Anderson Acoustics

# Community Noise Information Report
# Bishopsgate

5th June 2015 – 1st September 2015

# Introduction

At the request of local residents, Heathrow Airport Ltd installed a temporary noise monitor in the Bishopsgate area between Windsor Great Park and Englefield Green between 5th June 2015 and 1st September 2015. This report presents an analysis of operational and noise data over this period.

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

- **Section 2 – Key Findings** are presented.
- **Section 3 – Background & Methodology** provides an overview of how the airport operates, noise 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 Bishopsgate including routes, proximity, spatial distribution, height and aircraft types. As flight track data has been collected for many years in the airport's noise and track-keeping (NTK) system, analysis has compared the noise monitoring period with an equivalent period in 2011.
- **Section 5 – Noise Monitor Data** presents an analysis of aircraft noise event and overall community noise levels as measured at the noise monitor. Noise data is analysed only for the monitoring period. Comparison with a historic period is not possible as monitoring has not taken place at the same location previously.
- **Section 6 – Noise Modelling** presents noise levels derived from the verified Heathrow Airport noise model. Average noise levels and noise event statistics have been generated across the wider geographic area for an average day of operations that affect this community (in this case predominantly westerly operations) across the summer of 2011 and 2015 to provide a broader understanding of whether there are any differences in noise exposure between the two years. The baseline year of 2011 was agreed as no trials took place in this period and is prior to changes perceived by some members of the community.
- **Section 7 – Appendices** presents large scale versions of all of noise modelling results and provides greater detail on noise terminology around how sound is described, how aircraft noise is measured and how differences of sound level relate to human perception.

It should be noted that this report is intended to describe noise exposure rather than the impact of that exposure - we cannot judge how each individual will respond. 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 a comprehensive analysis, it is not intended to be exhaustive. Should there be any questions or comments arsing from the data presented herein, these should be addressed to the HCNF for additional analysis.

Note: Wherever this report refers to "*the summer period of 2015*", it should be noted that this is specifically the measurement period from 5th June 2015 to 1st September 2015. Similarly, "*the summer of 2011*" specifically refers to the period from 5thth June 2011 to 1st September 2011.

# Key Findings

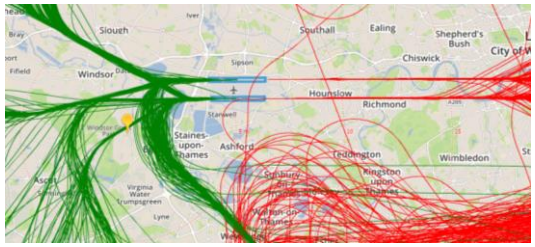
| Operations and the community |
|---|
| The noise monitor at Bishopsgate is predominantly overflown by westerly departures. It is located close to the centre line of the MID departure route from the southern runway and the western edge of the DET route when aircraft depart from the northern runway. A number of aircraft departing to the east of the airport on the CPT route will pass over the monitor at a higher altitude. |
| On westerly operations, the route usage on MID and DET has not changed significantly between 2011 and 2015. |
| There was, overall, a 17% increase in westerly operations passing through the westerly gate in the 2015 period compared to 2011. This increase was spread across the day. There was also an increase in easterly departures through the easterly gate. |
| The centre of the main concentration on DET and MID (southern runway) routes moved closer to the noise monitor at Bishopsgate in 2015. The DET route was less concentrated in 2015 resulting in more aircraft overhead at Bishopsgate. The main concentration of easterly CPT departures also moved closer to the noise monitor. |
| Overall, the average height of aircraft has not changed significantly although the number of the lowest aircraft (c. 1500ft) has doubled. |
| The proportion of departing A380 aircraft passing through the westerly gate during westerly operations increased from 0.9% to 4.1%. |

| Noise levels in the community based on measurement at Bishopsgate monitor | Difference in community noise levels between 2011 and 2015 based on noise modelling |
|---|---|
| At Bishopsgate, noise from aircraft makes a substantial contribution to community ambient noise levels during westerly operations. | The daytime average westerly day aircraft noise levels ($L_{Aeq,16hr,\ 07:00\ to\ 23:00}$) were between 1 and 2dB greater in 2015 compared to 2011. |
| Measured hourly ambient noise levels ($L_{Aeq,1\ hr}$) on an westerly day are 4-15 dB higher than those on a easterly day (during daytime hours). | In this area in 2015, there were up to 50 (c. 66%) more events per day with an $L_{Amax}$ greater than 65 dB over an average westerly day when compared to 2011. |
| In general, hourly ambient noise levels ($L_{Aeq,1\ hr}$) are 3dB higher when westerly departures use the southern compared to the northern runway. | There was an increase in average night-time aircraft noise $L_{Aeq,8hr}$ from 44 to 46dB and increase in N60 from 5 to 8 at Bishopsgate from 2011-2015. |
| The highest measured hourly ambient noise levels ($L_{Aeq,1hr}$) and greatest number of measured aircraft noise events occur in the 21:00-22:00 hour. This period has a high proportion of larger aircraft types and occurs when non-aircraft noise is reducing. | |
| On average,130 aircraft noise events were recorded on full days of westerly operations. On full days of easterly operations there were twelve events. | |
| Across the day, small twin-engine aircraft generate the most measured noise events (A320 family generate 55%); B777 12%, B747 9% and A380 5%. | |
| The B747 is, on average, the loudest aircraft in all comparisons presented in this report. | |

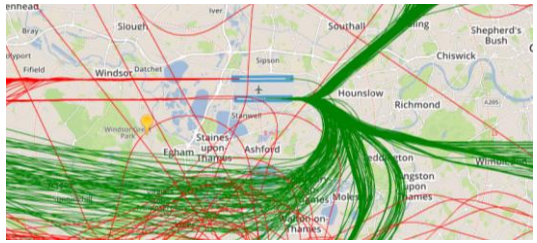
# Understanding how wind direction affects aircraft operations.

## 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 red, departures green.



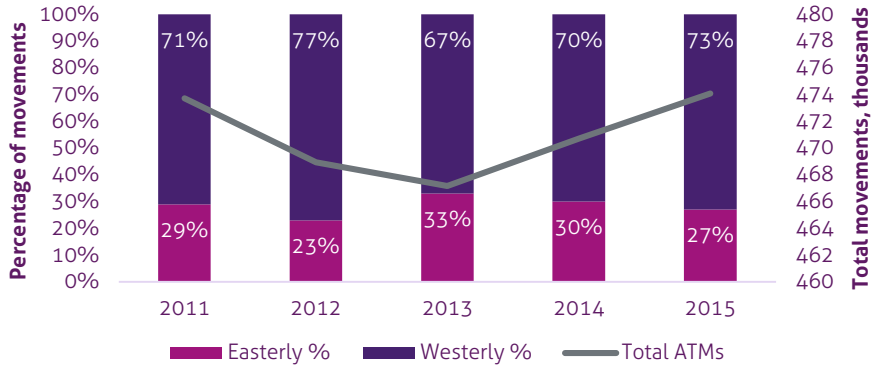

**Flight tracks on a westerly day (18th March 2016)**




**Flight tracks on an easterly day (8th March 2016)**

## The proportion of easterly/westerly operations

- Around Heathrow, the prevailing wind direction is from the west.
- Heathrow also operates what is know as the 'westerly preference'. Aircraft will continue to operate in a westerly direction until there are tail winds consistently of 5kts 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 5 full years.

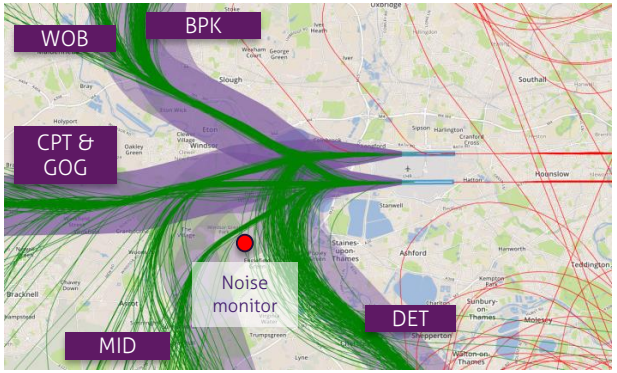



Note: Further information about operations at Heathrow can be found at http://www.heathrow.com/noise/heathrow-operations

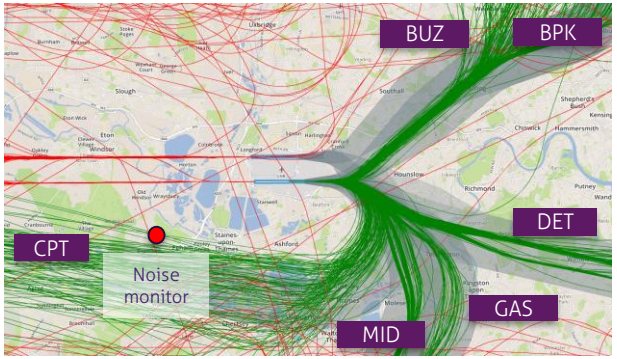
# Understanding where aircraft fly near to Bishopsgate.

- The images to the right presents a typical day of westerly operations (top) and easterly operations (bottom) with arrival tracks shown in red and departures in green.
- Aircraft departing the airport follow one of six pre-defined routes (NPRs), typically based upon their destination. These are represented by the purple and grey corridors.
- Bishopsgate is an area predominantly overflown by westerly departures. It is located close to the centre line of the MID departure route from the southern runway and the western edge of the DET route from the northern runway.
- During easterly operations the area can be overflown by aircraft departing following the CPT route. On average, these aircraft will have reached an altitude of 6,000ft.
- Although some departing aircraft on easterly operations will be audible at Bishopsgate, this report will focus on operations and noise events from westerly operations, in particular those on the MID route when aircraft are departing the southern runway (subsequently referred to as 27LMID).

**Arrival and departure tracks on westerly operations (NPRs shaded in purple)**




**Arrival and departure tracks on easterly operations (NPRs shaded in grey)**

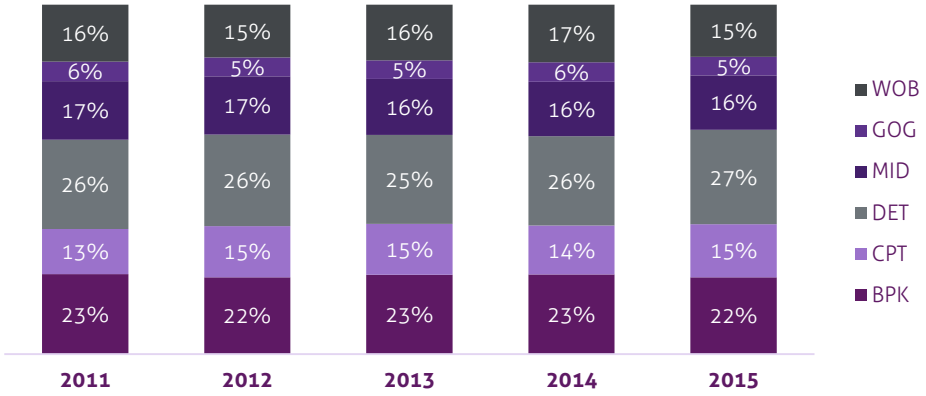



DET and GOG are the new names for the DVR and SAM routes respectively. Throughout this document they are referred to as DET and GOG

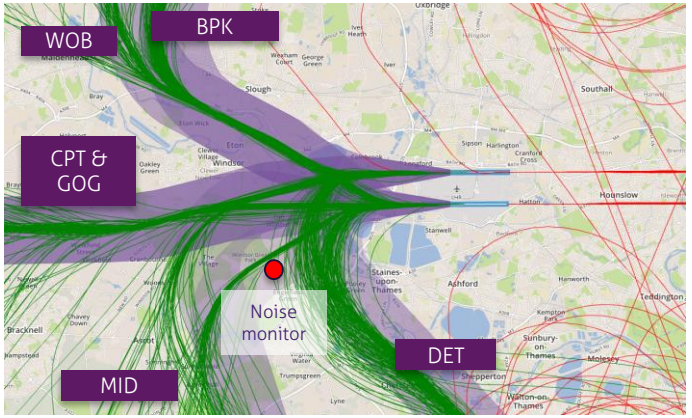
# Understanding where aircraft fly on westerly operations.

- The figure below shows the proportions of **annual** route usage by westerly operations for each year from 2011-2015.
- In 2015, 16% of westerly departures followed the MID route and 27% the DET route, the routes most pertinent to Bishopsgate.
- There are small fluctuations from year to year, but route usage has remained broadly consistent over the five year period.
- The westerly departure routes and typical tracks are shown again in the bottom right image.

**Annual departure route use during westerly operations**




**Arrival and departure tracks on westerly operations (NPRs shaded in purple)**



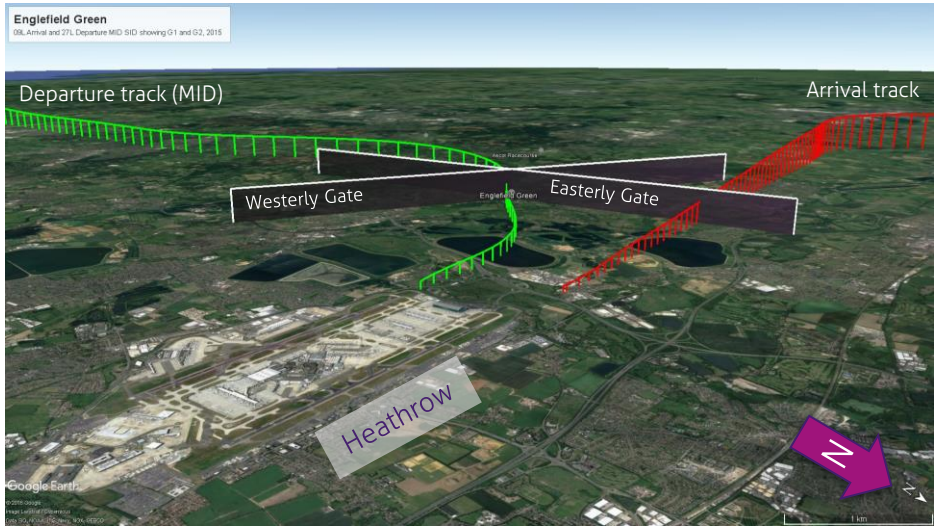
# Understanding operational and gate data.

## Operational data.

- The following operational data were provided for the period 5th June – 1st September 2015 and the same period for 2011:
  - 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.
- Two 'gates' were drawn over Bishopsgate centred on the temporary noise monitor; one to capture movements while the airport is on westerly movements (westerly gate) and one for easterly movements (easterly gate).




- The westerly gate is approximately perpendicular to the southern MID route while the easterly gate is perpendicular to the arrival tracks. Both extend to a height of 20,000ft.
- The heights and positions 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 penetrated 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 systems.
- The results confirming the integrity of the data and models are presented in the following report: http://www.heathrow.com/file_source/HeathrowNoise/Static/NLR_HCNF_20160125.pdf

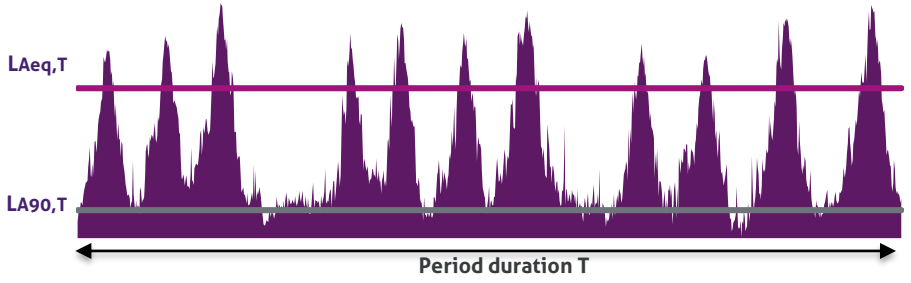
# Understanding measured noise data.

## Measured noise data:

- A Larson Davis 870, 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 has been excluded due to adverse weather conditions.
- For this report, noise data has been provided by Heathrow for the period 5th June 2015 – 1st September 2015. Note that a historical comparison is not available since the noise monitor was not installed at this location in previous years.

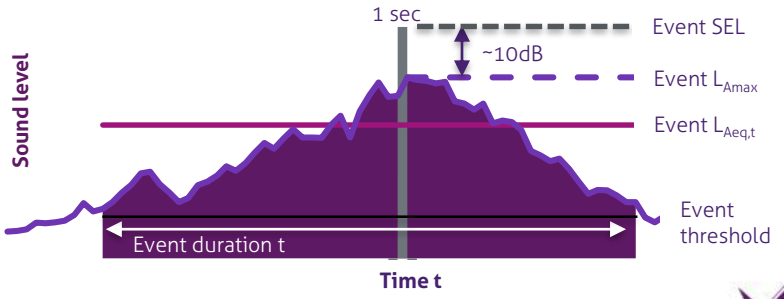
## Ambient and background noise levels:

- 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 sound level across period T from all sources;
  - $L_{A90,T}$ - the sound level exceeded for 90% of the time across period T from all sources, this is often regarded as a measure of the background noise;
  - The NTK system provides these metrics in 1hr periods ie 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.

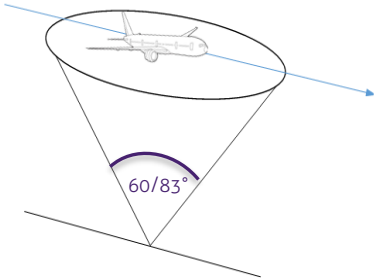


# Analysing noise levels from aircraft in this area.

**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**

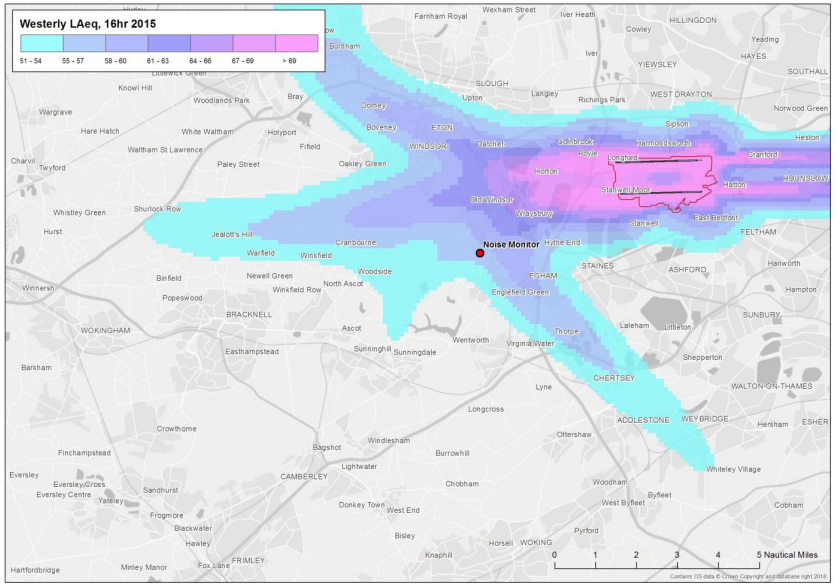



- This community information report will, where applicable, present results for overhead flights determined by CAA guidance as well as all registered aircraft noise events.

## Noise Modelling

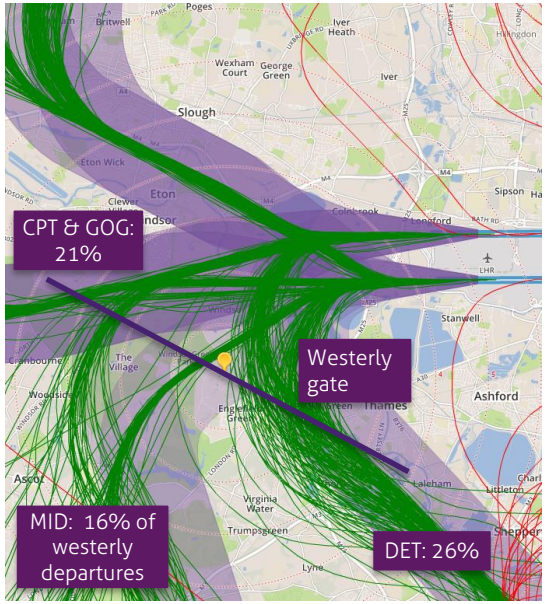
- Aircraft noise modelling has been used to provide an understanding of differences in the noise environment between 2011 and 2015 over the wider geographic area.
- Differences in daytime and night time levels for an **average day and night of westerly operations** across the summer of 2011 and 2015 have been derived using the Heathrow INM model developed for the 2014/15 departure trials and verified recently by NLR.

