Anderson Acoustics

HELIOS

Community Noise Information Report
Strawberry Hill House

13th August 2015 – 20th March 2016

Introduction

This report presents an analysis of operational and noise data for the community around Strawberry Hill. At the request of local residents, Heathrow Airport Ltd installed a temporary noise monitor in the grounds of Strawberry Hill House (SHH), Twickenham between 13th August 2015 and 20th March 2016.

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) has been analysed.
- **Section 4 – Flight track data** presents analysis of the flight tracks and operations around the Strawberry Hill area 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 2011/12.
- **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 easterly 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 "*2015/16*", it should be noted that this is specifically the measurement period from 13th August 2015 to 20th March 2016. Similarly, "*2011/12*" specifically refers to the period from 13th August 2011 to 20th March 2012.

Key Findings

Operations and the community

SHH is overflown by easterly departures only, in particular by aircraft using the DET route. During the night, there are no departures scheduled between 23:00 and 06:00, on occasion there are delayed departures after 23:00.

The number of aircraft using the DET route on easterly days was 22% higher in 2015/16 than 2011/12.

There was overall 47% more flights over the area in 2015/16 than 2011/12 due to an increased proportion of aircraft using the DET route and more easterly operations.

Overall, during an average full easterly day there were more aircraft flying in the vicinity of SHH than in 2011/12. The increase was generally spread across the day but between 06:00 and 07:00 the number has decreased slightly, whilst after 23:00 the number increased slightly.

Aircraft were on average 8% lower (around 260ft) in 2015/16 than in 2011/12.

Aircraft were more concentrated laterally around the centre of the DET noise preferential route (NPR).

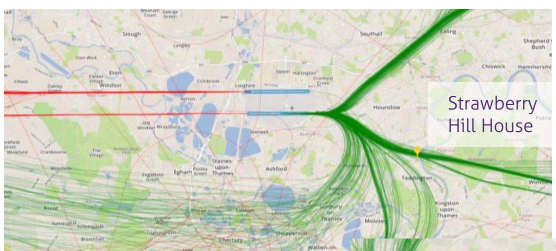
The proportion of A380 aircraft passing through the DET gate during easterly operations increased from 2.1% to 7%.

Noise levels in the community based on measurement at Strawberry Hill House	Difference in community noise levels between 2011 and 2015 based on noise modelling
At SHH, noise from aircraft makes a substantial contribution to community ambient noise levels during easterly, but not westerly operations.	The daytime average easterly day aircraft noise levels ($L_{Aeq,16hr,\ 07:00\ to\ 23:00}$) have typically increased by less than 1dB in this area between 2011 and 2015. It should be noted that, all other variables remaining constant, a difference of 26% noise events would equate to about a 1dB increase/decrease in $L_{Aeq,\ 16hr}$.
Measured hourly ambient noise levels ($L_{Aeq,1\ hr}$) on an easterly day are 9-16 dB higher than those on a westerly day (during daytime hours).	In this area in 2015, there were up to 25 (~12%) more events per day with an L_{Amax} greater than 65 dB over an average easterly day when compared to 2011.
The highest measured hourly ambient noise levels ($L_{Aeq,1hr}$), greatest number of measured aircraft noise events and the highest average aircraft L_{Amax} occur in the 22:00-23:00 hour. This period has a high proportion of larger aircraft types and occurs when non-aircraft noise is reducing.	There is no substantial difference between 2011 and 2015 in nighttime average aircraft noise levels ($L_{Aeq,\ 8hr\ 23:00\ to\ 07:00}$) and number of events ($N60_{,8hr}$) in the area.
Generally no aircraft noise events were recorded during days of westerly operations.	
The average measured maximum aircraft event noise level on an average easterly day is around 70.5dB L_{Amax}.	
Across the day, small twin-engine aircraft generate the most measured noise events (A320 family generate 60%); B777 12%, A380 7% and B747 4%.	
The A380 and B747 using the DET route over this area generate similar average L_{Amax} noise levels (77-78dB).	

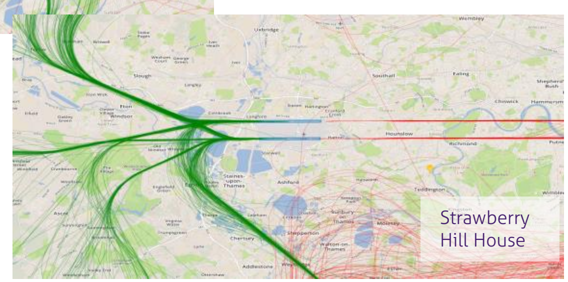
Understanding how wind direction affects aircraft operations.

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.
- Strawberry Hill/Twickenham is predominantly overflown by departing aircraft when the airport is on easterly operations.



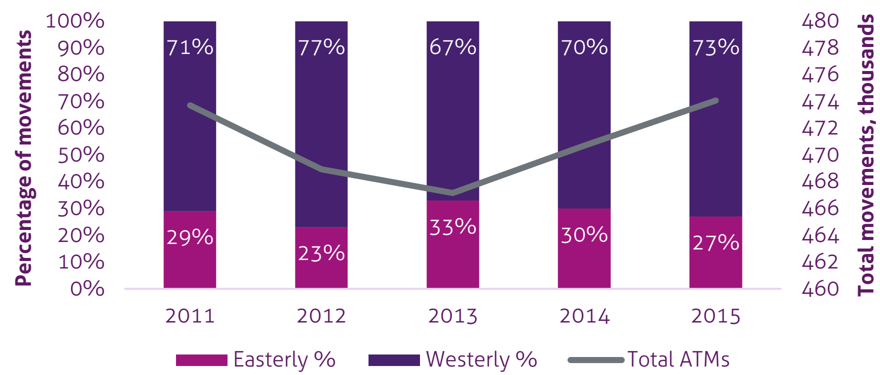
Flight tracks on an easterly day (18th March 2016)



Flight tracks on a westerly day (8th March 2016)

The proportion of easterly 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.

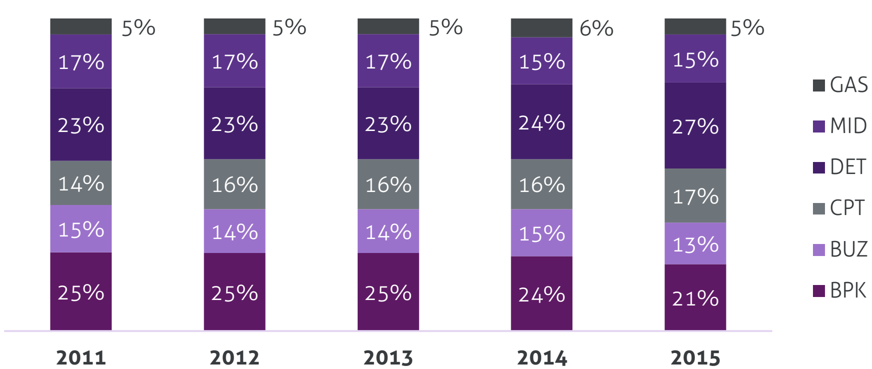


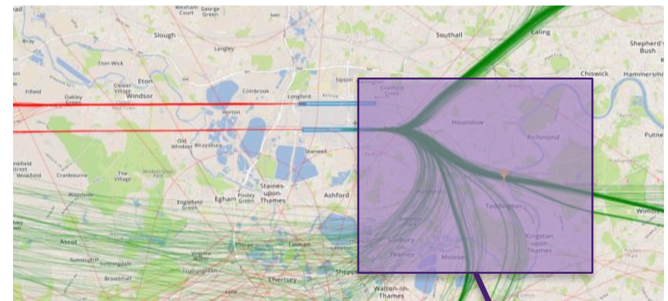
Note: Further information about operations at Heathrow can be found at http://www.heathrow.com/noise/heathrow-operations

