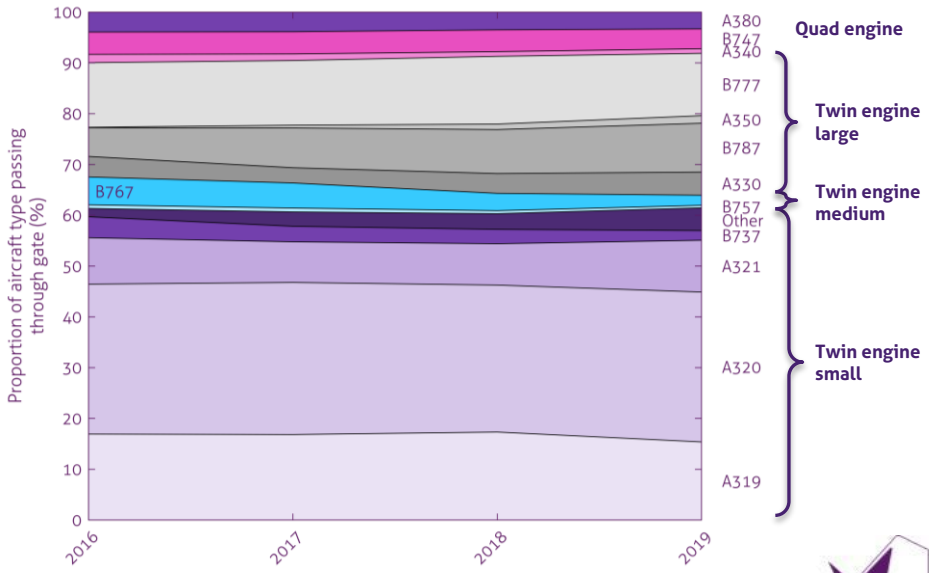


Is the fleet mix different between 2015 and 2019?

- The table to the right presents the mix of arriving aircraft that passed through the westerly gate and overall at Heathrow in the 2015 and 2019 periods.
- For simplicity the fleet mix has been split in to 5 groups:
  - the A380
  - quad (four) engine aircraft (including B747, A340),
  - twin engine large aircraft (B777, A350, B787)
  - twin engine medium aircraft (B767)
  - twin engine small aircraft (B737, A320 family)
- The analysis on Page 12 indicates that, on average, the number of arriving aircraft flying through the westerly gate has not changed significantly on days of full westerly operations between 2015 and 2019.
- The analysis on this page indicates that there was an 8% increase in the proportion of large twin engine aircraft through the gate on westerly arrivals between 2015 and 2019. This increase is in line with the changes occurring in the airport as a whole.
- The figure provides a more detailed picture of how the fleet mix has changed across the period. The aircraft categories used in this report are distinguished by the different colour schemes.
- The biggest single change was the increased use of the B787.

Fleet mix

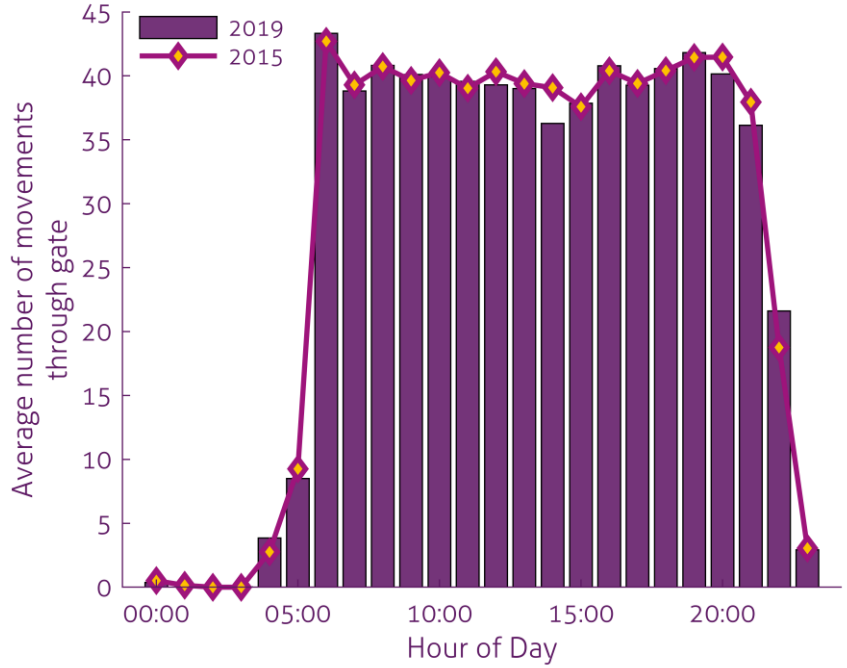
Category	Analysis gate		All LHR	
	2015	2019	2015	2019
A380	3.1%	3.3%	3.2%	3.3%
Quad engine	7.4%	4.8%	7.6%	4.8%
Twin engine large	20.0%	28.0%	20.9%	28.0%
Twin engine medium	6.3%	2.4%	1.7%	2.3%
Twin engine small	63.3%	61.6%	66.6%	61.6%



* Days of 100% westerly operations only

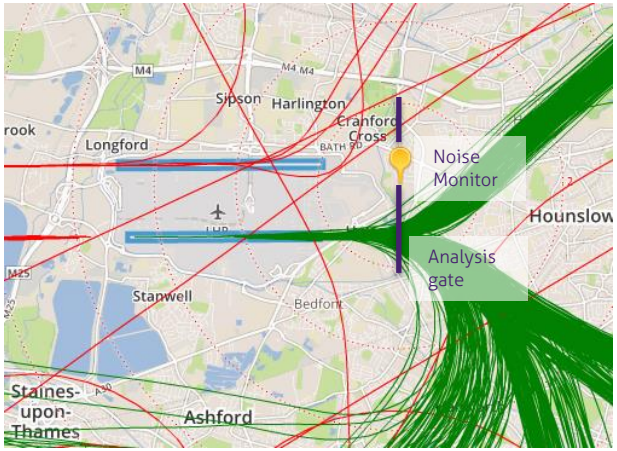
Does the number of flights over the area vary across the day? Is there a difference between 2015 and 2019?

- The figures to the right present the average number of arrivals through the analysis gate per hour in 2015 and 2019 during full days of westerly operations.
- The figures show that from 06:00 to 22:00 between 36 and 43 aircraft pass through the gate per hour. An average of 12 and 25 movements pass through the gate during the 2 hour periods before 06:00 and after 22:00 respectively.
- The busiest hour is between 06:00 and 07:00.
- Since the gate is wide enough to encompass both arrival paths on westerly operations, the plot does not show the effect of runway alternation on Cranford. The effect runway alternation has on the noise environment is shown on Page 35.
- Previous analysis on Page 12 has shown that there was a light decrease in the number of daily flights passing through the gate in 2019 compared to 2015. While the distribution of the movements across the day is very similar between the years, there are small differences such as there were approximately three movements fewer between 00:00 and 15:00 in 2019.
- Of the total 184 days in the 2019 monitoring period, 87 days (47%) were 100% westerly operations, and 35 days (19%) were on 100% easterly operations. The airport changed its direction of operation on the remaining days.



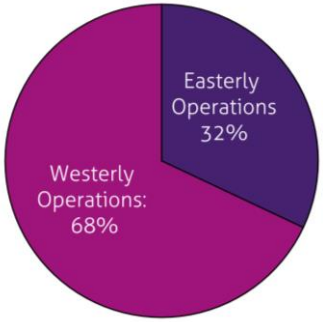
Overview of flight track data – Easterly operations

28th March – 27th September 2019

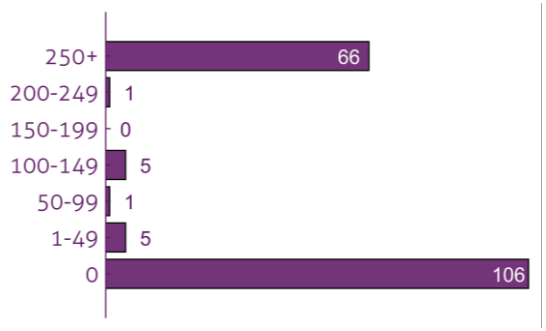


Example day of departing aircraft tracks in the vicinity of Cranford during easterly operations & the gate position (width 4km)

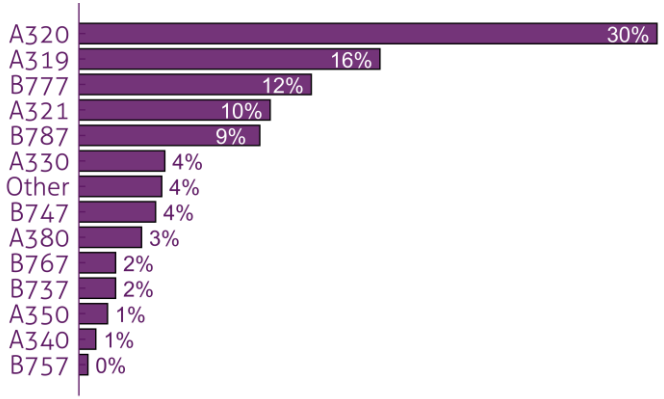
Total 248,164 operations into Heathrow



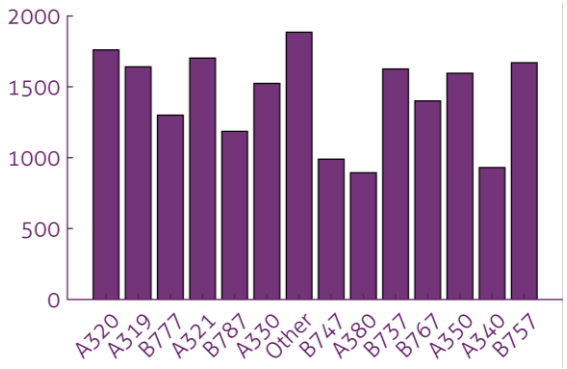
Number of easterly departures per day passing through the gate (184 days in total)



Proportion of departing aircraft types passing through the gate



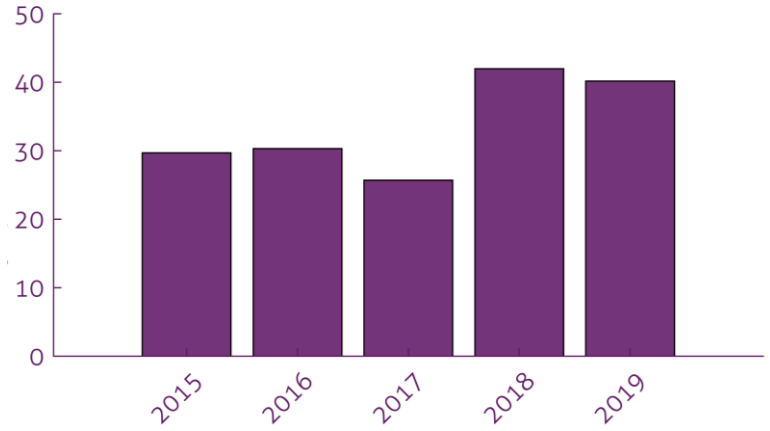
Average height of departing aircraft as they pass through the gate (ft)



Is the number of flights over the area different in 2019 compared to 2015?

- The figure to the right shows the total number of departures that passed through the analysis gate in the period from 28th March to 27th September from 2015 to 2019.
- Annually, between 25,000 and 42,000 departures passed through the gate on easterly operations. Due to the proximity of the gate to the airport, these figures include flights on all departure routes.
- Year to year changes can be attributed to fluctuations in the proportion of easterly or westerly operations (determined by wind direction) and total number of movements.
- The table indicates that the proportion of easterly operations in 2015 was 29%, in 2019 32%.
- On a full day of easterly operations;
  - there was not a significant change in the number of easterly departures through the gate in the 2019 period compared to 2015 and
  - there was a decrease in the number of overhead from 13 per day in 2015 to an average of just one per day in 2019.

Number of aircraft passing through the gate on easterly operations ('000s)



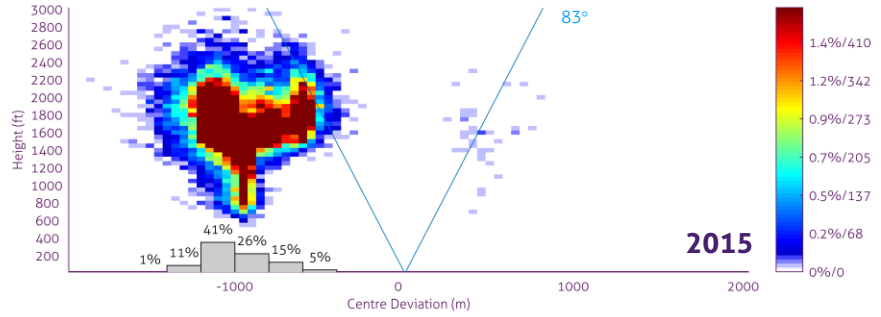
	2015	2019	Difference	Change (%)
Proportion of easterly operations (all Heathrow flights)	29%	32%	+3%	N/A
Average number of easterly departures passing through the gate during full days of easterly operations	674 (13)*	680 (1) *	+6 (-12)*	+1% (-90%)*

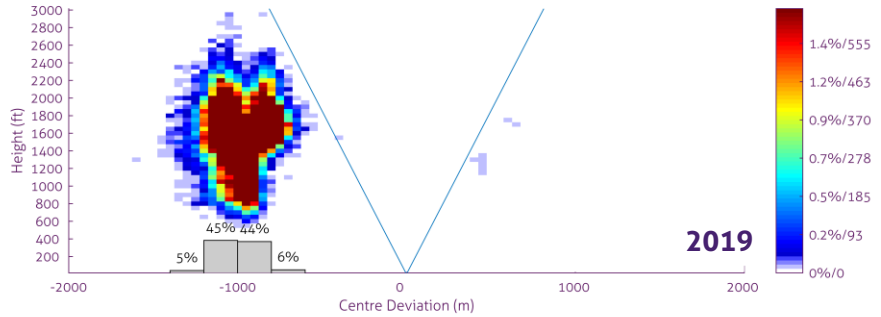
* Figures in parentheses indicate the number of flights passing through the 83 degree overhead cone.

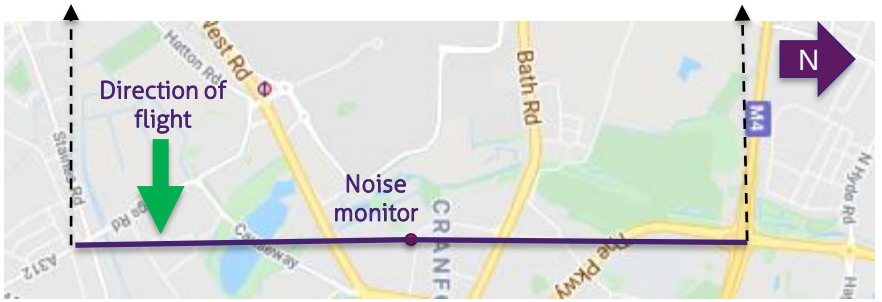
Note: Wherever this section of the report refers to *2019*, it should be noted that this is specifically the measurement period from 28st March to 27th September 2019. Similarly, 2015 specifically refers to the period from 28th March to 27th September 2015.

Is the concentration of easterly operations different between 2015 and 2019?

- The figures to the right are "heat maps" showing the 2D concentrations of aircraft as they pass through the gate during the 2015 (the upper figure) and 2019 (the lower figure) monitoring periods. Also shown by the grey bars is the concentration at different distances from the centre along the length of the gate.
- The scale has been normalised according to the proportion of movements. In other words, the same colour represents the same proportion of movements in each plot yet may represent a different number of movements.
- The figures show the width of the main swathe is approximately 400m narrower in 2019 compared to 2015 suggesting the flight path at this location is slightly more concentrated. This could be for reasons such as the proportion of departures using the associated routes or the way in which newer aircraft are flying those routes.
- The narrowing of the swathe is the reason for a reduction in the number of overhead aircraft identified on the previous page.



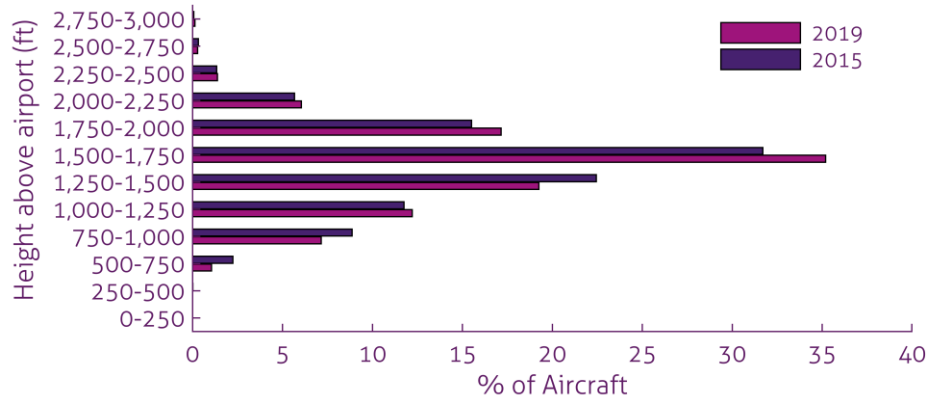


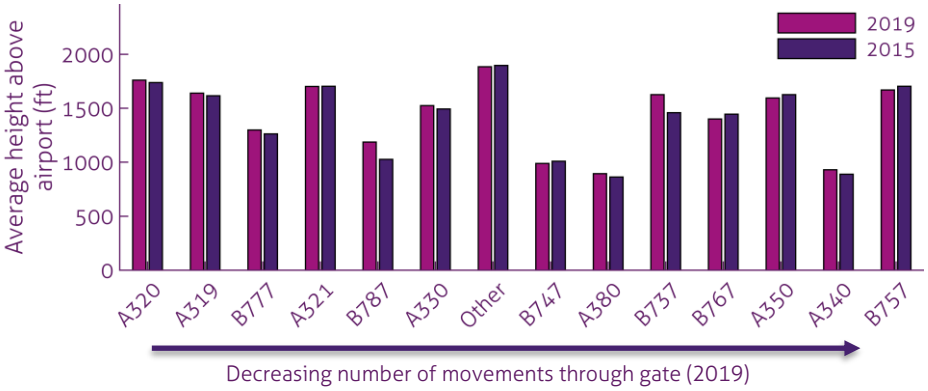


Are aircraft heights different between 2015 and 2019?

- The table to the right presents the average height of departing aircraft as they passed through the analysis gate in the 2015 and 2019 periods.
- This indicates that there was not a significant change in the height of departing aircraft above Cranford in the period between 2015 and 2019.
- The figures present the distribution of aircraft heights through the analysis gate comparing 2015 with 2019 (upper figure) and the average height by aircraft type (lower figure).
- The upper figure shows that although in both years the greatest proportion of aircraft passed through the gate between 1,500ft and 1,750ft; however, in 2019 a slightly lower proportion of aircraft passed through the gate at lower altitudes (<1,000ft) compared to 2015.
- The lower figure shows that the height of aircraft varies with type. The three quad engine aircraft types that operate into Heathrow; the A380, A340 and B747 were the lowest, typically passing over Cranford at less than 1,000ft.
- With the exception of the B777, B787 and B767 all other aircraft types passed through the gate at an average of greater than 1,500ft.

	2015	2019	Difference
Average height of departures passing through the analysis gate	1,530ft	1,590ft	+60ft



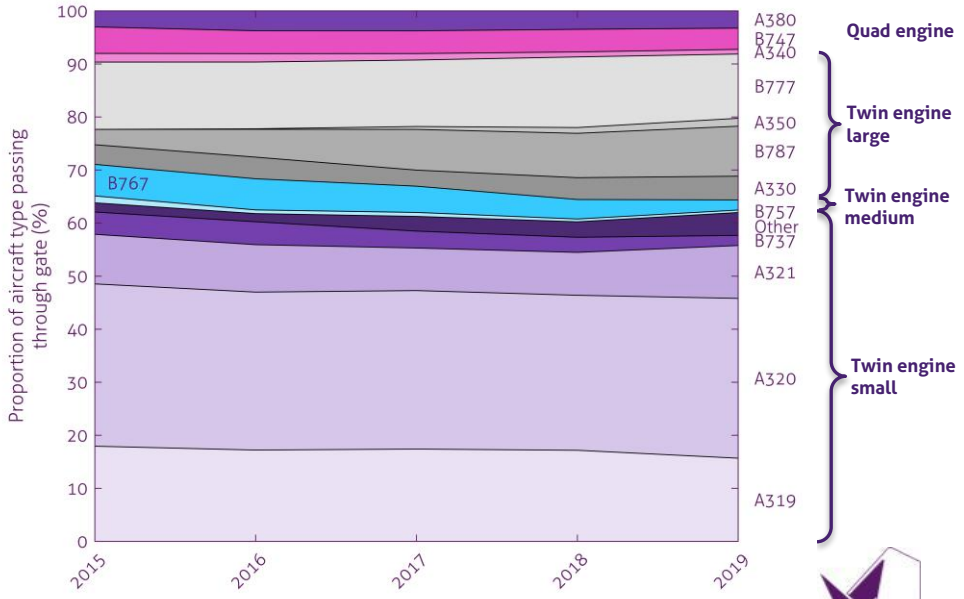


Is the fleet mix different between 2015 and 2019?

- The table to the right presents the mix of departing aircraft that passed through the gate and overall at Heathrow in the 2015 and 2019 periods.
- For simplicity the fleet mix has been split in to 5 groups:
  - the A380
  - quad (four) engine aircraft (including B747, A340),
  - twin engine large aircraft (B777, A350, B787)
  - twin engine medium aircraft (B767)
  - twin engine small aircraft (B737, A320 family)
- The analysis on Page 18 indicates that, on average, the number of departing aircraft flying through the gate has not changed significantly on days of full easterly operations between 2015 and 2019.
- The analysis on this page indicates that the proportion of large twin engine increased from 19 to 28% between 2015 and 2019 – largely driven by an increase in the use of the B787. All other aircraft size categories decreased over the same period with the exception of the A380.
- The figure provides a more detailed picture of how the fleet mix has changed across the period. The aircraft categories used in this report are distinguished by the different colour schemes.
- In addition to the increased use of the B787, the plot shows the introduction of the A350 from 2015 and the gradual phasing out of the B767.

Fleet mix

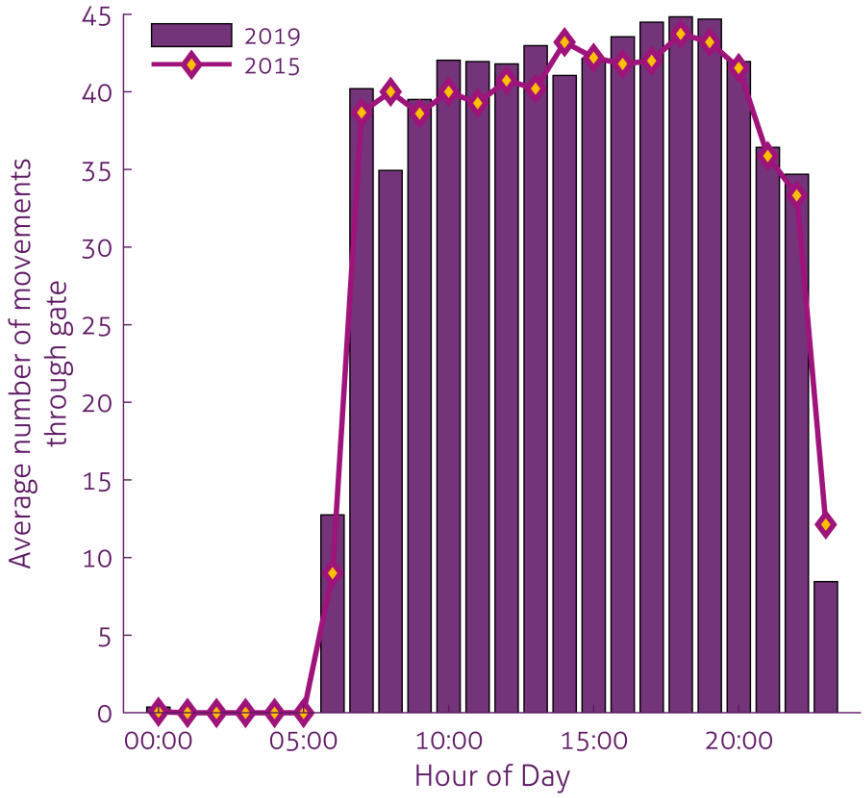
Category	Analysis gate		All LHR	
	2015	2019	2015	2019
A380	3.0%	3.3%	3.2%	3.3%
Quad engine	6.6%	4.9%	7.6%	4.8%
Twin engine large	19.3%	27.6%	20.9%	28.0%
Twin engine medium	6.2%	2.2%	1.7%	2.3%
Twin engine small	64.9%	62.1%	66.6%	61.6%



* Days of 100% easterly operations only

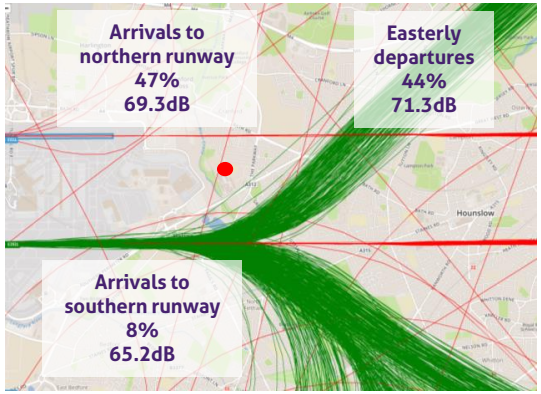
Does the number of flights over the area vary across the day? Is there a difference between 2015 and 2019?