**Example contours generated by aircraft noise modelling**



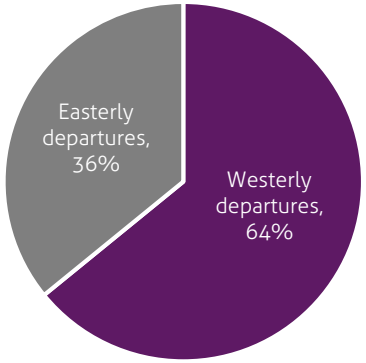
# Overview of flight track data

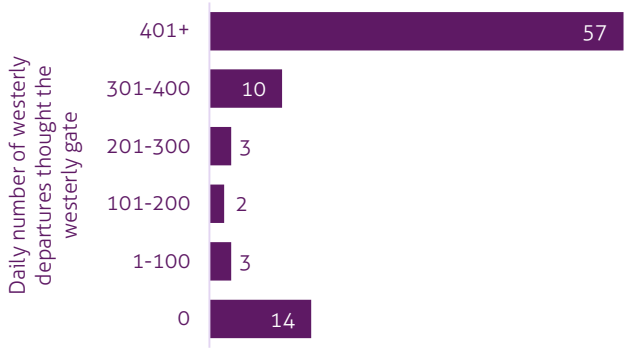
5th June 2015 - 1st September 2015




**Example day of departing aircraft tracks in the vicinity of Bishopsgate during westerly operations & the westerly gate**

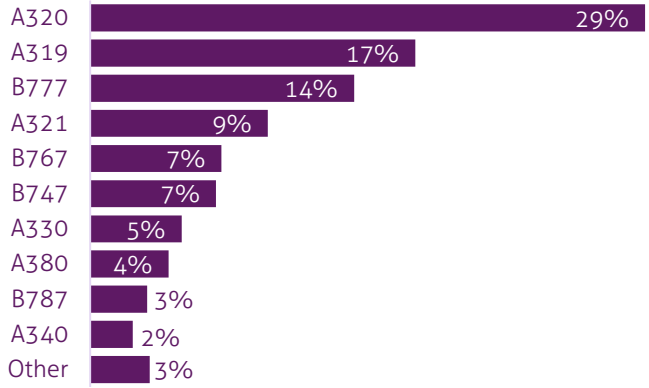
## Total 75,910 departures from Heathrow



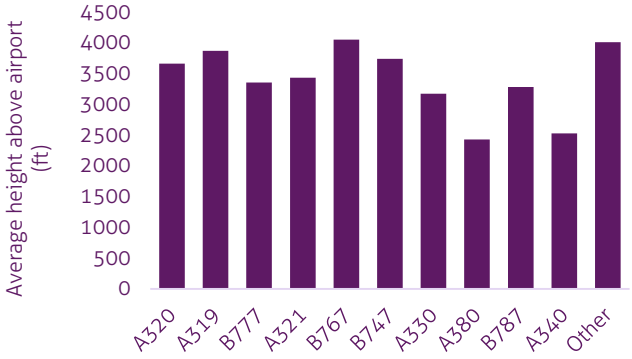




**Number of westerly departures per day passing through the westerly gate (89 days in total)**

## Proportion of departing aircraft types passing through the westerly gate

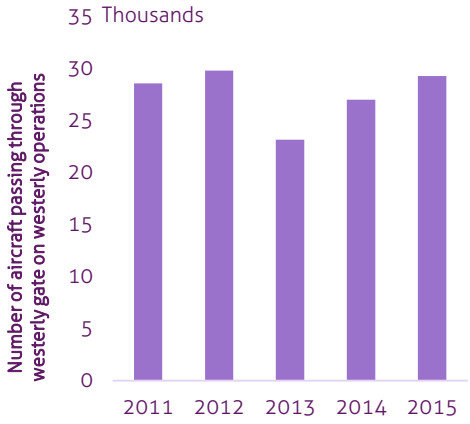


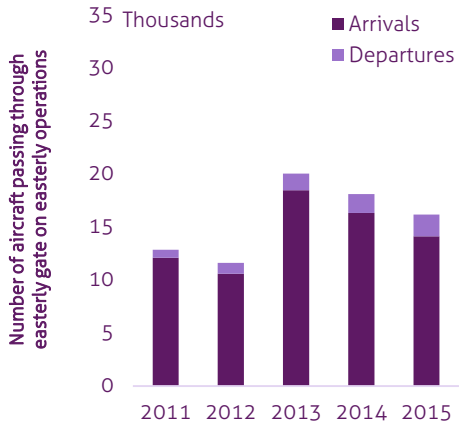

## Average height of departing aircraft as they pass through the westerly gate



# Is the number of flights over the area different in 2015 to 2011?

- The figure to the right shows the total number of departures that passed through the westerly and easterly gates (on westerly and easterly operations respectively) in the period from 5th June – 1st September from 2011 to 2015.
- Annually, between 23,000 and 30,000 departures penetrated the westerly gate and between 10,000 and 20,000 movements passed through the easterly gate of which the majority are arrivals to the northern runway.
- Year to year changes can be attributed to fluctuations in the proportion of westerly operations (determined by wind direction), total number of movements and the proportion of aircraft flying each departure route.
- The table indicates that the proportion of westerly operations in 2011 was 80%, in 2015 77%.
- On a full day of westerly operations;
  - There was a 17% increase in departures through the westerly gate in the 2015 period compared to 2011.
  - The proportion of departures passing overhead at the monitor increased (as indicated by the numbers in parentheses).
- On full days of easterly operations, the number of both departures and arrivals passing through the easterly gate increased.




| | 2011 | 2015 | Change | Change (%) |
|---|---|---|---|---|
| Proportion of westerly operations (all Heathrow flights) | 80% | 77% | -3% | N/A |
| Average number of westerly departures passing through the westerly gate during days of 100% westerly operations. | 363 (46)* | 425 (55) * | +62 (+8)* | +17% (+17%)* |
| Average number of westerly arrivals passing through the westerly gate during days of 100% westerly operations. | 0 | 0 | - | - |
| Average number of easterly departures passing through the easterly gate during days of 100% easterly operation. | 35 (1)* | 101 (9)* | +66 (8)* | +189% |
| Average number of easterly arrivals passing through the easterly gate during days of 100% easterly operations. | 535 (1)* | 694 (2)* | +159 (1)* | +30% |

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

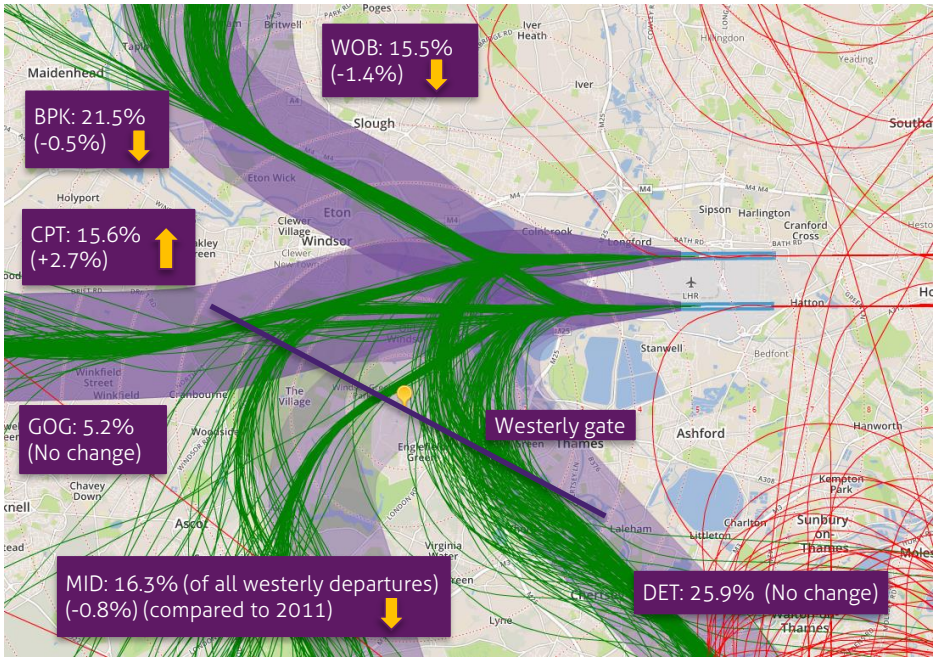
Note: Wherever this section of the report refers to *2015*, it should be noted that this is specifically the measurement period from 5th June 2015 to 1st September 2015. Similarly, 2011 specifically refers to the period from 5th June 2011 to 1st September 2015.

# Is route use different between 2011 and 2015?

- The figure to the right presents the proportion of flights using each route during a typical full westerly day in the 2015 period compared to 2011. Aircraft on the MID route and departing the southern runway are generally regarded as 'overhead' in the Bishopsgate area (it is noted that aircraft that are not overhead may still be audible in this area).
- **In the 2015/16 period, the proportion of westerly departures on a westerly day using the MID and DET route decreased from 43% over the same period in 2011/12 to 42.2%.** DET was the most commonly used westerly departure route in the 2015 period.
- Use of the CPT and GOG route (aircraft on these routes are to the north of Bishopsgate and are not 'overhead') increased by 2.7% to 21% from 2011 to 2015).

| Westerly departure route | 2011 | 2015 | Number difference | % difference |
|---|---|---|---|---|
| BPK | 10,647 | 10,092 | -555 | -5% |
| CPT | 6,228 | 7,284 | 1,056 | 17% |
| DET | 12,388 | 12,046 | -342 | -3% |
| GOG | 2,508 | 2,466 | -42 | -2% |
| MID | 8,177 | 7,578 | -599 | -7% |
| WOB | 8,196 | 7,167 | -1,029 | -13% |
| TOTAL* | 48,144 | 46,633 | -1,511 | -3% |

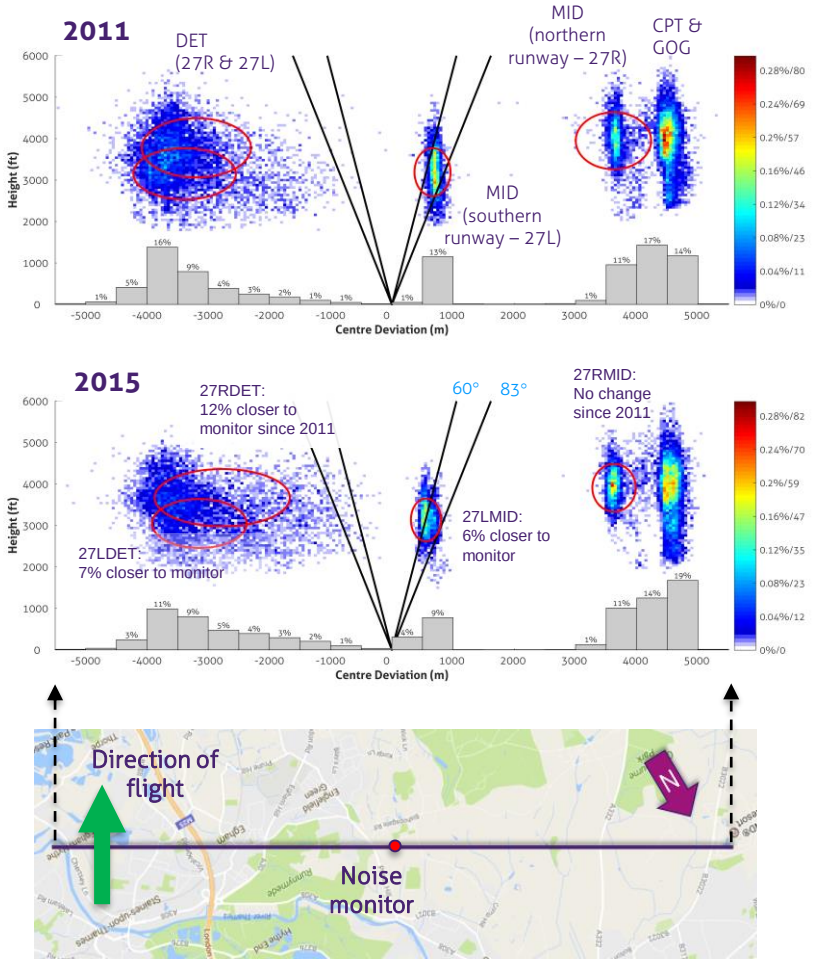
- The figures presented reflect a change in the proportion of aircraft using each departure route, and a decrease in westerly operations during 2015 period compared to 2011.




*Note: More details of movements trends can be found in Heathrow's Annual Flight Performance Reports and the CAA reports at http://www.heathrow.com/noise/facts,-stats-and-reports/reports and on the ERCD website.*

# Is the concentration of westerly operations different between 2011 and 2015?

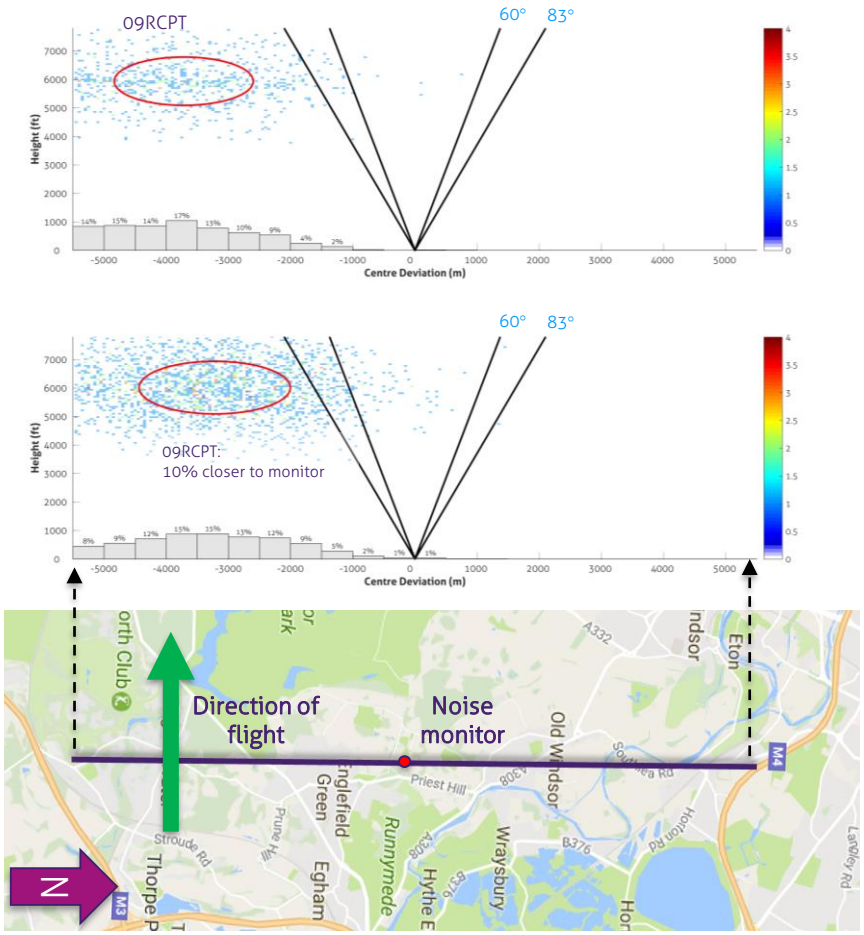
- The figures to the right are heat maps showing the 2D concentrations of departing aircraft as they pass through the westerly gate during the 2011 (the upper figure) and 2015 (the lower figure) monitoring period in addition to the concentration at different distances from the centre along the length of the gate shows by the grey bars.
- The scale presents colours for the proportion of aircraft in each grid square (pixel). For example a "red" indicates 0.28% of the movements passing through a grid square in the gate in both figures (it should be noted that the number of movements this represents may differ between the figures – in 2011, 80 flights represent 0.28%, in 2015 this figure was 82).
- The gate has been designed to be perpendicular to the route closest to the noise monitor, 27LMID. Since the gate is straight, it will cross the DET, CPT and GOG routes at an angle which will result in a wider swathe on the heat maps and is not representative of actual concentration. Therefore, is not possible to compare the concentration of different routes but may still be useful in comparing changes year to year.
- The figures indicate that the MID, CPT and GOG are routes are no more concentrated in the 2015 period compared to 2011 while those flying the DET route are more dispersed at the point of passing through the westerly gate.
- The position of the main concentration of the DET route from the northern runway has moved about 12% closer to the noise monitor while the MID route from the southern runway (27LMID) is 6% closer to the monitor.




Note: The "heat maps" have been normalised to account for differences between the number of westerly departures in each of the monitoring periods. This allows the concentrations in each graph to be compared. This method does not account for any changes in daily number of movements passing through the gate - these changes are presented on Page 13. The maps are divided into grid squares, 50m horizontally by 60ft vertically.

# Is the concentration of easterly operations different between 2011 and 2015?

- The figures to the right are heat maps showing the 2D concentrations of aircraft departing on easterly operations as they pass through the easterly gate.
- The grey bars under the 'heat map' show the actual concentration at different distances from the centre of the gate.
- Easterly arrivals, which are predominantly 4km north of the monitor at an altitude of 1,000ft and do not generate noise events at Bishopsgate, have been omitted from the figure.
- The number of aircraft on the easterly Compton route (09RCPT) has increased while the main centre of concentration has moved 10% closer to the noise monitor. It should be noted that due to the fixed width of the gate a number of aircraft on 09RCPT may have been omitted from the analysis

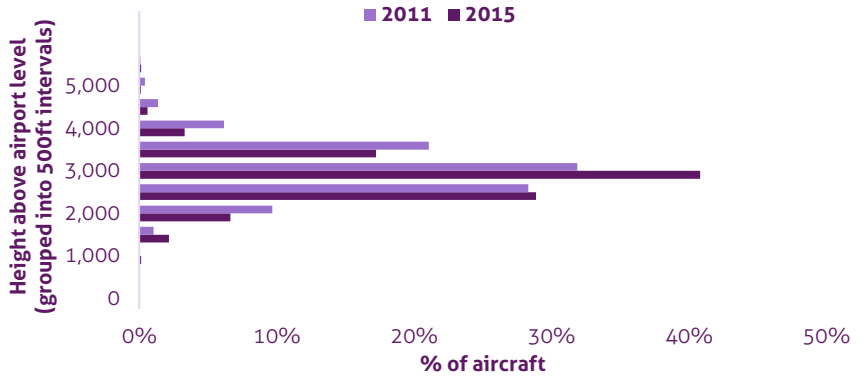


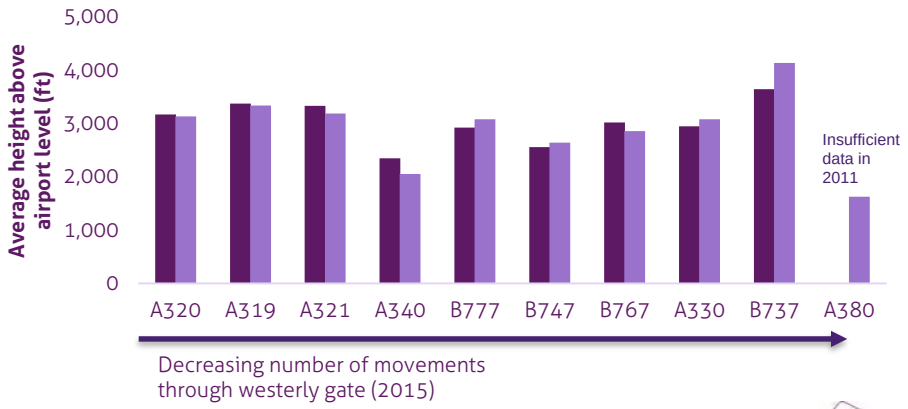

Note: The "heat maps" have been normalised to account for differences between the number of westerly departures in each of the monitoring periods. This allows the concentrations in each graph to be compared. This method does not account for any changes in daily number of movements passing through the gate - these changes are presented on Page 13. The maps are divided into grid squares, 50m horizontally by 60ft vertically.