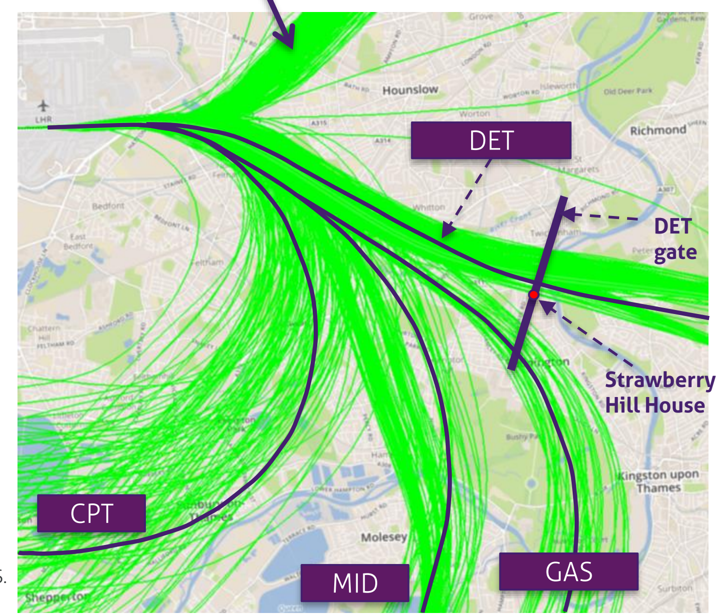
Understanding where aircraft fly during easterly operations.

- Aircraft taking off from Heathrow during easterly operations (towards London) follow one of six pre-defined routes, typically based upon their destination.
- The image to the right shows an example day of tracks for departing during easterly operations.
- Strawberry Hill is located close to the easterly 'Detling' (DET) and GAS departure routes. The figure also shows the 'DET gate' used for analysis of noise events, aircraft heights and concentration in the vicinity of Strawberry Hill. It is noted that aircraft flying 'over' this area are predominantly those using the DET route.
- The figure below shows the proportions of **annual** route usage by easterly operations for each year from 2011-2015. The proportion of aircraft using DET, MID has increased use over this period. GAS has remained similar. Route usage to the north (BPK and BUZ) has decreased.

Annual departure route use during easterly operations







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

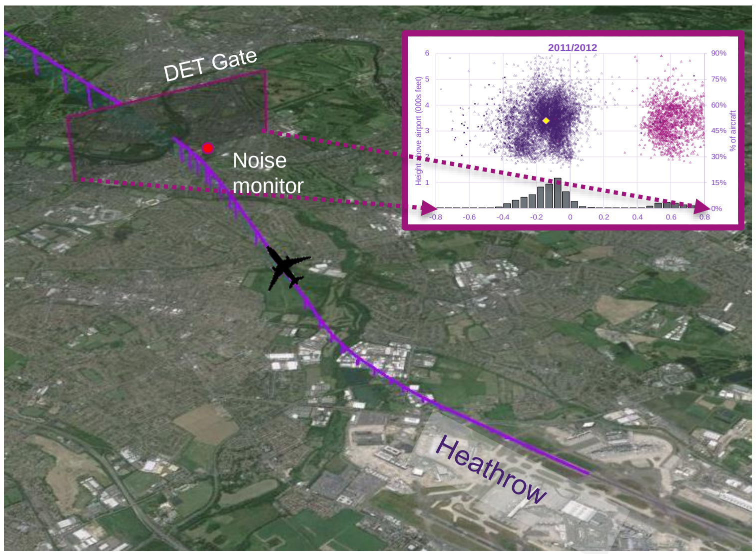
Understanding operational and gate data.

Operational data.

- The following operational data were provided for the period 13th August 2015 – 20th March 2016 and the same period for 2011/12:
  - 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 'gate' was drawn over the noise monitor at Strawberry Hill House centred on the dominant route used by aircraft passing in the vicinity – this is the Detling (DET) route. This is illustrated in the figure below.



- The 'DET gate' is 3,000m wide (the width of the NPR at this point) and 17,000 feet high (note: this gate was also used for the Teddington Flight Path Analysis conducted by PA Consulting but was referred to as the "DVR gate").
- The heights and positions of each aircraft passing through the gate were extracted from Heathrow's NTK system (ANOMs). Only Heathrow aircraft departing to the east (easterly operations) were investigated for this report.
- 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

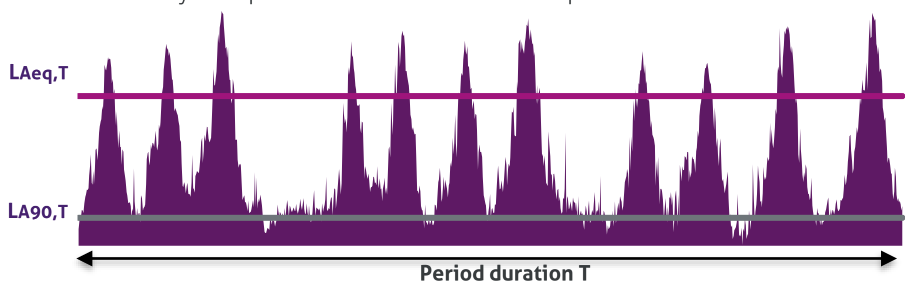
Understanding measured noise data.

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 13th August 2015 – 20th March 2016. Note that a historical comparison is not available since the noise monitor was not installed at this location in previous years.

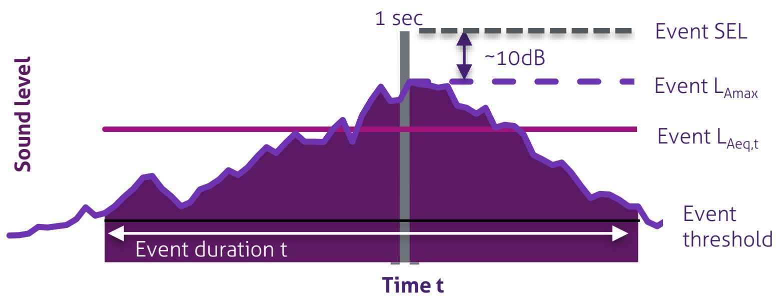
Ambient and background noise levels:

- 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:

- 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.

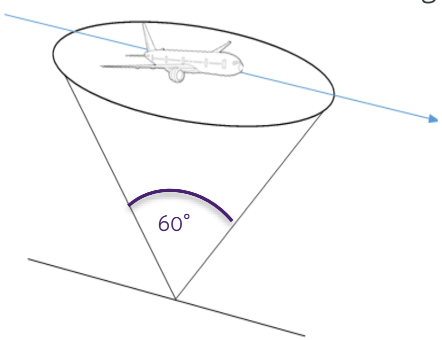


Analysing noise levels from aircraft in this area.

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 but one definition involves drawing an imaginary cone with a 60° apex above the noise monitor. This is illustrated in the figure below.

Flights are considered overhead if the aircraft pass within 60°cone above the noise monitor

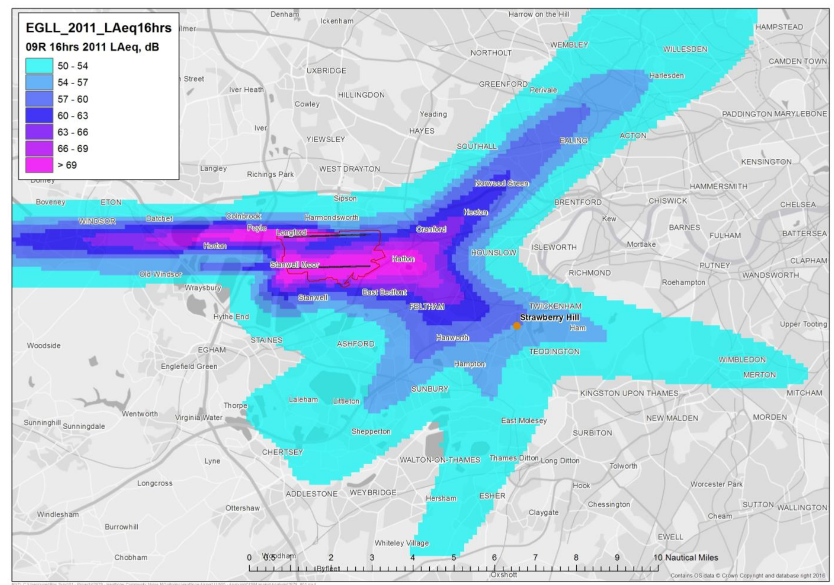


- Although this method has its limitations, this community information report will, where applicable, present results for all overhead flights as well as all registered aircraft noise events.