- The figures to the right present the average number of departures through the analysis gate per hour in 2015 and 2019 during days of 100% easterly operations.
- The figures show that during daytime hours (07:00-23:00) between 35 and 45 aircraft pass through the gate each hour on average.
- There is a gradual increase in the number of flights each hour throughout the day until the hour between 19:00 and 20:00, after which there are fewer flights each hour until midnight.
- Due to the historic Cranford Agreement, there is no runway alternation on easterly operations.
- Previous analysis on Page 18 has shown that there a similar number of daily flights through the gate in 2019 compared to 2015; however, there has been a slight change in the distribution of flights across the day over the same period. In 2019, there were more flights before 07:00 but fewer in the hours between 08:00 and 09:00 and after 23:00.
- Of the total 184 days in the 2019 monitoring period, 87 days (47%) were 100% westerly operations, and 35 days (19%) were on 100% easterly operations. The airport changed its direction of operation on the remaining days.



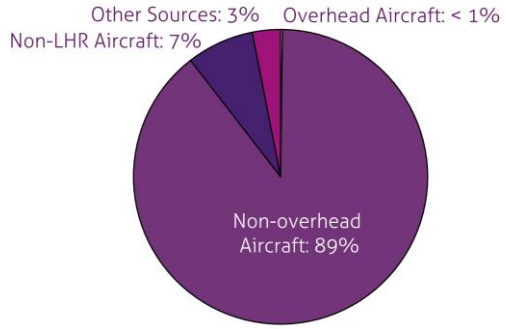
Overview of noise monitor data recorded at Cranford

28th March – 27th September 2019



Monitor location, % noise events by route & average L_{Amax}

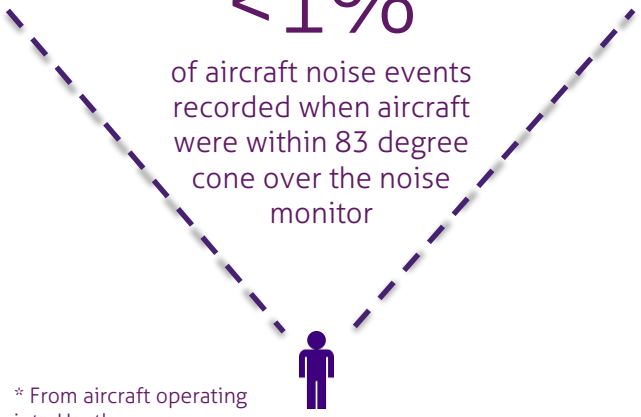
92,508 Measured Noise Events*



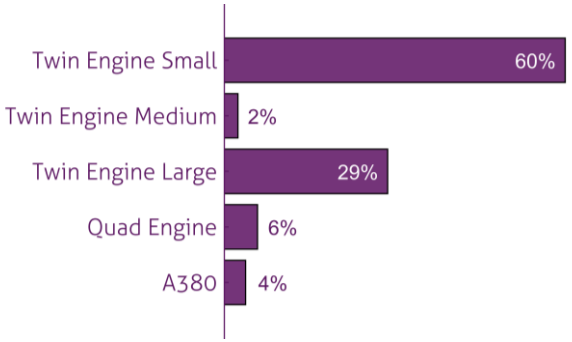
* From all noise sources

<1%

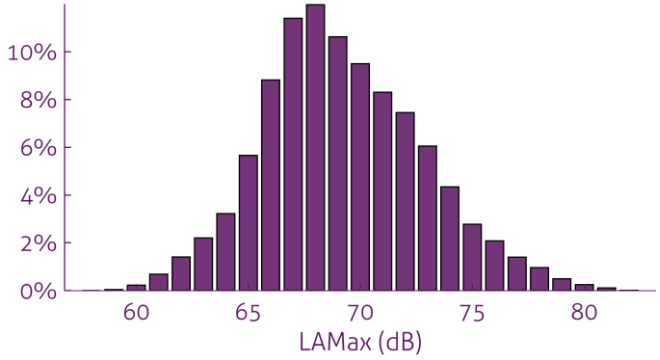
of aircraft noise events recorded when aircraft were within 83 degree cone over the noise monitor



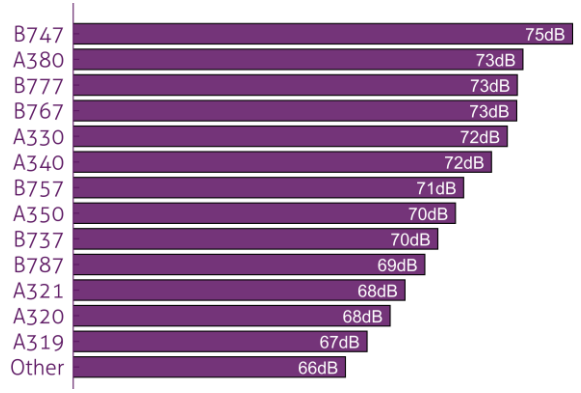
* From aircraft operating into Heathrow



Noise events by aircraft size



Overall distribution of maximum event noise level



Average L_{Amax} by aircraft type*

*Arrivals to the northern runway only

Noise monitoring overview

Monitoring location, duration and setup

- A temporary noise monitor was installed in the grounds of Cranford Primary School, Cranford between 28th March and 27th September 2019.
- The monitor was set up to record noise events based on a threshold sound pressure level of 58.2dB being exceeded for more than 10 seconds.
- The location of the noise monitor is shown in the figure to the right. It is close to the arrival path on westerly operations (red) and the north of departures on easterly operations (green).

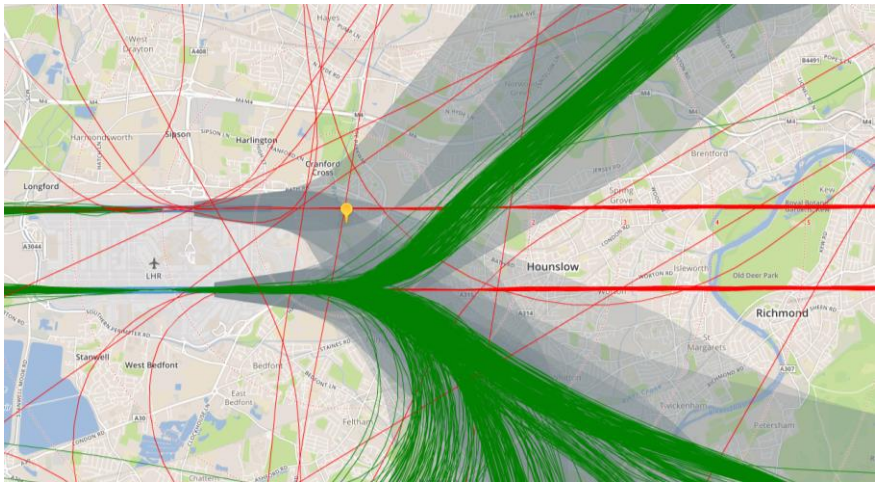
Noise event summary

- A total of 52,508 noise events were measured during the monitoring period. Of these around 90% were from aircraft using Heathrow and 3% were from non-aircraft sources.
- Over half of the aircraft registering noise events at the noise monitor were arrivals on westerly operations, the majority of which were to the northern runway. Over 44% of aircraft noise events were from departures from the southern runway on easterly operations.
- Only a handful of operations were deemed overhead. Despite being close to the northern arrival path, the altitude of the aircraft at this point is low and fall outside the 83 degree cone.

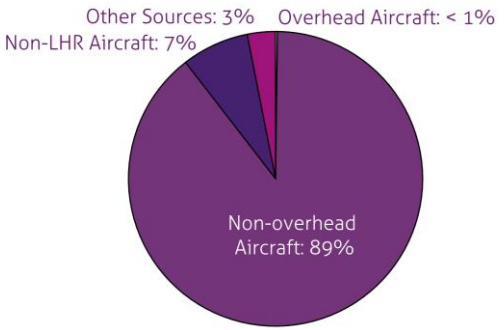
Percentage of aircraft noise events by route

Westerly Arrivals		Easterly Departures		Overhead
27L	27R	09L	09R	
9	47	<1	44	<1

Noise preferential routes, monitor position and flight tracks on typical easterly (green) and westerly (red) day

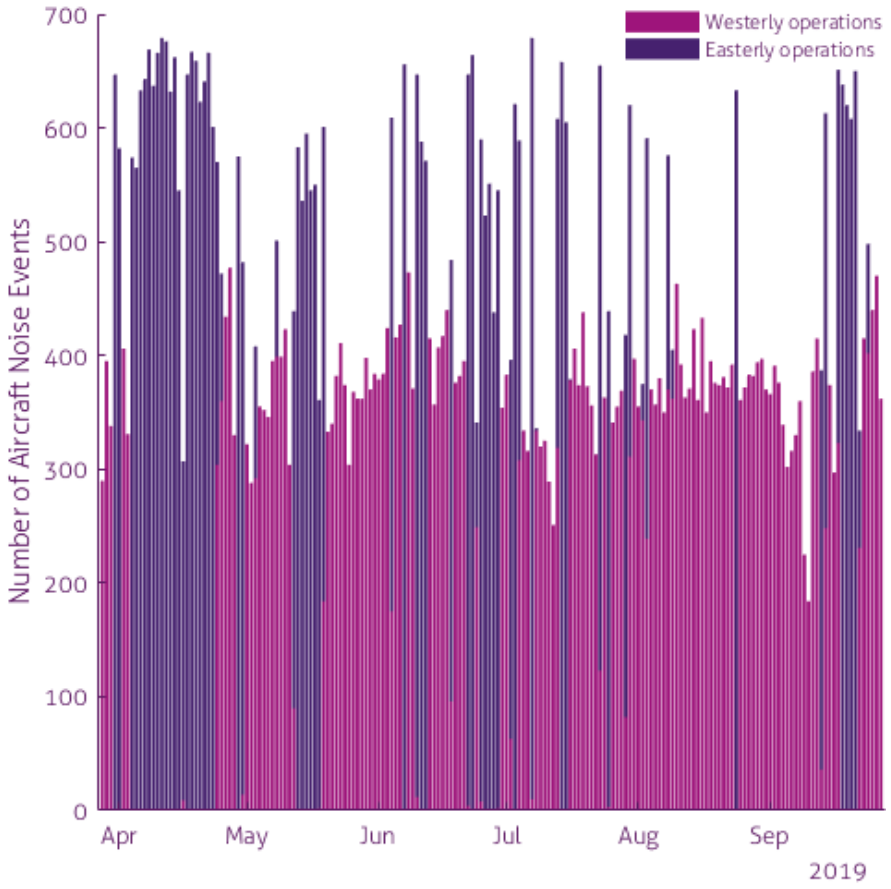


Measured noise event summary



Does the direction of operation affect the number of measured aircraft noise events?

- Noise events are captured at Cranford during both westerly and easterly operations. During westerly operations, the noise events are generally registered from aircraft approaching the northern runway. On easterly operations, noise events are registered from aircraft on all six departure routes.
- During the monitoring period, 87 out of 184 days (47%) were 100% westerly operations and 35 days (19%) were 100% easterly operations. On the remaining days, the airport switched direction of operation during the day.
- During full days of westerly operations, there were, on average, 369 aircraft noise events triggered per day.
- During full days of easterly operations, there was an average of 608 aircraft noise events.
- Over the full six-month monitoring period, only 200 (<1%) aircraft noise events were recorded by aircraft passing within the 83 degrees overhead cone.
- It is noted that an absence of aircraft noise events does not necessarily mean that aircraft would be inaudible. There may be aircraft further away that are audible but have not triggered the noise event detection threshold.



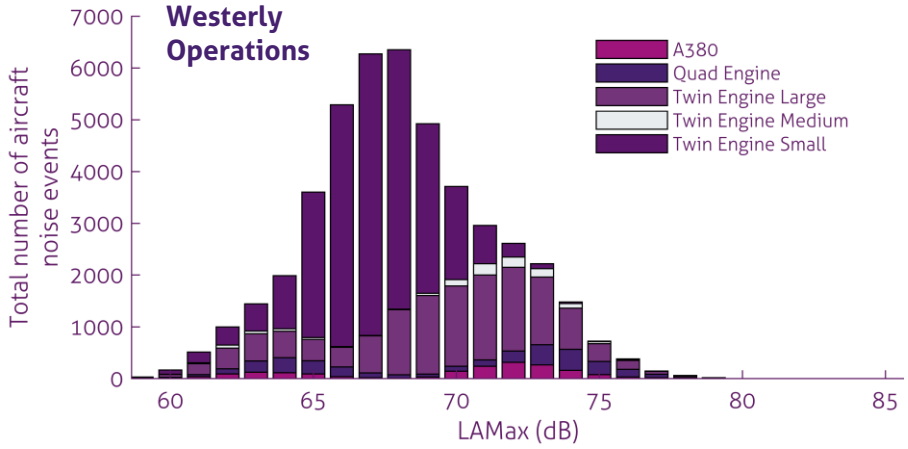
What was the range of L_{Amax} noise levels from aircraft events?

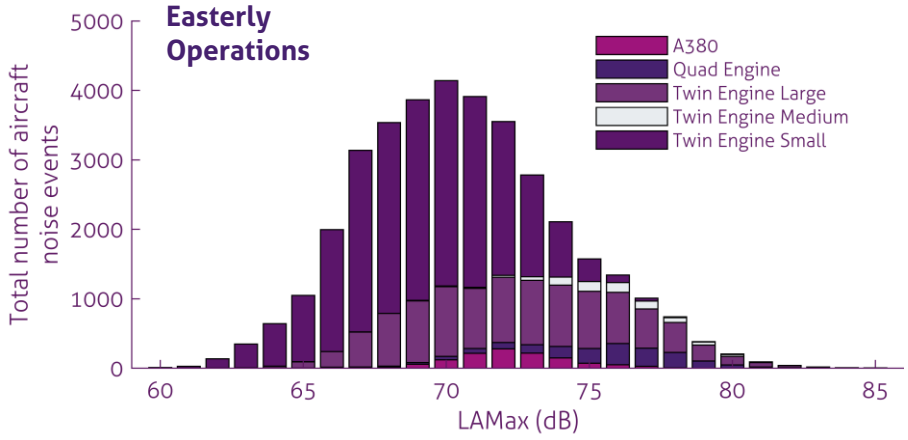
- The figures to the right present the range of L_{Amax} noise levels for all aircraft noise events measured at the Cranford monitor during the monitoring period on westerly (top) and easterly (bottom) operations. An explanation of metrics is given on Page 8.
- The table below presents the average L_{Amax} of each aircraft type group and direction of operation.
- The average L_{Amax} of all aircraft events is 68.6 and 71.3dB on westerly and easterly operations respectively.

Aircraft group	Average L_{Amax}, dB	
	Westerly	Easterly
A380	70.2	72.8
Quad engine	70.3	76.0
Twin engine large	69.9	73.0
Twin engine medium	70.7	76.3
Twin engine small	67.6	69.9

- As this analysis considers all events measured at this monitor, regardless of distance or route, these results cannot be used to compare the relative noise levels of aircraft types. An analysis of aircraft type noise levels is presented on Page 30.
- For non-aircraft related events, the mean L_{Amax} is 66.8dB reaching a maximum of 89.0dB.

* Note: throughout this report, unless otherwise stated, the arithmetic mean is calculated.

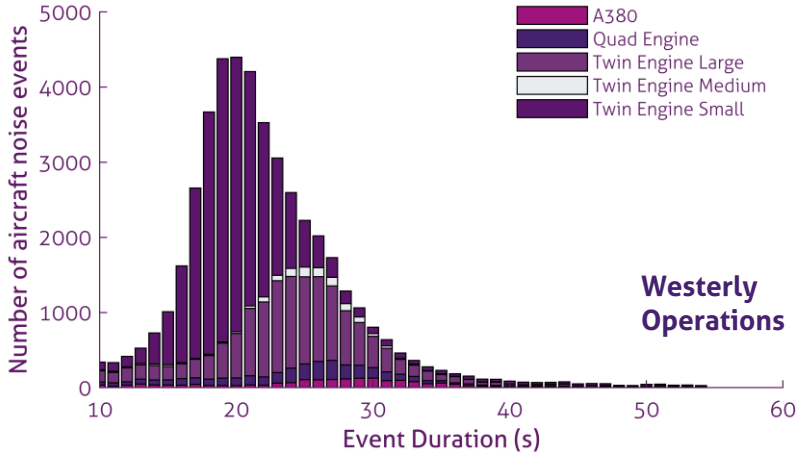


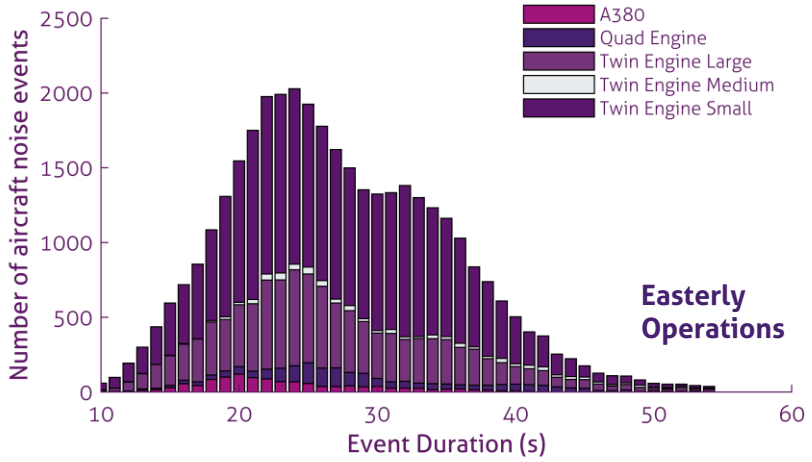


How does the duration of an aircraft event vary?

- The duration of an event (as defined for the purposes of this comparison only) is the time for which the noise level exceeds the event threshold level, which in this case is 58.2dB.
- In addition, events are only recorded if the duration is longer than 10s to prevent impulsive sounds that are not characteristic of aircraft noise being recorded or to prevent shorter duration transient events such as cars or lorries being captured.
- The average duration of all measured aircraft events was 27 seconds. The table below gives the average event duration for each aircraft size category and direction of operations. At this location, there appears to be little correlation between the size of aircraft and the average duration of the noise events they generate.
- Approximately 6% of events recorded a duration in excess of 60 seconds. Considering the distribution in the figure to the right, it is assumed that these events will have been contaminated by other noise sources and were therefore removed from analysis.

Aircraft group	Average noise event duration (seconds)	
	Westerly	Easterly
A380	29.9	25.7
Quad engine aircraft	26.4	33.1
Twin engine - large	26.8	29.7
Twin engine - medium	27.3	36.8
Twin engine - small	23.2	29.5





Which aircraft types account for the measured noise events?

- The table to the right shows the proportion of aircraft noise events recorded for each aircraft type overall, by runway (on westerly arrivals) or route (on easterly departures).
- The aircraft types listed are limited to the most common aircraft types operating at Heathrow. The remaining aircraft types are listed under 'Other'.
- As with the Heathrow Airport's traffic in general, the A320 family (A319, A320 & A321) dominate - accounting for 54% of all aircraft noise events detected by the monitor.
- The B777 and B787 (twin-engine large) series of aircraft accounted for around 14% and 9% of the measured aircraft noise events respectively.
- The newest aircraft type in service, the A350, was responsible for 1% of events over the monitoring period.
- The majority of the events when the southern runway is in use on westerly operations are from larger, and, therefore, louder, aircraft.

Aircraft Type	Total*	Westerly Arrivals		Easterly Departures					
		27R	27L	BPK	CPT	DET	GASGU	MID	ULT
A320	29%	14%	1%	3%	1%	3%	1%	3%	2%
A319	15%	7%	1%	2%	0%	2%	0%	2%	1%
B777	14%	6%	2%	1%	2%	2%	0%	0%	1%
A321	10%	5%	0%	1%	0%	1%	0%	1%	1%
B787	9%	4%	1%	1%	1%	1%	0%	0%	1%
B747	5%	2%	1%	0%	1%	0%	0%	0%	0%
A330	5%	2%	0%	0%	1%	0%	0%	0%	0%
Other	4%	2%	0%	0%	0%	0%	0%	0%	1%
A380	4%	2%	1%	0%	0%	1%	0%	0%	0%
B767	2%	1%	0%	0%	1%	0%	0%	0%	0%
B737	2%	1%	0%	1%	0%	0%	0%	0%	0%
A350	1%	1%	0%	0%	0%	0%	0%	0%	0%
A340	1%	0%	0%	0%	0%	0%	0%	0%	0%
B757	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total**	**100%**	**47%**	**9%**	**10%**	**7%**	**11%**	**2%**	**7%**	**7%**

* Percentage based on 89,576 aircraft noise events recorded between 28th March and 27th September 2019.
** Totals may differ to sum of aircraft types due to rounding

Comparison of average noise levels for different aircraft types

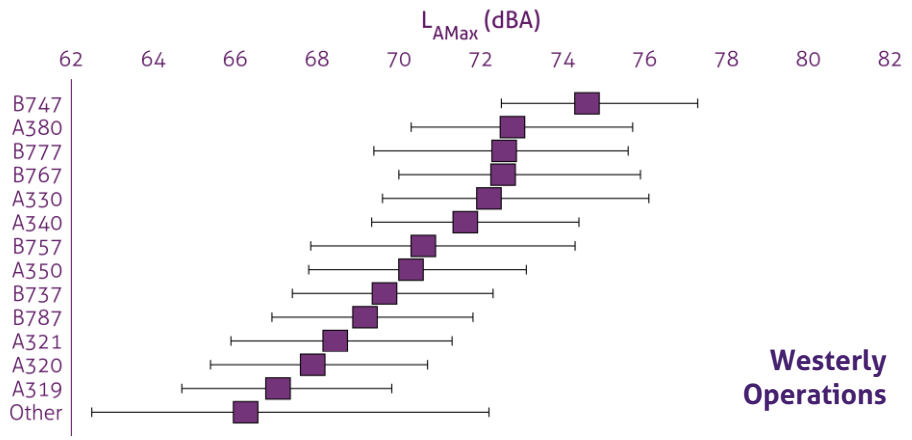
The plots to the right show the average L_{Amax} of each aircraft type in addition to the 5th and 95th percentile on the arrival path to the northern runway (27R) on westerly operations (top) and departures on easterly operations (bottom).

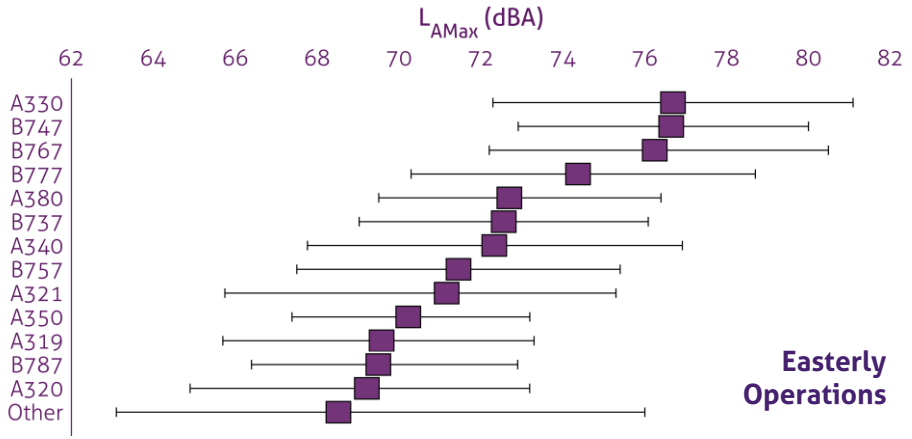
Westerly Operations

- The highest average measured noise level is from the B747, which at 75dB L_{Amax} was approx. 2dB louder than the next loudest aircraft types (the A380, B777 and B767).
- The A320 family (A319, A320 and A321) are the quietest common aircraft types at 67-68dB.
- The average L_{Amax} of the Other category was 66dB; however, the range of levels was relatively high since it comprised of a number of different aircraft types.

Easterly Operations

- The relative noise levels of the aircraft types are considerably different on departure (compared to the westerly arrivals) with the departures being typically 2dB louder overall.
- The highest average measured noise levels are from the A330 and B747 at 77dB.
- The newest aircraft types operating into Heathrow, the B787 and A350, both large twin engine aircraft, are of comparable levels to the A320 family aircraft (small twin engine).





How does the number of aircraft noise events vary across a day?

It is recognised that the response to aircraft noise is related to more than average noise levels alone. The number of events and their individual levels are becoming increasingly recognised as a useful indicator of community response to aircraft noise.

The N_{above} metrics describe the number of events in a period where the L_{Amax} exceeds a given value.