# Are aircraft heights different between 2011 and 2015?

- The table to the right presents the average height of aircraft on the MID route departing the southern runway (27LMID) as they passed through the westerly gate in the 2011 and 2015 periods.
- **This indicates that aircraft above Bishopsgate were on average broadly the same height in 2015 than 2011.**
- The figures present the distribution of these aircraft height through the westerly gate comparing 2011 with 2015 (upper figure) and the average height by aircraft type (lower figure).
- The upper figure shows that generally aircraft heights were more concentrated vertically in 2015 than in 2011 although **there was a greater proportion of aircraft flying at the lower altitudes (c.1500ft) in 2015.**
- The lower figure shows that the height of aircraft varies with type. The B737 is the highest aircraft type while the A380 and A340 are the lowest.
- The B777, B747, A330 and B737 are higher in 2015 compared to 2011 while the A321, A340 and B767 decreased in height.

| | 2011/12 | 2015/16 | Difference |
|---|---|---|---|
| Average height of departures through westerly gate on MID (southern runway) | 3,191ft | 3,135ft | -56ft |



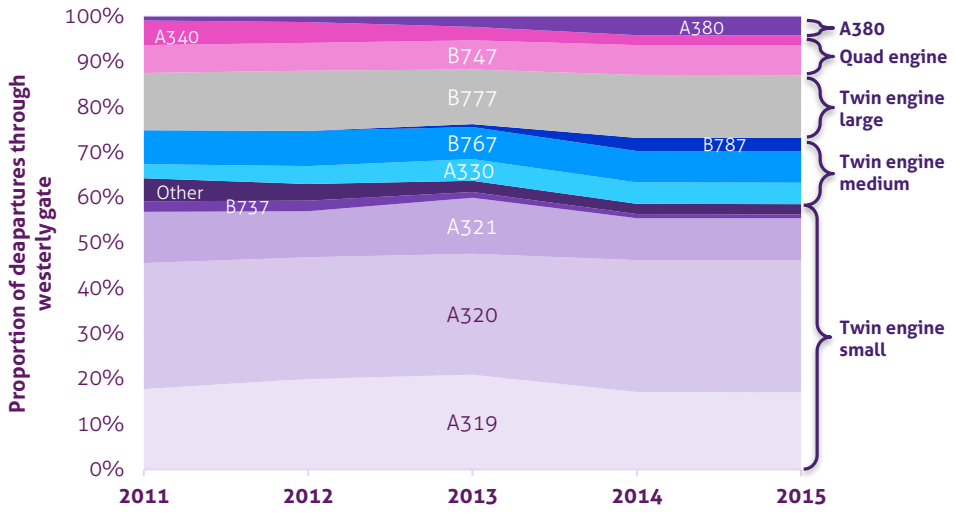



# Is the fleet mix different between 2011 and 2015?

- The table to the right presents the mix of departing aircraft that passed through the westerly gate and overall at Heathrow in the 2011 and 2015 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)
  - twin engine medium aircraft (B767, B787, A330) and
  - twin engine small aircraft (B737, A320 family).
- Previous slides indicated that the number of departing aircraft flying through the westerly gate has increased on an average day of full westerly operations between 2011 and 2015.
- The analysis on this page indicates that there was an increase in the proportion of A380 operations departing through the westerly gate from 0.9% in 2011 to 4.1% in 2015. The proportion of the other 4 engine (quad) aircraft types reduced. The medium and large twin aircraft (which make up a greater proportion of the movements) also increased, whilst the proportion of small twin aircraft reduced.
- 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 increase in use of the A380 as noted earlier, there were increases in the use of the B787 (introduced in 2011, 0% to 3%) while the A340 and B737 both saw a steady decrease.

**Fleet mix**

| Category | Westerly gate | | All LHR | |
|---|---|---|---|---|
| | 2011 | 2015 | 2011 | 2015 |
| A380 | 0.9% | 4.1% | 0.9% | 3.1% |
| Quad engine | 11.6% | 8.8% | 12.0% | 7.2% |
| Twin engine large | 12.7% | 13.8% | 12.2% | 13.3% |
| Twin engine medium | 10.6% | 14.7% | 9.2% | 12.9% |
| Twin engine small | 64.3% | 58.6% | 65.7% | 63.4% |



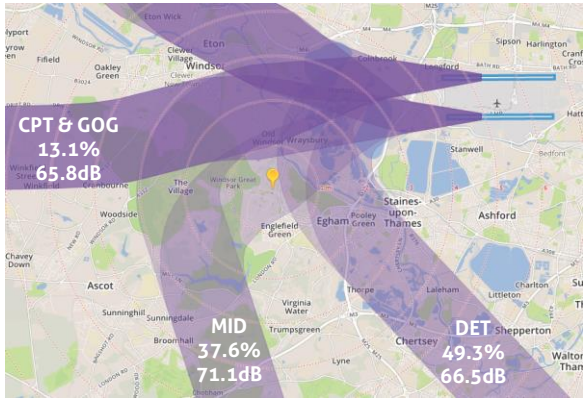

* Days of 100% westerly operations only

# Does the number of flights over the area vary across the day? Is there a difference between 2011 and 2015?

- The figures to the right present the average number of departures through the westerly (upper) and easterly (lower) gates per hour in 2011/12 and 2015/16 during days of 100% westerly/easterly operations
- The upper figure shows that the distribution of departing aircraft passing through the westerly gate was broadly equal across daytime hours in 2015 (22-28) flights per hour. Approximately 7 flights passed through the gate during the hours 06:00-07:00 and 23:00 and 00:00.
- The 17% increase in aircraft passing through the gate (see Page 13) compared to 2011 was generally distributed across the day from 07:00-22:00
- The analysis indicates that on average, on a day of full westerly operations, there were around on average 7 delayed departures between 23:00 and 00:00 that pass through the westerly gate. It is noted that the range is between 3 and 20 for this hour.
- The lower figure also shows the increase in departures passing through the easterly gate on easterly operations is spread across the day while the pattern across the day is similar to 2011.
- Of the total 89 days in the 2015 monitoring period, 58 days (65%) were 100% westerly operations and 13 days (15%) were on 100% easterly operations.

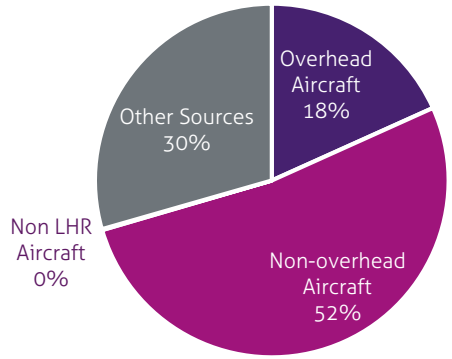

# Overview of noise monitor data recorded at Bishopsgate

5th June 2015 – 1st September 2015



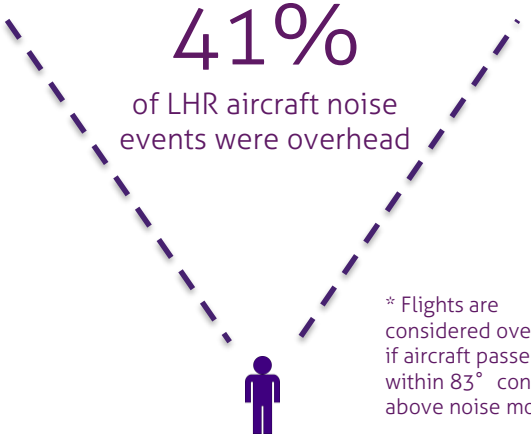

**Monitor location, % noise events by route & average $L_{Amax}$**

13,127 Measured Noise Events

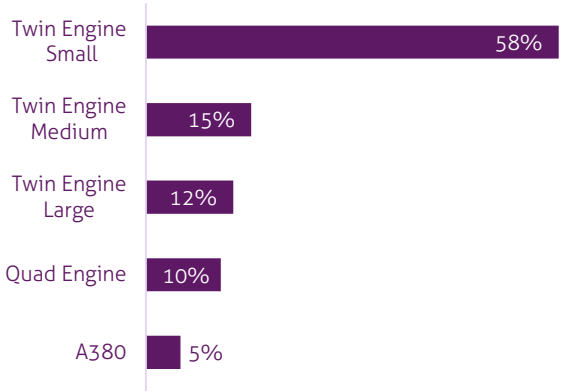



41%

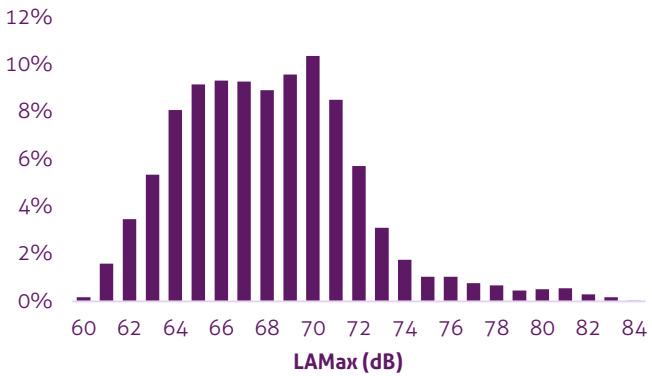
of LHR aircraft noise events were overhead



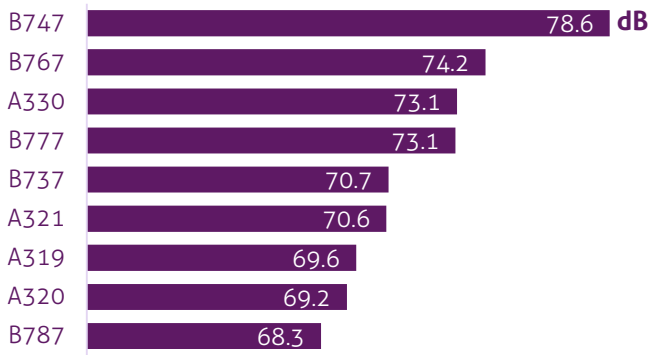
* Flights are considered overhead if aircraft passes within 83° cone above noise monitor




**Noise events by aircraft size**




**Overall distribution of maximum event noise level $L_{Amax}$ - Heathrow aircraft**




**Average $L_{Amax}$ by Aircraft Type***

*Overhead aircraft on westerly departures only

# Noise monitoring overview.

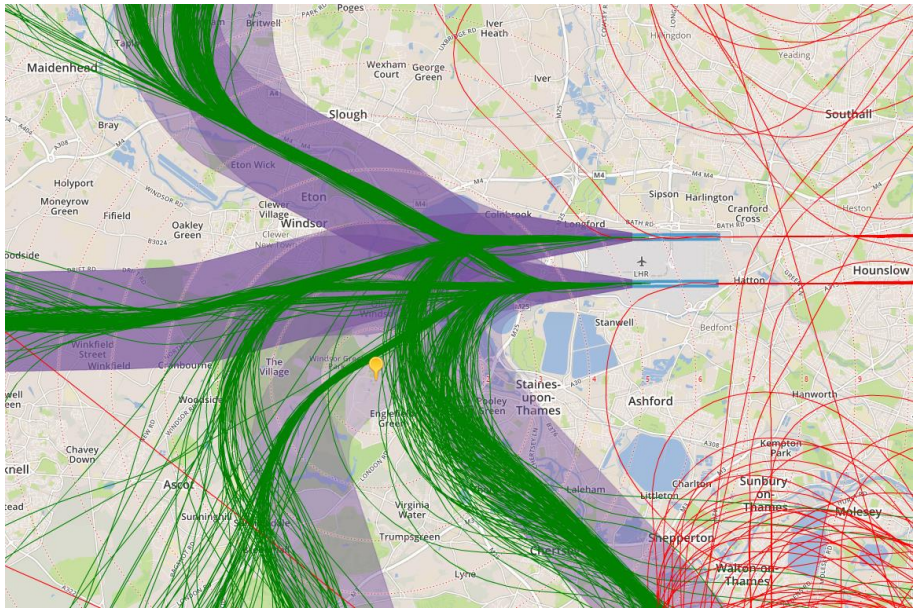
## Monitoring location, duration and setup

- A temporary noise monitor was installed in the Bishopsgate area between Windsor Great Park and Englefield Green between 05/06/2015 and 01/09/2015.
- The monitor was set up to record noise events based on a threshold sound pressure level of 60 dBA being exceeded for more than 10 seconds.
- The location of the noise monitor is shown in the figures to the right. It is close to the centre line of the MID noise preferential routes (NPR) from the southern runway, and close to the outer edge of the DET NPR from the northern runway.

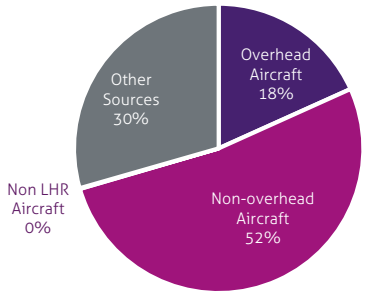
## Noise event summary

- A total of 13,127 noise events were measured during the monitoring period. Of these around 70% were from aircraft using Heathrow and 30% were from non-aircraft sources. Eleven events were registered from aircraft not using Heathrow.
- Overall, 48% of the aircraft registering noise events at the noise monitor were using the DET route, 37% from aircraft using the MID route.
- Overall, 41% of aircraft registering noise events were overhead - 81% of these were on the MID route, 16% DET.

**Noise preferential routes, monitor position and flight tracks on typical westerly day**




**Measured Noise Events Summary**

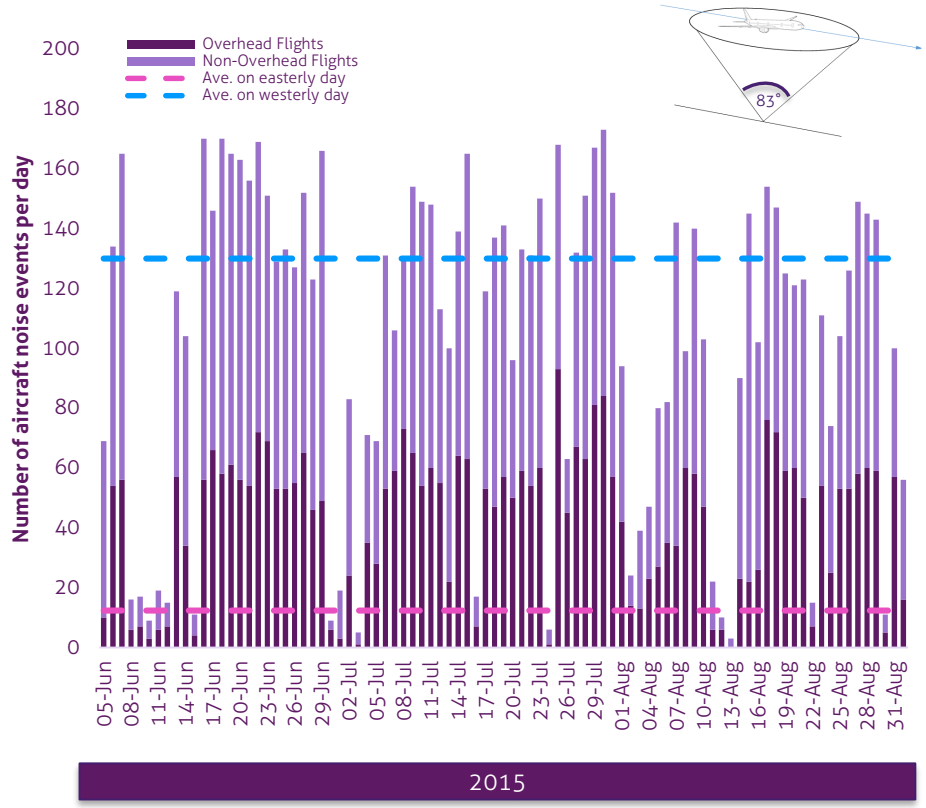



**Percentage of noise events by route**

| Routes % | | | | | | | | | Overhead % |
|---|---|---|---|---|---|---|---|---|---|
| CPT | | DET | | GOG | | MID | | Easterly Operations | |
| 27L | 27R | 27L | 27R | 27L | 27R | 27L | 27R | | |
| 11 | 0 | 5 | 43 | 1 | 0 | 36 | 1 | 3% | 41% |

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

- Noise events are captured at Bishopsgate mostly during periods of westerly operations and by aircraft using the DET and MID route.
- During the monitoring period 58 out of 89 days (69%) were 100% westerly operations and 13 days (17%) were 100% easterly operations. On the remaining days, the airport switched direction of operation during the day.
- During days of full westerly operations, there were, on average, 130 aircraft noise events triggered per day.
- During 100% easterly operations there was an average of twelve aircraft noise events – predominantly from departures following the Compton (CPT) route.
- On average, 41% of measured aircraft noise events were recorded by aircraft passing within the 83° overhead cone.
- Over the 89 days for which monitoring was taking place, 21% of days experienced 150 or more aircraft events whilst 17% of the days had less than 20 aircraft noise events.
- It is noted that an absence of aircraft noise events does not mean that aircraft would not necessarily be audible. There may be aircraft further away that are audible but have not triggered the noise event detection threshold.



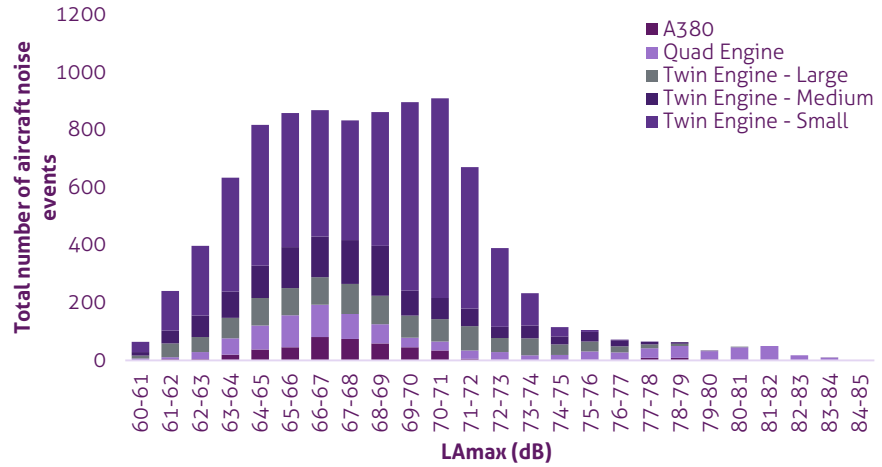
# What was the range of $L_{Amax}$ and SEL noise levels from aircraft events?

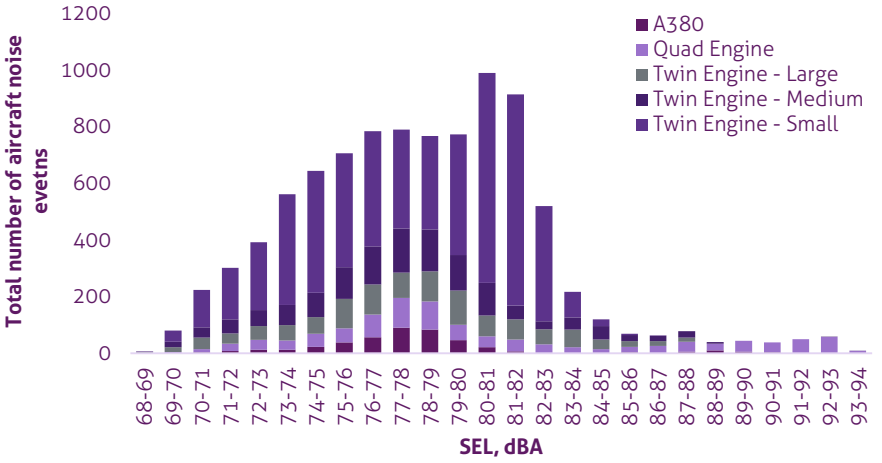
- The figures to the right present the range of $L_{Amax}$ (top) and SEL (bottom) noise levels for **all aircraft noise events measured at Bishopsgate**. An explanation of metrics is given on p8.
- The table below presents the average* $L_{Amax}$ and SEL for each aircraft type group.
- The average $L_{Amax}$ of all aircraft events is 68.1dB. The distribution of $L_{Amax}$ is similar for all aircraft groups although most of the louder events (>76dB) are generated by the B747.

| Aircraft group | Average $L_{Amax}$ | Average SEL, dBA |
|---|---|---|
| A380 | 67.8 | 77.9 |
| Quad engine | 70.4 | 81.1 |
| Twin engine large | 68.3 | 77.9 |
| Twin engine medium | 67.6 | 77.7 |
| Twin engine small | 67.7 | 77.7 |

- 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 p25-26.
- For non-aircraft related events, the mean $L_{Amax}$ is 64.9dB reaching a highest value of 93dB.