Noise Modelling

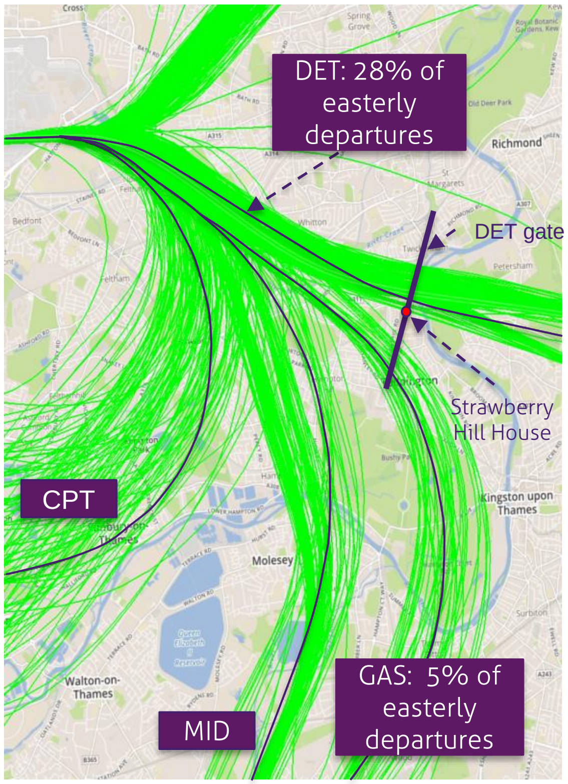
- Aircraft noise modelling has been used to provide an understanding of differences in the noise environment between 2011 and 2015 over the wider geographic area.
- Differences in daytime and night time levels for an **average day and night of easterly operations** across the summer of 2011 and 2015 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



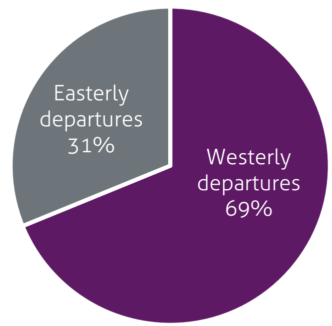
Overview of flight track data

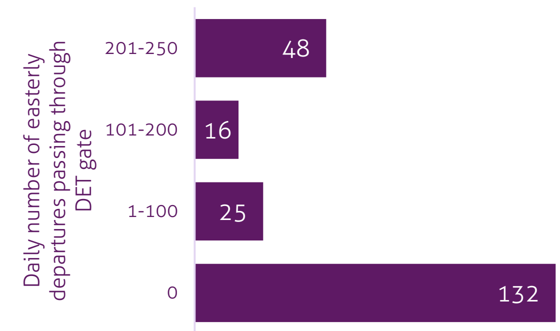
13th August 2015 – 20th March 2016



Example day of departing aircraft tracks in the vicinity of Strawberry Hill during easterly operations & the DET gate

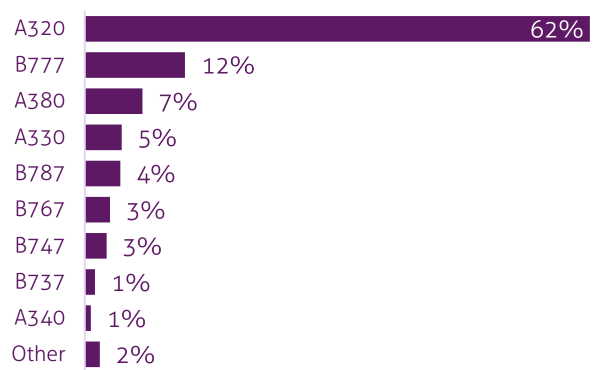
Total 140,278 departures from Heathrow



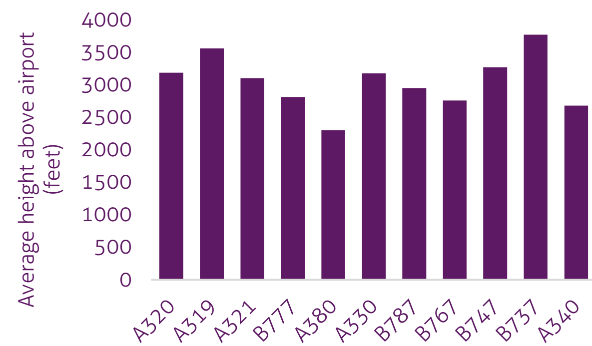


Number of easterly departures per day passing through the DET gate (221 days in total)

Proportion of departing aircraft types passing through the DET gate

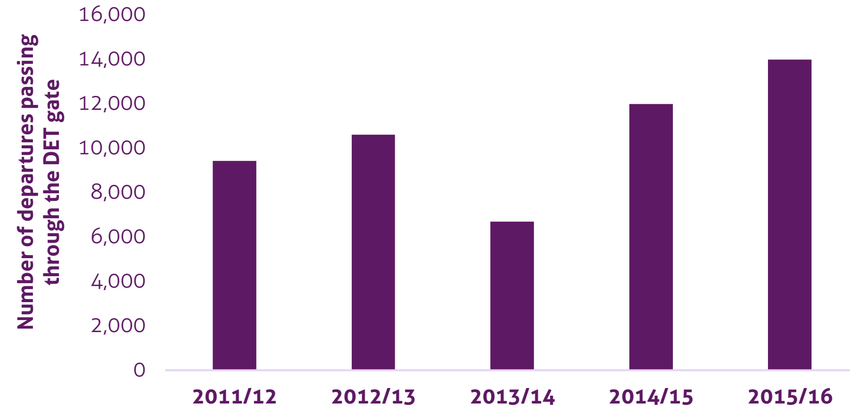


Average height of departing aircraft as they pass through the DET gate



Is the number of flights over the area different in 2015/16 to 2011/12?

- The figure to the right shows the total number of departures that passed through the DET gate in the periods 2011/12 to 2015/16.
- Over the five year period, between 6,500 and 14,000 departures penetrated the DET gate with most aircraft being registered during the 2015/16 period.
- The 2015/16 value can be attributed to a greater number of easterly operations and a higher proportion of those flying the DET route, the details of which are given in the table in the bottom right.
- **The proportion of easterly operations increased from 24% in 2011/12 to 31% of all movements for 2015/16 monitoring period**.
- Additionally, the table shows that more easterly operations passed through the gate in the 2015/16 monitoring period than during the 2011/12 equivalent.
- During days of easterly operations during the 2015/16 monitoring period approximately one-third of aircraft taking-off from Heathrow passed through the DET gate. This represents **an increase in the average proportion of easterly departures passing through the DET gate of around 6% compared to the same period in 2011/12**.
- During days of 100% easterly operations, on average **22% more aircraft flew through the DET gate in 2015/16 than 2011/12 -** 213 departing aircraft in 2015/16, 38 more than in 2011/12.
- There were 132 days out of 221 (60%) during which no aircraft passed through the gate.



	2011/12	2015/16	Change	Change (%)
Proportion of easterly operations (all Heathrow flights)	24%	31%	+7%	N/A
Average proportion of easterly departures passing through the DET gate during days of 100% easterly operations	27%	33%	+6%	N/A
Average number of easterly departures passing through the DET gate during days of 100% easterly operations	175	213	+38	+22%
Average number of easterly departures using the DET route passing through the DET gate during days of 100% easterly operations	146	180	+33	+23%

Note: Wherever this report refers to "*2015/16*", it should be noted that this is specifically the measurement period from 13th August 2015 to 20th March 2016. Similarly, "*2011/12*" specifically refers to the period from 13th August 2011 to 20th March 2012 etc

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Is route use different between 2011/12 and 2015/16?