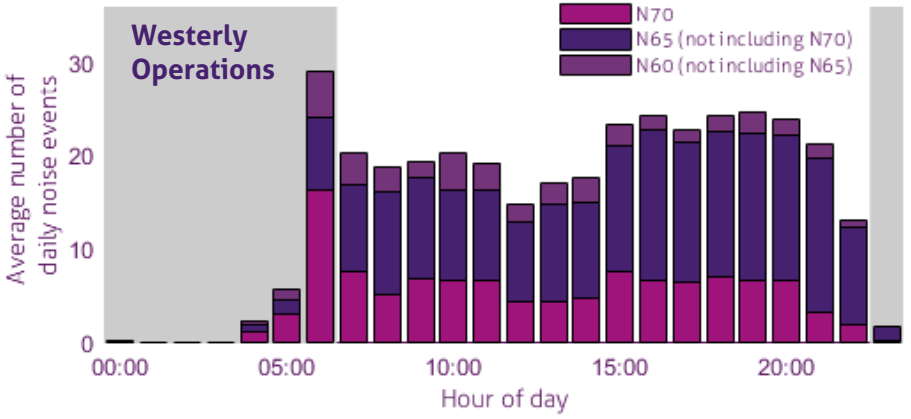
The figures to the right shows the average hourly N60, N65 and N70 values across an average 24hr day for full days of westerly operations (top) and easterly operations (bottom).

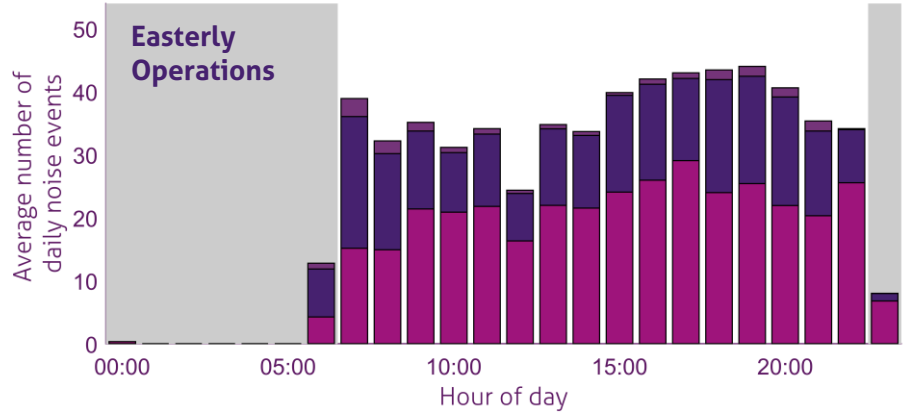
Westerly Operations

- During daytime hours, there are typically between 15 and 25 noise events per hour; however, the busiest hour occurs between 06:00 and 07:00, during which there are, on average, 29 recorded events. It is during this hour that the highest proportion of louder noise events occur (N70).
- The first early morning events are recorded from 04:30 while a number of noise events from late arrivals occur after 23:00.

Easterly Operations

- During daytime hours, there are typically between 24 and 44 noise events per hour, with the busiest period occurring between 19:00 and 20:00.
- There are a higher proportion of louder events (N70) on easterly operations compared to westerly.
- The first early morning event are recorded from 06:00 while a number of delayed departures occur between 23:00 and 24:00.





How does the number of aircraft noise events vary across a day?

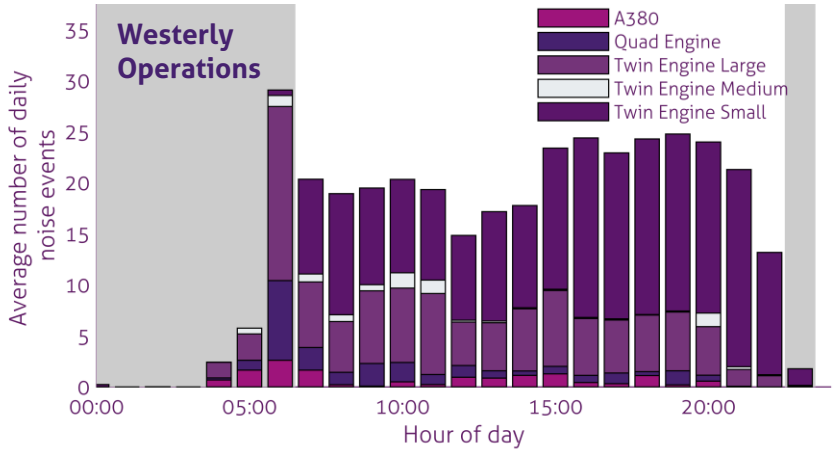
The figures to the right show the average number of noise events during each hour of the day for days of full days of westerly (top) and easterly (bottom) operations broken down by aircraft size categories.

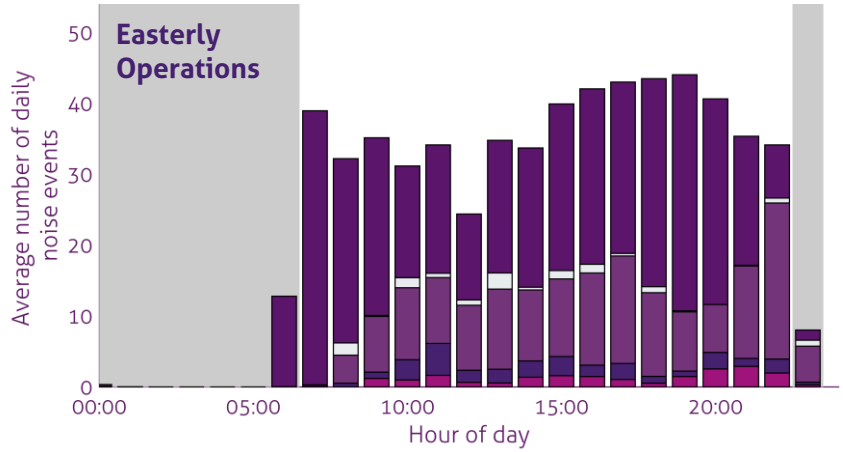
Westerly Operations

- In the early morning period before 07:00, the vast majority of aircraft noise events are from large twin or quad engine aircraft.
- After 07:00, the proportion of each aircraft size category is more representative of the fleet mix operating into Heathrow with a greater proportion of noise events from small twin engine aircraft.
- After 21:00, noise events are recorded from predominantly small twin engine aircraft.

Easterly Operations

- During the first two hours of departures between 06:00 and 08:00, noise events are almost solely measured from small twin engine aircraft.
- As with the westerly operations, the proportion of each aircraft size category is more representative of the fleet mix operating into Heathrow after 08:00.
- After 22:00, the majority of noise events are from large twin engine aircraft such as the B777 and B787.





How does the L_{Amax} vary across a day?

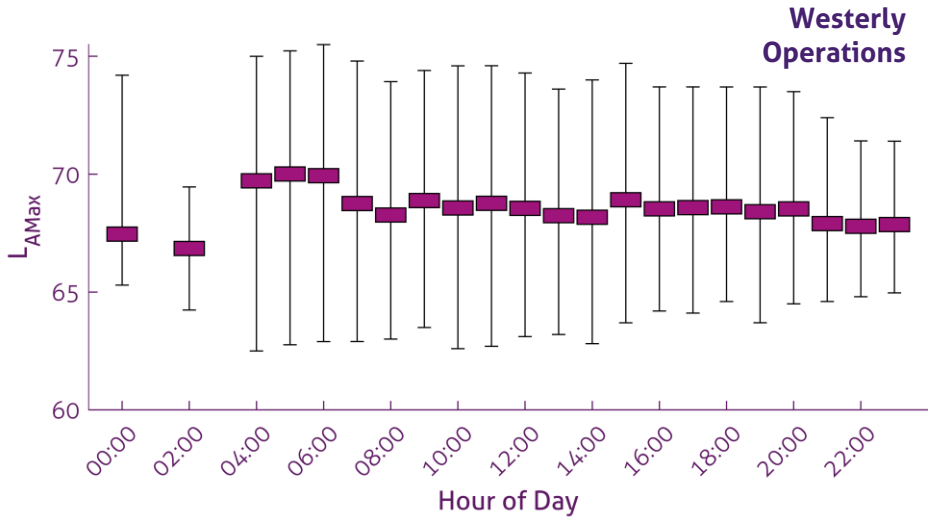
The figures to the right shows the average and range of L_{Amax} values of aircraft noise events for each hour of the day on westerly (top) and easterly (bottom) operations. The range represents the 5th and 95th percentile in each hour.

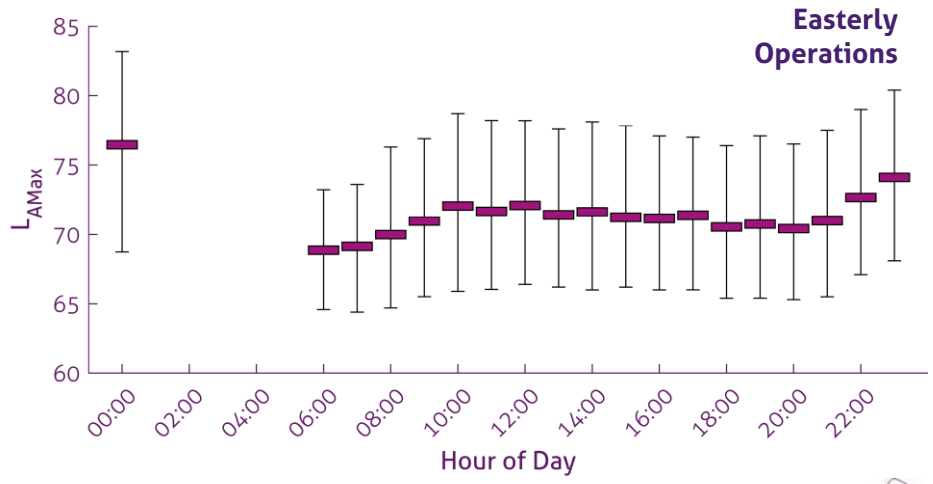
Westerly Operations

- Between 04:30 and 07:00, the average L_{Amax} of measured aircraft noise events is at its greatest at approximately 70dB. This corresponds to the high proportion of larger aircraft as shown on the previous page.
- After this period, the average L_{Amax} generally decreases throughout the day reaching 68dB by midnight.
- The range between the 5th and 95th percentile in each hour also decrease throughout the day from 13 to 6dB.

Easterly Operations

- The average L_{Amax} of measured aircraft noise events increases from 69dB in the hour between 06:00 and 07:00 to 72dB in the hour between 10:00 and 11:00. It then decreases throughout the day and evening before it starts to increase again after 21:00.
- The final hour of the day has the greatest average L_{Amax} at 74dB, most of the movements during this hour were delayed departures.





Average minutes in an hour during which aircraft noise exceeded monitor threshold

The figure to the right shows the average number of minutes in each hour when the sound level within an aircraft noise event exceeding the measured noise event threshold – in this case 58.5dB – on full days of full westerly (top) and easterly (bottom) operations.

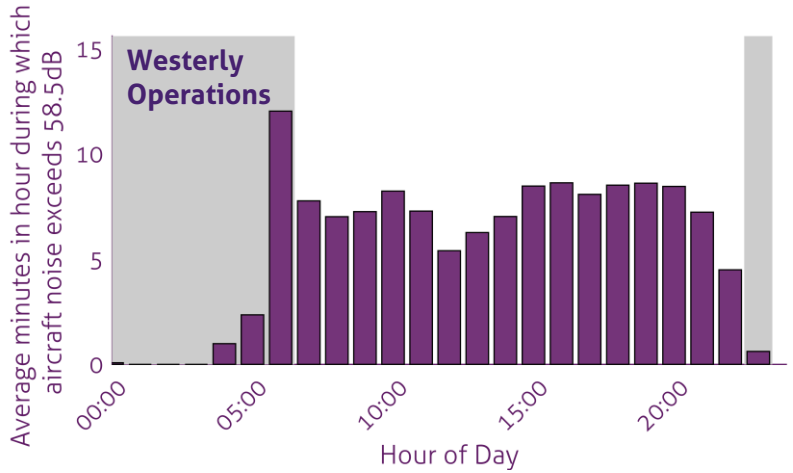
It should be noted that individual aircraft events may be audible when the level is below that of the monitor threshold and therefore the total time the events are audible may be greater than given in the figure. This would be particularly the case during the night when background noise is lowest.

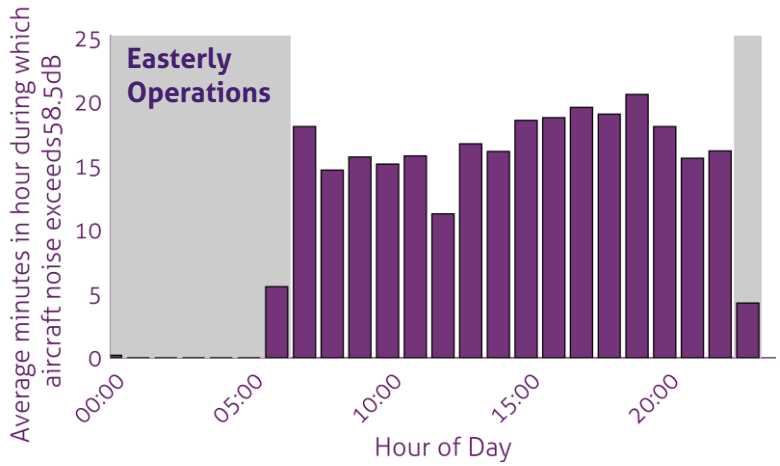
Westerly Operations

- During day time hours, the monitor threshold was exceeded for between five and nine minutes each hour although the greatest proportion of the hour above the threshold occurred between 06:00 and 07:00 reaching an average of 12 minutes.

Easterly Operations

- During day time hours, the monitor threshold was exceeded for between 11 and 21 minutes each hour with the greatest proportion of the hour above the threshold occurring between 19:00 and 20:00.
- During the first hour of departures, the monitor threshold was exceeded for an average of approximately five minutes.
- Delayed departures after 23:00, resulted in the monitor threshold being exceeded for an average of four minutes.





Note: It is important not to compare the results on this page with other sites since the individual threshold can vary from monitor to monitor. The same noise event would register a longer duration if a lower threshold were to be used.

Do aircraft contribute to overall ambient noise levels?

The figure to the right shows the average hourly $L_{Aeq,1hr}$ (ambient) and $L_{A90,1hr}$ (background) noise levels on days where 100% of operations were either westerly or easterly. It also shows the effect of runway alternation on overall noise levels.

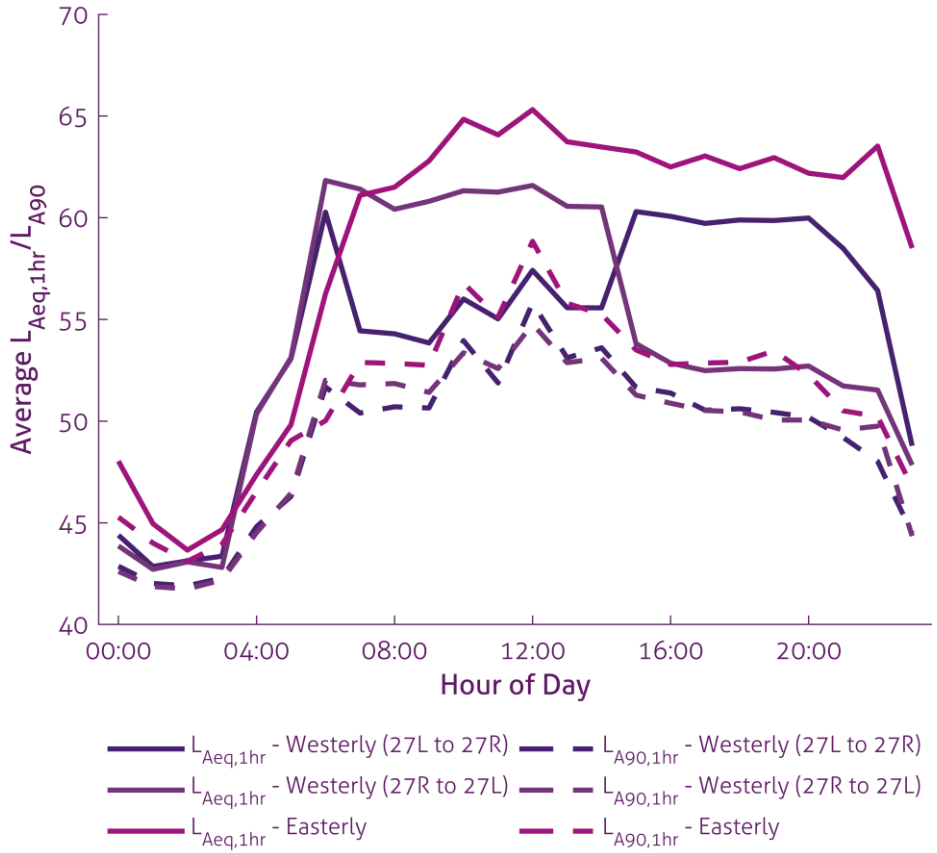
It should be noted that these metrics describe the overall noise environment including all noise sources, not just aircraft noise.

Westerly Operations

- When the northern runway is in use, the average $L_{Aeq,1hr}$ values fall between 56 and 62dB, and typically over 6dB higher compared to the same hour when the southern runway is in use.
- Between 06:00 and 07:00, both runways are used for arrivals resulting in the average hourly level of the two alternation patterns being within 1.5dB of each other.
- During the period the monitor was in place, the average daytime ($L_{Aeq,16hr}$) and night-time ($L_{Aeq,8hr}$) levels from all noise sources were 57dB and 53dB respectively.

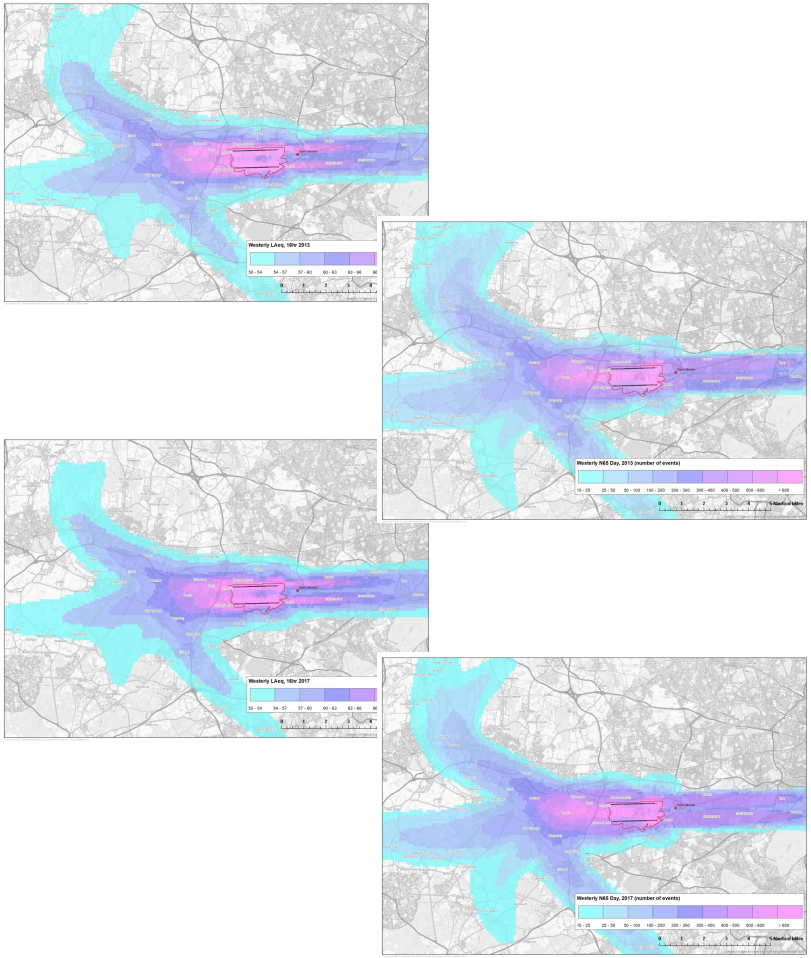
Easterly Operations

- During full days of easterly operations the average $L_{Aeq,1hr}$ values fall between 61 and 65dB with the loudest hour occurring between 12:00 and 13:00.
- The average daytime ($L_{Aeq,16hr}$) and night-time ($L_{Aeq,8hr}$) levels from all noise sources were 63dB and 53dB respectively.



Modelled long term average aircraft noise levels around the airport

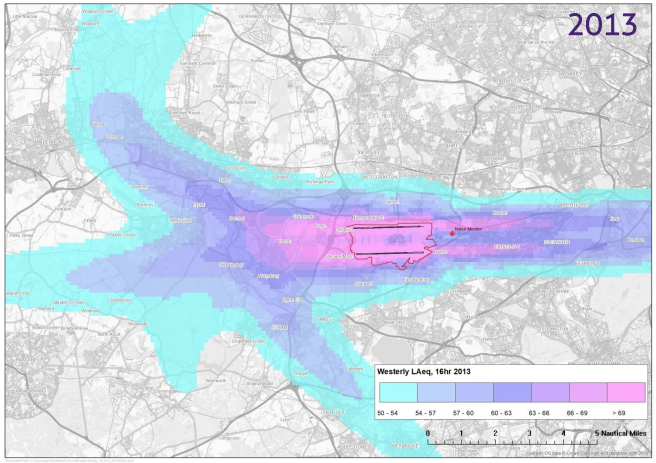
- While a noise monitor can provide an in-depth picture of the noise environment at a specific location, the data cannot be used to provide an understanding of the noise environment over a wider geographical area.
- The Heathrow AEDT model has been run using flight track data for **2013 and 2017** to investigate whether there are any differences in daytime ($L_{Aeq,16hr}$/N65) and night-time ($L_{Aeq,8hr}$/N60) for an **average day and night of easterly and westerly operations** across the summer in each of these years.
- Note that these contours are specific to easterly and westerly operations, and are not the same as the ERCD published annual contours, which derive an overall average for the summer that combines westerly and easterly operations. The following maps only use days when there were either full easterly or westerly operations across that day.
- Daytime $L_{Aeq,16hr}$ values are presented in bands >50dB, >54dB and then in 3dB increments to 69dB.
- Night-time $L_{Aeq,8hr}$ values are presented in 5dB bands starting at >40dB up to 65dB.
- These are longer term metrics averaged over 16 and 8 hours and do not directly reflect the shorter term fluctuations between individual events.
- It should be noted that aircraft noise modelling to average levels around 50dB carries increasing uncertainty in the result. In areas where aircraft noise levels are in this range, it should be noted that many non-aircraft noise sources may be of similar (or even higher) levels. Interpretation of the modelled results at this noise level should bear this in mind.

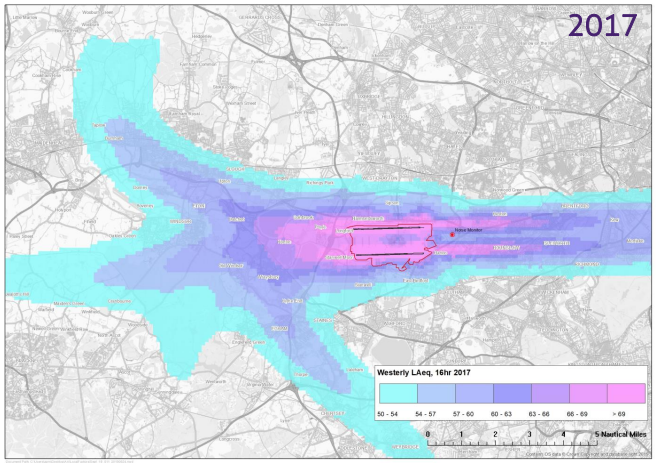


Average **daytime** aircraft noise levels – westerly operations

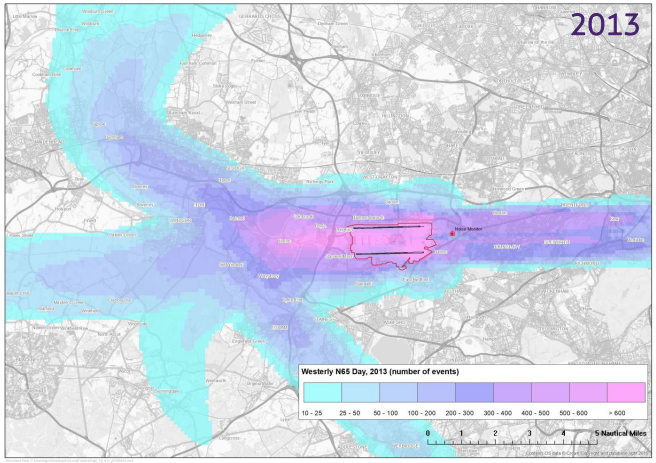
- The figures to the right show the 2013 and 2017 daytime $L_{Aeq,16hr}$ bands in the left column and N65 bands in the right column for **an average summer day when the airport is on 100% westerly operations**.
- The position of the noise monitor is marked by the red dot.
- The N65 is defined as the number of aircraft noise events where the L_{Amax} exceeds 65dB over the 16 hour day period 07:00-23:00.
- Larger figures are shown in Appendix A.