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

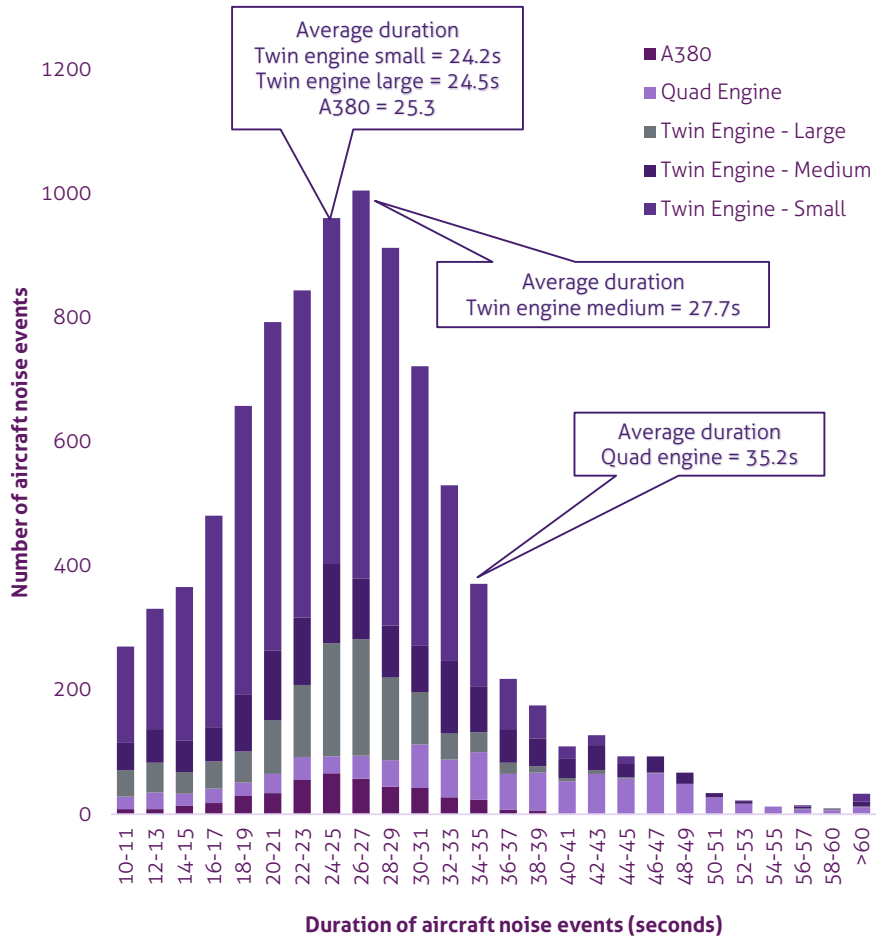


# How does the duration of an aircraft event vary?

- The duration of an event (as defined for the purposes of this comparison) is the time for which the noise level exceeds the event threshold level, which, in this case is 60dBA.
- In addition, events are only recorded if the duration is longer than 10s to prevent impulsive sounds which 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 26 seconds. The duration is largely dependent on the noise level of the event with the average event duration of the twin engine aircraft and A380 being around 24-27 seconds while the duration of the quad engine aircraft, predominantly the B747s, are longer at 35 seconds.
- The >60 seconds category includes all events with durations more than 60 seconds, which are most likely to be due to one event combining with another (e.g. one of which may not necessarily be an aircraft event)

| Aircraft group | Average noise event duration (seconds) |
|---|---|
| A380 | 25.3 |
| Quad engine aircraft | 35.2 |
| Twin engine - large | 24.5 |
| Twin engine - medium | 27.7 |
| Twin engine - small | 24.2 |



# 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 route and whether the analysis shows it to be overhead at the noise monitor.
- 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 55% of all aircraft noise events detected by the monitor.
- The B777 (twin-engine large) series of aircraft account for around 12% of the measured aircraft noise events, of which around two-thirds were using the DET route..
- Around 9% of aircraft noise events were from B747 aircraft (of which most were on the CPT route, with around quarter being overhead)
- 5% of the events were from the A380 of which less than 1% were overhead (using the DET route)
- The newest aircraft type in service, the B787 accounted for 3% of all recorded aircraft noise events, all of which were on the DET route and around a third were overhead.

| Aircraft Type | Total* | Route | | | | | | Overhead** |
|---|---|---|---|---|---|---|---|---|
| | | Easterly | CPT | DET | GOG | MID | WOB | |
| A320 | 30% | 0% | 0% | 15% | 0% | 15% | 0% | 18% |
| A319 | 15% | 0% | 0% | 5% | 0% | 10% | 0% | 10% |
| B777 | 12% | 1% | 1% | 8% | 1% | 1% | 0% | 2% |
| A321 | 10% | 0% | 0% | 6% | 0% | 4% | 0% | 5% |
| B747 | 9% | 1% | 4% | 1% | 1% | 2% | 0% | 2% |
| B767 | 7% | 1% | 4% | 2% | 0% | 1% | 0% | 1% |
| A380 | 5% | 0% | 0% | 4% | 0% | 0% | 0% | 0% |
| A330 | 4% | 0% | 1% | 2% | 0% | 1% | 0% | 1% |
| B787 | 3% | 0% | 0% | 3% | 0% | 0% | 0% | 1% |
| A340 | 1% | 0% | 0% | 0% | 0% | 1% | 0% | 0% |
| B757 | 1% | 0% | 1% | 0% | 0% | 0% | 0% | 0% |
| B737 | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Other | 1% | 0% | 0% | 1% | 0% | 0% | 0% | 0% |
| **Total*** ** | **100%** | **3%** | **11%** | **48%** | **2%** | **37%** | **0%** | **41%** |

* Percentage based on 9,251 aircraft noise events recorded between 5th June 2015 and 1st September 2015
** Defined as being with the 83 degree cone described on page 9
***Totals may differ to sum of aircraft types due to rounding

# Comparison of average maximum noise level ($L_{Amax}$) for different aircraft.

The plots on the right show the average (arithmetic mean) $L_{Amax}$ of each aircraft type for which at least 10 movements were registered within the 83° **overhead** cone on westerly operations (upper chart) or on the **MID** route departing the southern runway (lower chart) in addition to the maximum and minimum level for each aircraft type.

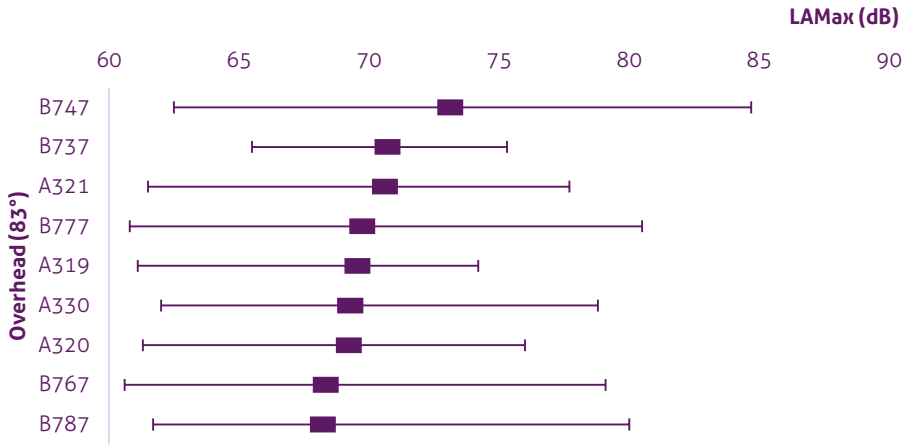
Note that some aircraft on the MID route are not overhead and vice versa (see heat maps on p15 to further understanding).

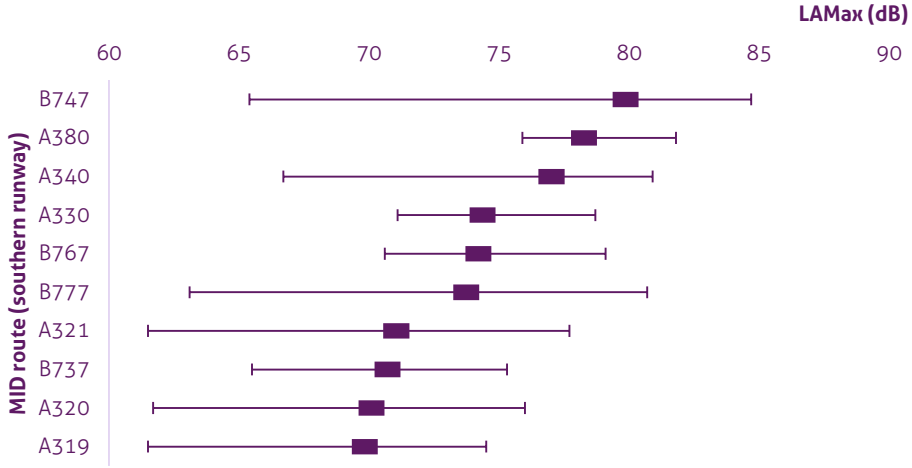
### Overhead aircraft

- The highest average measured noise level is from the B747, which at 73dB $L_{Amax}$ was approx. 2dB louder than the next loudest aircraft type the B737.
- It should be noted that there is a large range of levels for each aircraft type.
- The B787 (the newest aircraft in service in a twin engine medium category) was on average the quietest overhead aircraft, generating an $L_{Amax}$ of 68dB.

### Aircraft using the MID (southern) route

- When comparing aircraft using the MID departure route from the southern runway, the average $L_{Amax}$ of the B747 was approx. 2dB greater than the A380 at 80dB. The A340 (another 4 engine aircraft) was on average almost 3 dB less than the B747.
- The A330, B767 and B777 comprise the next loudest group of aircraft with noise levels generally falling between 73-75dB.
- In general, the noise levels of the aircraft decrease with size, the three quad-engine types are shown to be the noisiest and the four small twin engine aircraft the quietest.




In accordance with CAA guidance, this analysis has been used the 83 degree overhead cone.

# Comparison of average Sound Exposure Level (SEL) for different aircraft.

The plots on the right show the average (arithmetic mean) SEL of each aircraft type for which at least 10 movements were registered within the **83° overhead** cone on westerly operations (upper chart) or on the **MID** route departing the southern runway (lower chart) in addition to the maximum and minimum level for each aircraft type.

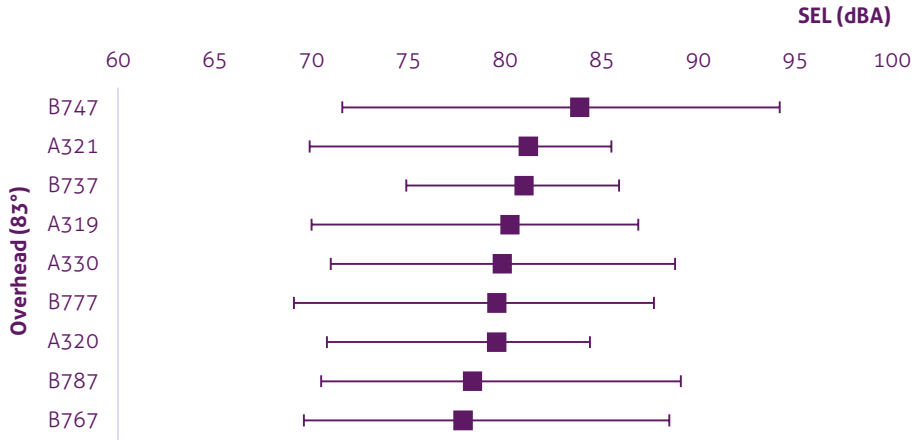
Note that some aircraft on the MID route are not overhead and vice versa (see heat maps on p15 to further understanding).

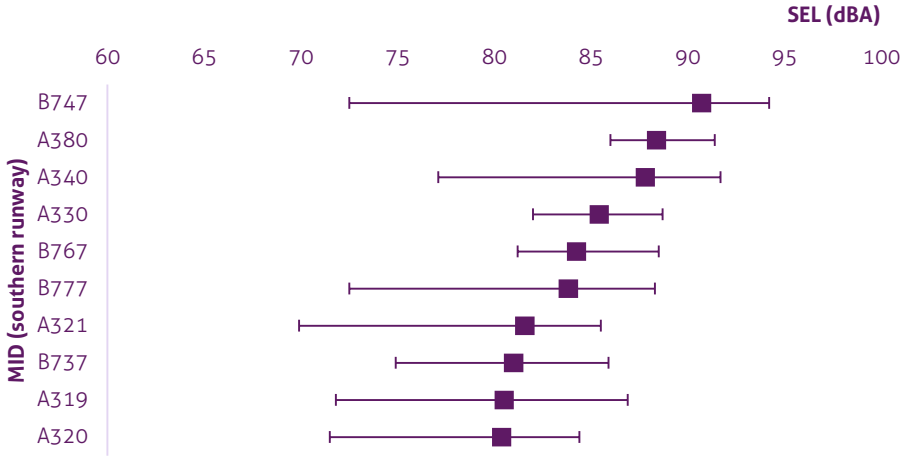
### Overhead aircraft

- The highest average SEL noise level is from the B747 at 84dBA, approx. 3dB greater than the A321, B737 and A319
- The range between maximum and minimum SEL for each aircraft type is usually greater than 10dB.
- The B767 (the newest aircraft in service) was the quietest aircraft type with an average SEL of 78.4dB.

### Aircraft using the MID route (southern runway)

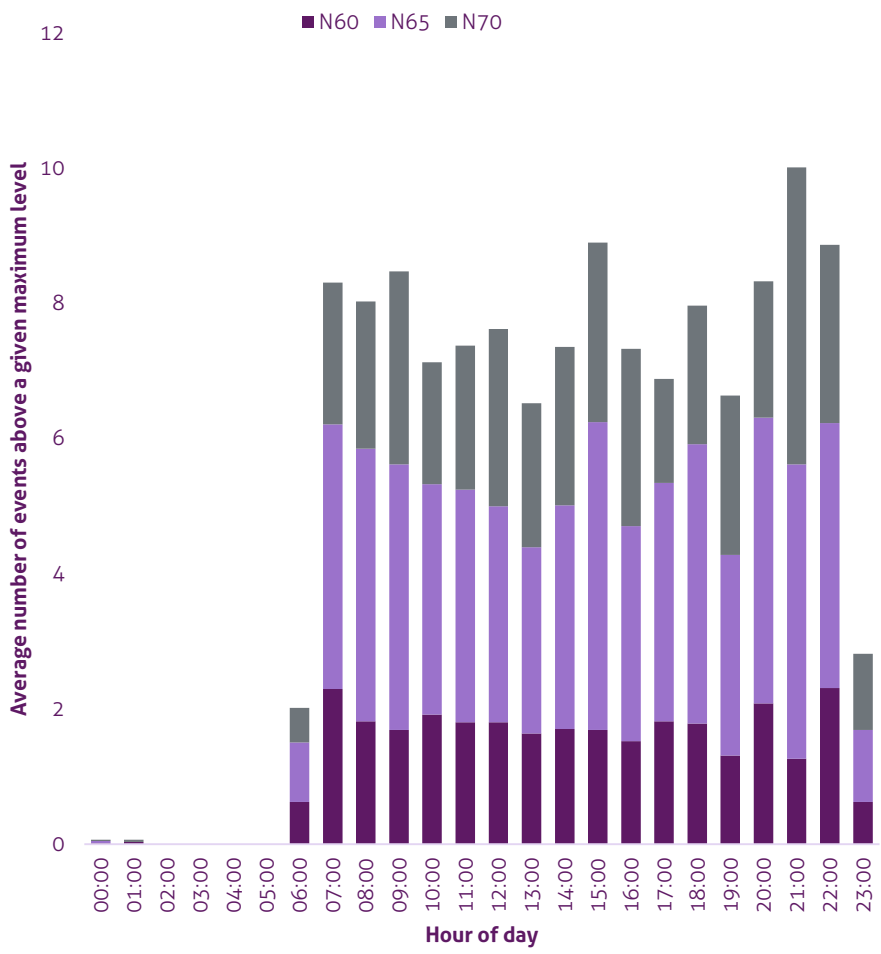
- When comparing aircraft departing the southern runway and following the MID route, the average SEL of the B747 was about 2dB greater than the A380. The A340 (another 4 engine aircraft) was on average around 0.6 dB less than the A380.
- The A330, B777 and B767 comprise the next loudest group of aircraft generally falling between 83-86dB.
- The four small twin engine aircraft form the quietest group with average SELs between 80 and 82dB



# How does the number of noise events above 60, 65 and 70 dB $L_{Amax}$ noise events vary across a day (N60, N65 and N70)?

- 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 $N_{above}$ set of metrics describes the number of events in a period where the $L_{Amax}$ exceeds a given value. For example, an $N65_{1hr}$ of 10 means that ten aircraft generated a maximum noise level greater than 65dBA in a single hour.
- The figure to the right shows the average hourly N60, N65 and N70 values across an **average 24hr day for days of 100% of westerly operations**.
- Between the hours of 07:00 and 23:00 there are typically, between 6 and 10 events being registered per hour. Most noise events are recorded in the hour between 21:00 and 22:00.
- On an average westerly day, the N65 during the 16h day period (07:00-23:00) was 126; the N60 during the 8h night (23:00-07:00) was less than 5.
- The N60 during the night period on westerly days was less than 5 and predominantly made up of scheduled departures in the 06:00-07:00 hour and late runners between 23:00 and 00:00.
- On westerly days, there are on average 3 noise events occurring in the hour from 23:00 to 00:00 reaching a maximum of 10 events on one day. On 20 of the 89 days, there were no noise events recorded from late runners.



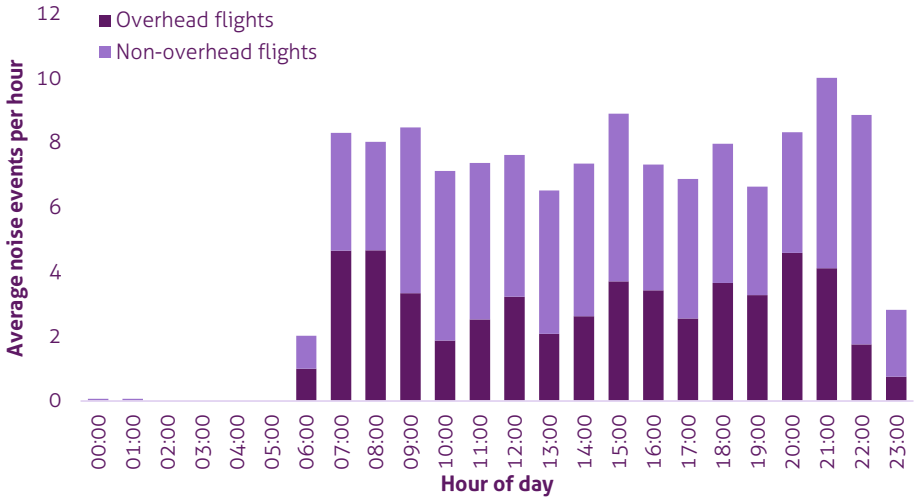
# How does the number of aircraft noise events vary across a day?

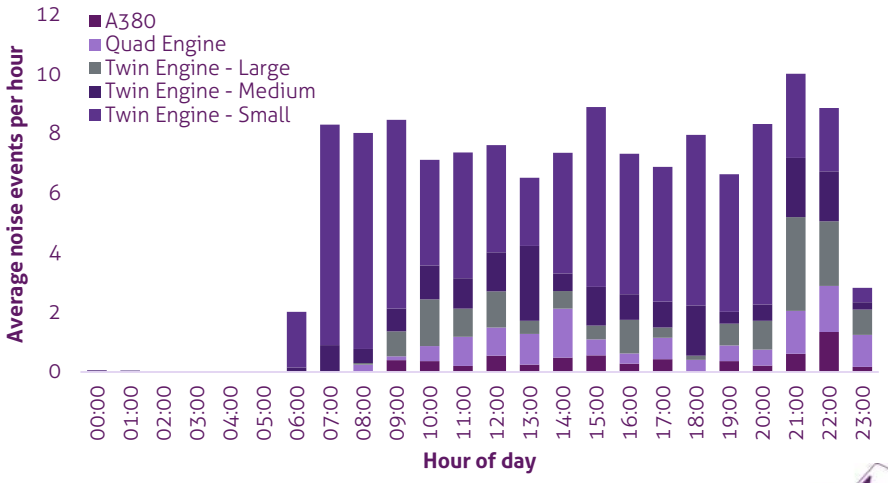
**The top right figure shows the average number of noise events during each hour of the day for days of full westerly operations.**

- During daytime hours, there were typically between 6 and 10 aircraft noise events flights per hour of which up to five were overhead (passing within the 83° cone above the monitor).
- The busiest hour of the day in terms of aircraft noise events fell between 21:00 and 22:00 while the busiest hour for overhead aircraft was 07:00-08:00.