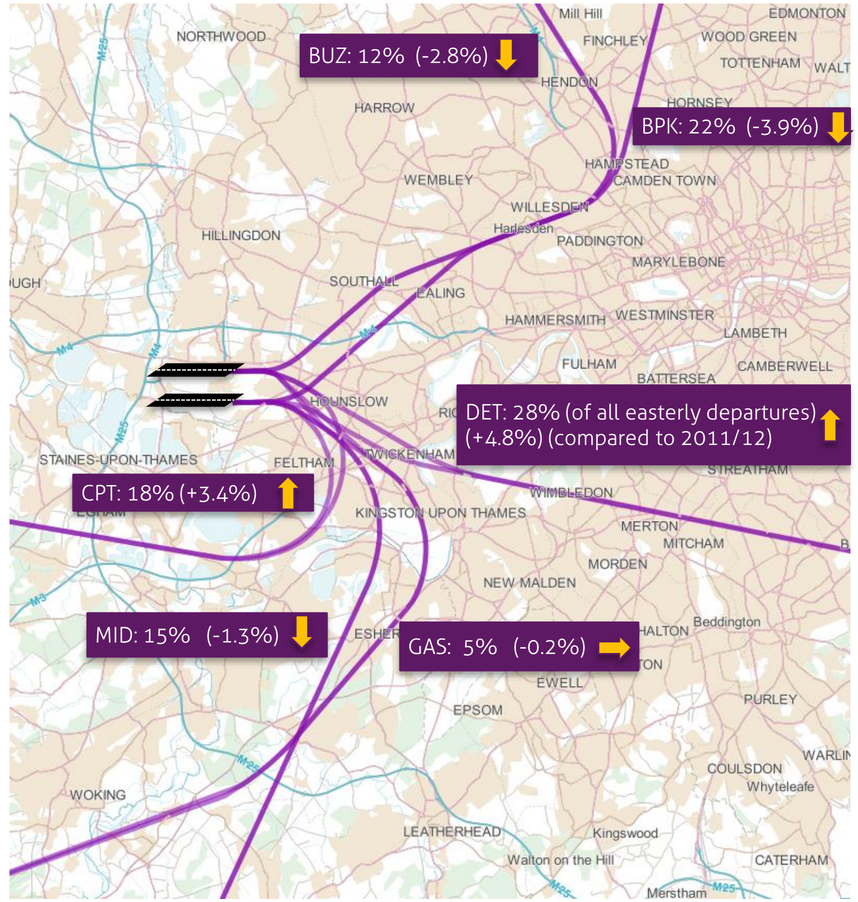
- The figure to the right presents the proportion of flights using each route during a typical full easterly day in the 2015/16 period compared to 2011/12. Aircraft on the DET route are generally regarded as 'overhead' Strawberry Hill/Twickenham area (it is noted that aircraft that aircraft that are not overhead may still be audible in this area).
- **In the 2015/16 period, the proportion of all easterly departures using the DET route increased from 23% over the same period in 2011/12 to 28%.** DET was the most commonly used easterly departure route in the 2015/16 period.
- Use of the GAS route (aircraft on this route are to the south of Strawberry Hill and not 'overhead') was around 5% in both periods.

Actual numbers of aircraft and percentages of total movements in each time period

Easterly departure route	2011/12	2015/16	Number difference	% difference
BPK	8,738	9,286	+548	+6%
BUZ	5,244	5,317	+73	+1%
CPT	4,837	7,405	+2,568	+53%
DET	8,022	11,785	+3,763	+47%
MID	5,694	6,502	+808	+14%
GAS	1,862	2,171	+309	+17%
TOTAL*	34,397	42,466	+8,069	+23%

- The figures presented reflect a change in the proportion of aircraft using each departure route, and an increase in easterly operations during 2015/16.

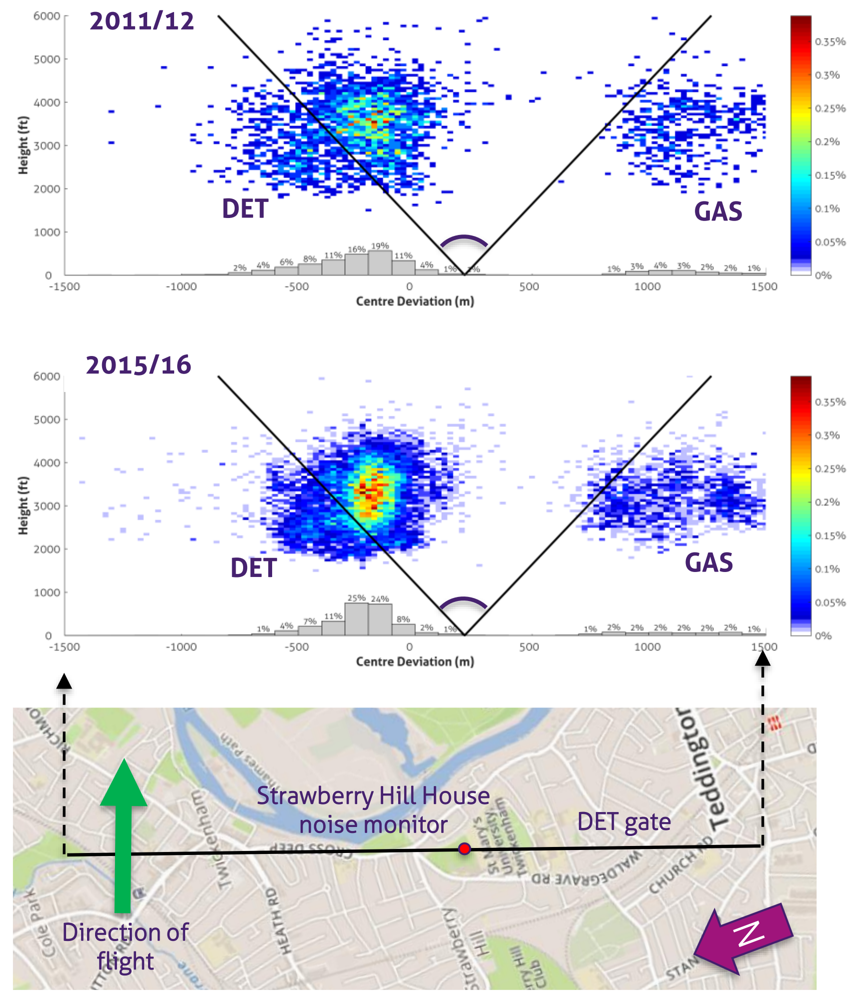
Percentage of route use on fully easterly days in 2015/16 and change since 2011/12



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 flights different between 2011/12 and 2015/16?