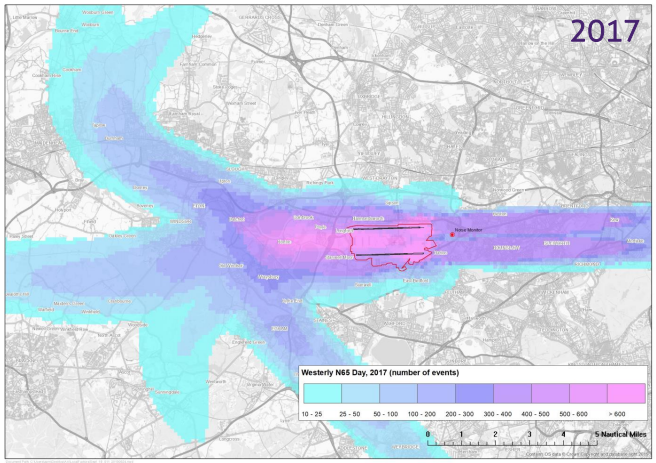
$L_{Aeq,16hr}$





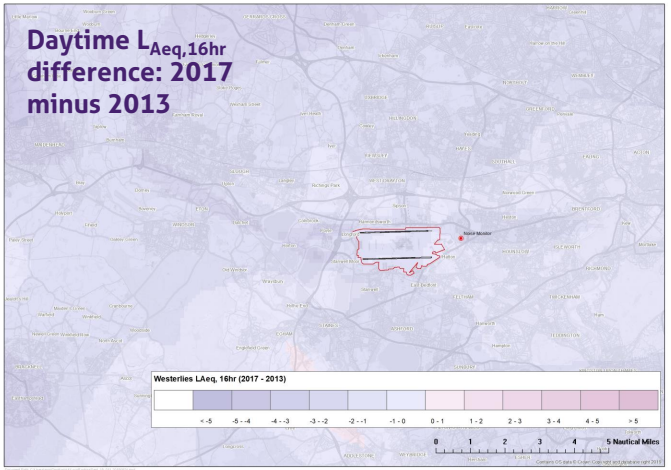
N65, Daytime

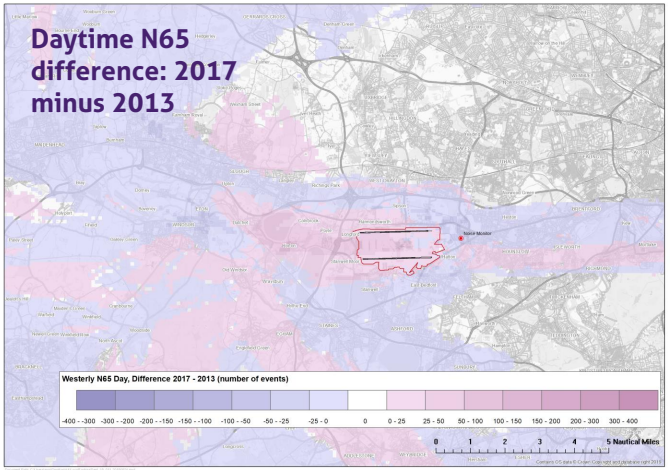




Differences in average **daytime** aircraft noise levels – westerly operations

- The difference in the modelled average $L_{Aeq,16hr}$ and $N65_{16hr}$ contours around Heathrow between 2013 and 2017 are shown in the figures to the right. This is for **an average summer day when the airport is on 100% westerly operations**.
- The upper image shows the change in daytime $L_{Aeq,16hr}$ and the bottom image shows the change in daytime $N65_{16hr}$. Areas with a decrease in average exposure are shown in blue and those areas with an increase in average exposure shown in pink.
- At Cranford, there was approximately a 1dB decrease in average modelled daytime $L_{Aeq,16hr}$ noise level between 2013 and 2017, while the modelling also indicates an decrease of up to 25 daytime N65 events.
- It should be noted that, all other variables remaining constant, a difference of approximately 20-25% in number of noise events, would correspond to about a 1dB increase/decrease in $L_{Aeq,16hr}$ and a 100% difference would correspond to about a 3dB increase/decrease in $L_{Aeq,16hr}$.
- Larger figures are shown in Appendix A.

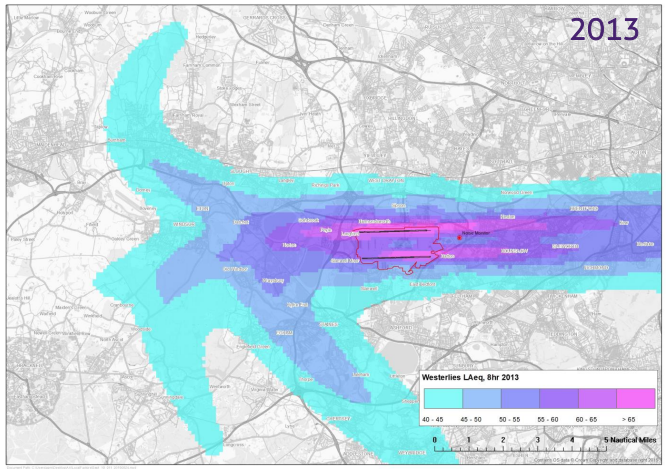


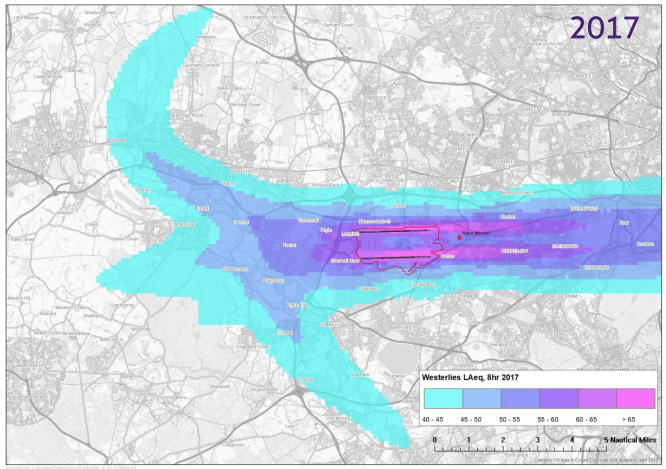


Average **night-time** aircraft noise levels – westerly operations

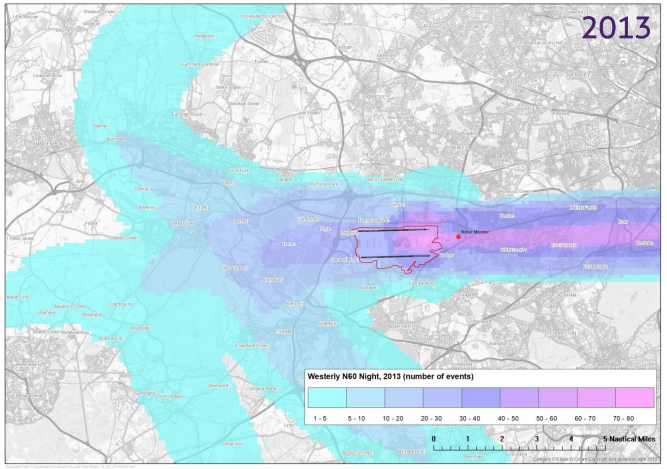
- The figures to the right show the 2013 and 2017 night-time $L_{Aeq,8hr}$ bands in the left column and N60 bands in the right column. This is an average noise level on **an average summer night 23:00-07:00 when there are 100% westerly operations**.
- The $L_{Aeq,8hr}$ contours are presented in 5dB intervals from >40 to >65dB.
- The N60 is defined here as the number of aircraft noise events that exceed 60dB over the 8 hour night period 23:00-07:00.
- Larger figures are shown in Appendix A.

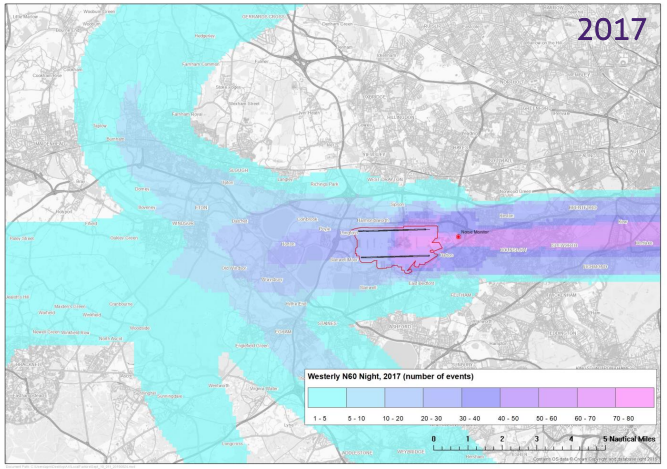
Night-time $L_{Aeq,8hr}$





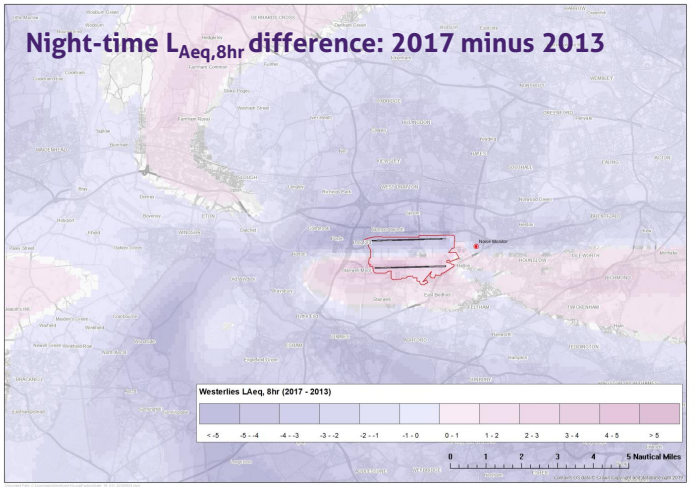
N60, Night-time

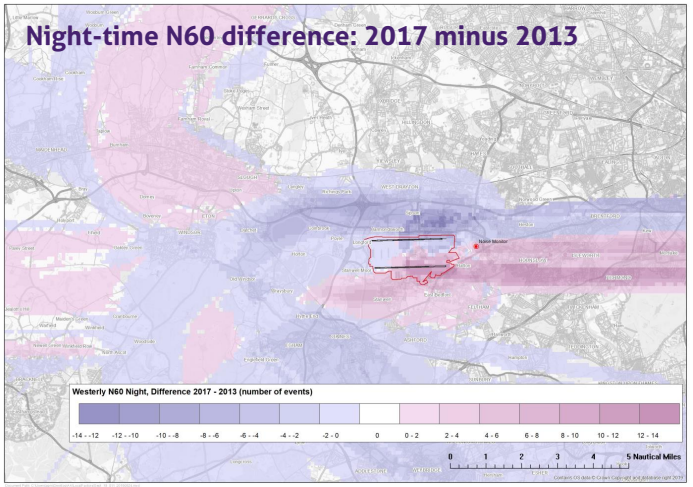




Differences in average **night-time** aircraft noise levels – westerly operations

- The difference in the modelled average $L_{Aeq,8hr}$ (upper figure) and $N60_{8hr}$ (lower figure) values **on 100% westerly operations** around Heathrow between 2013 and 2017 are shown in the figures to the right.
- Areas with an average decrease are shown in blue and those areas with an average increase in pink.
- The results indicate a decrease in average night-time aircraft noise $L_{Aeq,8hr}$ decreased by approximately 1dB. However, the N60 increased by up to two at Cranford from 2013 to 2017.
- It would appear that a change to the proportion of arrivals using each runway is the main driver for changes to the noise environment under the arrival paths on westerly operations. This is since the area in line with the approach to the northern runway generally experiences a decrease in noise, while the area in line with the approach to the southern runway generally experiences an increase in noise.
- Larger figures are shown in Appendix A.

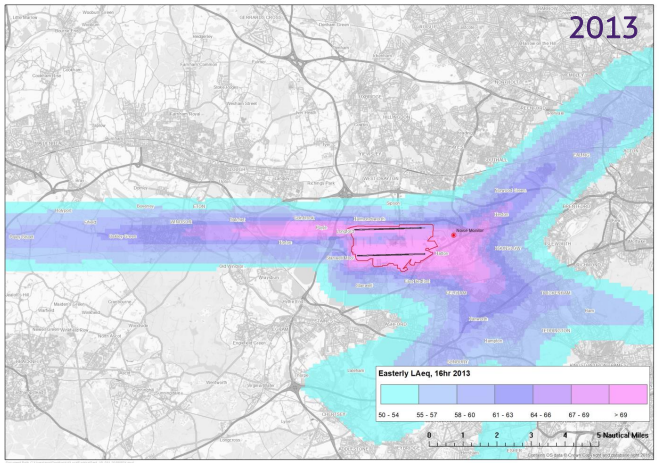


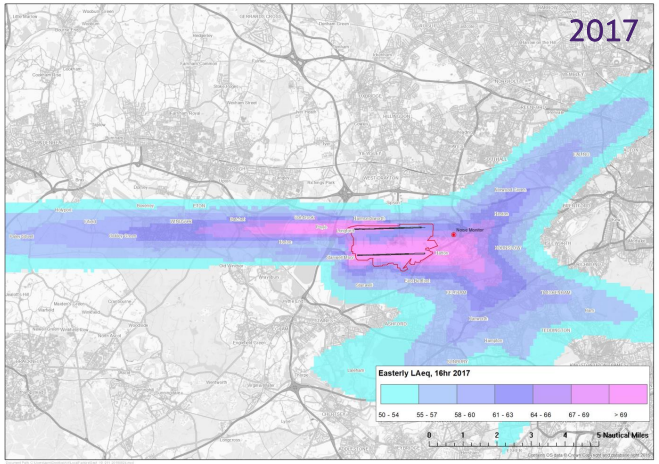


Average **daytime** aircraft noise levels – easterly operations

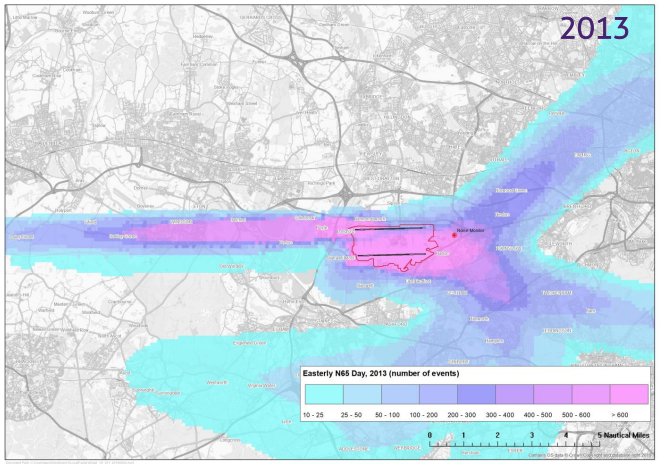
- The figures to the right show the 2013 and 2017 daytime $L_{Aeq,16hr}$ bands in the left column and N65 bands in the right column for **an average summer day when the airport is on 100% easterly operations**.
- The position of the noise monitor is marked by the red dot.
- The N65 is defined as the number of aircraft noise events where the L_{Amax} exceeds 65dB over the 16 hour day period 07:00-23:00.
- Larger figures are shown in Appendix A.

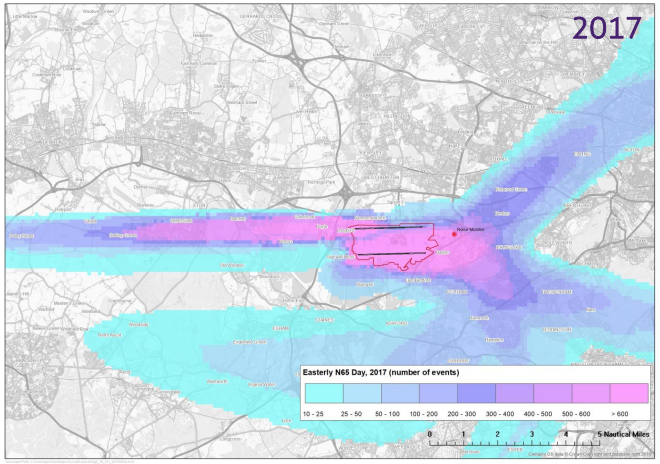
$L_{Aeq,16hr}$





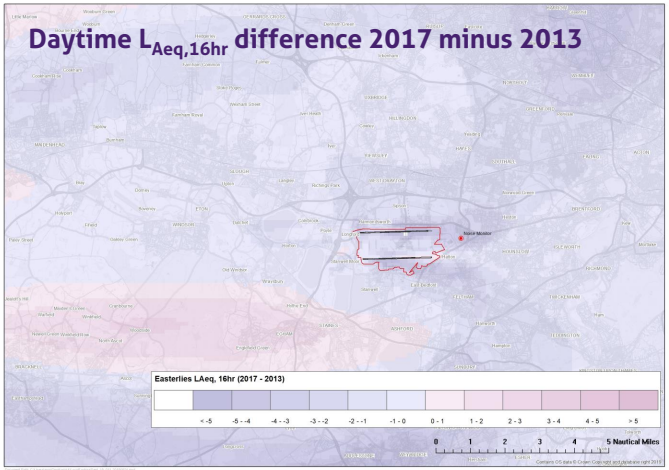
N65, Daytime

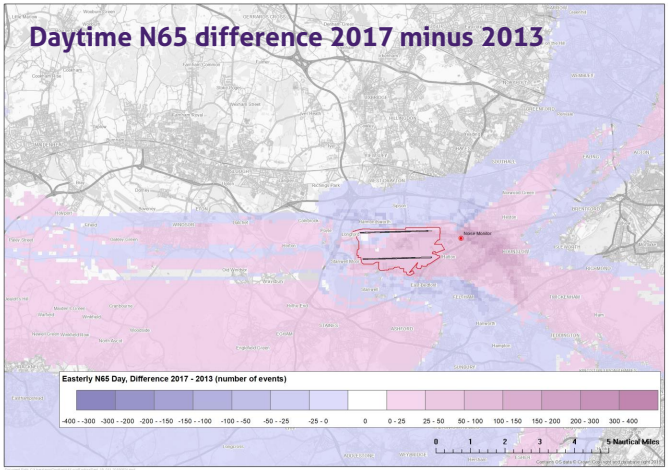




Differences in average **daytime** aircraft noise levels – easterly operations

- The difference in the modelled average $L_{Aeq,16hr}$ and $N65_{16hr}$ contours around Heathrow between 2013 and 2017 are shown in the figures to the right. This is for **an average summer day when the airport is on 100% easterly operations**.
- The upper image shows the change in daytime $L_{Aeq,16hr}$ and the bottom image shows the change in daytime $N65_{16hr}$. Areas with a decrease in average exposure are shown in blue and those areas with an increase in average exposure shown in pink.
- At Cranford there was a decrease of approximately 2dB in average modelled daytime noise level $L_{Aeq,16hr}$ between 2013 and 2017; however, the modelling indicates an increase of up to 50 daytime N65 events.
- It should be noted that, all other variables remaining constant, a difference of approximately 20-25% in number of noise events would correspond to about a 1dB increase/decrease in $L_{Aeq,16hr}$, whilst a 100% difference would correspond to about a 3dB increase/decrease in $L_{Aeq,16hr}$.
- Larger figures are shown in Appendix A.

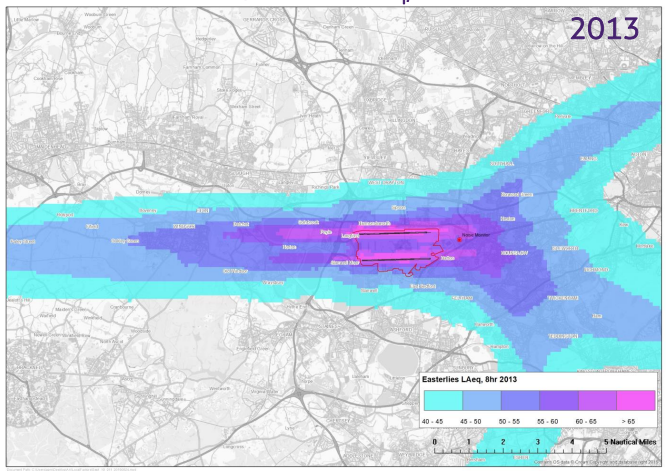


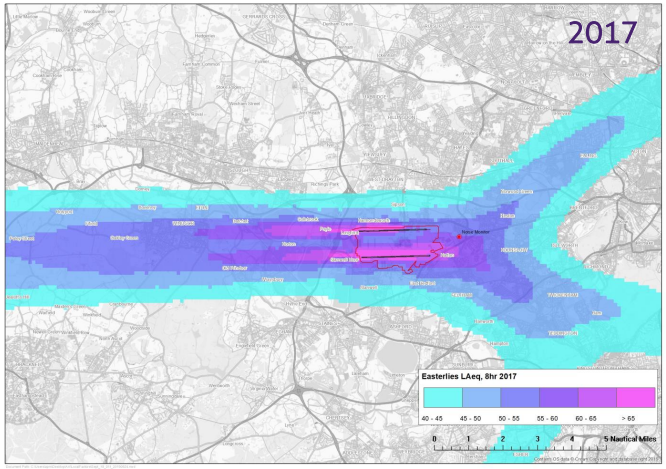


Average **night-time** aircraft noise levels – easterly operations

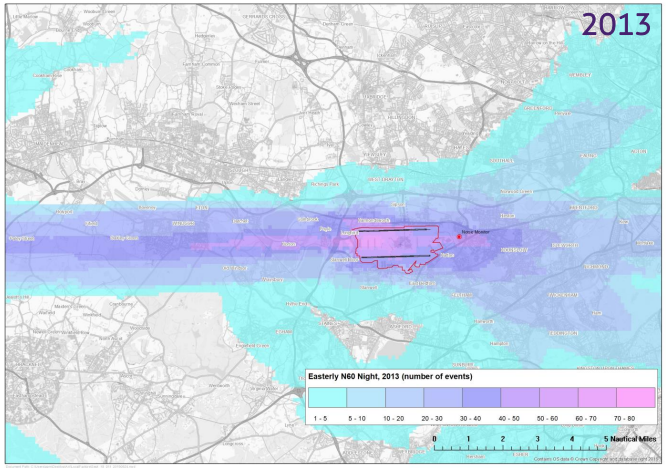
- The figures to the right show the 2013 and 2017 night-time $L_{Aeq,8hr}$ bands in the left column and N60 bands in the right column. This is an average noise level on **an average summer night 23:00-07:00 when there are 100% easterly operations**.
- The $L_{Aeq,8hr}$ contours are presented in 5dB intervals from >40 to >65dB.
- The N60 is defined here as the number of aircraft noise events that exceed 60dB over the 8 hour night period 23:00-07:00.
- Larger figures are shown in Appendix A.