**The lower figure shows the same data broken down by aircraft size.**

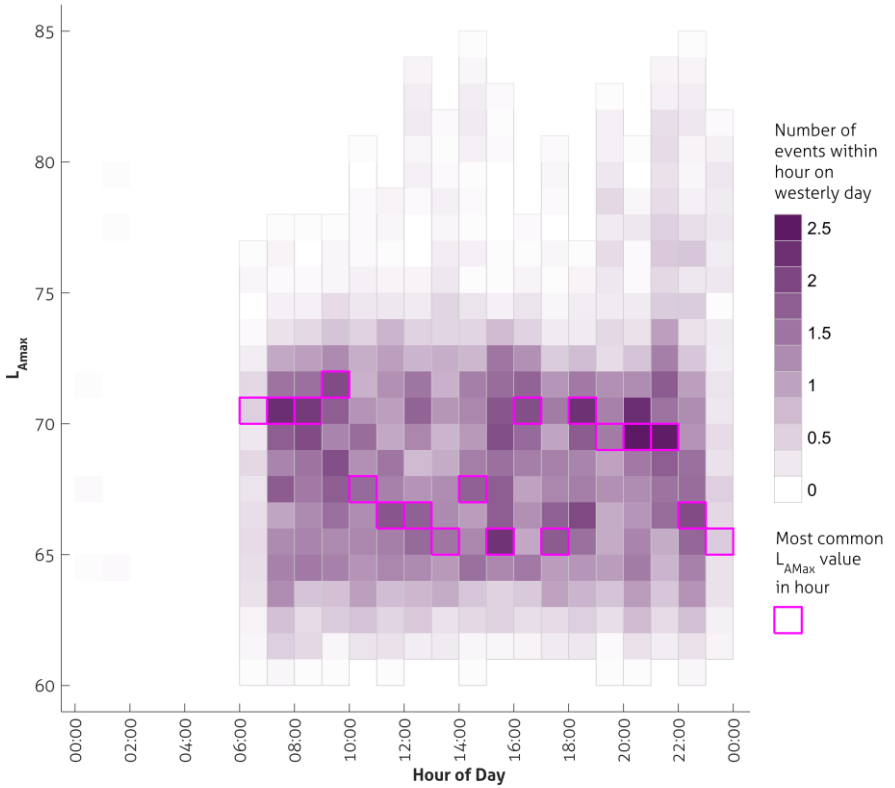
- Before 09:00, 90% of noise events were from smaller aircraft with less than twin-engine medium and small – predominantly the A320 family.
- The proportion of the smallest aircraft decreases until 13:00-14:00 when larger twin engine and quad engine aircraft account for two thirds of the noise events.
- The hours after 14:00 see the number of small twin engine aircraft increase until 21:00 when there is a sudden increase in the number and proportion of larger aircraft types. Between 21:00 and 23:00, the B777 accounts for almost 30% of all aircraft noise events while the A330, A380 and B747 each account for about 10%.
- On average, there were around 3 aircraft noise events in the 23:00-00:00 period. These are from delayed departures. It is noted that the range is between 0 and 10 for this hour. Of the total 89 days in the 2015 monitoring period, 58 days were 100% westerly operations, there were no delayed departures on 20 days.
- The number of the noisier, larger wide body aircraft increasing in the evening hours is reflected in the $N_{above}$ plots on the previous slide (p29).



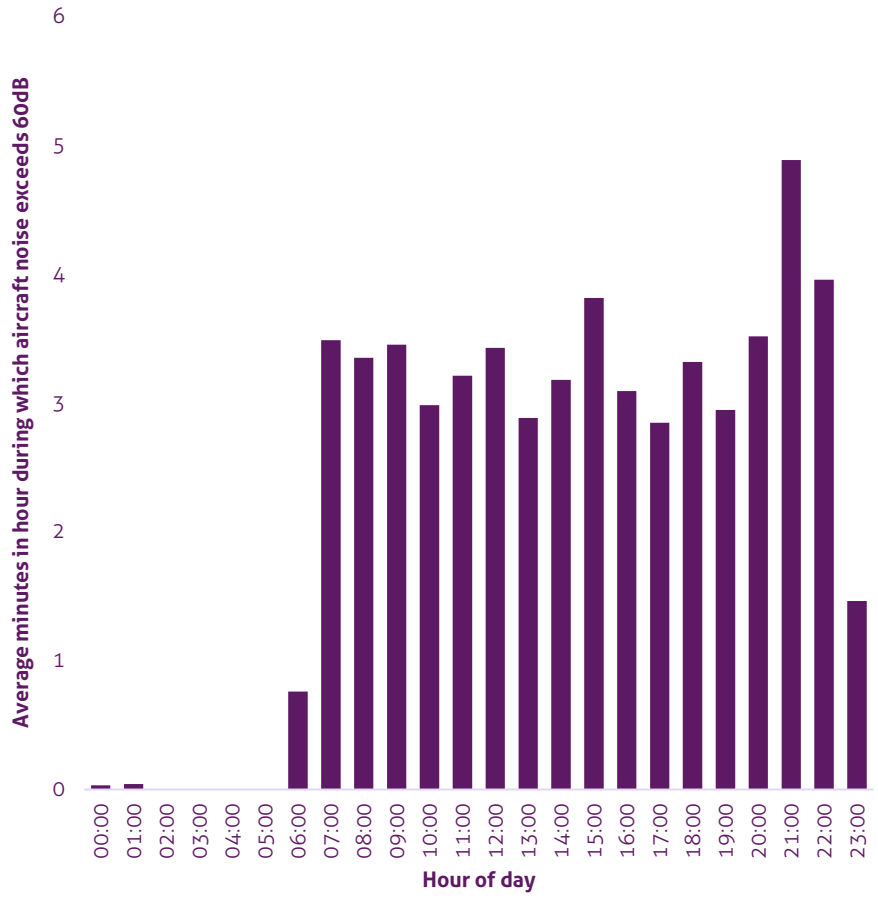
# How does the $L_{Amax}$ vary across a day?

- The figure to the right shows the range of $L_{Amax}$ values of aircraft noise events for each hour of the day. The average number of aircraft events in each decibel interval and hour on a typical westerly day is shown by the colour of each square; the darker the square, the more aircraft events occurred during that hour at a given level.
- The $L_{Amax}$ value which occurred most often in each hour is highlighted with a pink border.
- During daytime hours, typical $L_{Amax}$ values ranged between 65 and 72dB. The lowest mode $L_{Amax}$ occured during 4 hours while the highest mode $L_{Amax}$ was between 09:00 and 10:00.
- The increase in larger aircraft between 21:00 and 22:00, as seen on the previous page, is reflected in the larger number of noise events between 70 and 80dB.



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

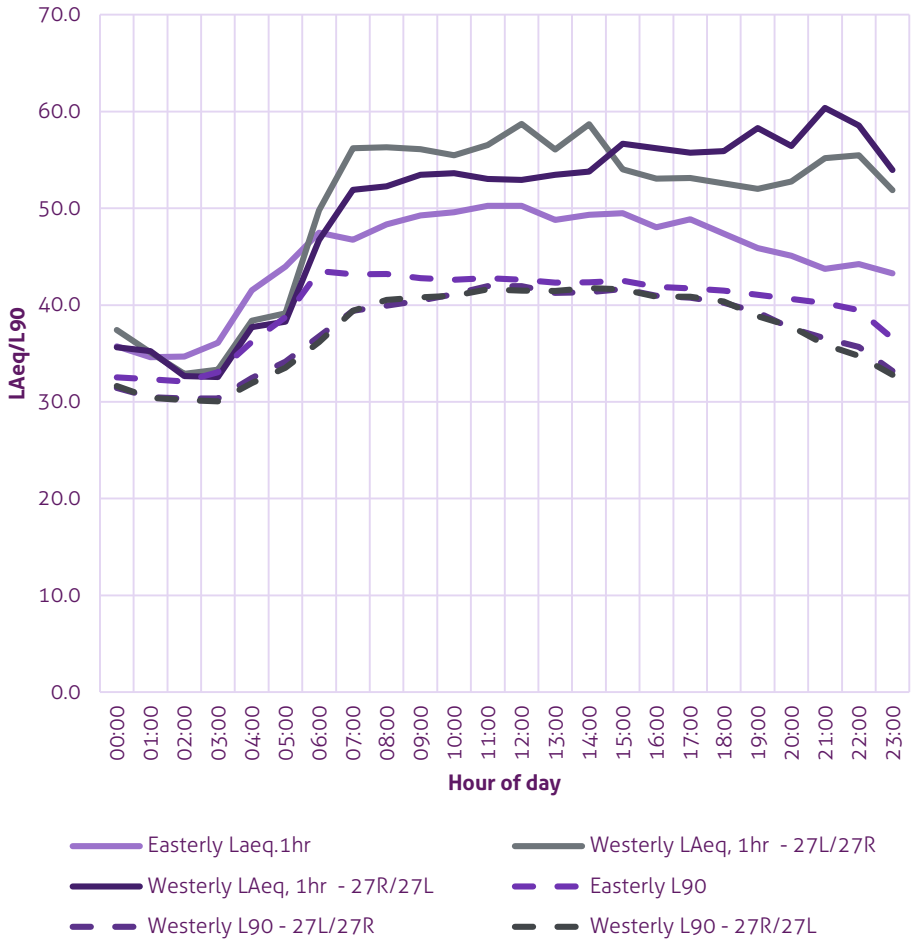
- The figure to the right shows the average number of minutes in each hour when the sound level within an aircraft noise event exceeding the measured noise event threshold - in this case 60dBA – on a day of full westerly operations. At this location this could be described as the amount of time (in minutes) that the aircraft noise level exceeds 60 dBA.
- 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.
- The figure shows that on 100% westerly days aircraft noise exceeded the monitor threshold for a total of between 3 and 4 minutes in each hour (5-6% of the hour) between the hours of 7am and 9pm.
- Between 9pm and 10pm this increased to 5 minutes. As with other analysis, this increase is because of the increase in movements by larger aircraft which generate longer events.




* 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.

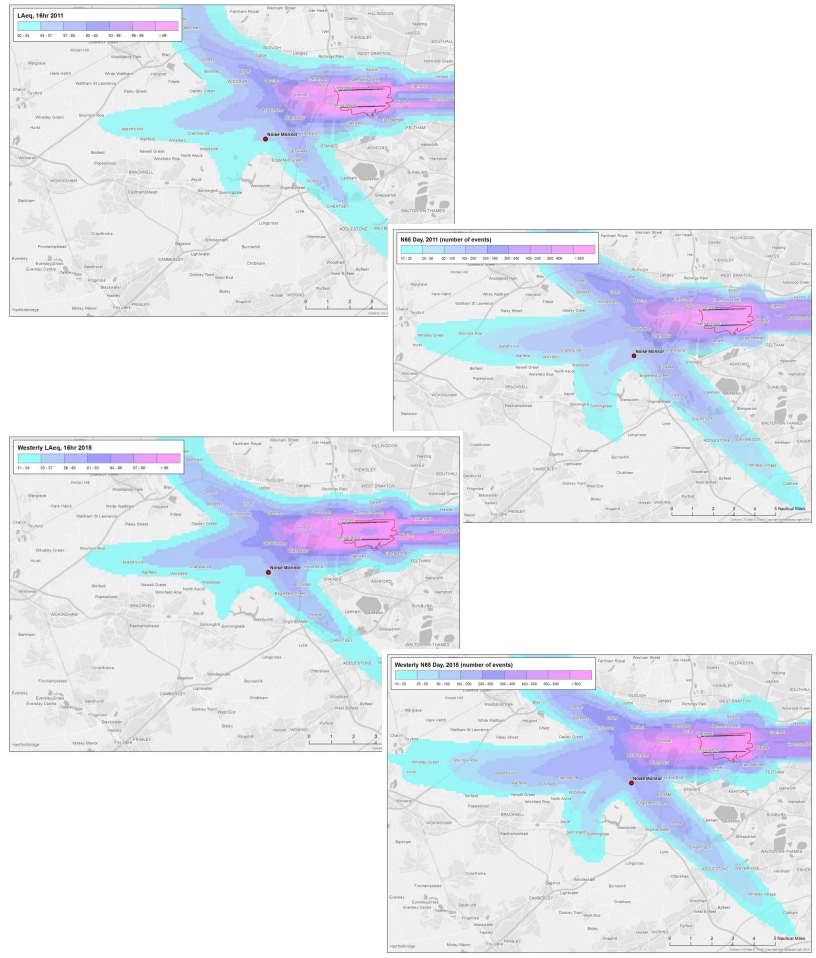
# Do aircraft contribute to overall ambient noise levels on days of westerly operations?

- The figure to the right shows the average (arithmetic mean) hourly $L_{Aeq,1hr}$ and $L_{A90,1hr}$ on days where 100% of operations were either westerly or easterly. It should be noted that these metrics describe the overall noise environment including all noise sources, not just aircraft noise.
- Full westerly days have been broken down into days where the northern runway is in use from 7am-3pm followed by the southern runway from 3pm-11pm (denoted 27R/27L) and the reverse (denoted 27L/27R).
- During days of full westerly operations daytime $L_{Aeq,1hr}$ values were typically around 4-15dB higher when compared with the same hour during a full easterly day. This indicates that the overall noise environment for each hour is governed by aircraft noise when on westerly operations.
- Furthermore, daytime $L_{Aeq,1hr}$ values are around 3dB higher when the southern runway is in use compared to the northern runway during westerly operations.
- The contribution of aircraft noise to the noise environment is most discernible during the period 21:00 and 23:00 with $L_{Aeq,1hr}$ reaching 60dB on westerly operations at a time when background noise is reducing
- During the period the monitor was in place, the average daytime $L_{Aeq,16hr,\ 1hr\ average}$ between 07:00 and 23:00 was 55dB on westerly operations and 48dB on easterly operations from all noise sources.
- During the night, the average $L_{Aeq,8hr,1hr\ average}$ between 23:00 and 07:00 was 45dB on westerly operations and 42dB on easterly operations.



# Comparing longer term average daytime ($L_{Aeq, 16hr}$ /N65) and night-time ($L_{Aeq, 8hr}$ /N60) aircraft noise levels around the airport using modelling.

- 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 INM model has been run using flight track data for **2011 and 2015** to investigate whether there are any differences in daytime ($L_{Aeq, 16hr}$ /N65) and nighttime ($L_{Aeq, 8hr}$ /N60) for an **average day and night of westerly operations** across the summer in each of these years.
- Note that these contours are specific to westerly operations and are not the same as the traditional annual contours which derive an overall average for the summer that combines westerly and easterly operations. They only use days when there were full westerly operations across that day.
- Daytime $L_{Aeq, 16hr}$ values are presented in bands >50 dB, > 54dB and then in 3 dB increments to 69 dB.
- Night-time $L_{Aeq, 8hr}$ values are presented in 5dB bands starting at >40 dB to 65 dB.
- These are longer terms metrics averaged over 16 and 8hrs and do not directly reflect the shorter term fluctuations between individual events.
- It should be noted that aircraft noise modelling to levels around 50 dB 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 mind.



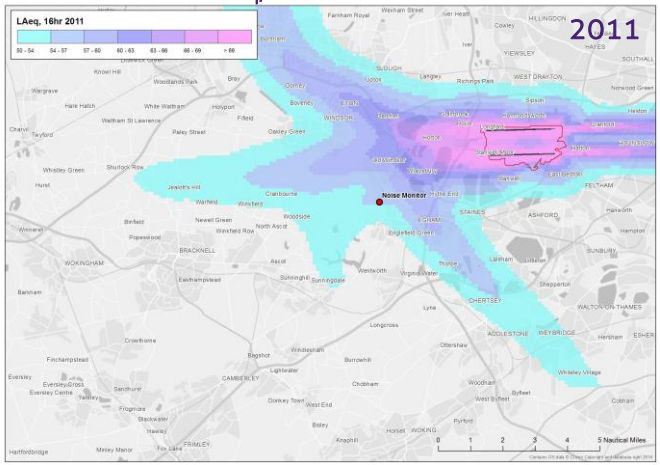
# Modelled average **daytime** $L_{Aeq,\ 16\ hour}$ and N65 aircraft noise levels

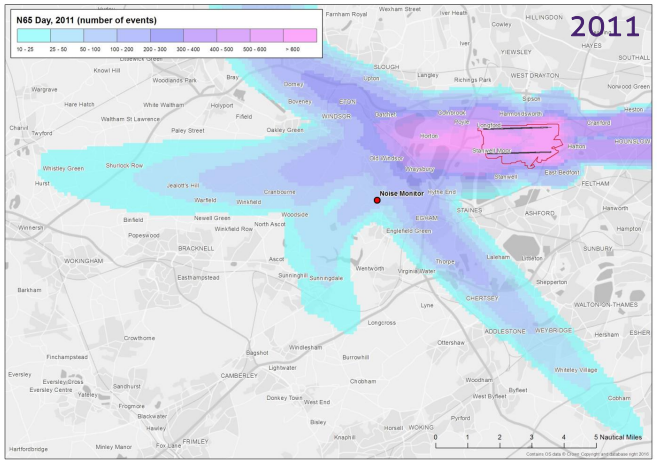
- The figures to the right show the 2011 and 2015 daytime $L_{Aeq,\ 16hr}$ bands in the left column and N65 bands in the right column for **an average westerly summer day when the airport is on 100% westerly operations**.
- The position of the noise monitor is marked by the orange dot.
- The N65 is defined as the number of aircraft noise events where the $L_{Amax}$ exceeds 65dBA over the 16 hour day period between 7am and 11pm.

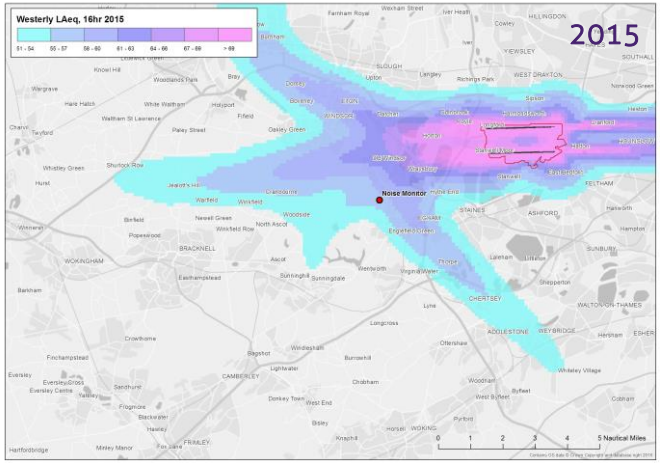
- Larger figures are shown in Appendix A.