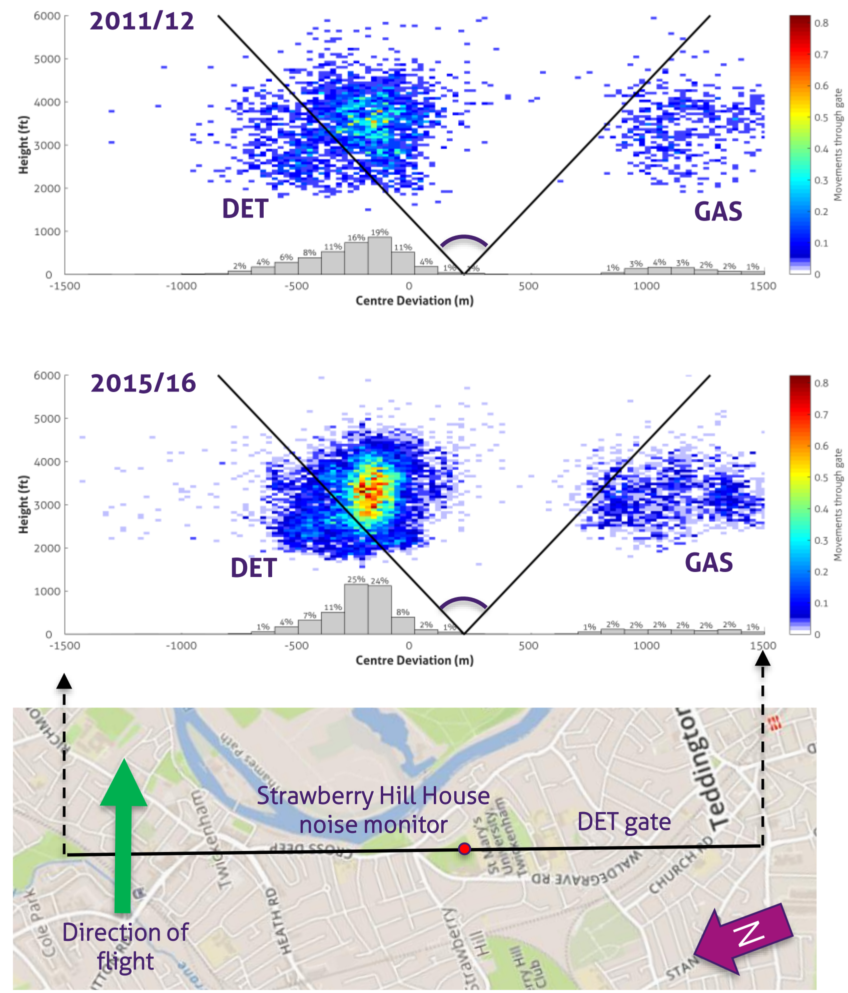
- The figures to the right are 'heat maps' showing the 2D concentrations of easterly departing aircraft as they passed through the DET gate during the 2011/12 (the upper figure) and 2015/16 (the lower figure) monitoring period.
- These figures have been designed to illustrate the degree of concentration. The scale presents consistent colours for the proportion of aircraft in the grid. For example a "red" indicates 0.35% of the movements passing through a grid square in the gate in both figures.
- The grey bars under the 'heat map' show the actual concentration at different distances from the centre of the gate.
- The figures indicate that **aircraft were more concentrated on the DET route over an area to the north of Strawberry Hill House in 2015/16 compared to 2011/12.**
- In 2015/16, 49% of departing aircraft passed through the DET gate directly above a 200m wide section of the gate to the east of Strawberry Hill House - in 2011/12 this figure was 34%.
- Noise events generated by the aircraft movements that fall within the 60° overhead cone (see page 9) shown in the lower heat map have been considered as "overhead" in the noise data analysis.



Note: The "heat maps" have been normalised to account for differences between the number of easterly 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 12. The maps are divided into grid squares, 25m horizontally by 60ft vertically.

Is the number of flights different between 2011/12 and 2015/16?

- The figures to the right are 'heat maps' showing the 2D concentrations of easterly departing aircraft as they passed through the DET gate during the 2011/12 (the upper figure) and 2015/16 (the lower figure) monitoring period.
- These figures differ from those on the previous page in that they show the average number of movements through the gate on a full day of easterly operations, thus highlighting the change in the number of flights passing through the gate as presented on page 12 (rather than the change in concentration shown on page 14).
- The figures confirm that **more aircraft passed through the easterly gate in 2015/16 on full days of easterly operations compared to the same period in 2011/12.**

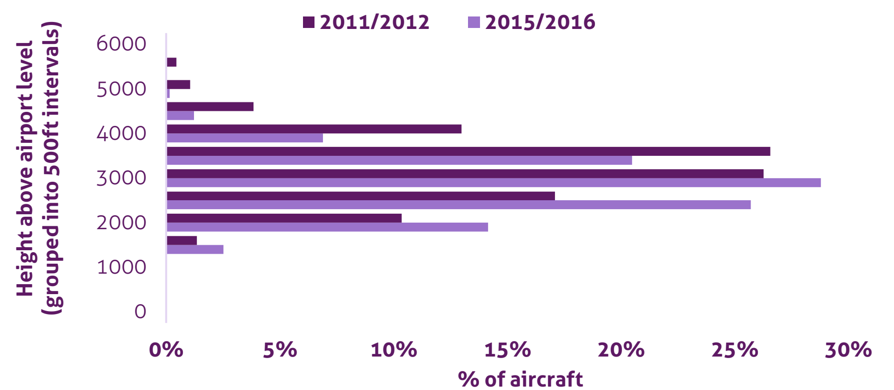


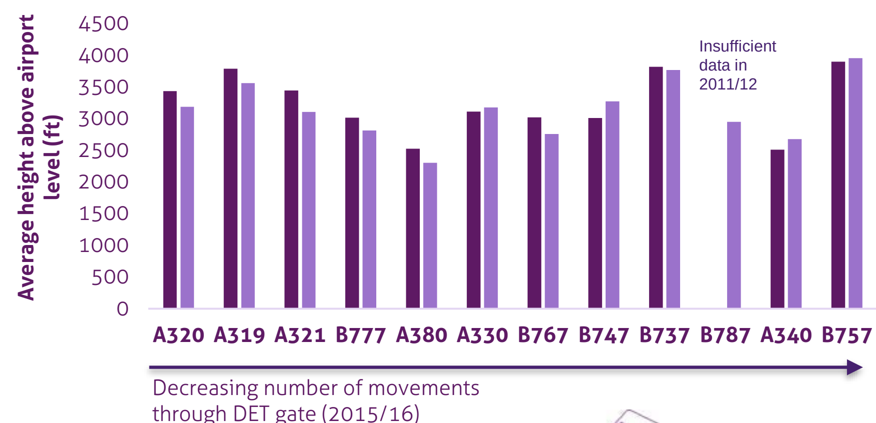
Note: These "heat maps" have not been normalised to account for differences between the number of easterly departures in each of the monitoring periods. This allows the numbers of movements in each year to be compared. The maps are divided into grid squares, 25m horizontally by 60ft vertically.

Are aircraft heights different between 2011/12 and 2015/16?

- The table to the right presents the average height of all flights from Heathrow as they passed through the DET gate in 2011/12 and 2015/16.
- **This indicates that aircraft above Strawberry Hill were on average 261ft lower in 2015/16 than 2011/12.**
- The figures present the distribution of aircraft height through the DET gate comparing 2011/12 with 2015/16 (upper figure) and the average height by aircraft type (lower figure).
- The upper figure shows that generally aircraft heights were lower in 2015/16 than in 2011/12.
- Of note there are reductions in the proportions of aircraft passing the gate at heights between 3,500 and 4,000ft, but an increase between 3,000ft and 1,500ft.
- The lower figure indicates that all aircraft types, with the exception of the A330, B747, A340 and B757, were on average lower in 2015/16 than in 2011/12.

	2011/12	2015/16	Difference
Average height at DET gate (feet)	3,393	3,132	-261

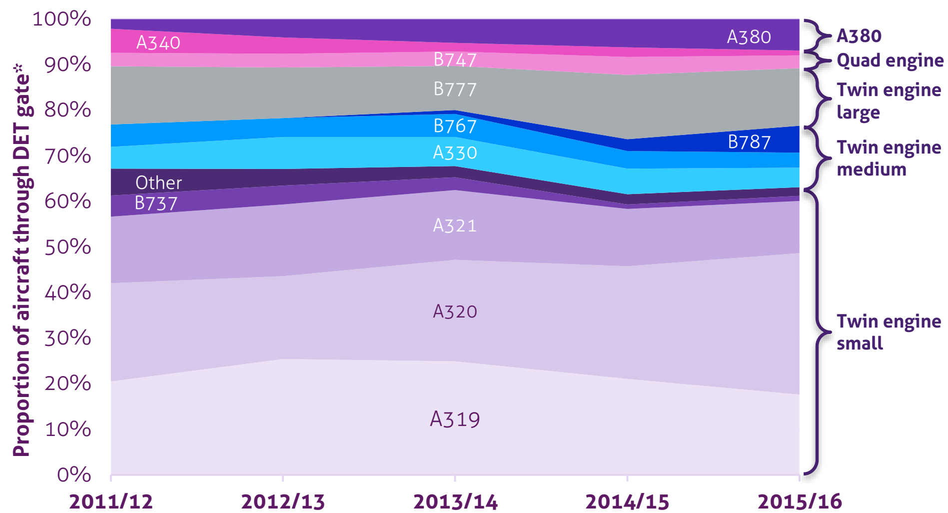




Is the fleet mix different between 2011/12 and 2015/16?