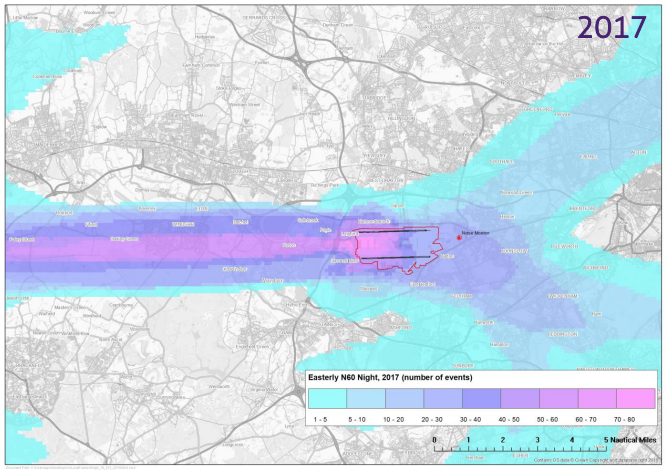
Night-time $L_{Aeq,8hr}$





N60, night-time

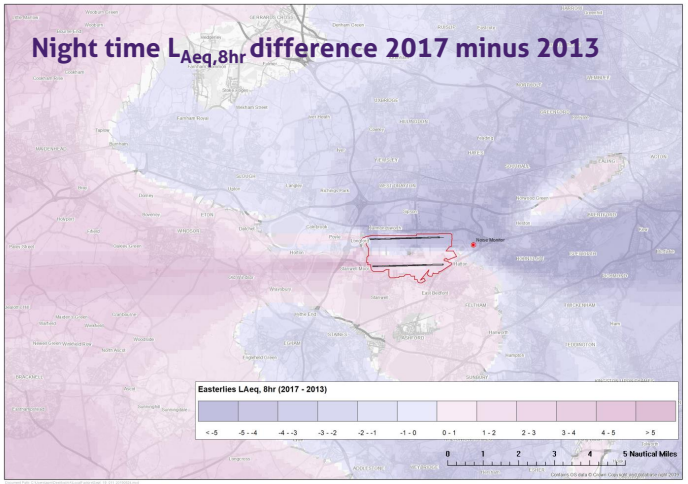


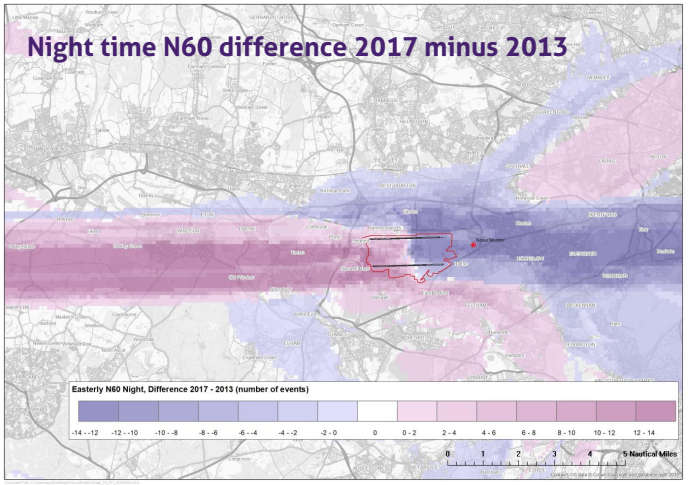


Differences in average **night-time** aircraft noise levels – easterly operations

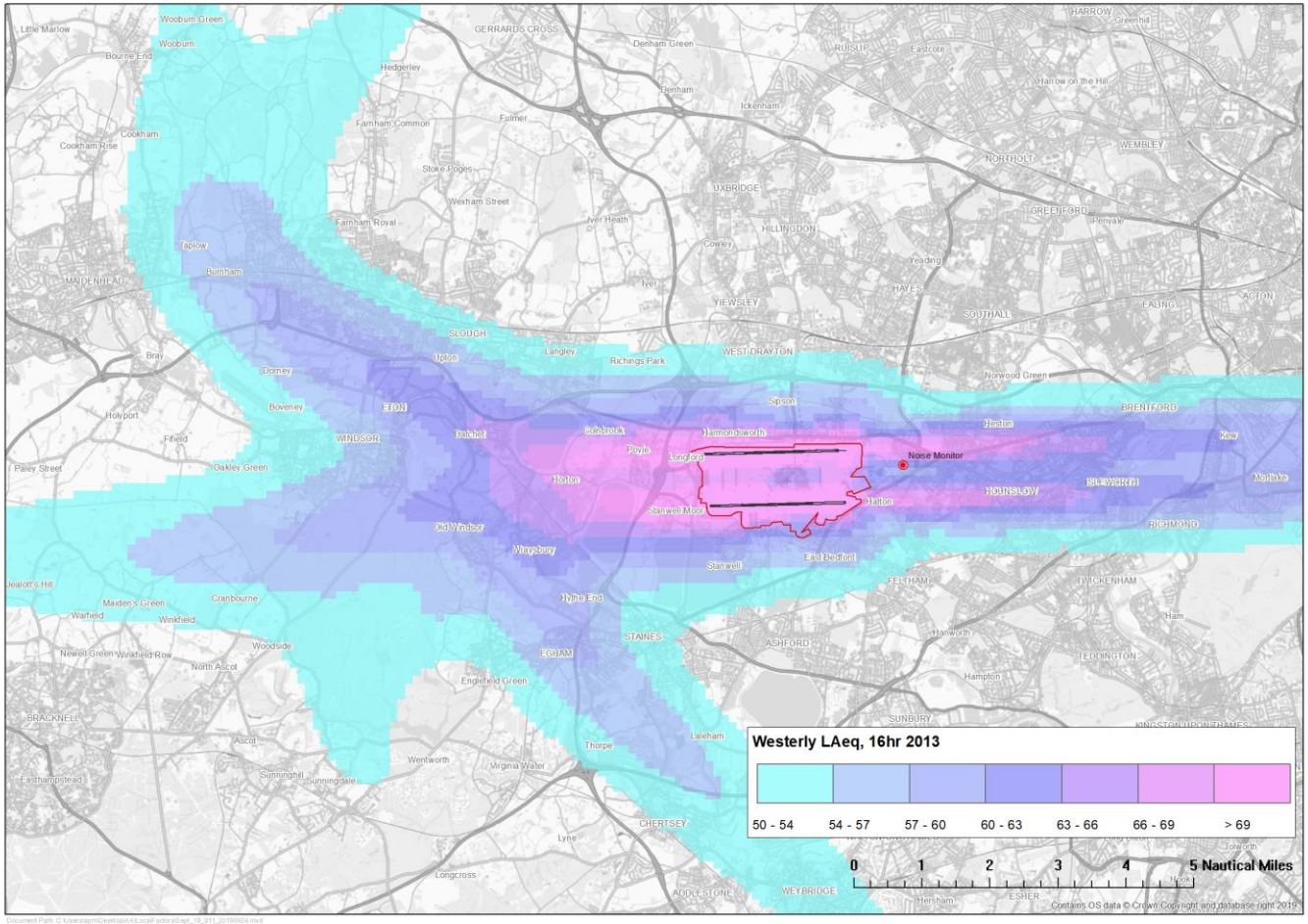
- The difference in the modelled average $L_{Aeq,8hr}$ (upper figure) and $N60_{(8\ hr)}$ (lower figure) values **on 100% westerly operations** around Heathrow between 2013 and 2017 are shown in the figures to the right.
- Areas with an average decrease are shown in blue and those areas with an average increase in pink.
- The results indicate a decrease in average night-time aircraft noise $L_{Aeq,8hr}$ of up to 3dB and a decrease in N60 of up to six at Cranford from 2013 to 2017.

- Larger figures are shown in Appendix A.

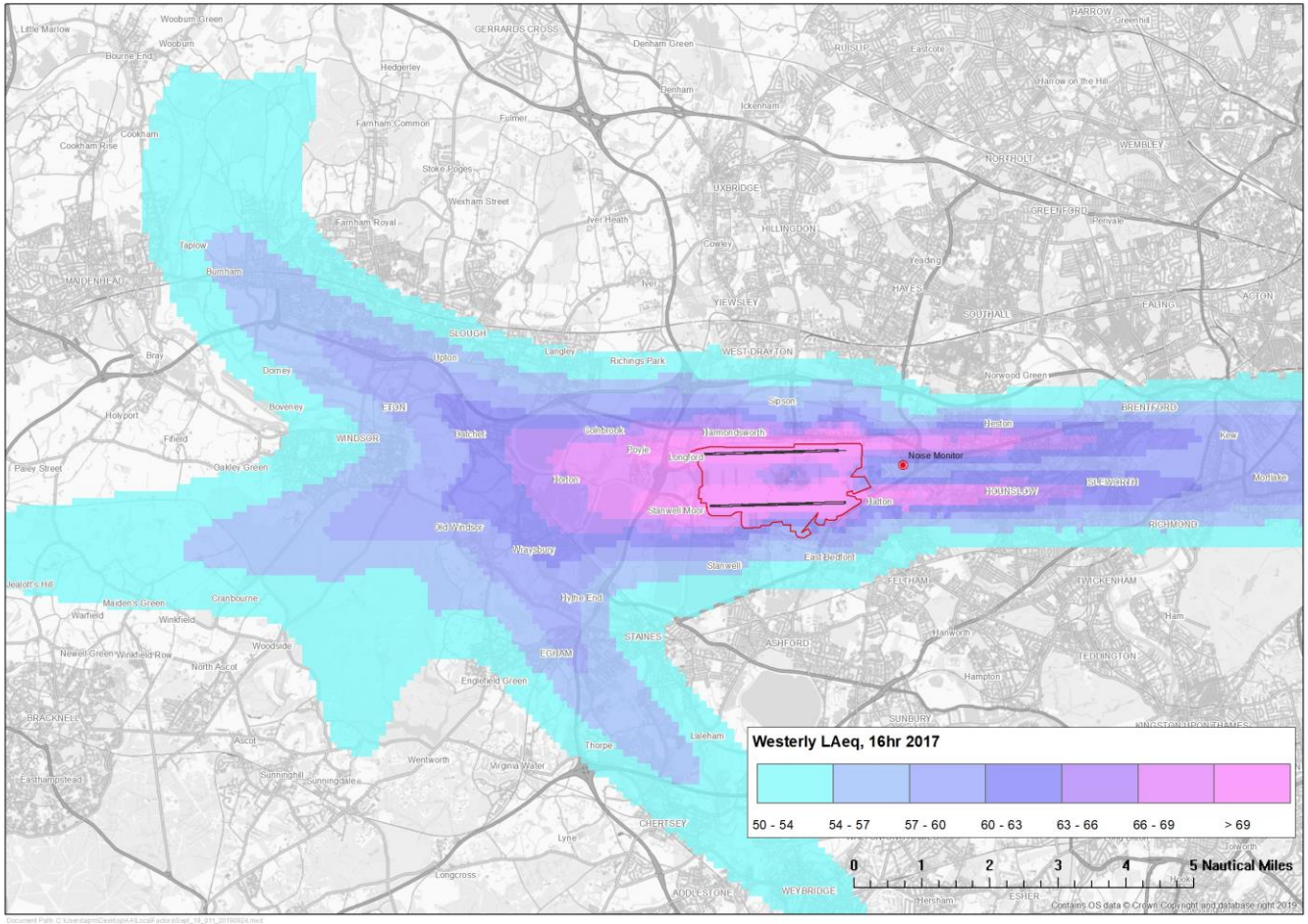




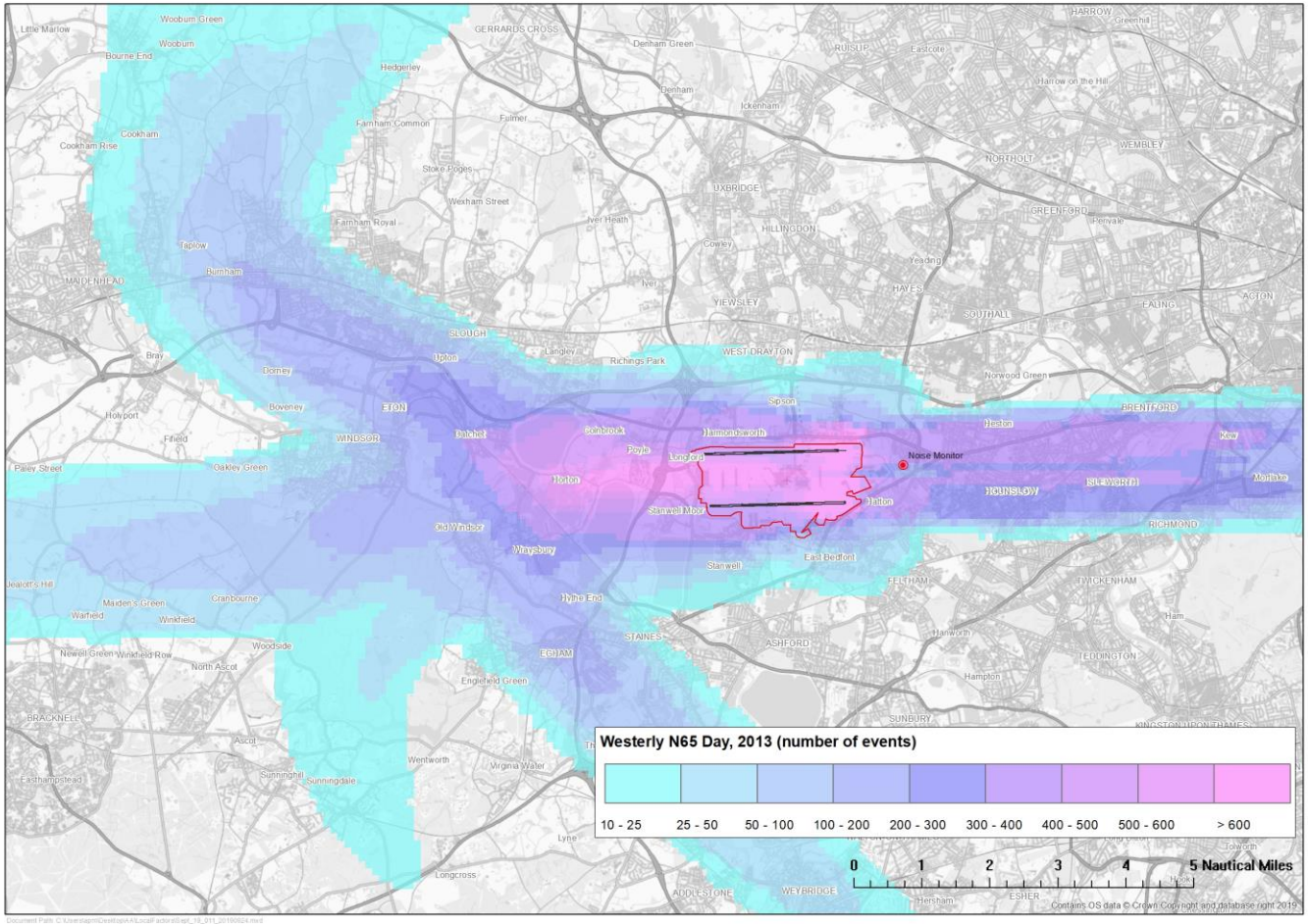
Appendix A: Average westerly day $L_{Aeq,16hr}$ contours (2013)



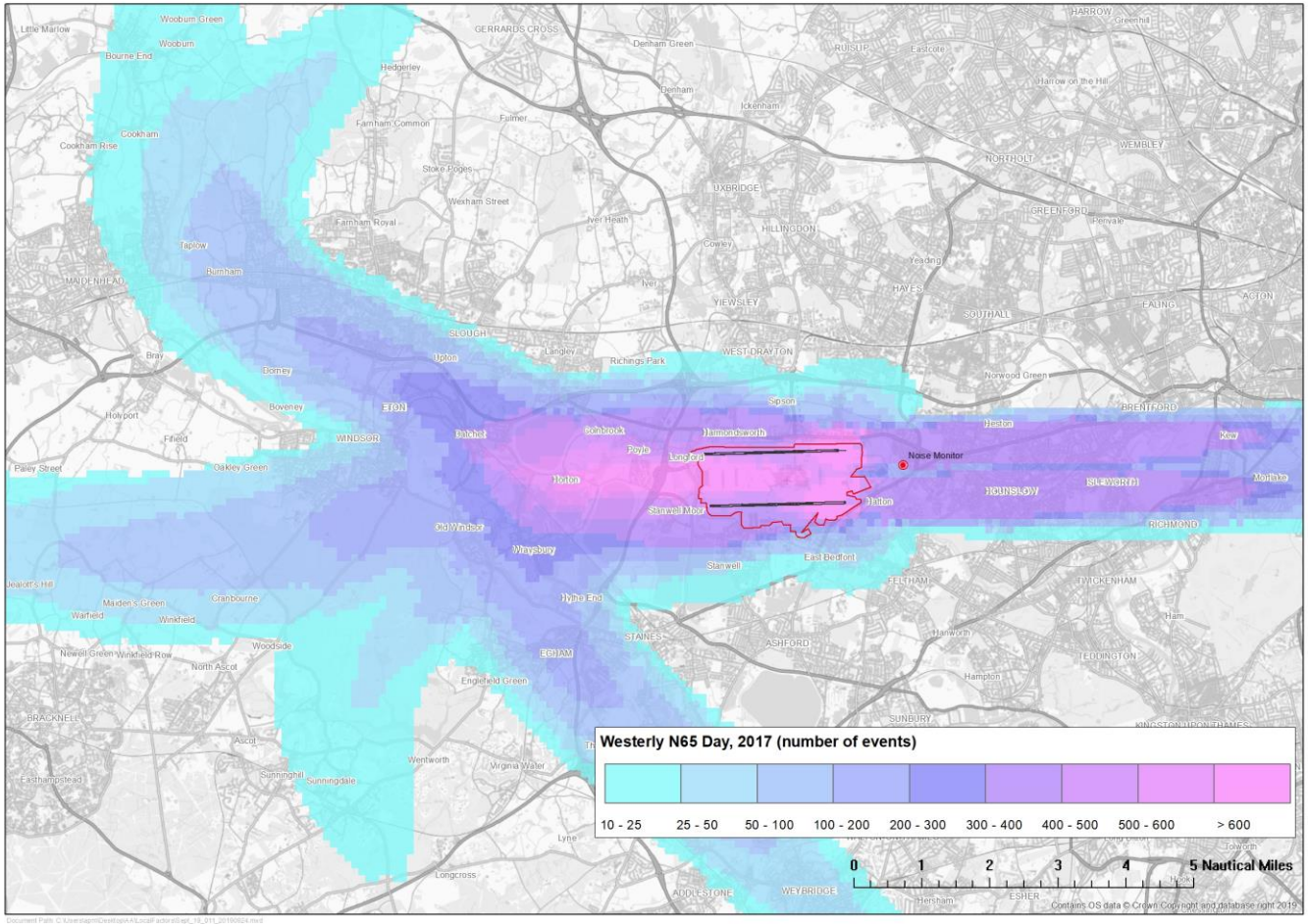
Appendix A: Average westerly day $L_{Aeq,16hr}$ contours (2017)



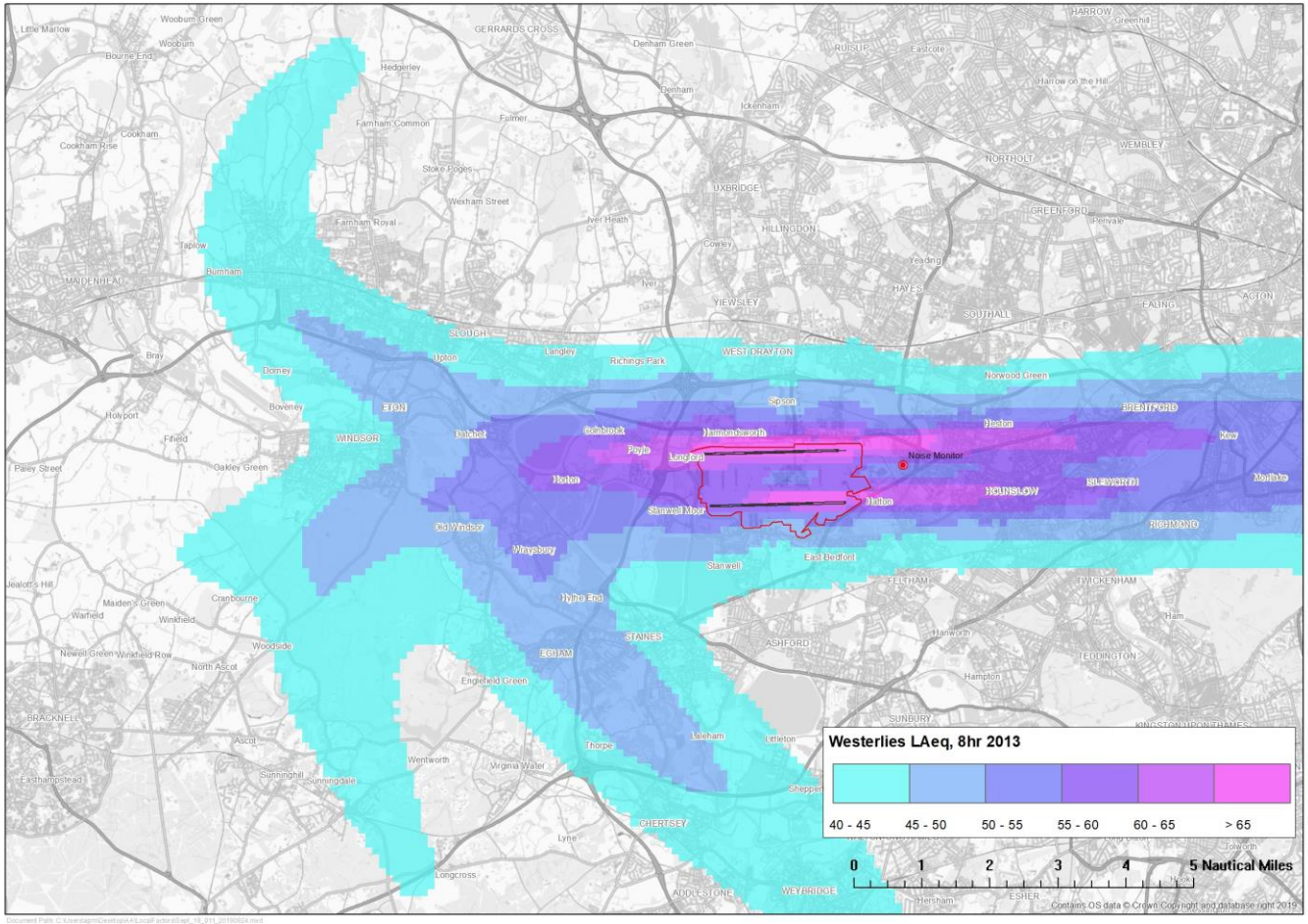
Appendix A: Average westerly day $N65_{16hr}$ contours (2013)



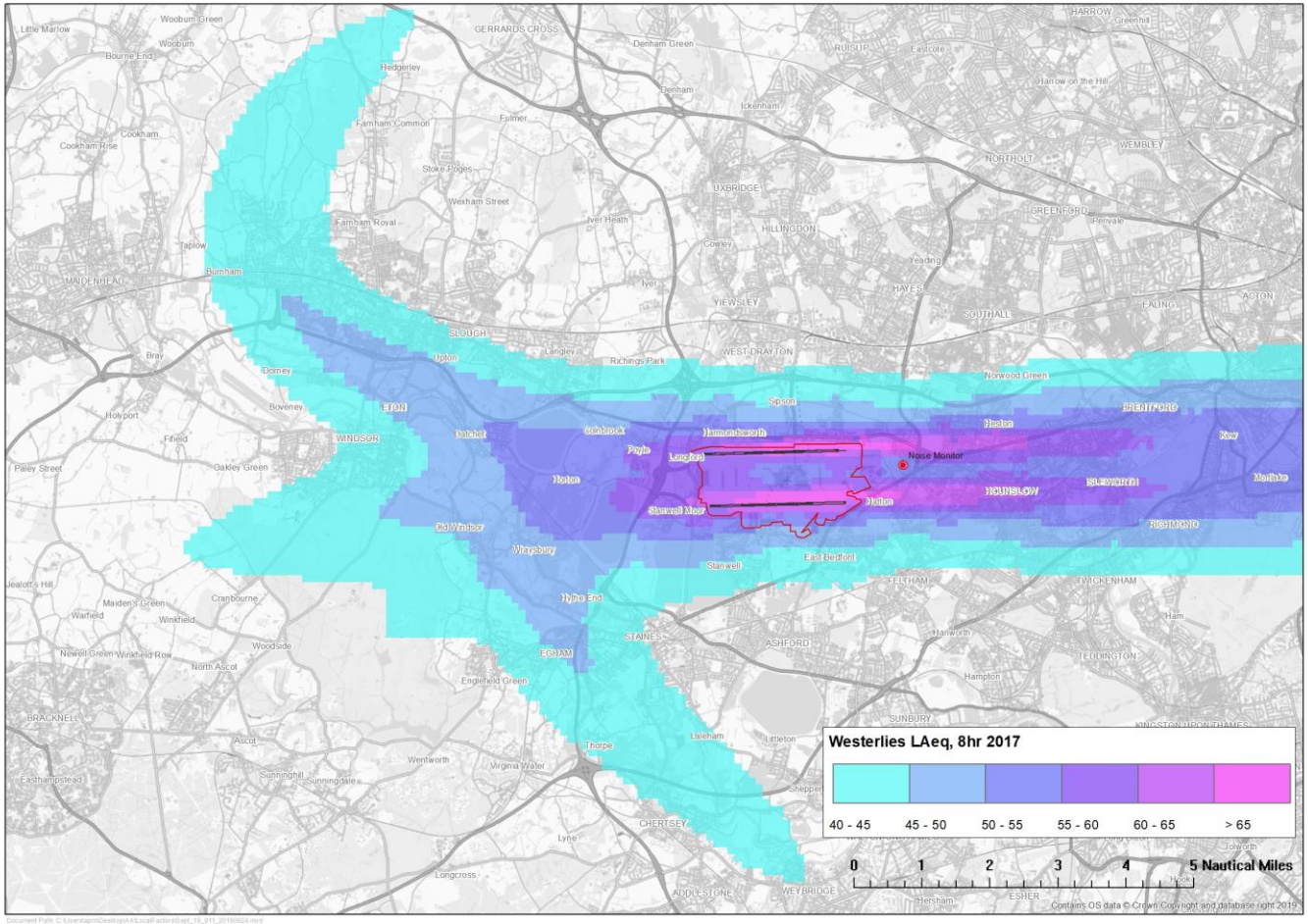
Appendix A: Average westerly day $N65_{16hr}$ contours (2017)