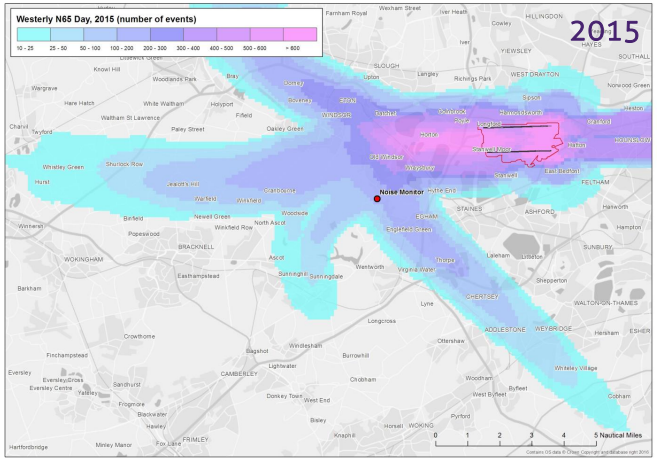
$L_{Aeq,16hr}$

N65, Daytime



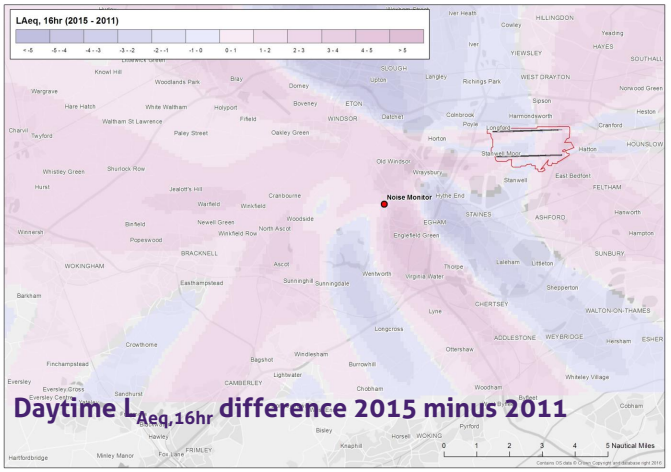



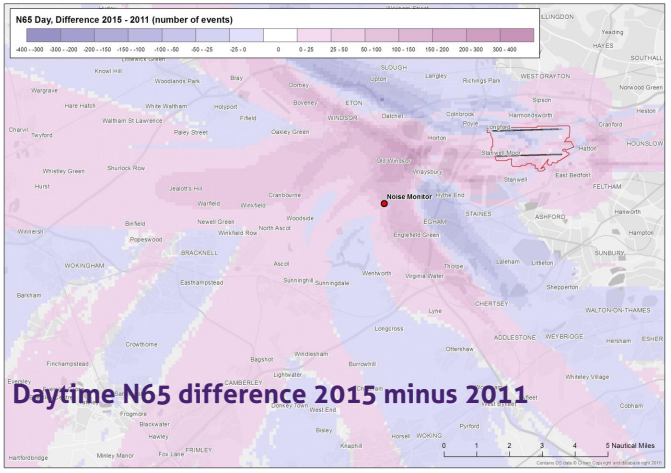
# Modelled **daytime** $L_{Aeq,\ 16\ hour}$ and $N65_{(16\ hour)}$ differences - 2011 to 2015

- The difference in the modelled average $L_{Aeq,\ 16hr}$ and $N65_{16\ hr}$ contours around Heathrow between 2011 and 2015 are shown in the figures to the right. This is for **an average westerly 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 Bishopsgate there was between a 1 and 2dB increase in average modelled daytime noise level $L_{Aeq,16hr}$ between 2011 and 2015 to 55dB.
- The modelling indicates an increase of up to 50 (+66%) daytime N65 events.
- It should be noted that, all other variables remaining constant, a difference in 15% of noise events, would correspond to about a 1dB increase/decrease in $L_{Aeq,16hr}$ and a 100% increase would correspond to about a 3dB increase/decrease in $L_{Aeq,16hr}$.

- Larger figures are shown in Appendix A.




**Daytime $L_{Aeq,16hr}$ difference 2015 minus 2011**



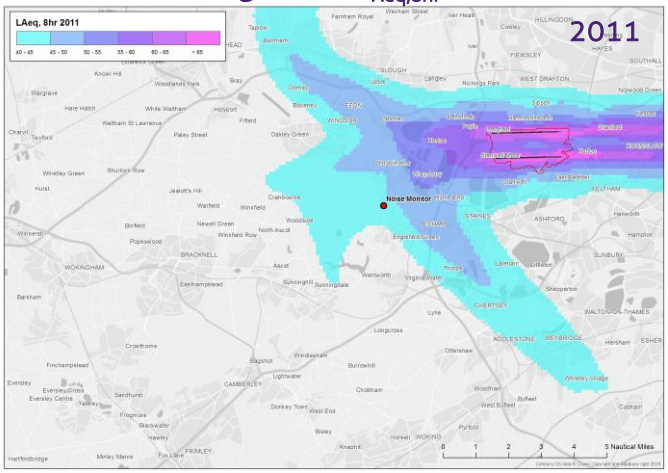

**Daytime N65 difference 2015 minus 2011**

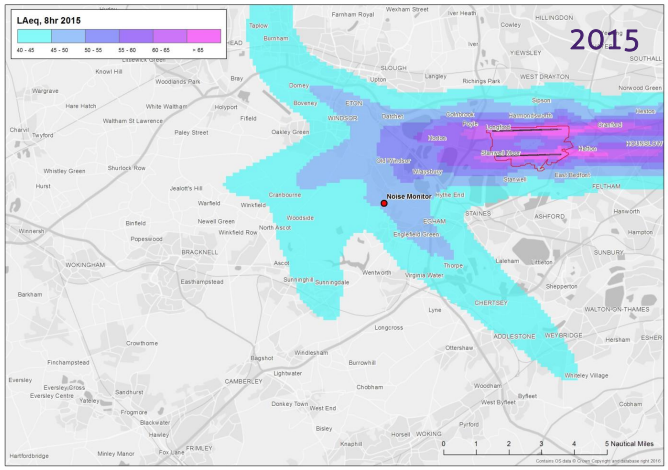
# Modelled average **night time** $L_{Aeq, 8hr}$ and N60 aircraft noise levels.

- The figures to the right show the 2011 and 2015 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 westerly summer night between 11pm and 7am when there are 100% westerly operations. Generated from **an average westerly summer day when the airport is on 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 60dBA over the 8 hour night period between 11pm and 7am.
- The figures to the right shows the average $N60_{8hr}$ values for 2011 and 2015 from 1 up to greater than 80 when the airport is on westerly operations.

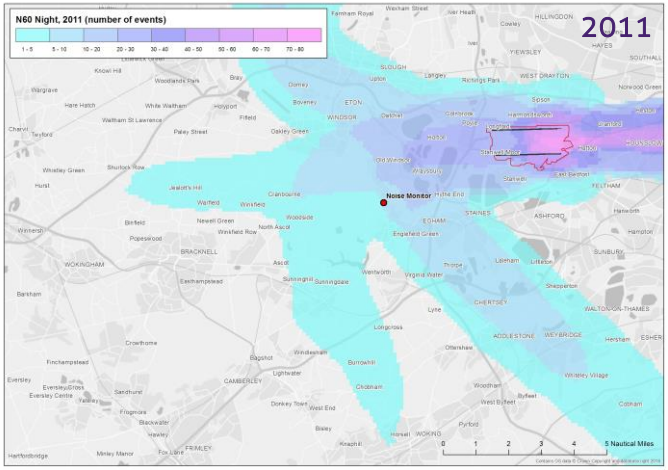
- Larger figures are shown in Appendix A.

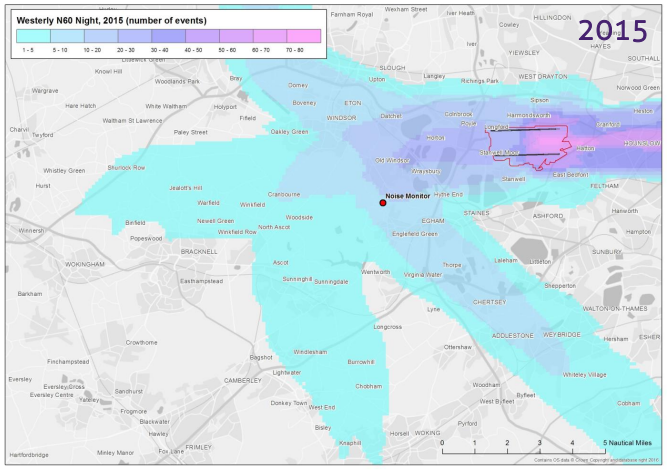
Night-time $L_{Aeq,8hr}$




N60, night-time

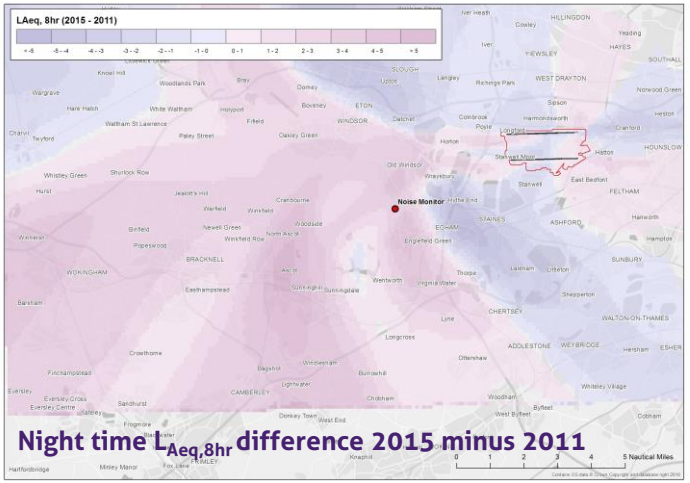


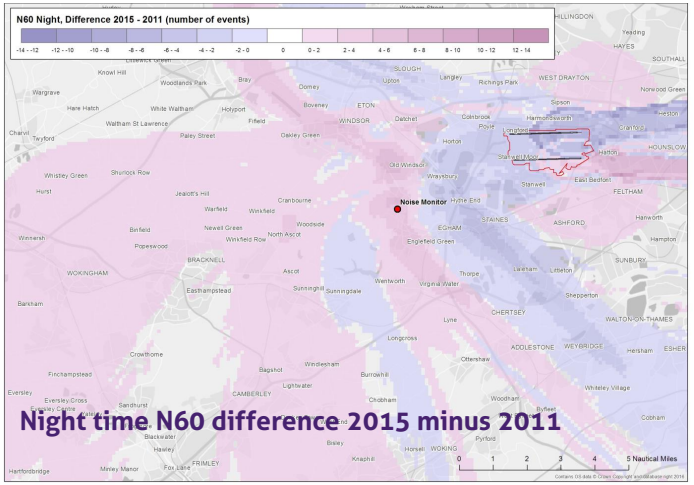



# Modelled average **night-time** $L_{Aeq, 8hr}$ and N60 differences - 2011 to 2015

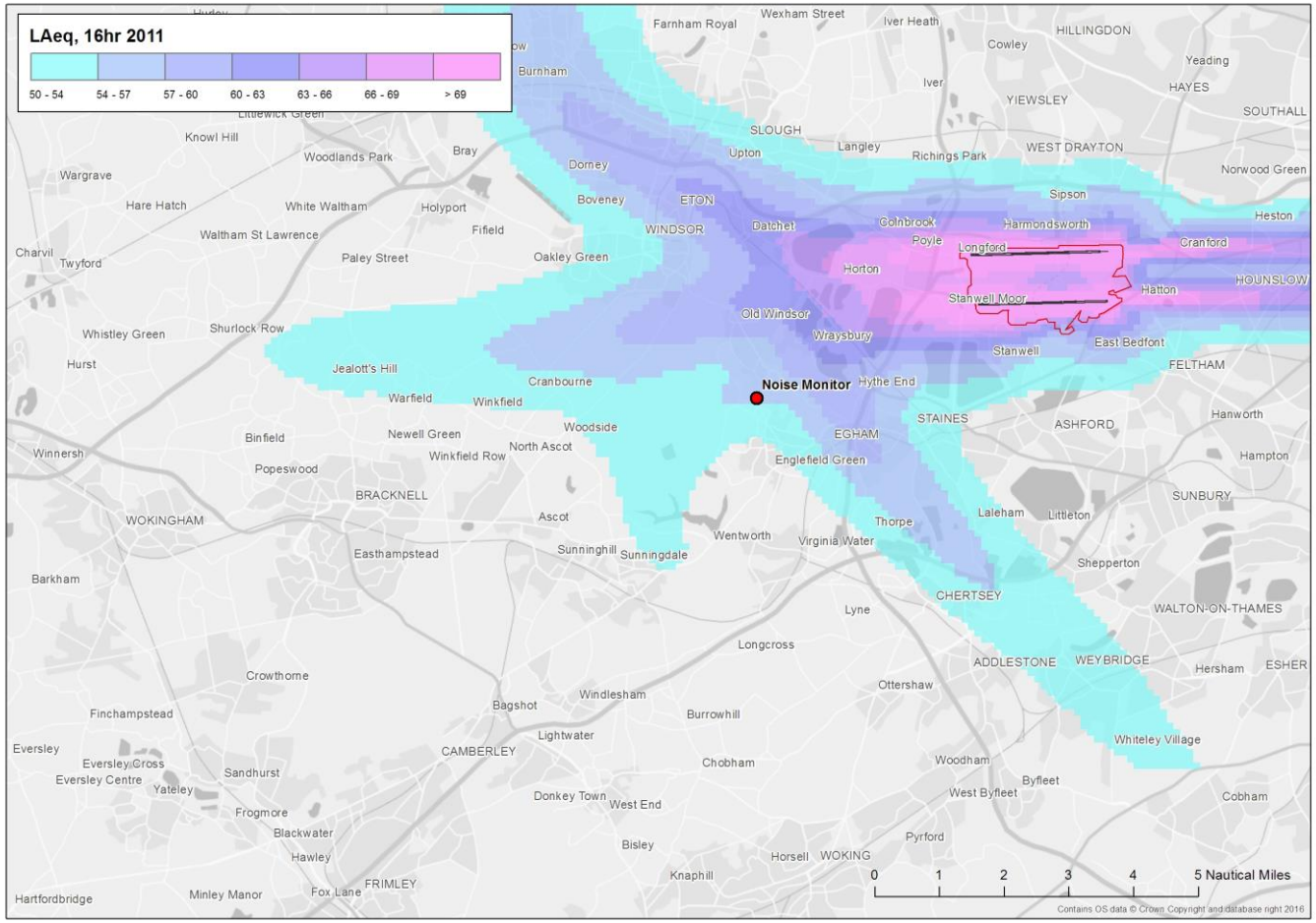
- The difference in the modelled average $L_{Aeq, 8hr}$ (upper figure) and $N60_{(8\ hr)}$ (lower figure) values **on 100% westerly operations** around Heathrow between 2011 and 2015 are shown in the figures to the right.
- Areas with an average decrease are shown in blue and those areas with an average increase in pink.
- The results indicate an increase in average night-time aircraft noise $L_{Aeq,8hr}$ from 44 to 46dB and increase in N60 from 5 to 8 at Bishopsgate from 2011-2015.

- Larger figures are shown in Appendix A.

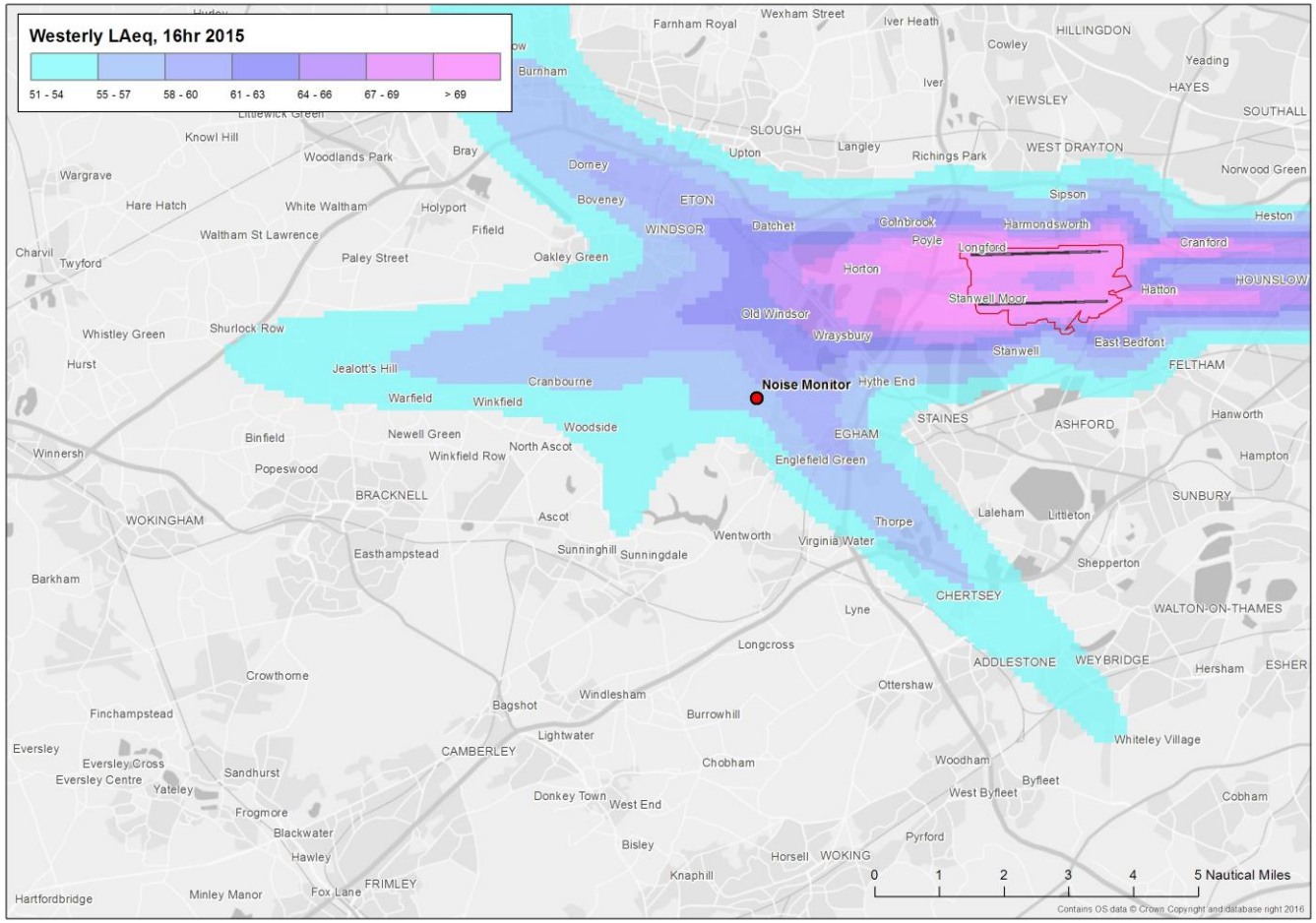


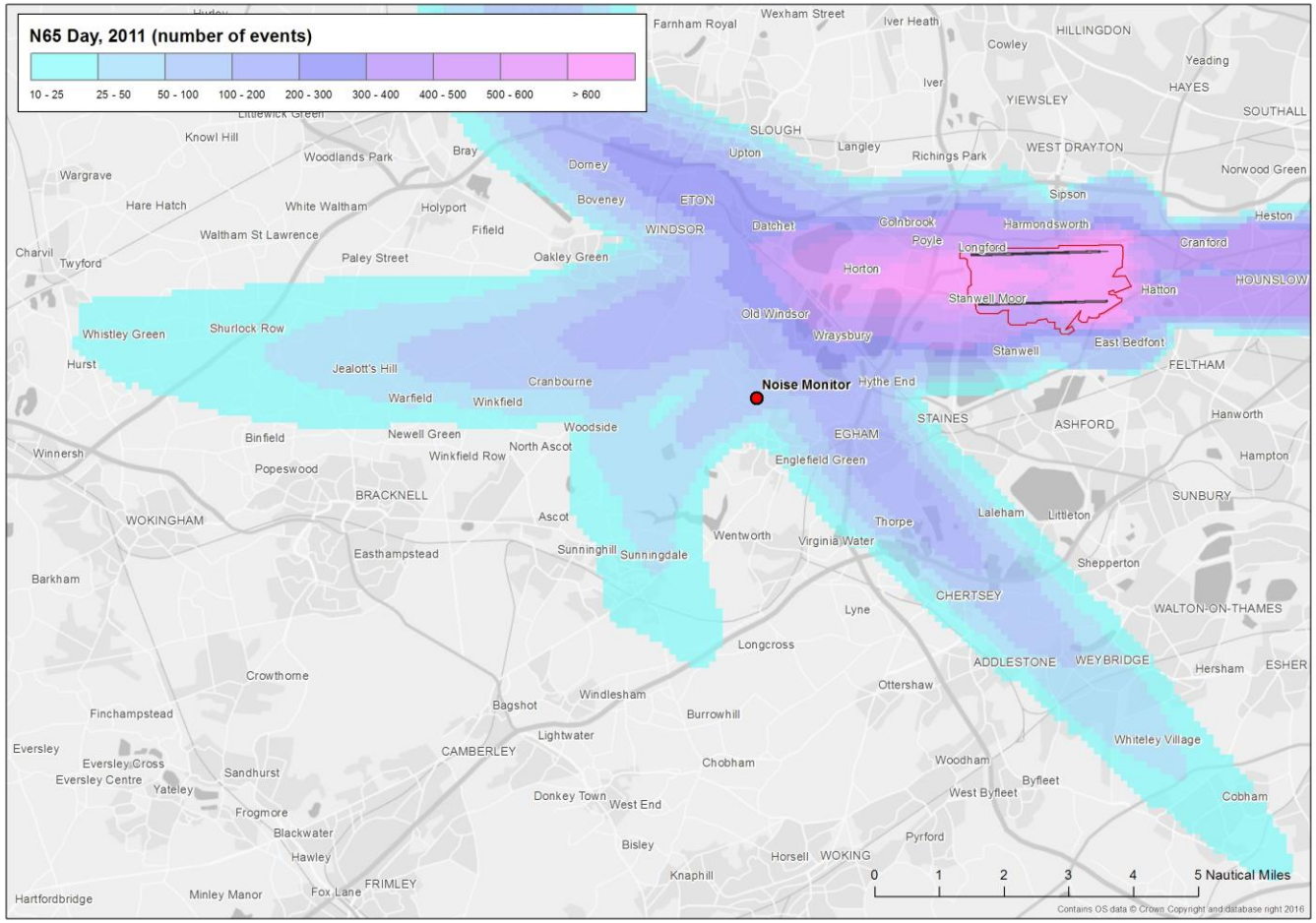
# Appendix A: Average westerly day $L_{Aeq, 16hr}$ contours (2011)