- The table to the right presents the mix of aircraft that passed through the DET gate and overall at Heathrow in 2011/12 and 2015/16.
- 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 (not yet in regular service))
  - twin engine medium aircraft (B767, B787, A330) and
  - twin engine small aircraft (B737, A320 family).
- Previous slides indicated that the number of flights flying through the DET gate has increased on an average day of full easterly operations between 2011/12 and 2015/16.
- The analysis on this page indicates that there was an increase in the proportion of A380 operations through the DET gate from 2.1% in 2011/12 to 7.0% in 2015/16. 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 6%) and A320 (22% to 31%), while the A340 and B737 both saw a steady decrease.

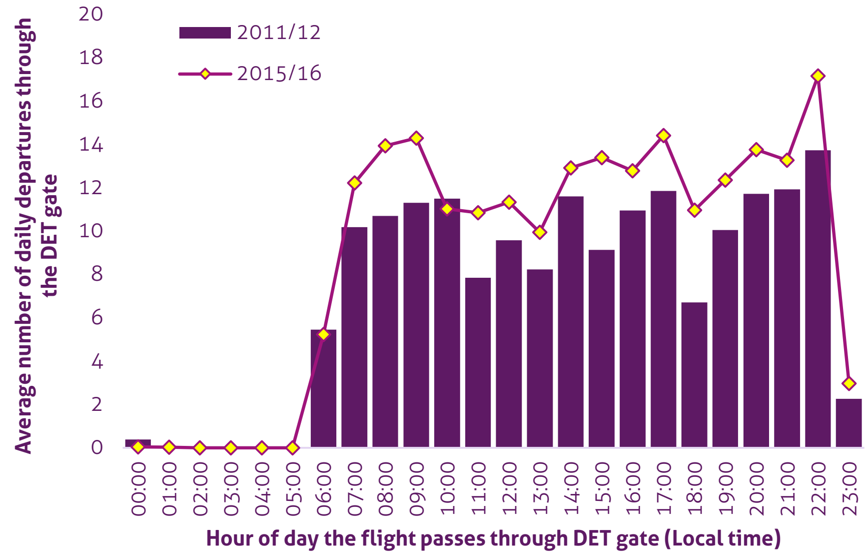
Fleet mix				
Category	**DET gate**		**All LHR**	
	11/12	**15/16**	**11/12**	**15/16**
A380	2.1%	7.0%	0.9%	3.4%
Quad engine	8.3%	3.4%	11.9%	6.7%
Twin engine large	12.7%	12.3%	11.6%	13.2%
Twin engine medium	10.4%	12.3%	10.1%	14.0%
Twin engine small	66.4%	65.0%	65.6%	62.6%



* Days of 100% easterly operations only

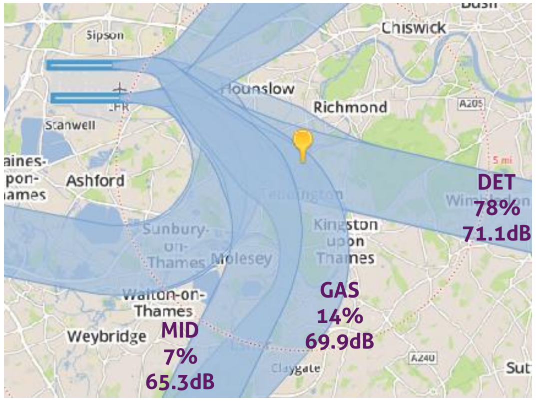
Does the number of flights over the area vary across the day? Is there a difference between 2011/12 and 2015/16?

- The figure to the right presents the average number of departures through the DET gate per hour in 2011/12 and 2015/16 during days of 100% easterly operations
- This shows that there is a broadly consistent cycle of use of this route across the day in both the 2015/16 and the 2011/12 periods. The first peak occurs between around 8-10am, then in early afternoon and then in the evening.
- With the exception of the hours 06:00-07:00 and 10:00-11:00, the increase in movements in 2015/16 relative to 2011/12 is reflected across most of the day, rather than in a unique period.
- As noted previously, there were 22% more easterly operations through the DET gate on an average day of full easterly operations in the 2015/16 monitoring period than 2011/12.
- The analysis indicates that on average, on a day of full easterly operations, there were around 3 delayed departures between 23:00 and 00:00 that pass through the DET gate. It is noted that the range is between 0 and 11 for this hour.
- Of the total 221 days in the 2015/16 monitoring period, 49 days were 100% easterly operations, there were no delayed departures on 10 of these days.



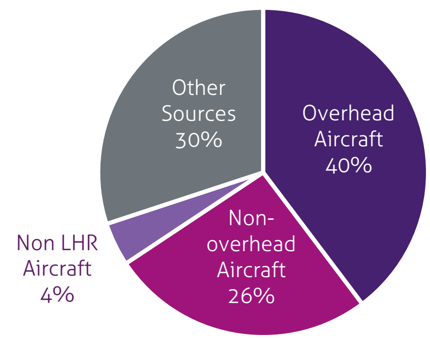
Overview of noise monitor data recorded at Strawberry Hill House

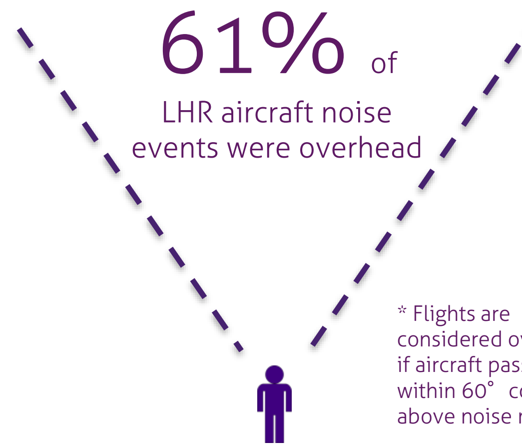
13th August 2015 – 20th March 2016



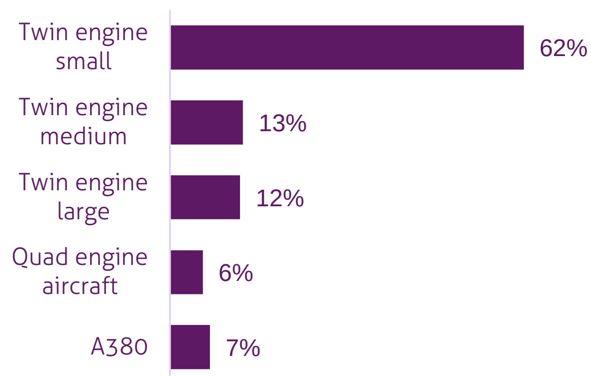
Monitor location, noise events by route (%) & average L_{Amax}

22,090 Measured Noise Events

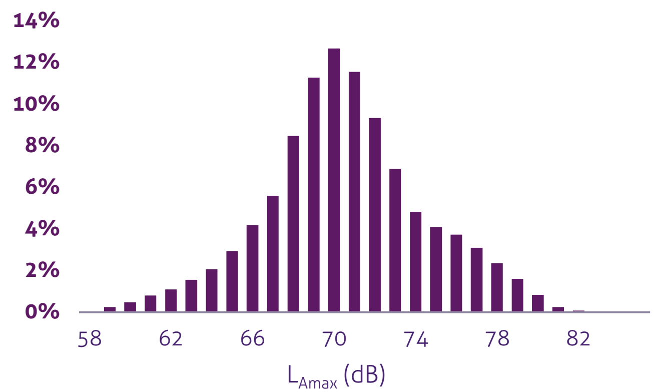




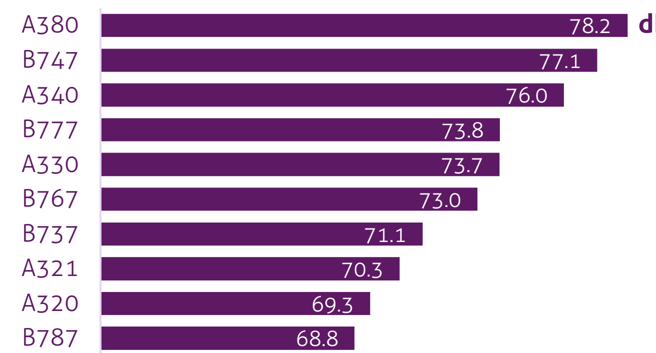
* Flights are considered overhead if aircraft passes within 60° cone above noise monitor



Noise events by aircraft type



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



Average L_{Amax} by Aircraft Type*

*Overhead aircraft only

Noise monitoring overview.