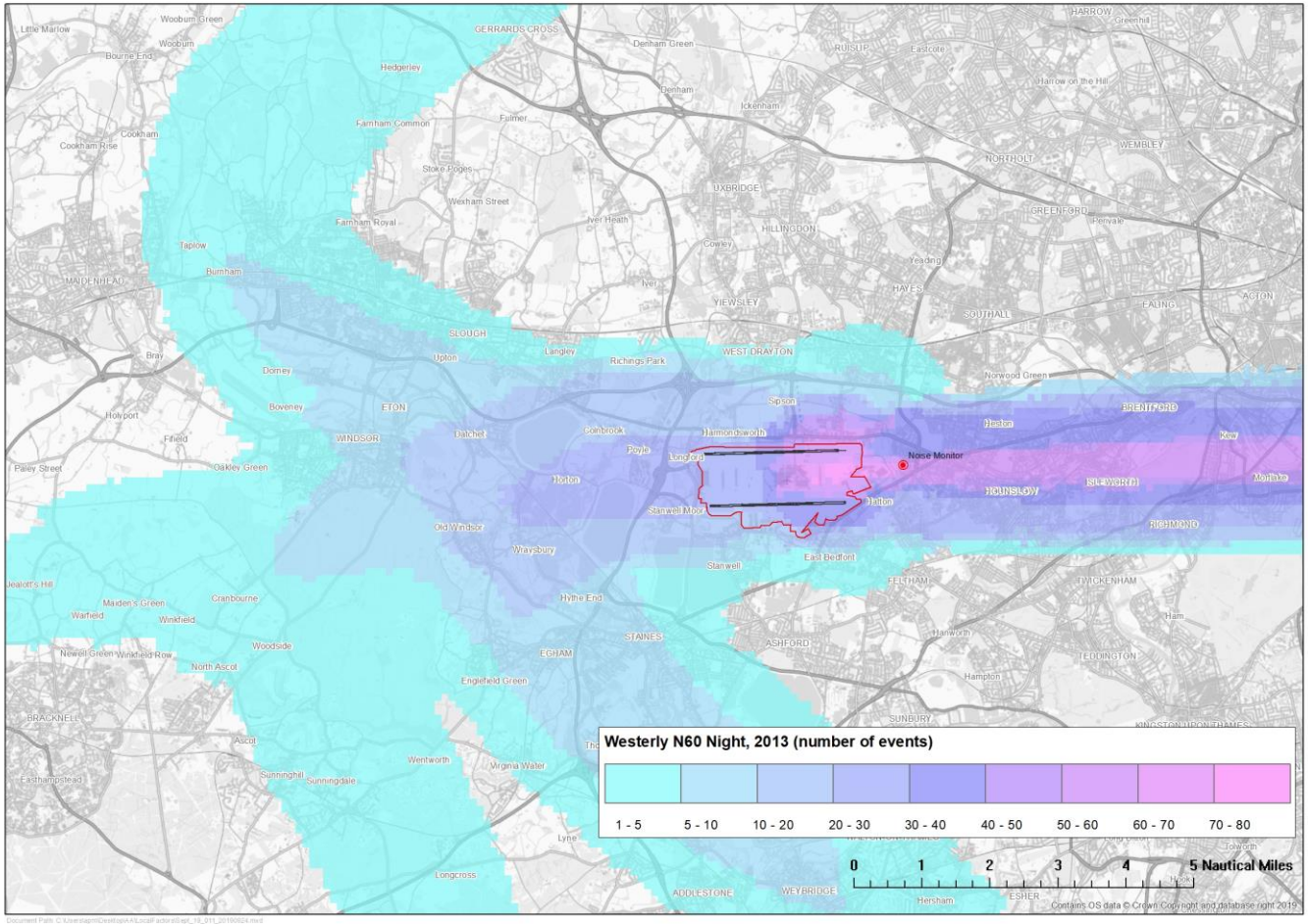
Appendix A: Average westerly night $L_{Aeq,8hr}$ contours (2013)



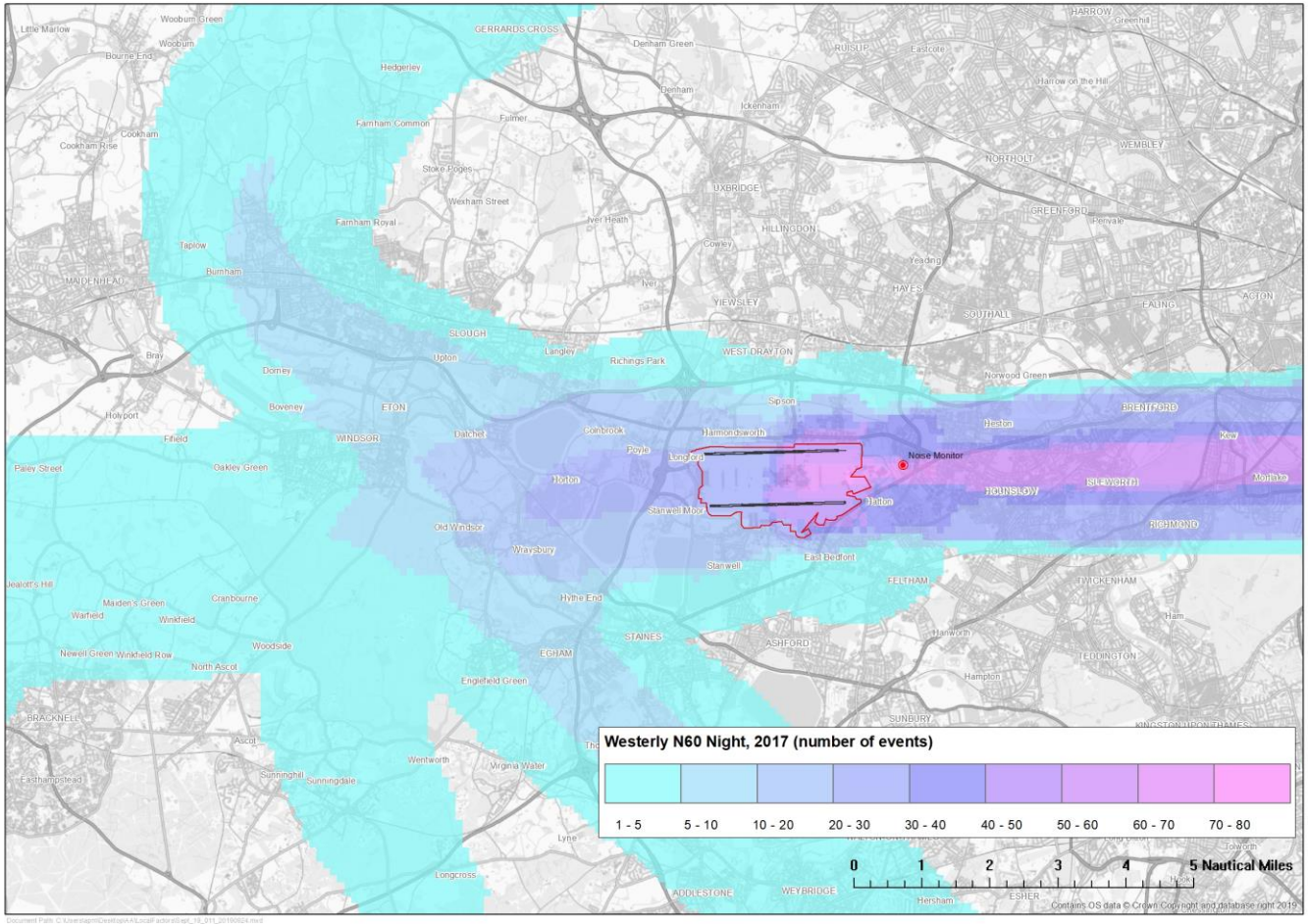
Appendix A: Average westerly night $L_{Aeq,8hr}$ contours (2017)



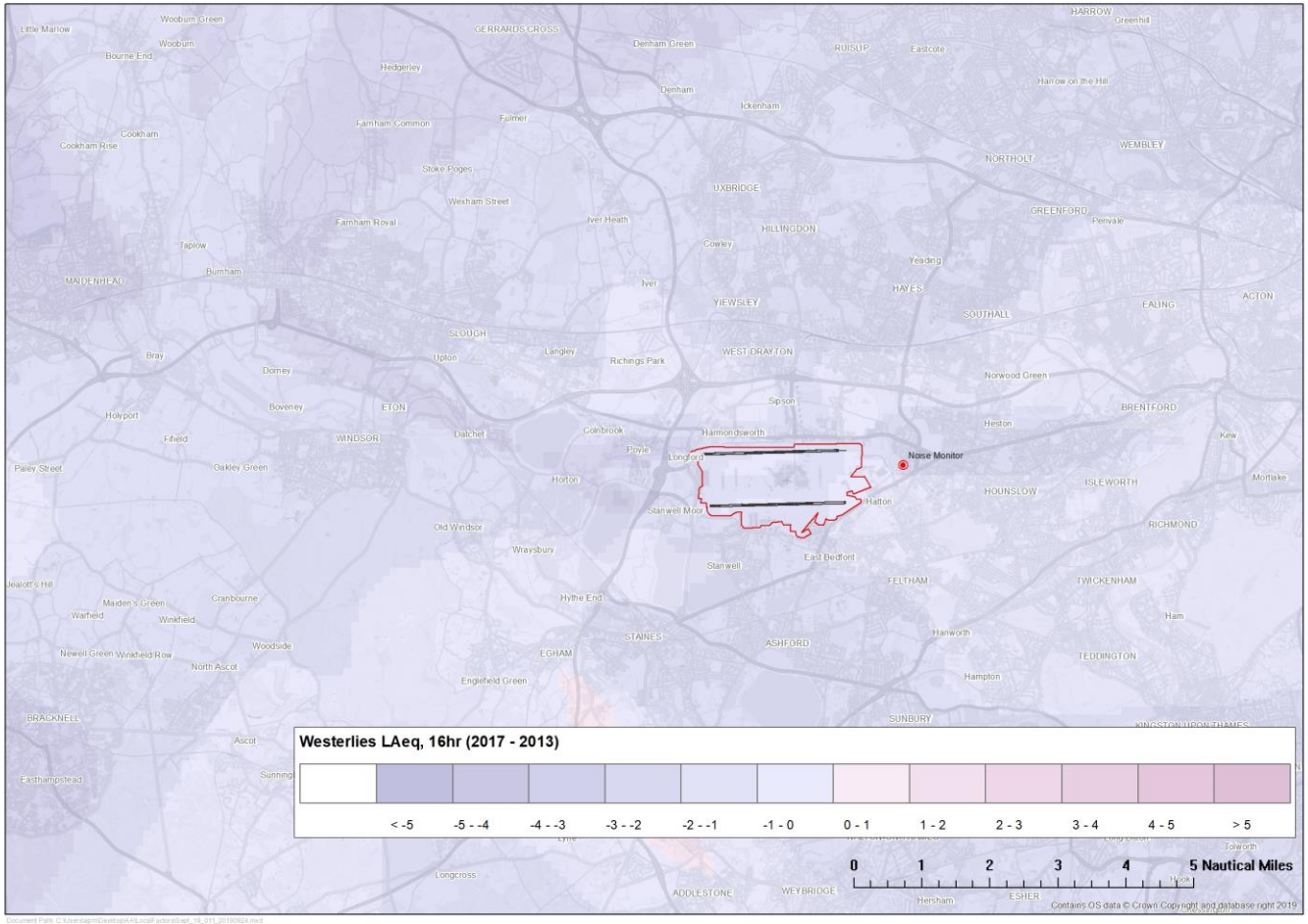
Appendix A: Average westerly night $N60_{8hr}$ contours (2013)



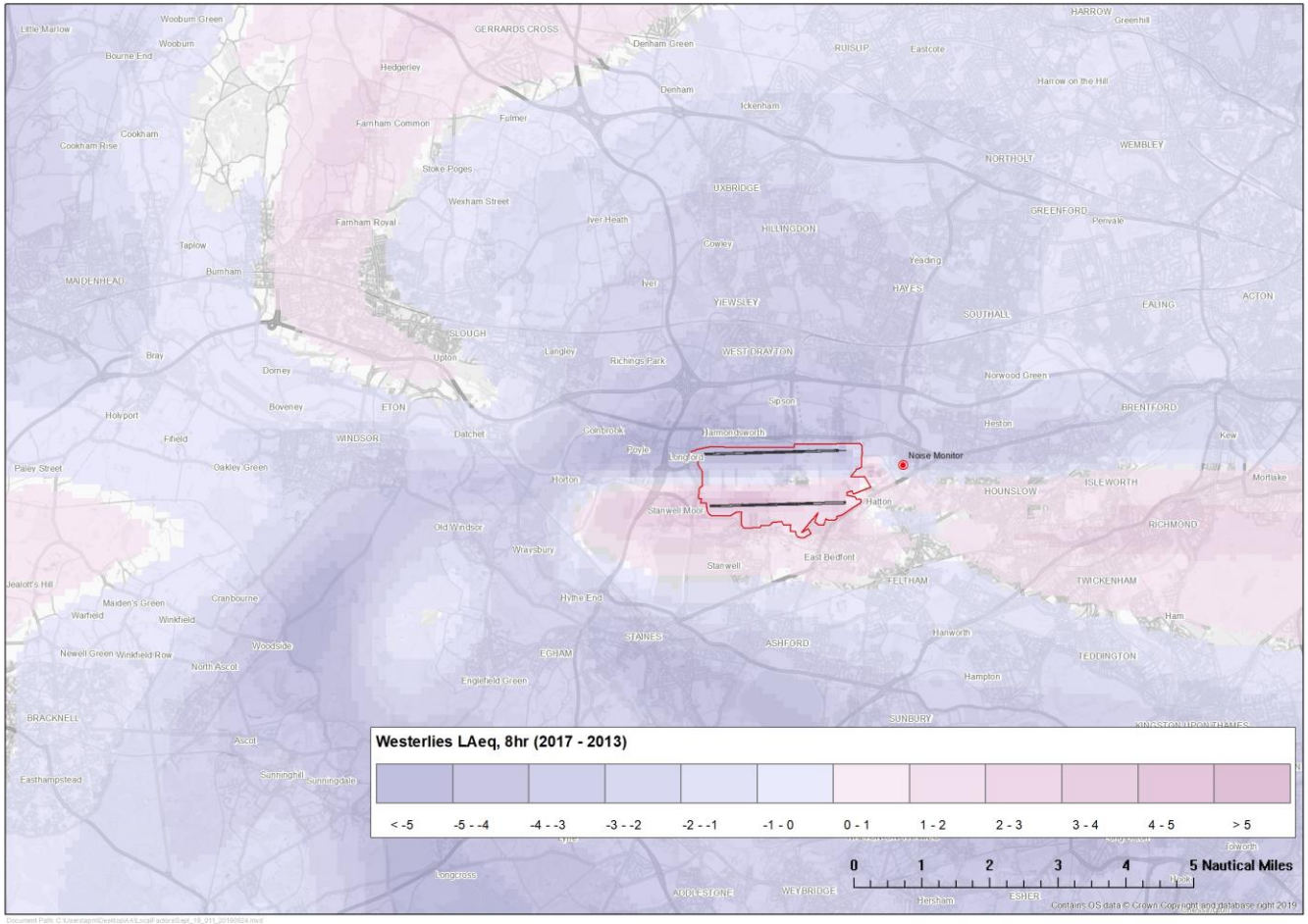
Appendix A: Average westerly night $N60_{8hr}$ contours (2017)



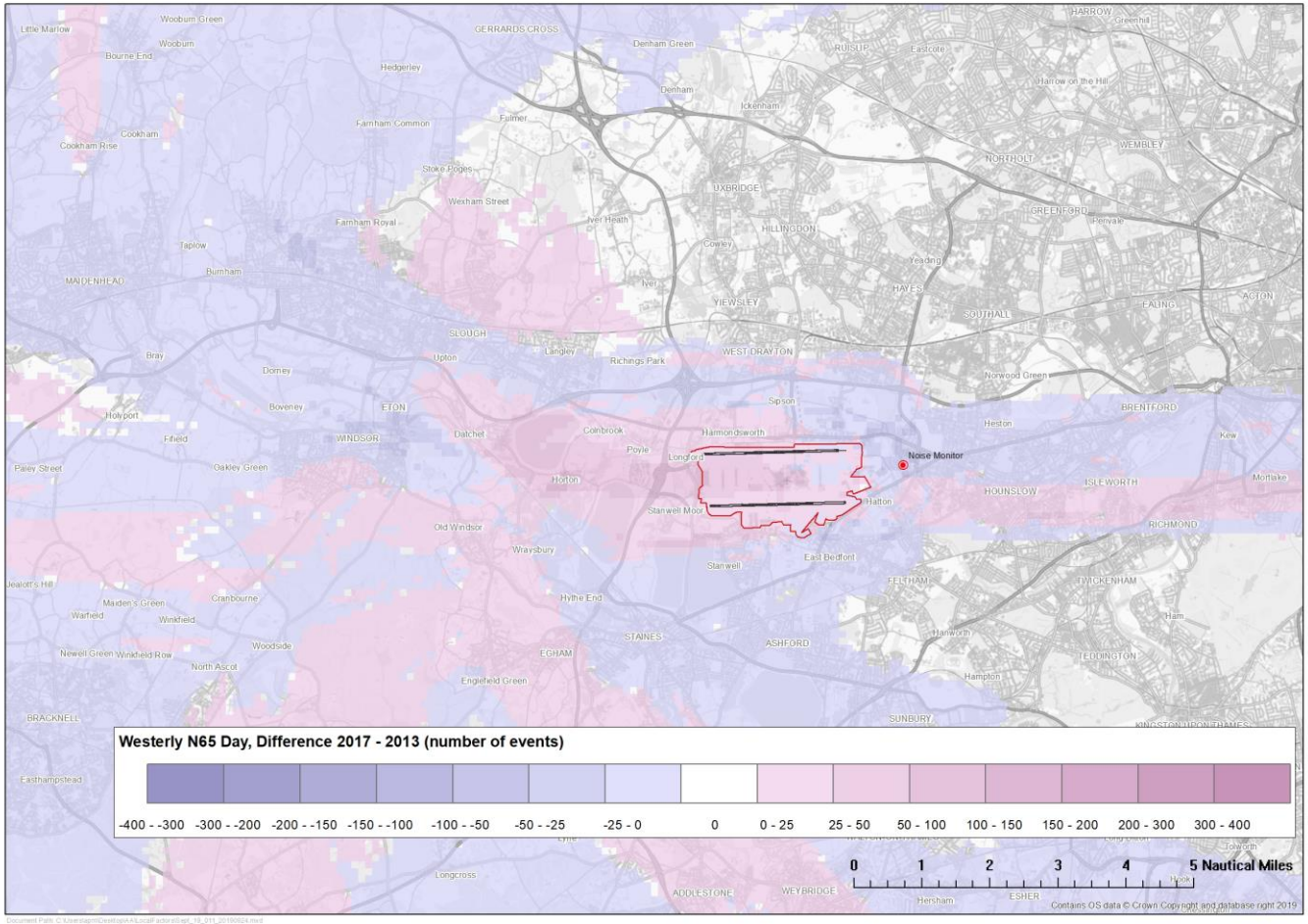
Appendix A: Average westerly day $L_{Aeq,16hr}$ difference (2017 minus 2013)



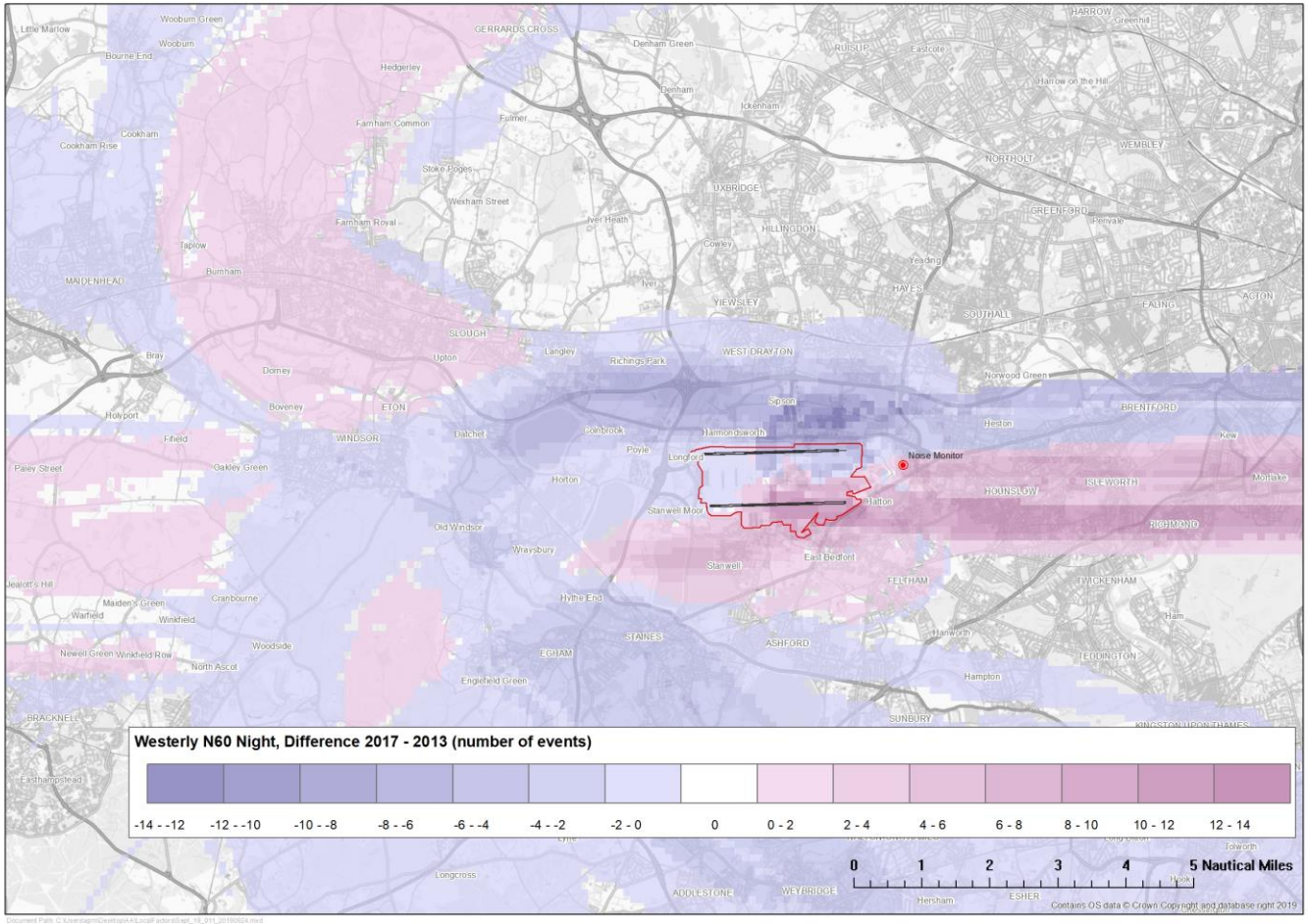
Appendix A: Average westerly night $L_{Aeq,8hr}$ difference (2017 minus 2013)



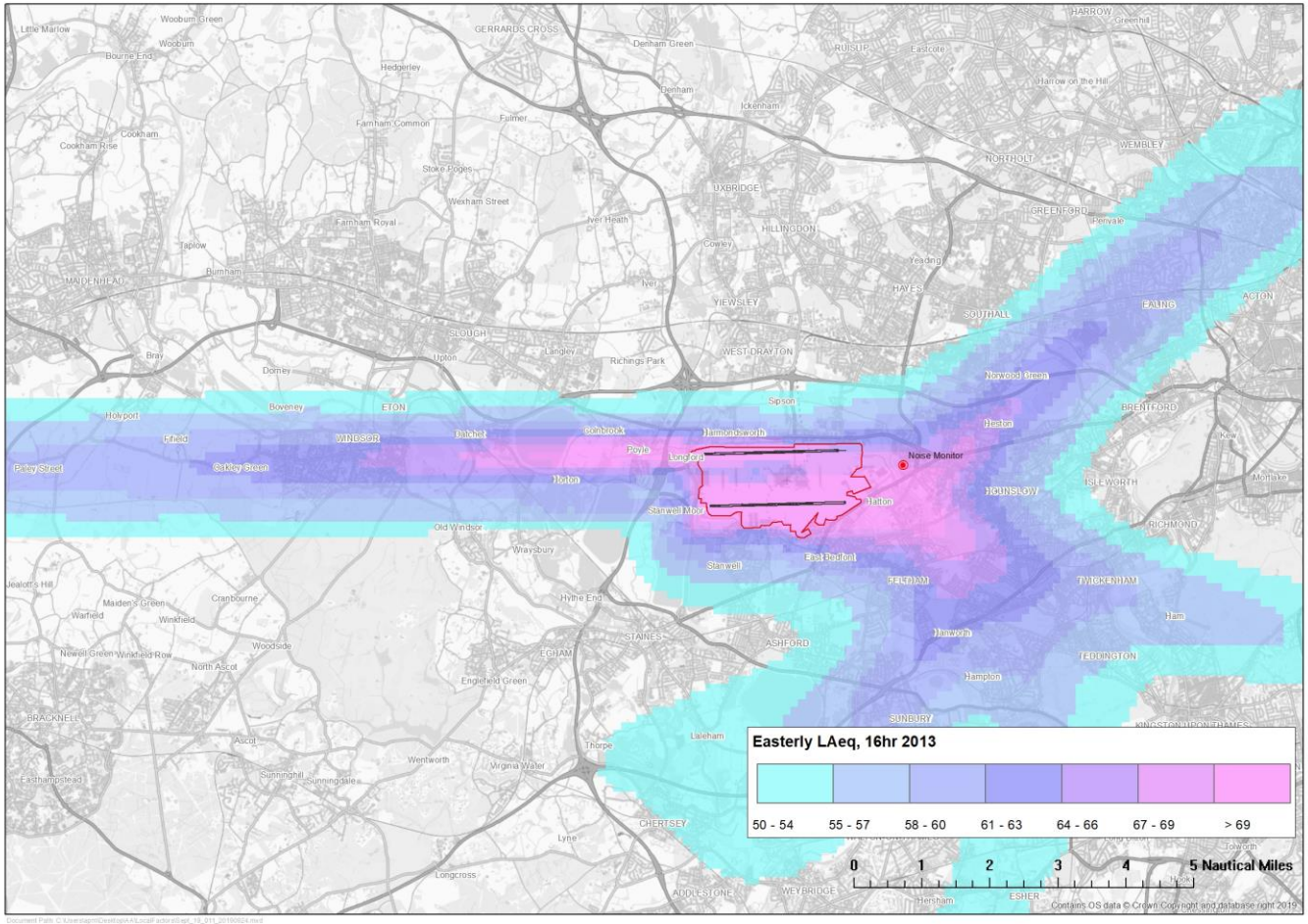
Appendix A: Average westerly day $N65_{16hr}$ difference (2017 minus 2013)