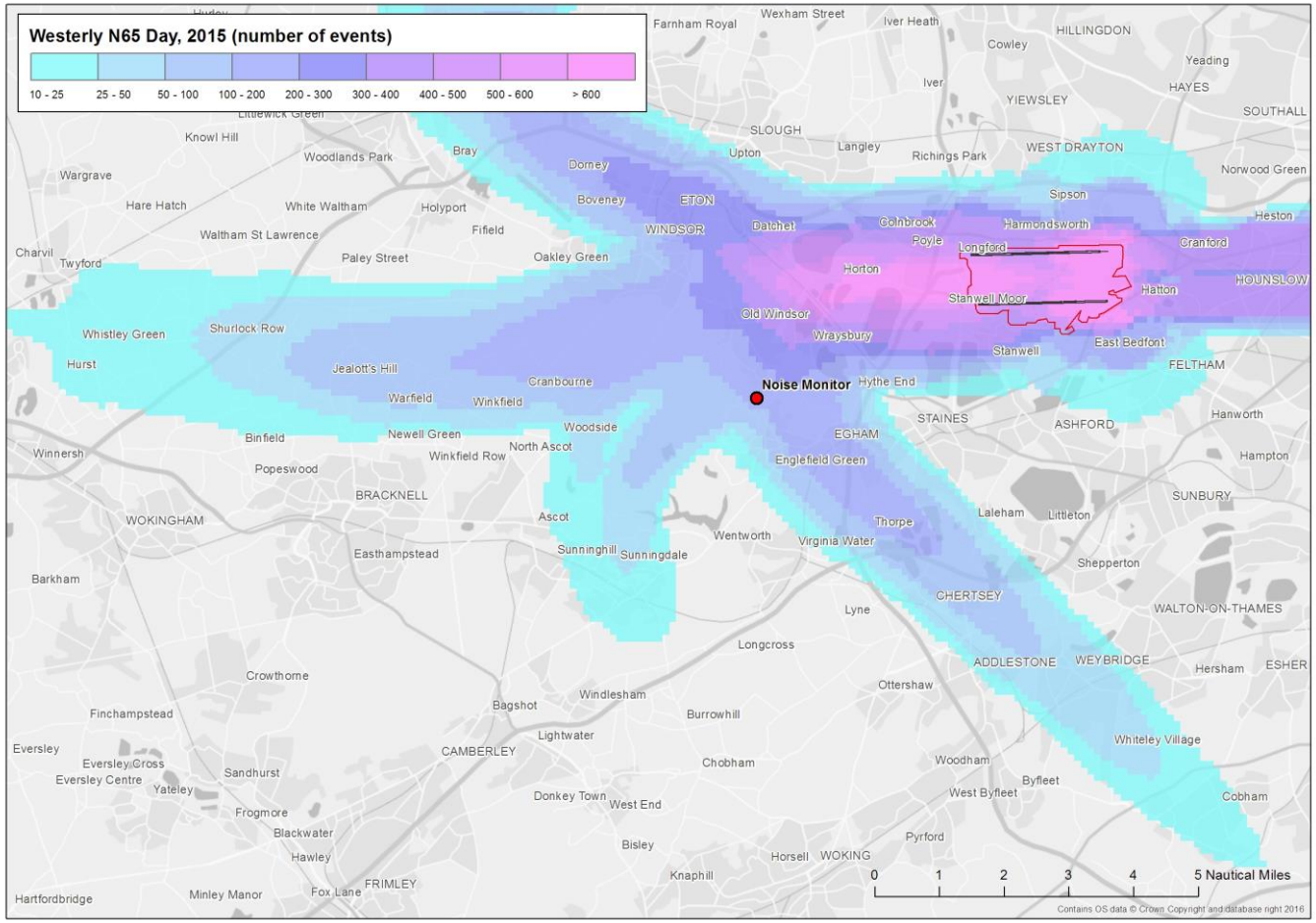
# Appendix A: Average westerly day $L_{Aeq, 16hr}$ contours (2015)



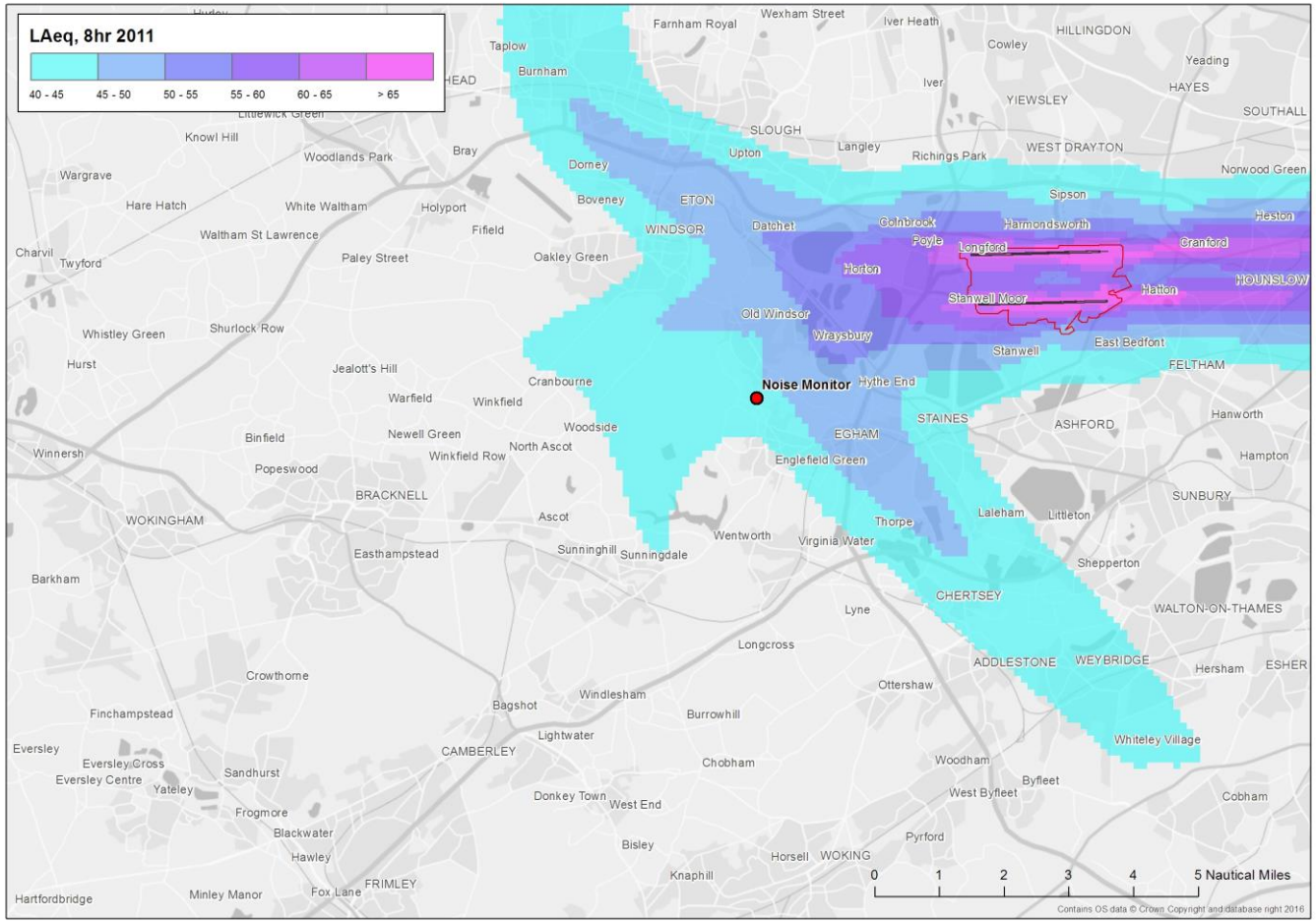
# Appendix A: Average westerly day $N65_{16hr}$ contours (2011)



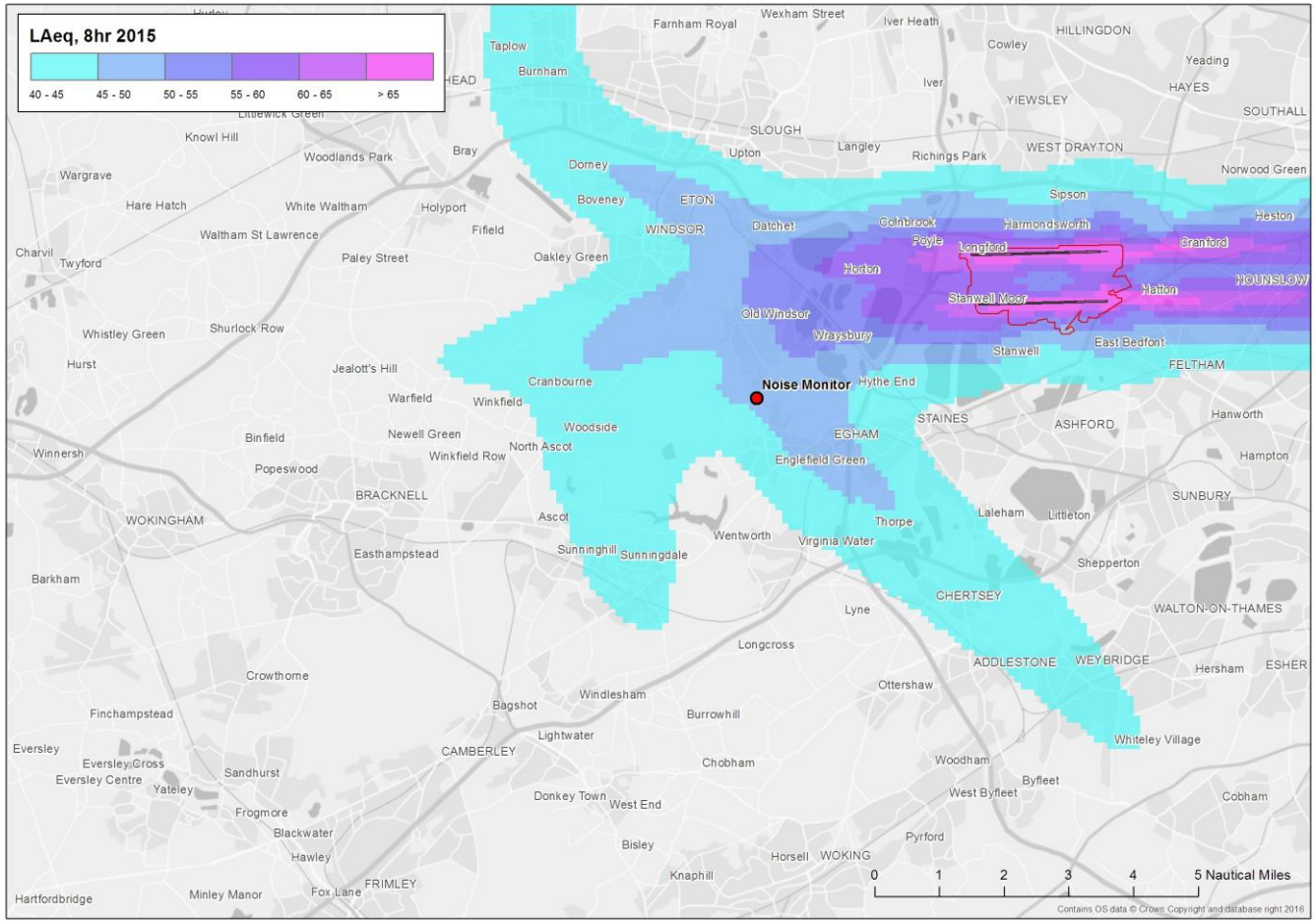
# Appendix A: Average westerly day $N65_{16hr}$ contours (2015)



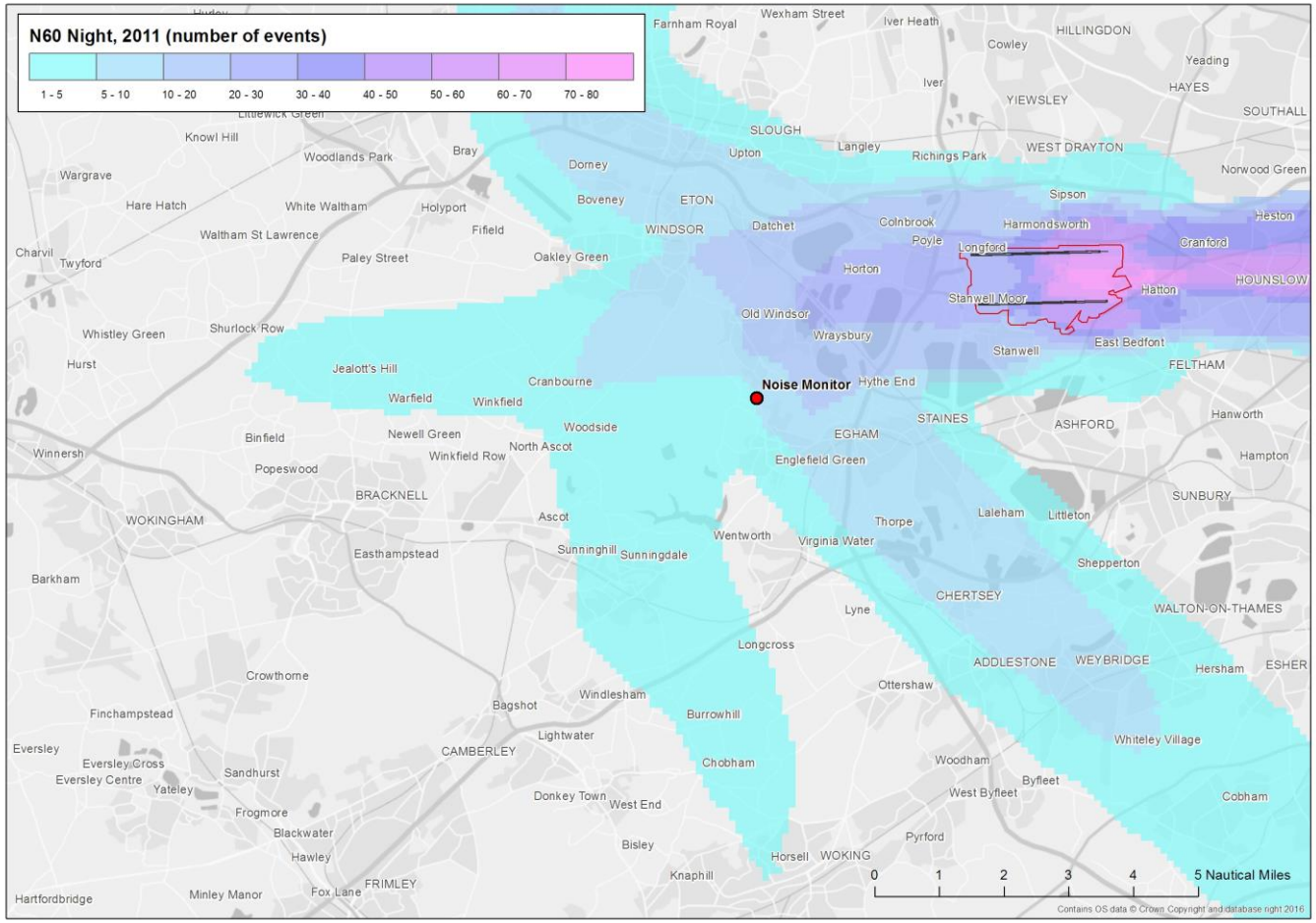
# Appendix A: Average westerly night $L_{Aeq, 8hr}$ contours (2011)



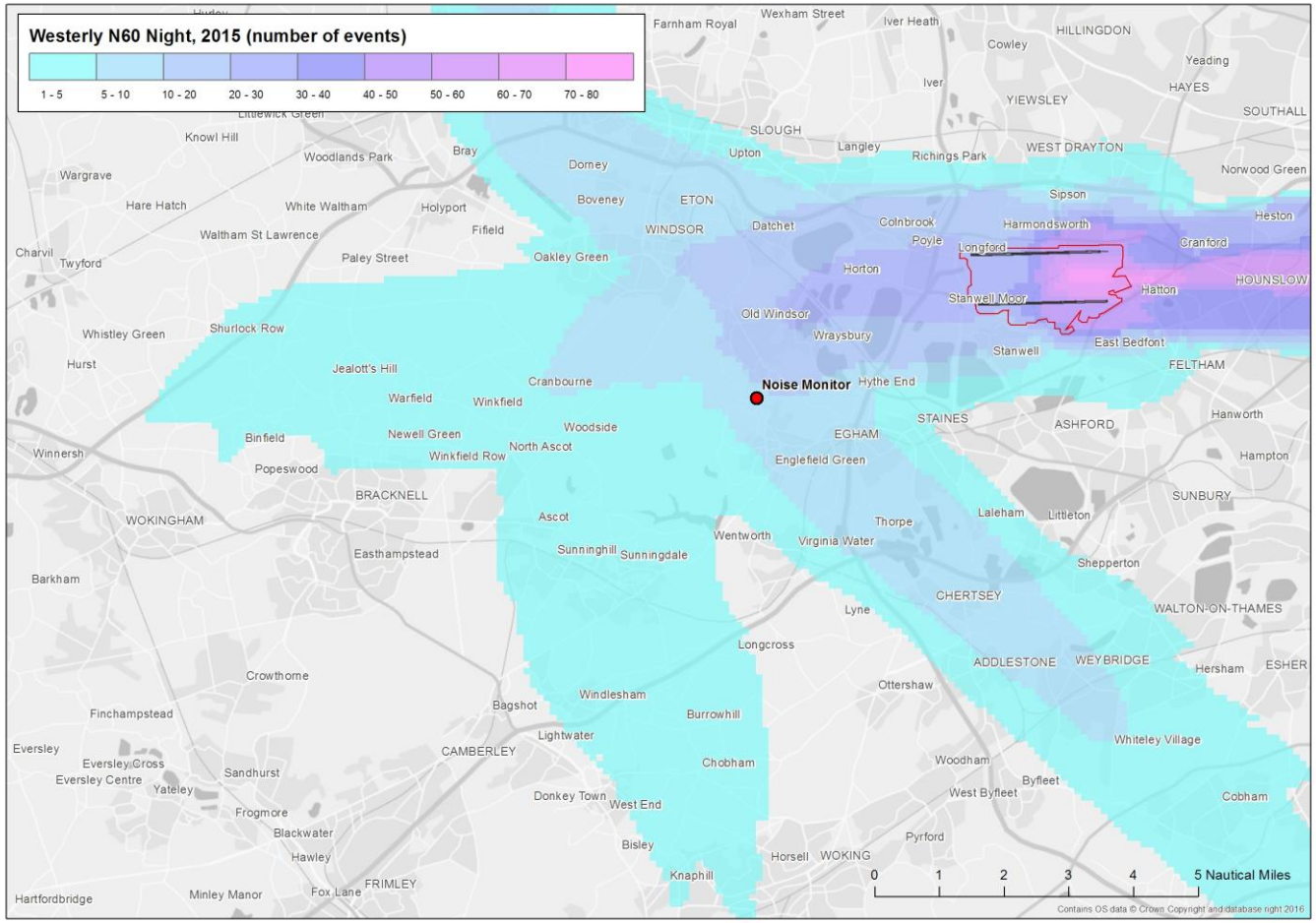
# Appendix A: Average westerly night $L_{Aeq, 8hr}$ contours (2015)