Monitoring location, duration and setup

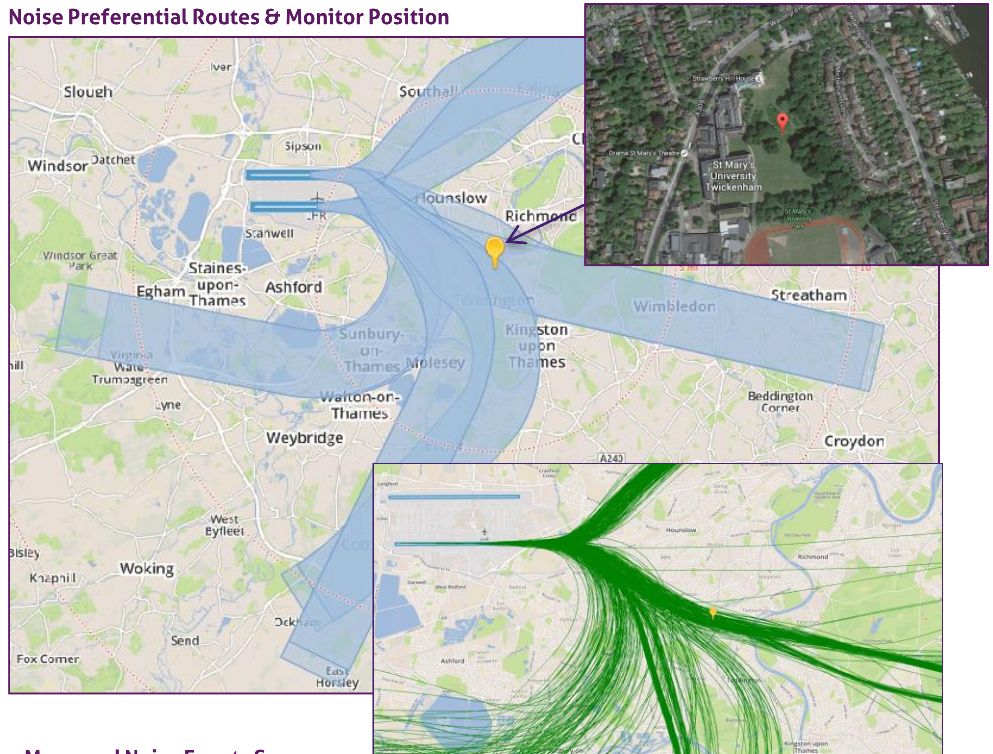
- A temporary noise monitor was installed in the grounds of Strawberry Hill House between 13/08/2015 and 20/03/2016.
- The monitor was set up to record noise events based on a threshold sound pressure level of 58 dBA being exceeded for more than 10 seconds.
- The location of the noise monitor is shown in the figures to the right. It is close to the centre line of the DET route, and close to the outer edge of the GAS noise preferential routes (NPRs).
- It should be noted that since the noise monitor was not set up in this location during the equivalent period of 2011/12 comparison of noise levels relative to those measured in the 2015/16 period is not possible.

Noise event summary

- A total of 22,090 noise events were measured during the monitoring period. Of these around 66% were from aircraft using Heathrow, 4% were from non-Heathrow aircraft and 30% were from non-aircraft sources.
- Overall, 78% of the aircraft registering noise events at the noise monitor were using the DET route; 61% of aircraft registering noise events were overhead (97% of these were on the DET route).

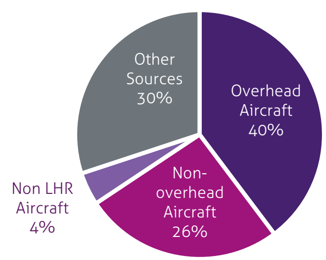
Routes (%)				LHR Traffic Overhead (%)
DET	GAS	MID	Other	
78	14	7	<1	61

Noise Preferential Routes & Monitor Position



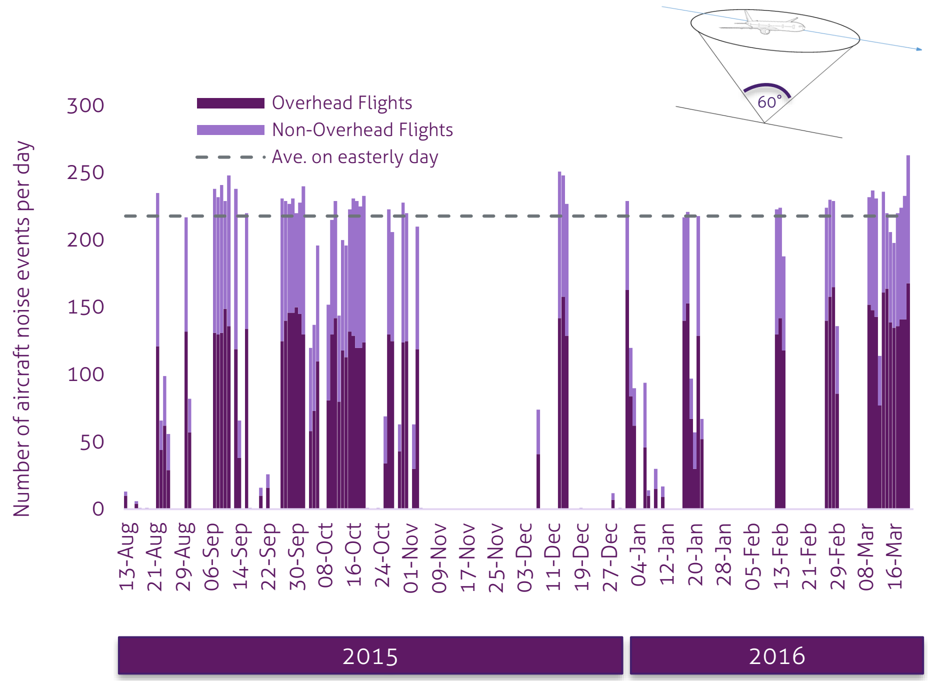
Noise monitor position and flight tracks on a typical easterly day

Measured Noise Events Summary



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

- Noise events are captured at Strawberry Hill House mostly during periods of easterly operations and by aircraft using the DET route.
- During the monitoring period 49 out of 221 days (21%) related to 100% easterly operations and 128 days (58%) related to 100% westerly operations. On 20% of the days, the airport switched direction of operation during the day resulting in a combination day of easterly and westerly operations.
- During days of full easterly operations, there were, on average, 218 aircraft noise events per day. However, during 100% westerly operations there was an average of less than one aircraft noise event.
- Over the 221 days for which monitoring was taking place, 23% of days experienced 200 or more aircraft events whilst 58% of the days had no aircraft events.
- A prolonged period of easterly winds in October led to many consecutive days of 200+ aircraft noise events.
- It is noted that just because there are no aircraft noise events that aircraft are not audible. There may be aircraft further away that are audible but have not triggered the noise event detection threshold.