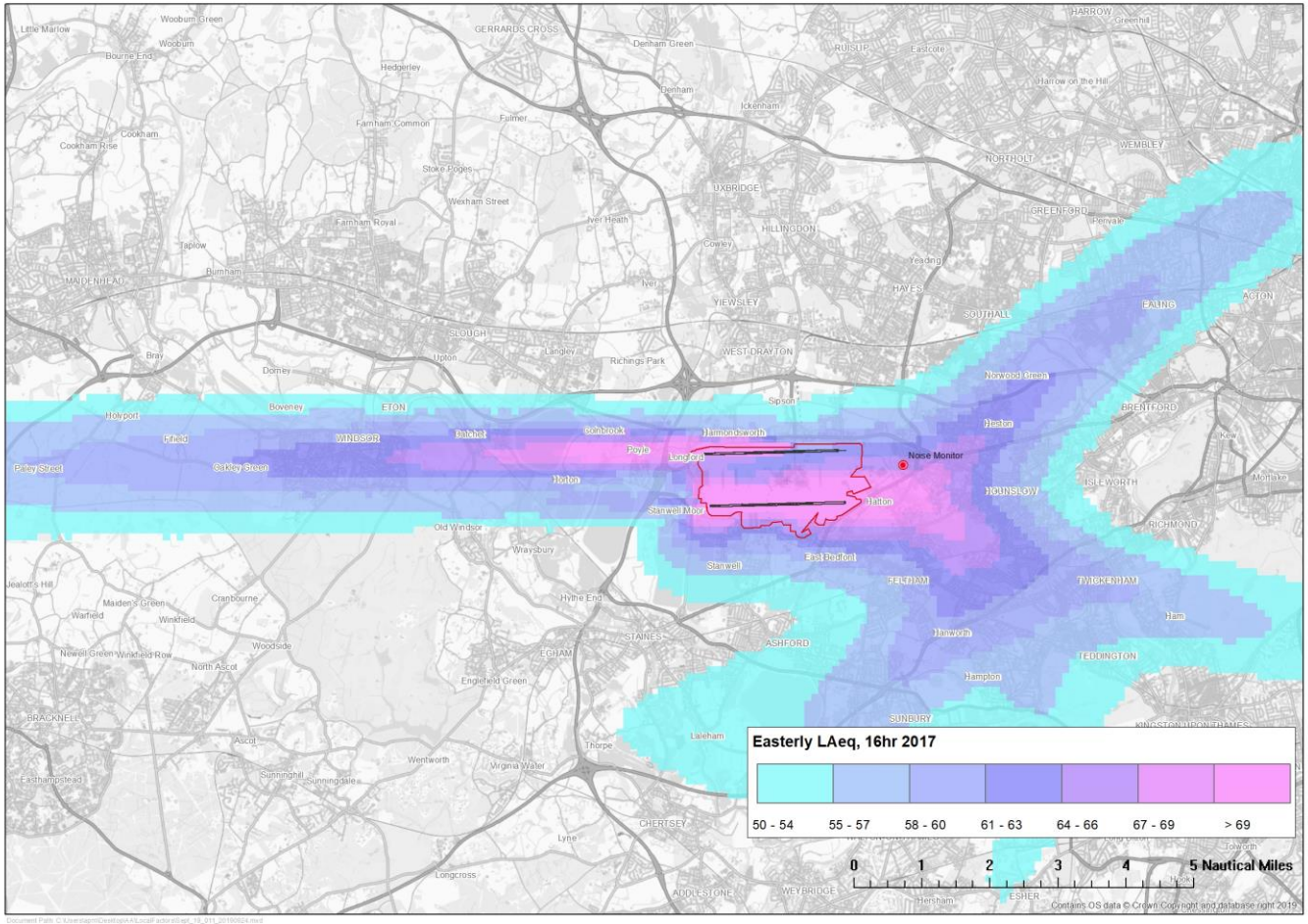
Appendix A: Average westerly night $N60_{8hr}$ difference (2017 minus 2013)



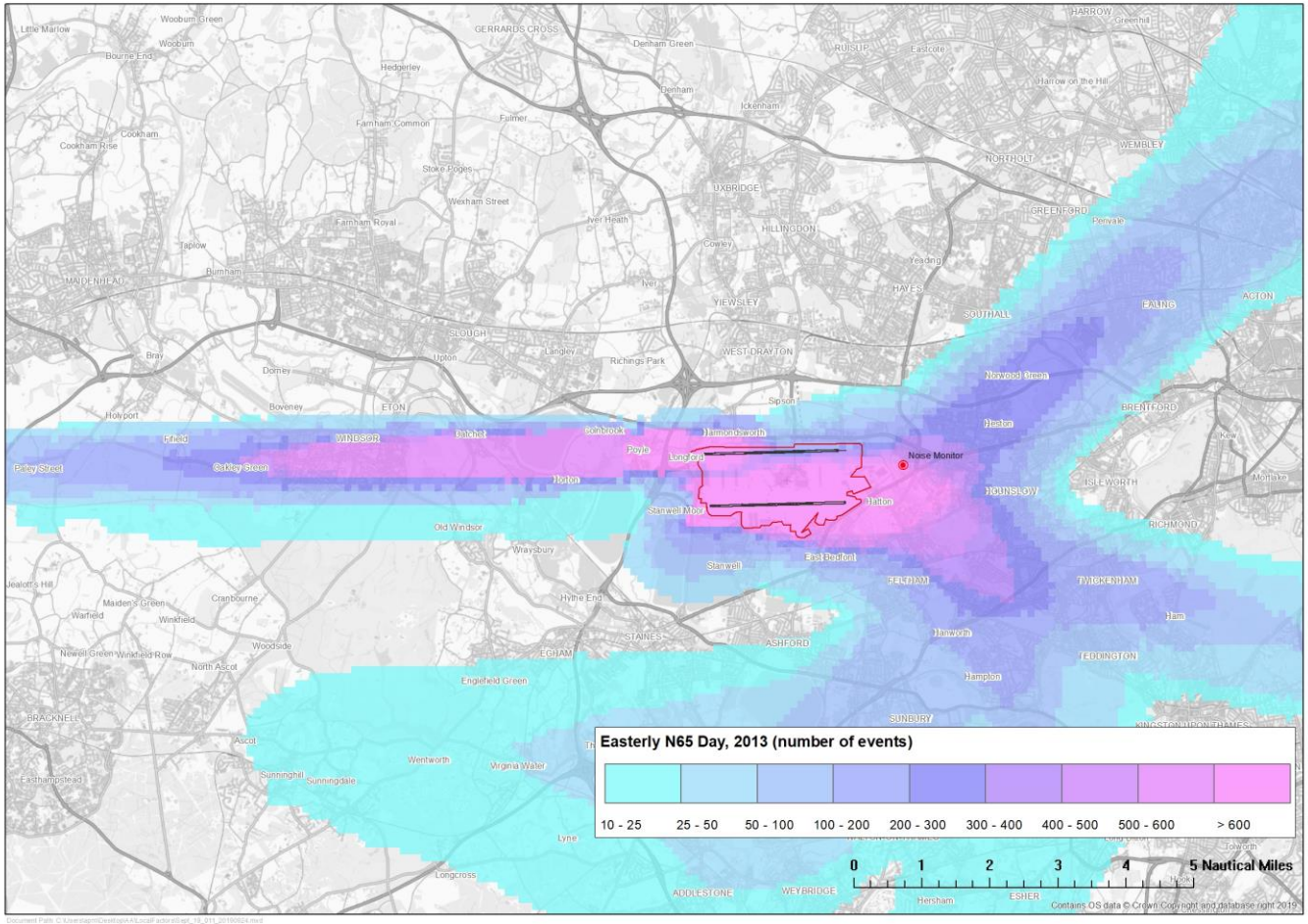
Appendix A: Average easterly day $L_{Aeq,16hr}$ contours (2013)



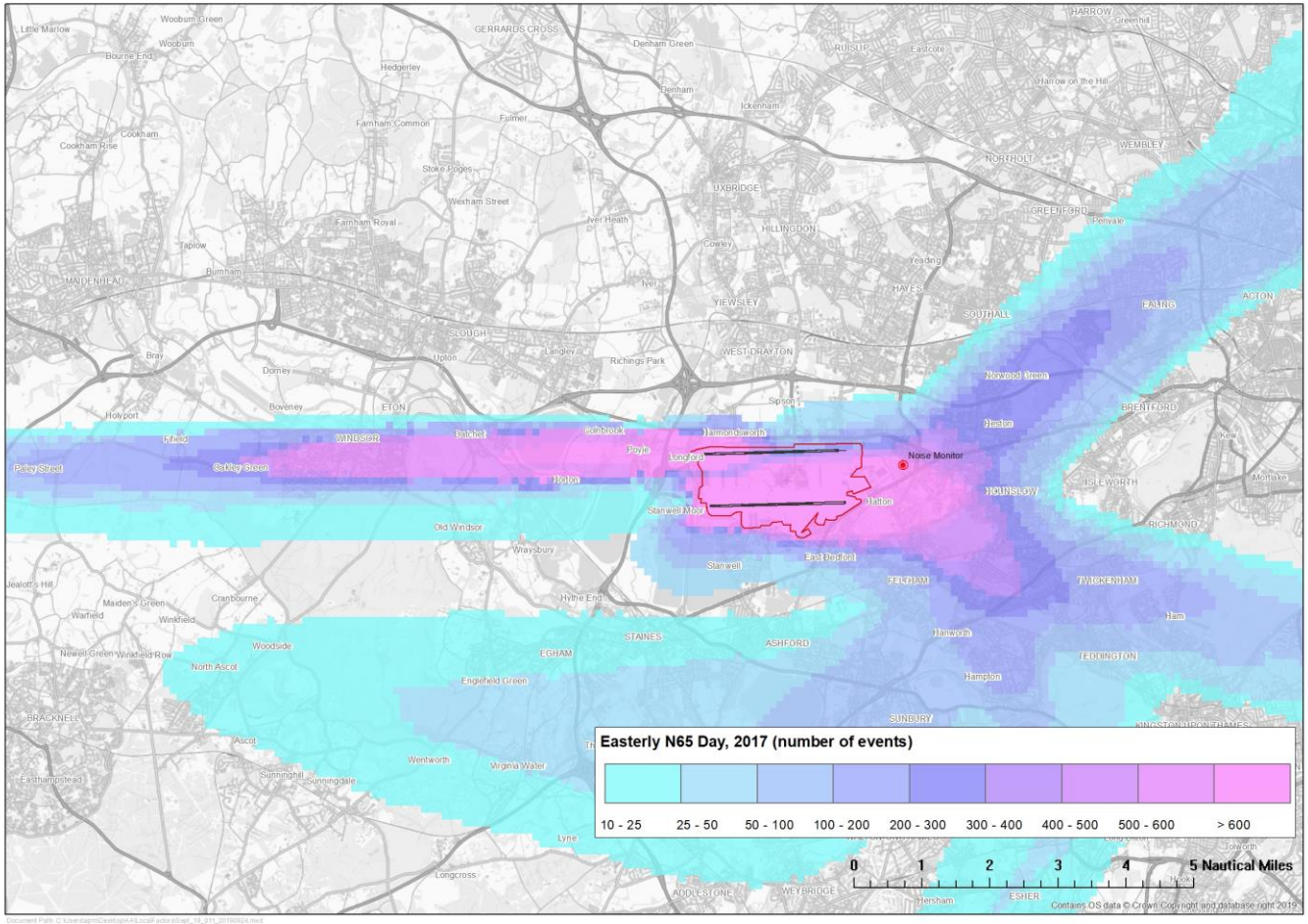
Appendix A: Average easterly day $L_{Aeq,16hr}$ contours (2017)



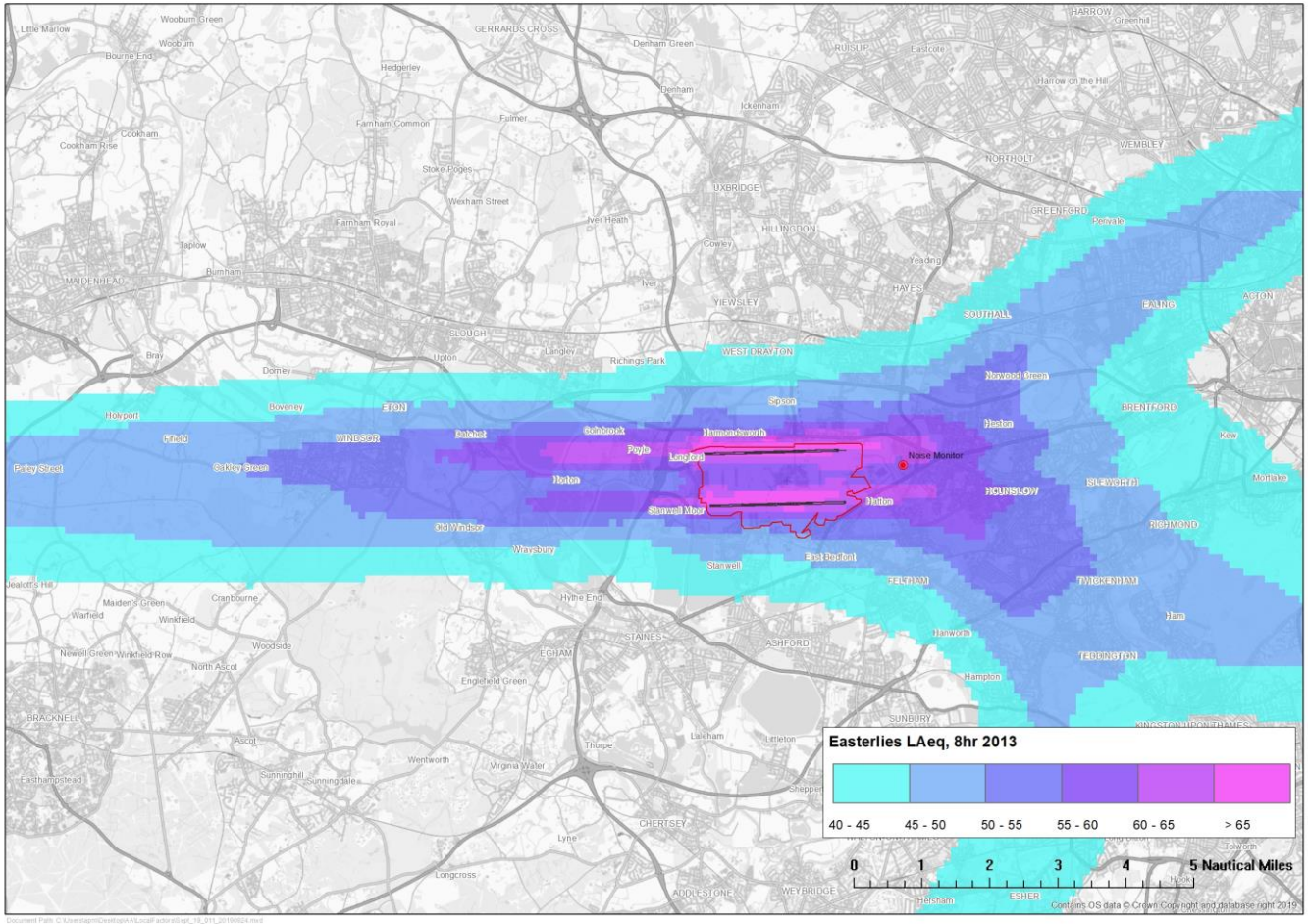
Appendix A: Average easterly day $N65_{16hr}$ contours (2013)



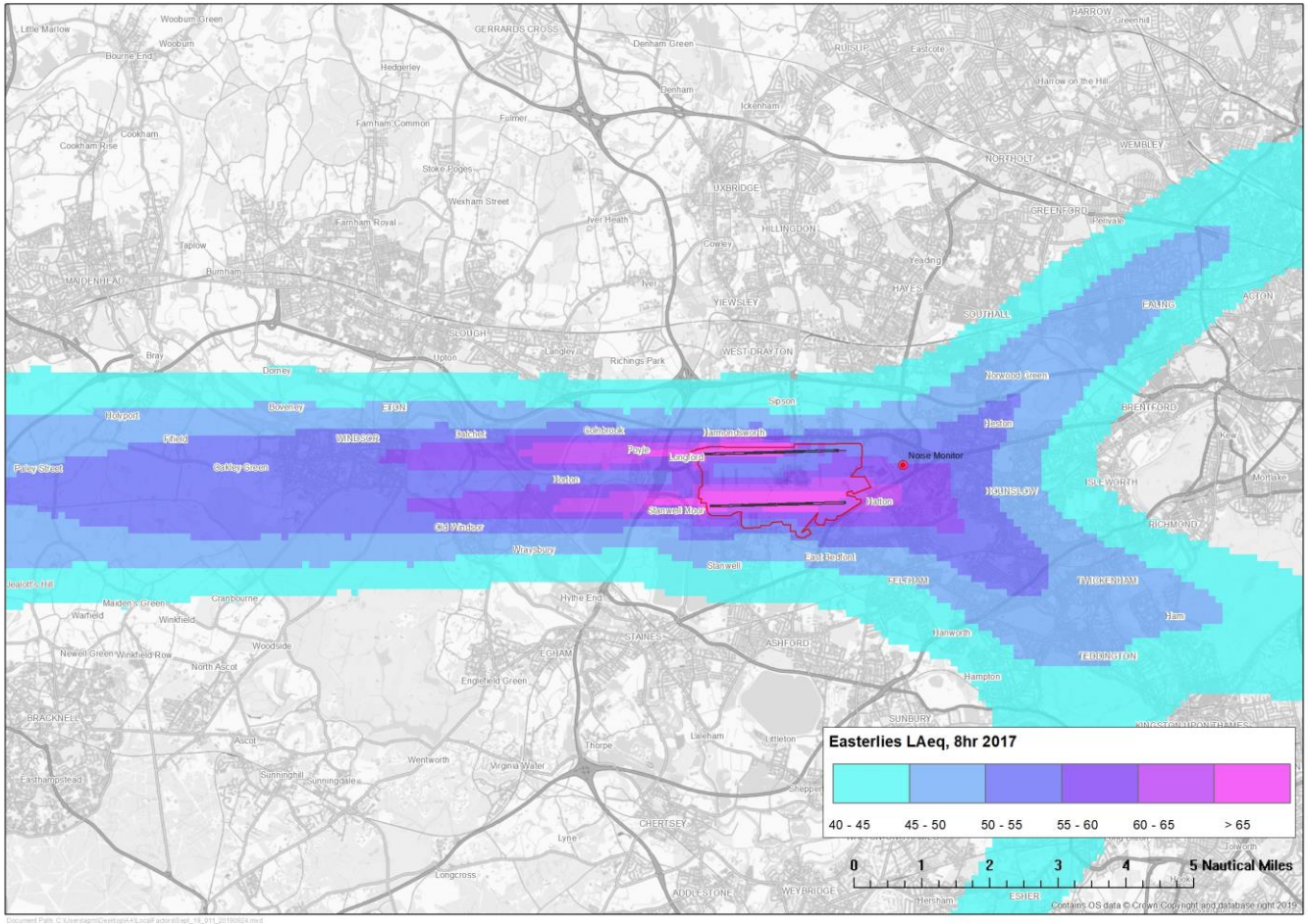
Appendix A: Average easterly day $N65_{16hr}$ contours (2017)



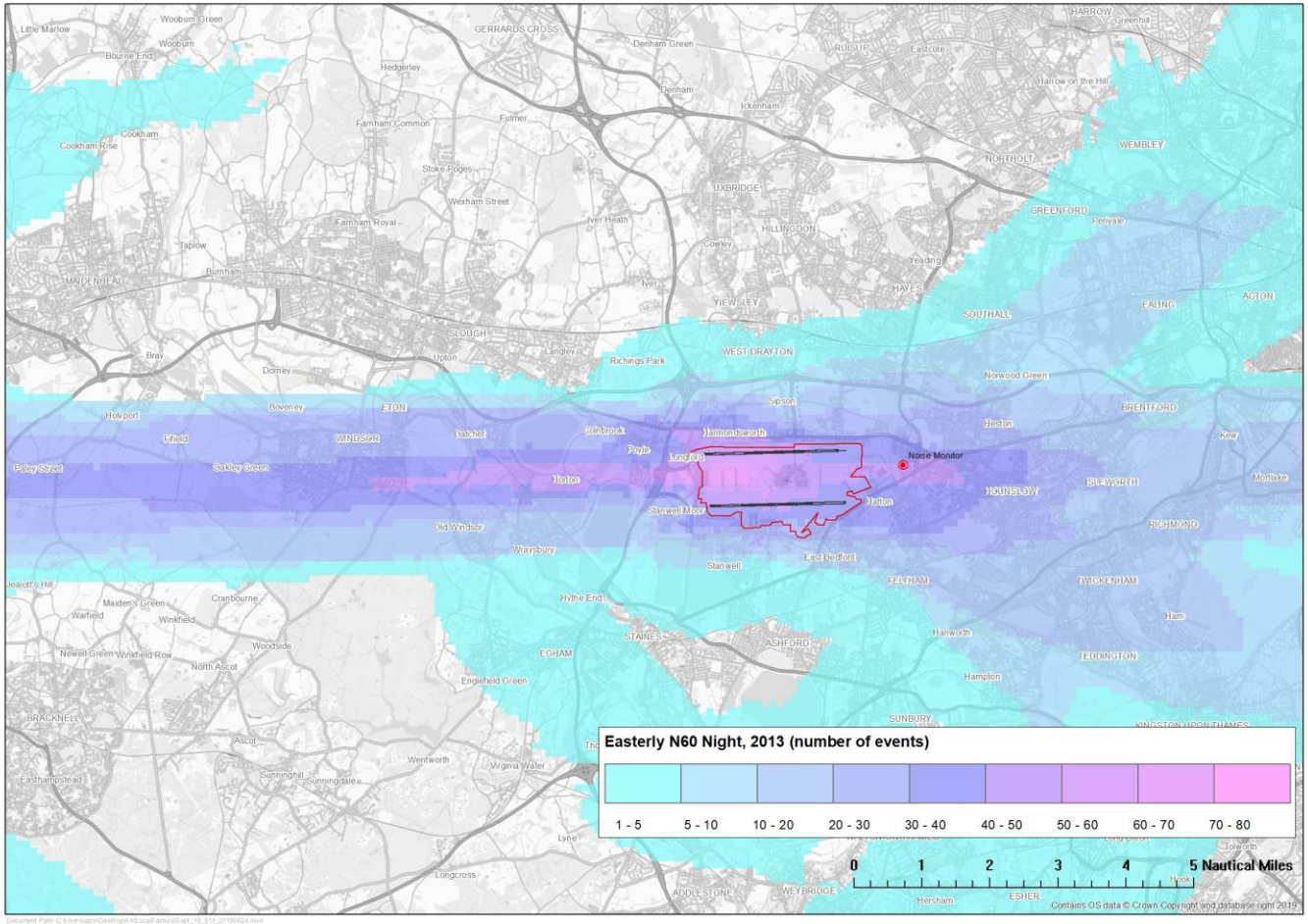
Appendix A: Average easterly night $L_{Aeq,8hr}$ contours (2013)