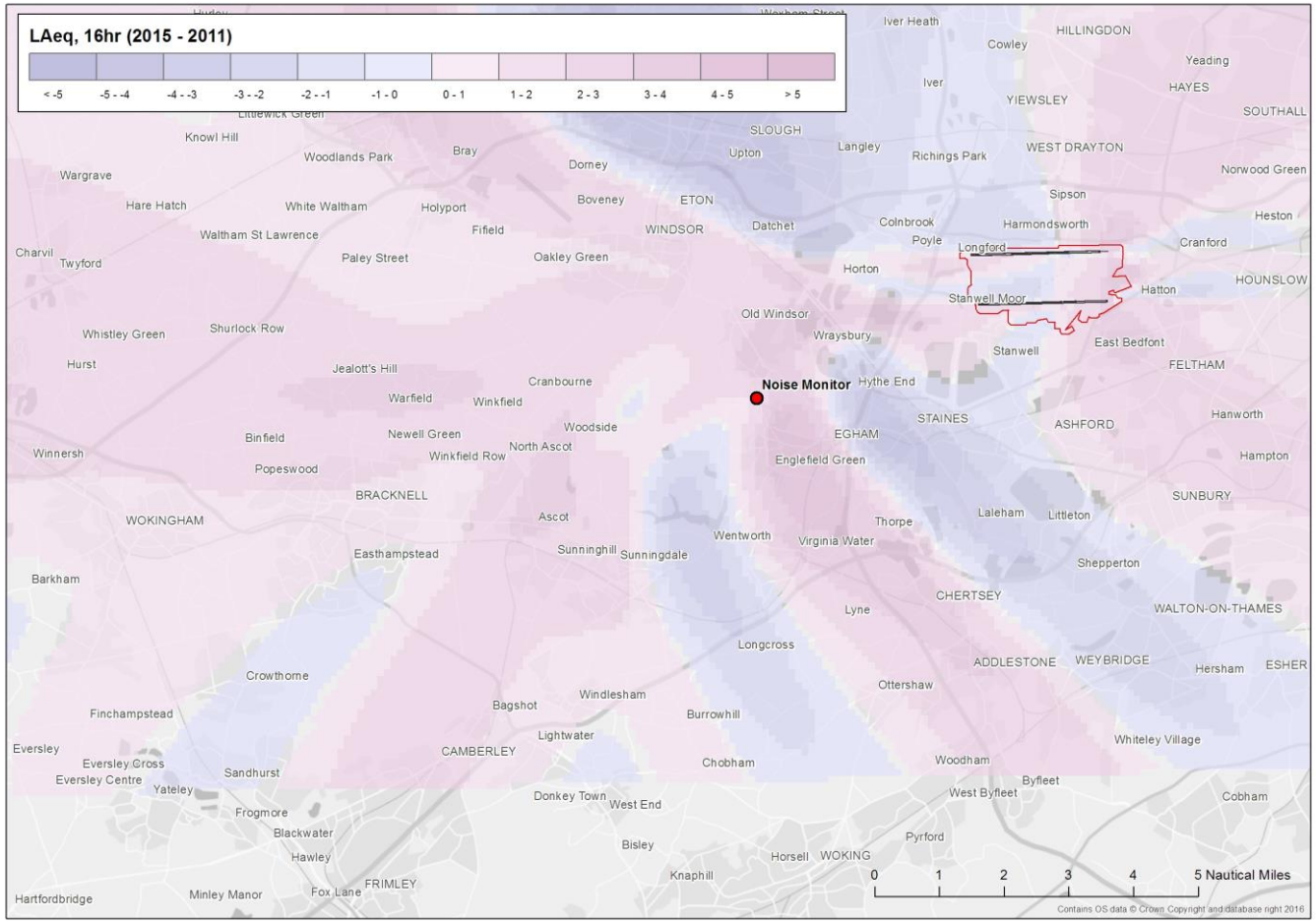
# Appendix A: Average westerly night $N60_{8hr}$ contours (2011)



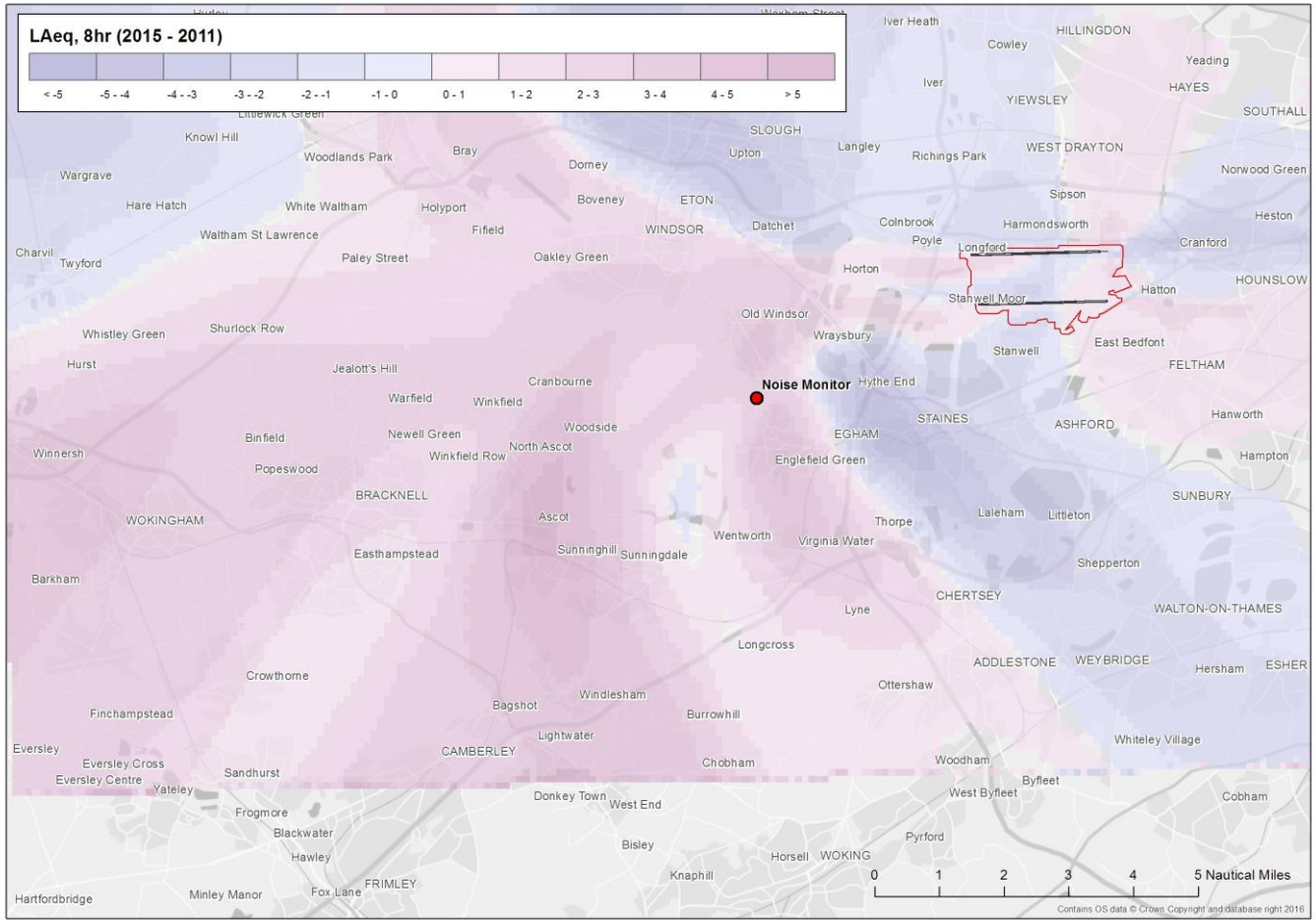
# Appendix A: Average westerly night $N60_{8hr}$ contours (2015)



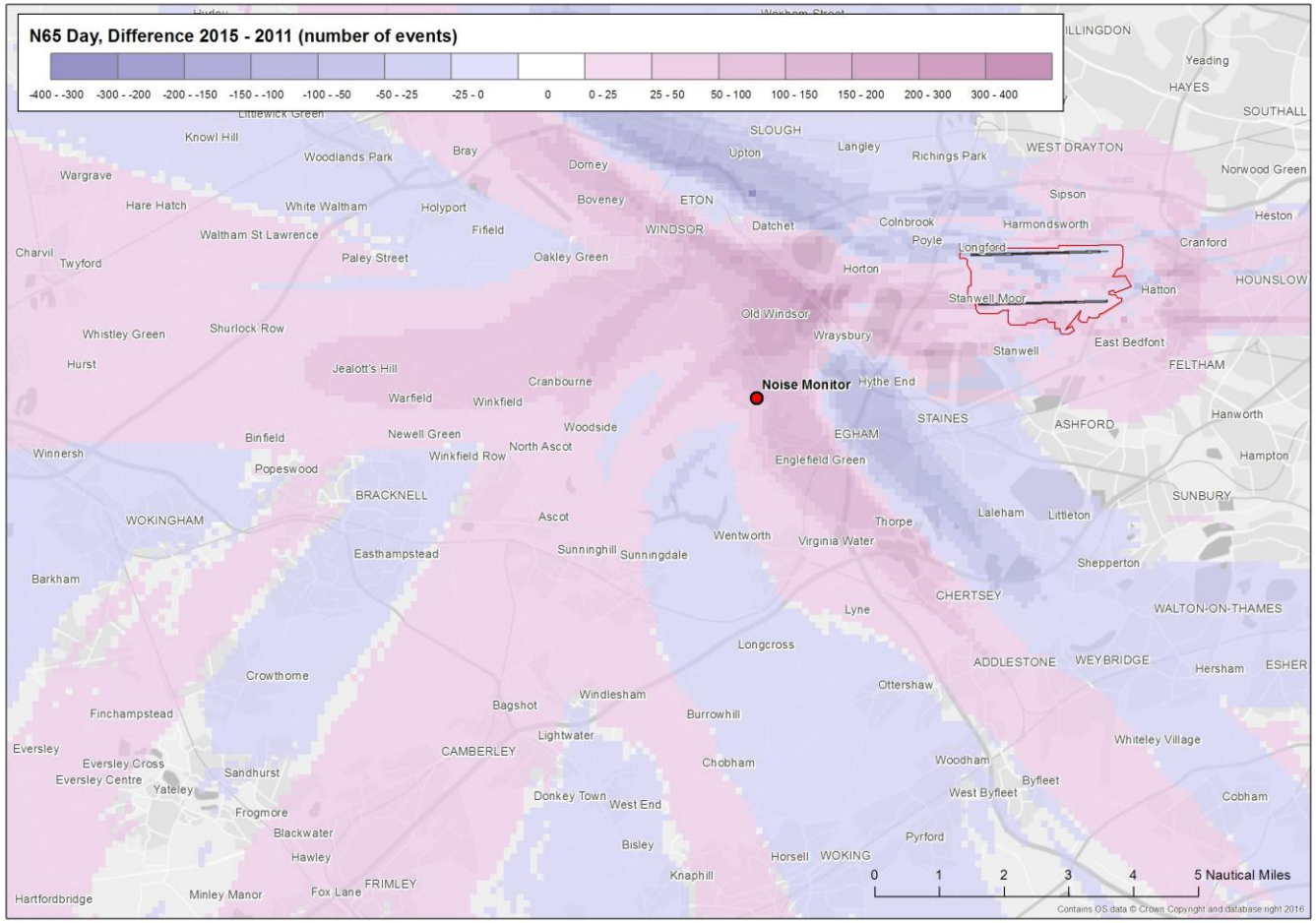
# Appendix A: Average westerly day $L_{Aeq, 16hr}$ difference (2015 minus 2011)



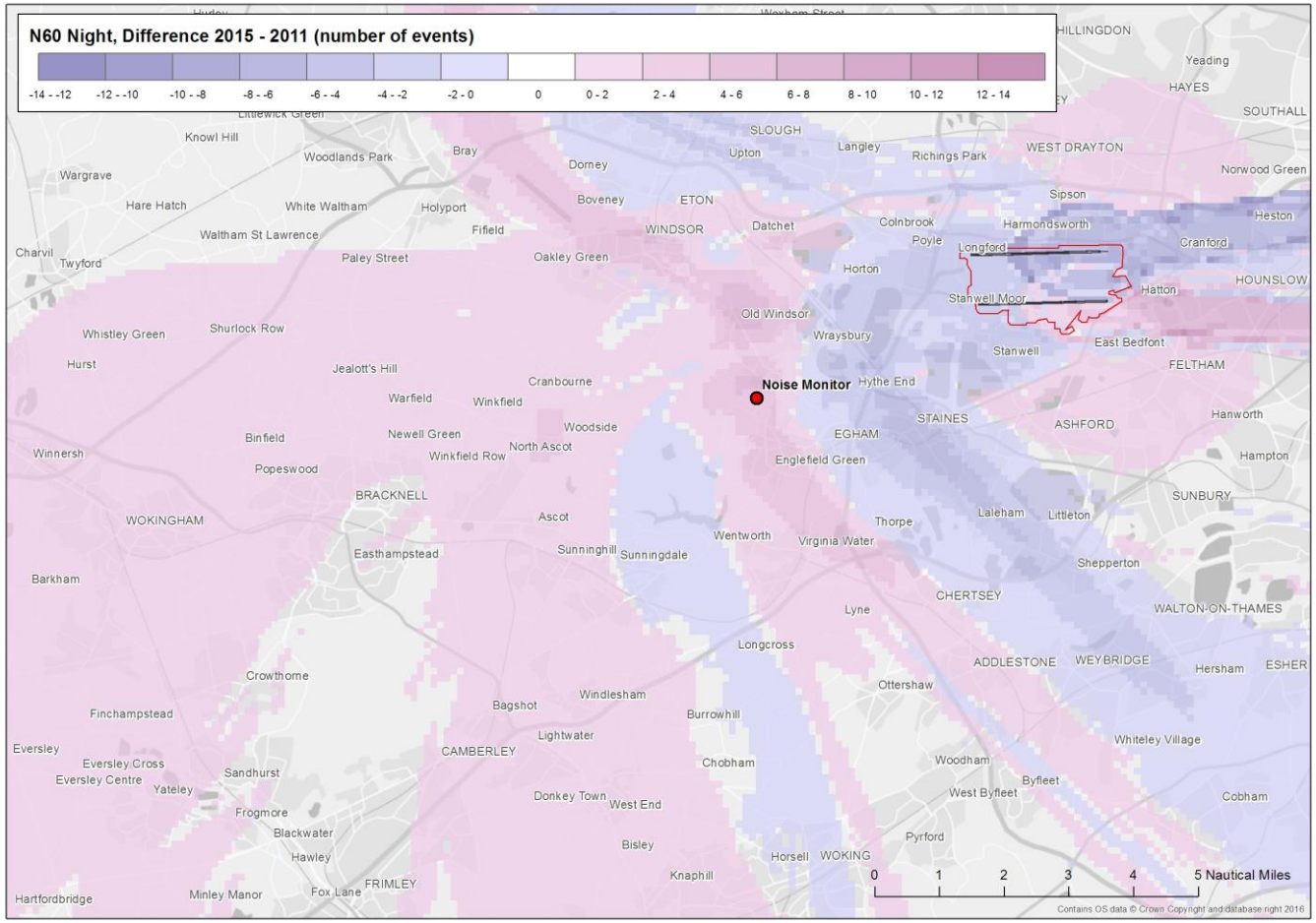
# Appendix A: Average westerly night $L_{Aeq, 8hr}$ difference (2015 minus 2011)



# Appendix A: Average westerly day $N65_{16hr}$ difference (2015 minus 2011)



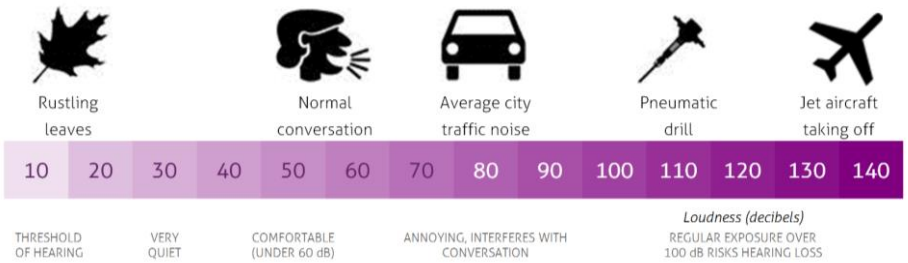
# Appendix A: Average westerly night $N60_{8hr}$ difference (2015 minus 2011)



# Appendix B: Noise Terminology

## How is noise measured?

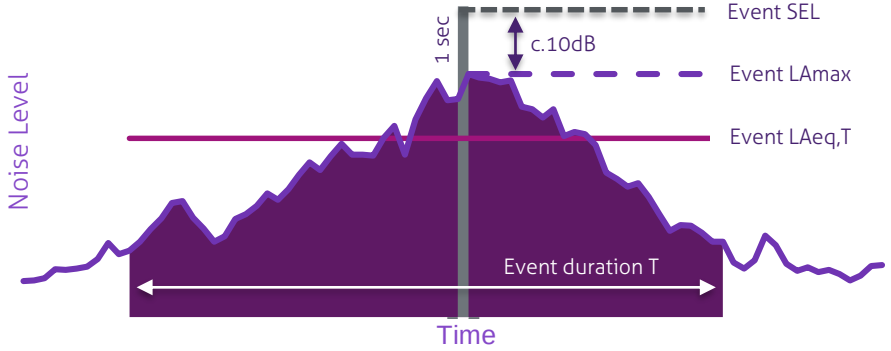
There is a million to one ratio between the threshold of hearing and the highest tolerable sound pressure. Noise is therefore measured using a logarithmic scale, to account for this wide range, called the decibel (dB). Typical noise levels of everyday sounds are shown in the figure below.




The human ear is capable of detecting sound over a 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 noise is therefore weighted across the frequency bands to represent the sensitivity of the ear. This is called 'A weighting' and is represented as dB(A). All units in this report use this A-weighting.

## How is aircraft noise measured?

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



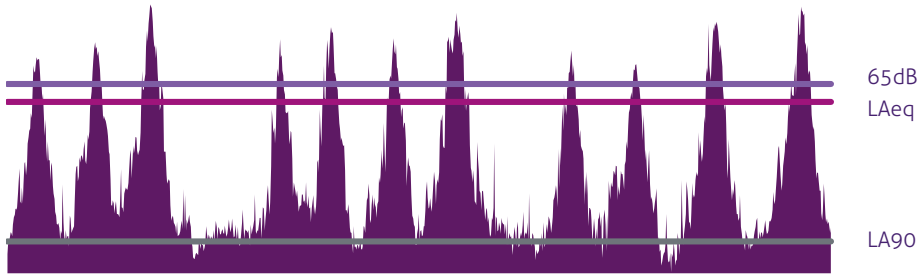

There are a number of metrics that can then be used to characterise a noise event all of which can be derived from modelling:

- The $L_{Amax}$ is the highest sound pressure level during the event, it is an instant value, this is used typically with noise limits;
- The $L_{Aeq,t}$ is the continuous sound pressure level that would generate the same energy as that of the fluctuating noise level during the event of period T. It is in effect the average noise level over the time of the event;
- The SEL (sound exposure level or single event level), is the sound pressure that would arise for if all the energy of the event were to be delivered in 1 second.

# Appendix B: Noise Terminology

## How is long term noise exposure measured?

The $L_{Amax}$ and SEL 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 such as the $L_{Aeq}$ in the UK. The $L_{Aeq}$ for a period of aircraft overflights is demonstrated in the figure below.




Although the $L_{Aeq}$ plays a role in policy and planning assessment it does not adequately describe community experience. Supplementary noise metrics have been developed to better reflect community experience in simpler language. For example, the N65 describes the number of events which 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 which is exceeded for more 90% of monitored period and is demonstrated by the grey line in the figure above.

## How does noise 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 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 increase 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 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 the 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 noise level relate to number of events?

Average noise 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 noise is measured, a doubling of noise 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 |
|---|---|
| x4 | +6dB |
| x2 | +3dB |
| 0 | 0 |
| ÷2 | -3dB |
| ÷4 | -6dB |