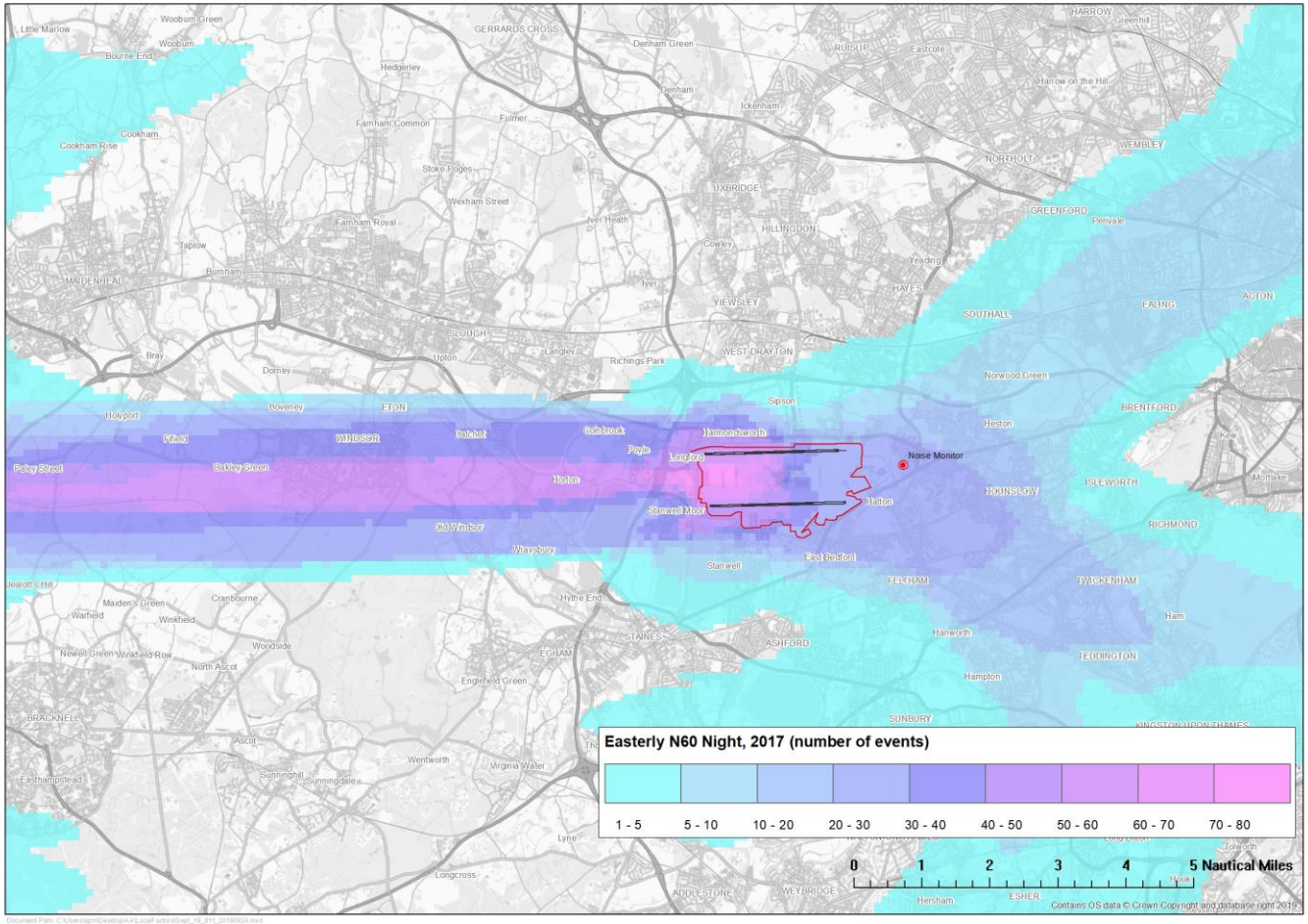
Appendix A: Average easterly night $L_{Aeq,8hr}$ contours (2017)



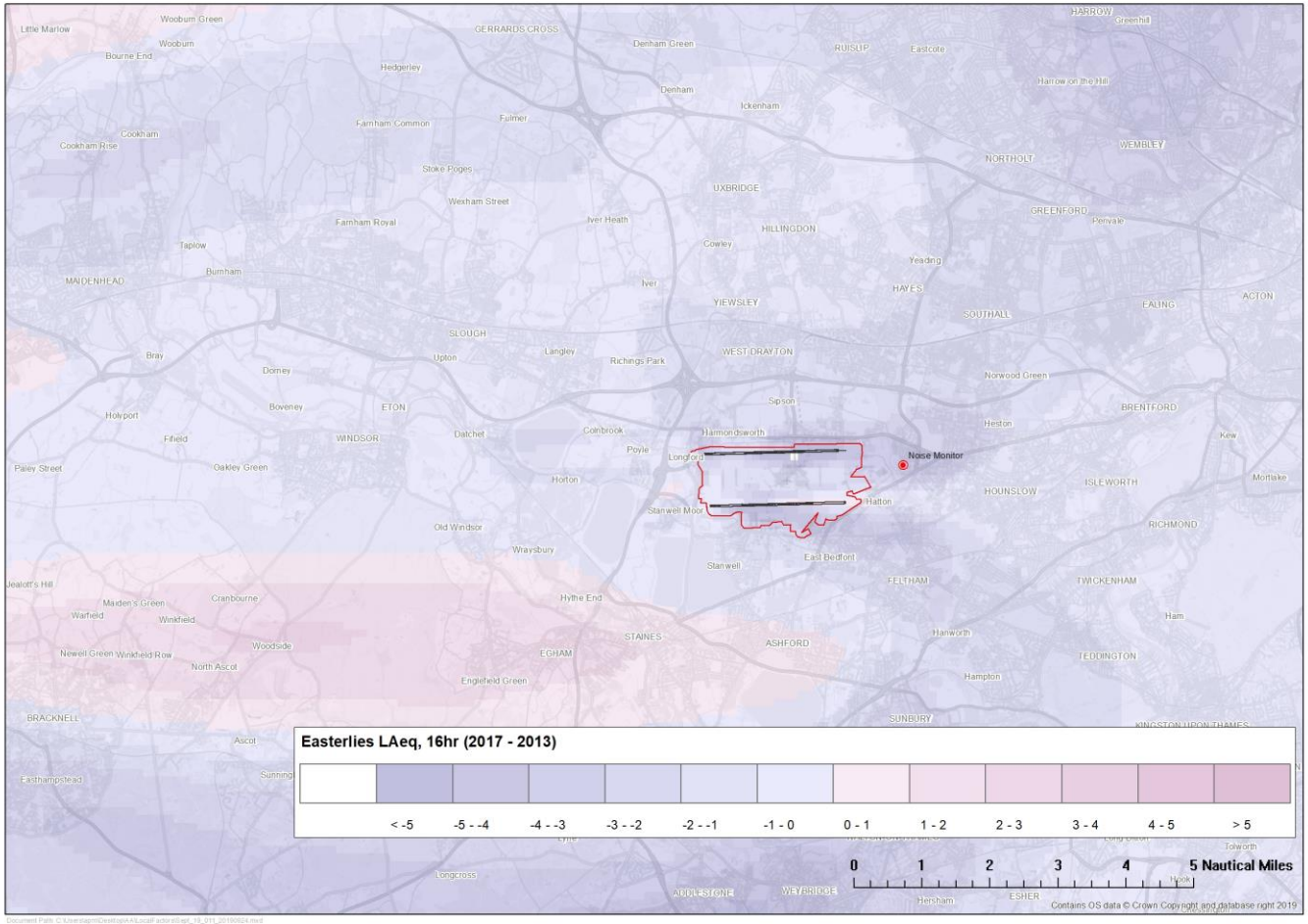
Appendix A: Average easterly night $N60_{8hr}$ contours (2013)



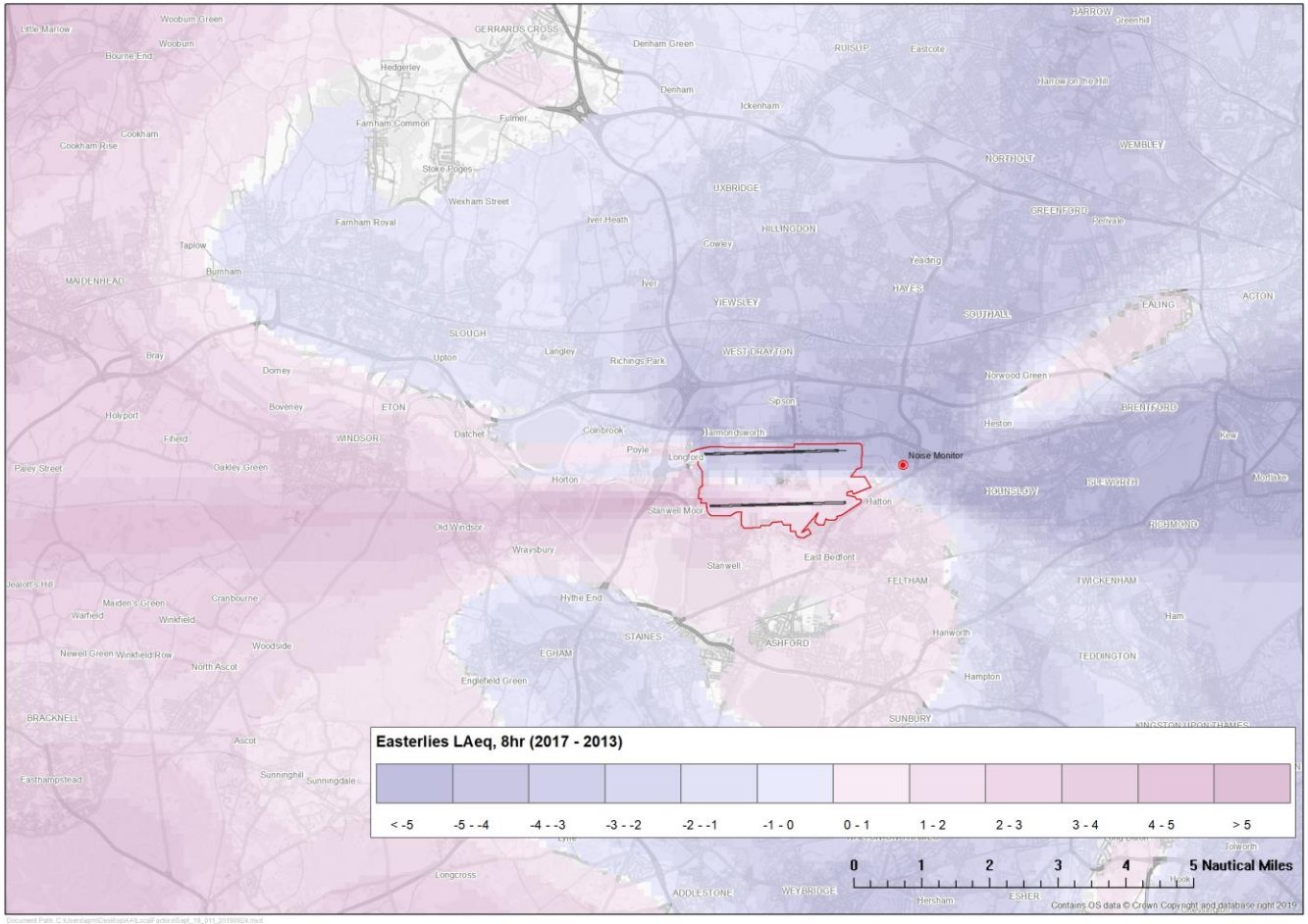
Appendix A: Average easterly night $N60_{8hr}$ contours (2017)



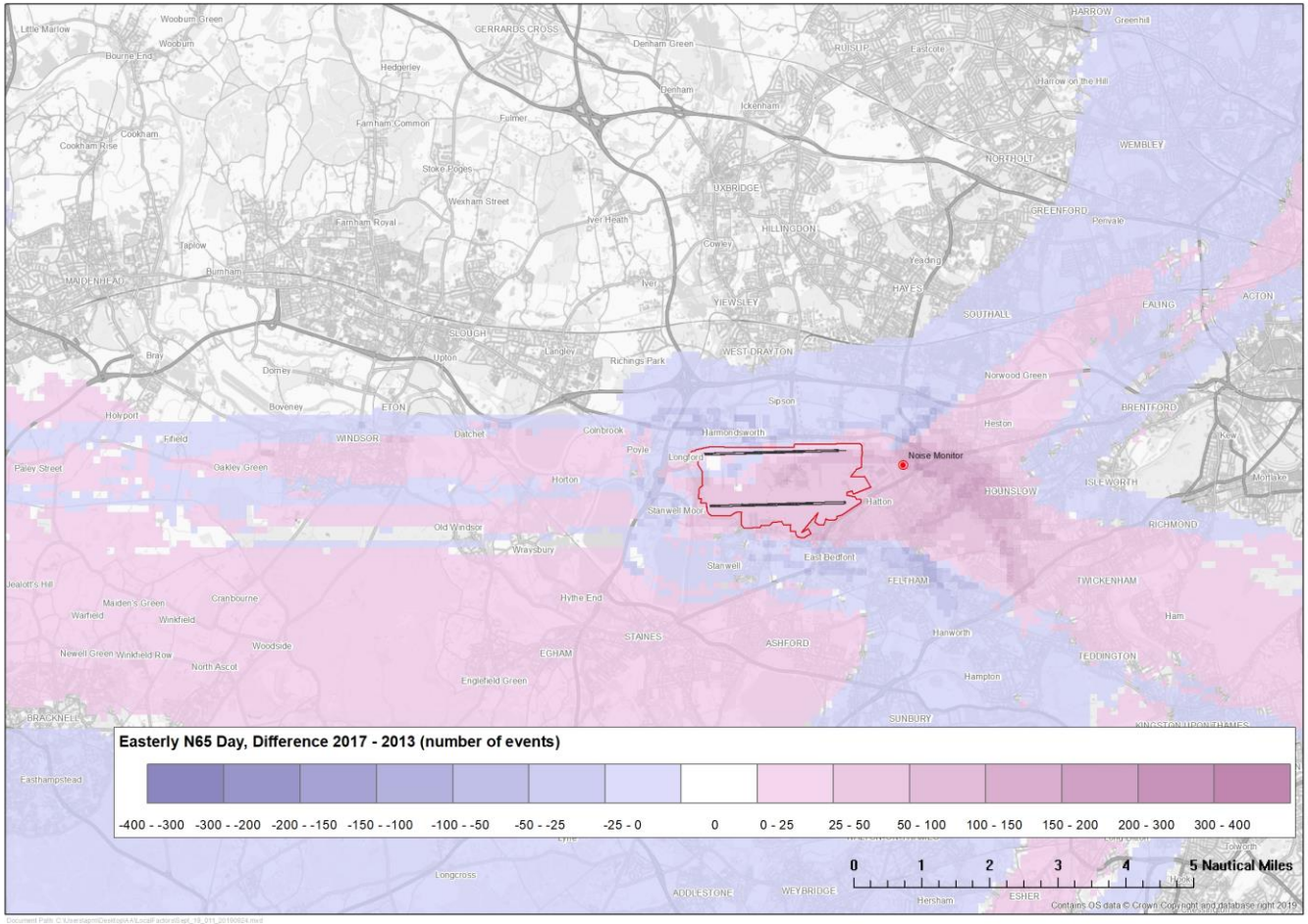
Appendix A: Average easterly day $L_{Aeq,16hr}$ difference (2017 minus 2013)



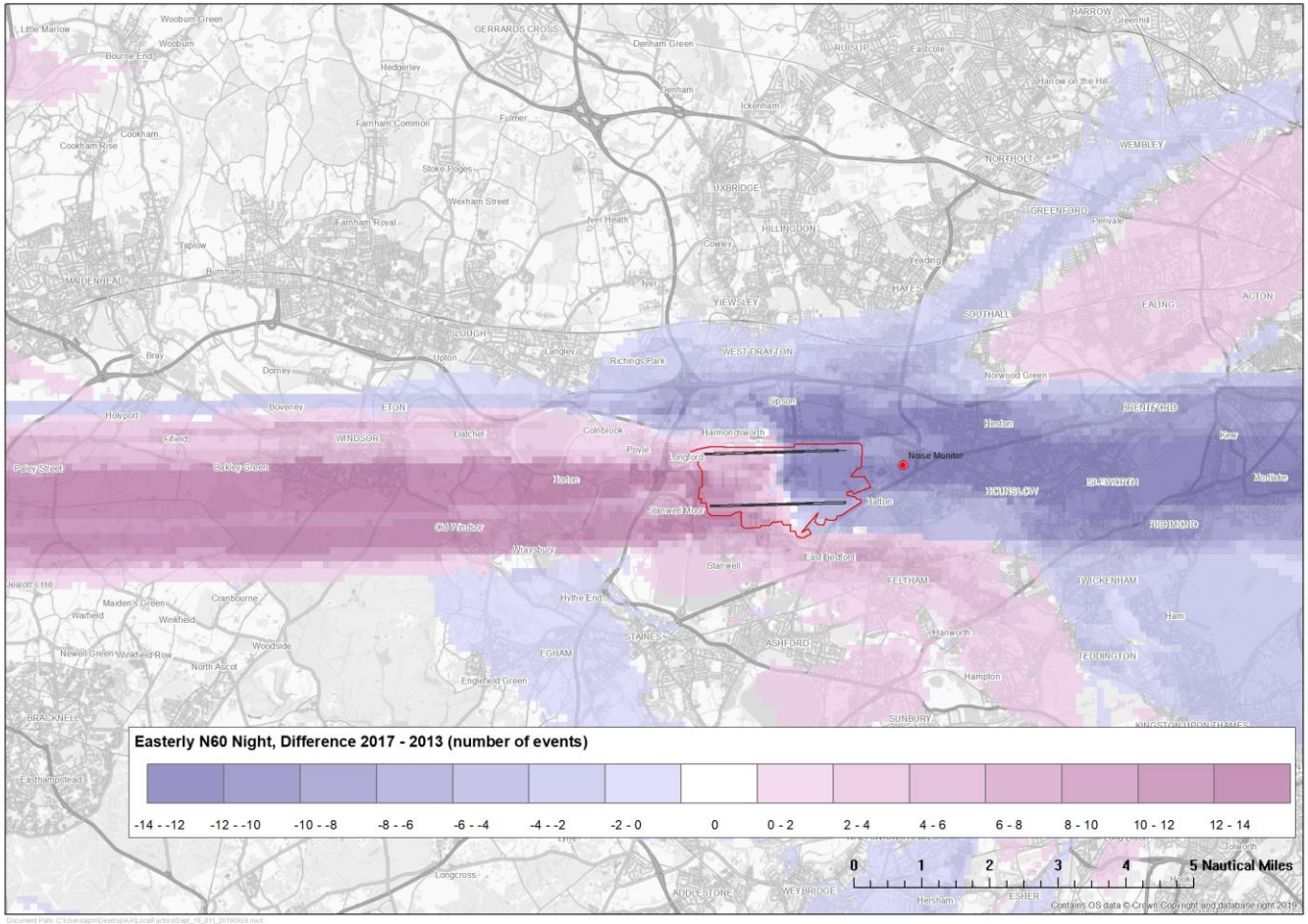
Appendix A: Average easterly night $L_{Aeq,8hr}$ difference (2017 minus 2013)



Appendix A: Average easterly day $N65_{16hr}$ difference (2017 minus 2013)



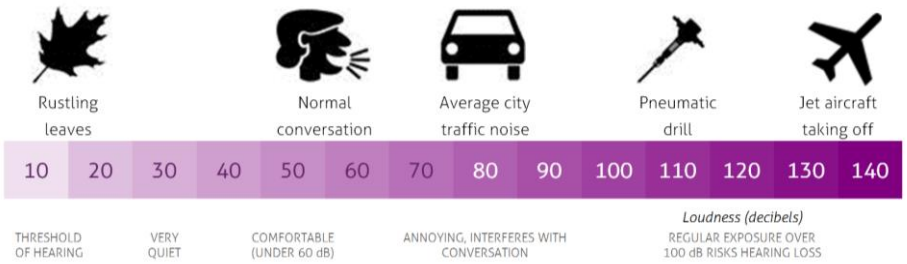
Appendix A: Average easterly night $N60_{8hr}$ difference (2017 minus 2013)



Appendix B: Noise Terminology

How is sound/noise measured?

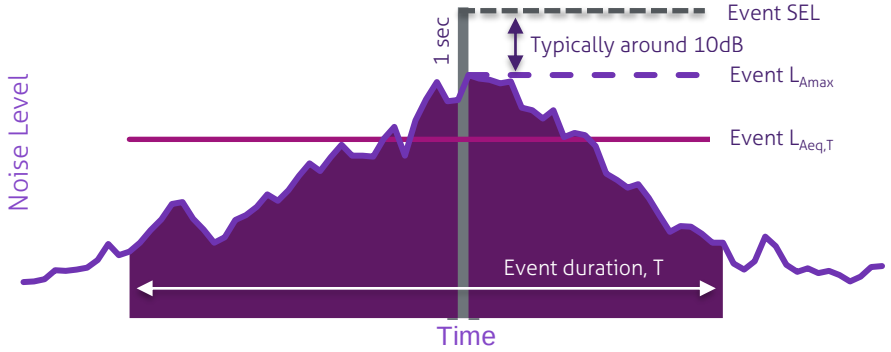
There is a million to one ratio between the threshold of hearing and the highest tolerable sound pressure. Furthermore, the ear mechanism responds in a non-linear manner: more efficiently to lower sounds than to higher sounds. Sound is therefore measured using a logarithmic scale, which accounts for both these features, called the decibel (dB) scale. Typical levels of everyday sounds are shown in the figure below.



As well as the large range of levels, the human ear is capable of detecting sound over a wide range of frequencies, from around 20 Hz to 20 kHz; however, its response varies depending on the frequency and is most sensitive to sounds in the mid-frequency range of 1 kHz to 5 kHz. Instrumentation used to measure sound (and where a single figure value is required) is therefore weighted across the frequency bands to represent the sensitivity of the ear. This is called 'A-weighting' and is represented as dBA, dB(A) or dB $L_{Aeq,T}$, for example. All units in this report use this A-weighting.

How is aircraft noise measured?

As an aircraft passes over a location, sound levels slowly increase from ambient levels, reach a maximum and decrease back down to ambient levels. An example flyover is shown below.



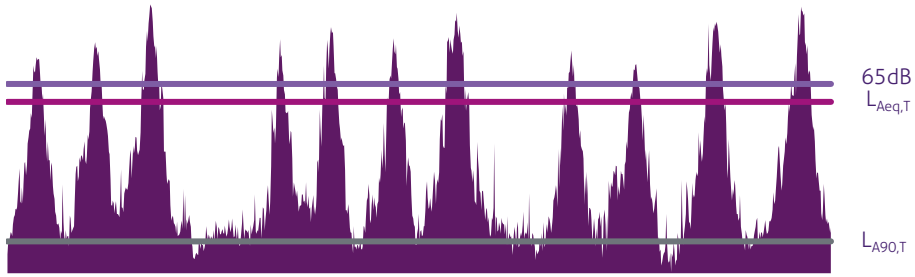
There are a number of metrics that can be used to characterise a noise event. The main ones in current use are shown above and described below. All of which can be derived from monitoring and modelling.

- The L_{Amax} is the highest A-weighted sound pressure level during the event. It is broadly an instantaneous value based on a response time of 125ms as per the Fast-time response. Can also be written L_{AFmax} or $L_{Amax,fast}$.
- The $L_{Aeq,T}$ is the equivalent continuous sound pressure level that would generate the same energy as that of the fluctuating level during the event of period, T. It is in effect the average level of the event.
- The SEL (sound exposure level or single event level) is the sound pressure that would arise if all the energy of the event was to be delivered in 1 second. It is a form of normalisation.

Appendix B: Noise Terminology

How is long term noise exposure measured?

The L_{Amax} and SEL metrics are useful at describing the noise level of individual events; but how is aircraft noise exposure measured over time? The standard approach is based on long term averages, primarily using the L_{Aeq} metric in the UK. The L_{Aeq} for a period of aircraft overflights, together with a particular threshold and L_{A90} (background) level, is demonstrated in the figure below. More on these below.



Although the L_{Aeq} plays a role in policy and planning assessment, it does not necessarily fully describe community experience. Supplementary noise metrics have been developed to further reflect community experience in, hopefully, understandable language. For example, the N65 describes the number of events that exceed 65dB, which, in the above example, would be 11 over the period displayed.

The L_{A90} is a useful indicator of background noise in the absence of aircraft or other distinctive noise events. The L_{A90} is defined as the noise level exceeded for more 90% of monitored period and is demonstrated by the grey line in the figure above.

How does sound level vary with distance?

As we move away from a sound source, the level we hear reduces since the sound energy is spread over a larger and larger area. If we assume a source, which is small compared to the distance from it, emits sound equally in all directions, we can generate some rules regarding sound levels at different distances. For example, if the distance between a source and the receiver is doubled, the sound level will reduce by 6dB, or if it is increased by a factor of 10, the level will reduce by 20dB.

Ratio of distances	Level difference
1	0dB
1.25	2dB
1.5	3.5dB
2	6dB
5	14dB
10	20dB

Appendix B: Noise Terminology

How is sound/noise level related to loudness?

Loudness is a subjective measure that describes the perceived strength of a sound. It is related to sound level but also related to other parameters such as frequency and duration. The table below provides an indication of how the perceived loudness of a sound changes with an increase or decrease in sound level. For example, an increase of 10dB corresponds to a doubling of perceived loudness. It should be noted that the table below should only act as a guide to the relationship between level and perceived loudness – since loudness is a subjective measure, the same sound will not create the same loudness perception by all individuals.

Level difference (dB)	Loudness perception
+20dB	x 4
+10dB	x 2
+6dB	x 1.5
+3dB	x 1.2
±0dB	0
-3dB	÷ 1.2
-6dB	÷ 1.5
-10dB	÷ 2
-20dB	÷ 4

How does average sound/noise level relate to number of events?

Average sound levels are determined by not only the level of individual aircraft events, but also the frequency of which they occur. Due to the logarithmic nature in which sound is measured, a doubling of sound energy relates to a 3dB increase in average noise level. Therefore, if the number of events is doubled over a given time period (assuming the levels of the events are the same), the $L_{Aeq,T}$ will increase by 3dB. Further factors are shown in the table below.

Number of events	Noise level difference
x10	+10dB
x4	+6dB
x2	+3dB
0	0
÷2	-3dB
÷4	-6dB
÷10	-10dB