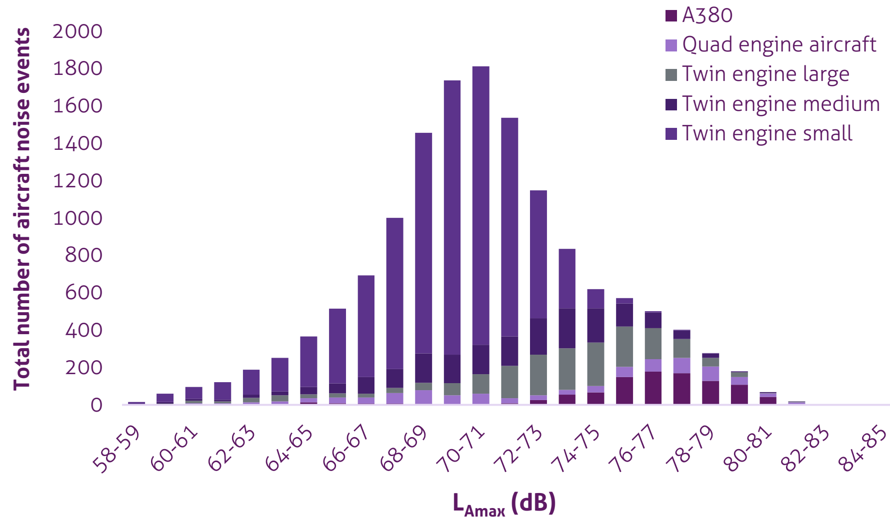
What was the range of L_{Amax} and SEL noise levels from aircraft events?

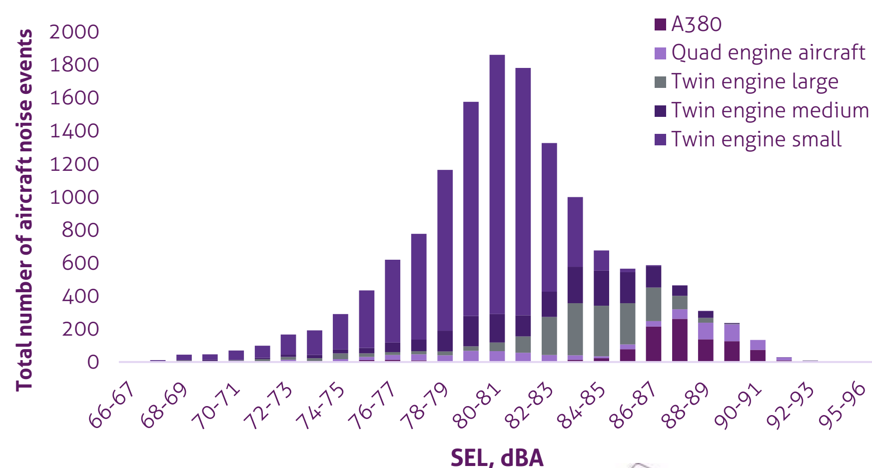
- The figures to the right present the range of L_{Amax} (top) and SEL (bottom) noise levels for **all aircraft noise events measured at Strawberry Hill House**. An explanation of metrics is given on p8.
- The table below presents the average* L_{Amax} and SEL for each aircraft type group.
- The average L_{Amax} of all aircraft events is 70.5dB. There is a relationship between the size of the aircraft and average L_{Amax}. The mean L_{Amax} of the largest aircraft group, the A380, is 7dB greater than that of the small twin engine aircraft. A similar relationship exists for the SEL.

Aircraft group	Average L_{Amax}	Average SEL, dBA
A380	76.2	86.9
Quad engine	72.5	83.7
Twin engine large	72.9	83.2
Twin engine medium	71.2	82.0
Twin engine small	69.1	79.4

- 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.
- As a comparison, the mean L_{Amax} of all non aircraft events is 65.5dB while maximum event levels are similar for aircraft and non-aircraft events.

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

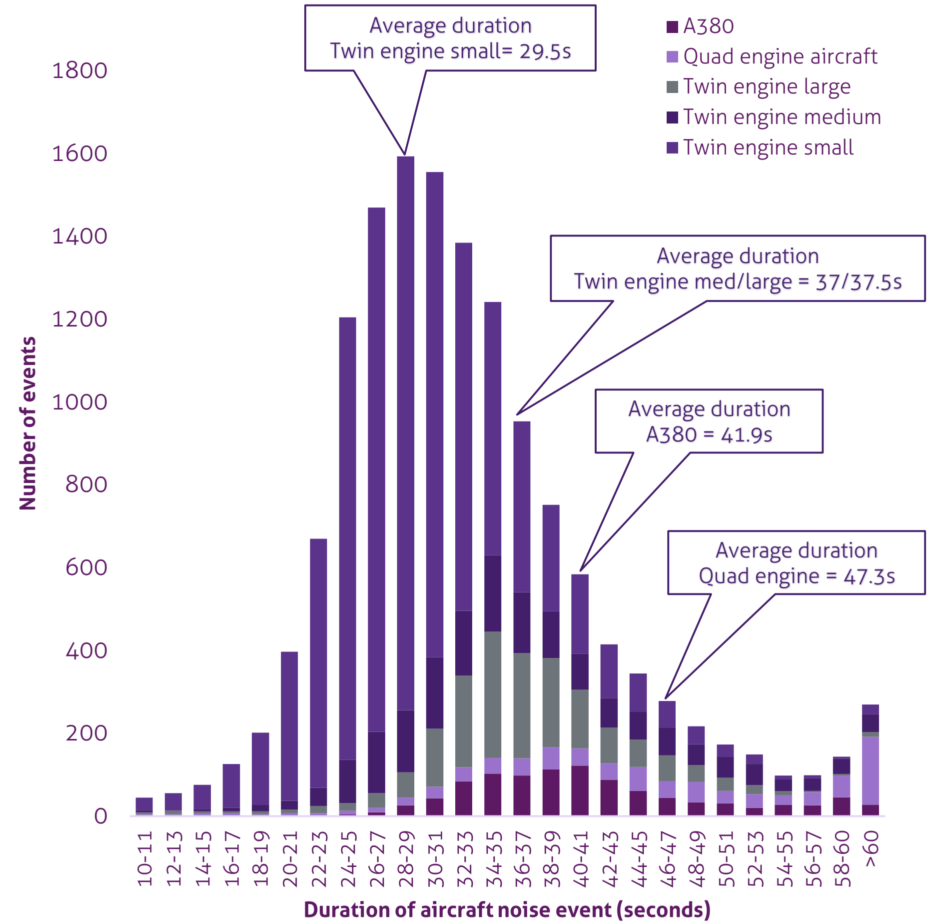




How does the duration of an aircraft event vary?

- The duration of an event is the time for which the noise level exceeds the event threshold level, which, in this case is 58dBA.
- 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 33 seconds. The duration is largely dependent on aircraft size with the average event duration of the largest aircraft (45 seconds) being 16 seconds longer than for the smallest (29 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	41.9
Quad engine aircraft	47.3
Twin engine - large	37.5
Twin engine - medium	37.0
Twin engine - small	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 route and whether the analysis shows it to be overhead at Strawberry Hill House.
- The aircraft types listed are limited to those that have registered more than 20 noise events over the monitoring period. 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 59% of all aircraft noise events detected by the monitor at Strawberry Hill House.
- The B777 series of aircraft account for around 12% of the measured aircraft noise events.
- Around 7% of aircraft noise events were from A380 aircraft, 4% from the B747 (which is a similar percentage to the newest aircraft type the B787).

Aircraft Type	Total*	Route			Overhead**
		DET	GAS	MID	
A320	30%	22%	6%	1%	22%
A319	17%	15%	2%	0%	15%
A321	12%	10%	2%	1%	8%
B777	12%	10%	1%	1%	3%
A380	7%	7%	0%	0%	2%
A330	5%	4%	1%	1%	3%
B787	4%	4%	0%	0%	3%
B747	4%	2%	1%	2%	1%
B767	4%	2%	1%	1%	0%
A340	2%	0%	0%	1%	0%
B737	1%	1%	0%	0%	1%
B757	0%	0%	0%	0%	0%
Other	2%	2%	0%	0%	1%
Grand Total***	**100%**	**78%**	**14%**	**7%**	**61%**

* Percentage based on 14,505 aircraft noise events recorded between 13th August 2015 and 20th March 2016
** Defined as being with the 60 degree cone described on page 9
*** Totals do not round up to 100% due to rounding and 23 aircraft flying other routes

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 20 movements were registered within the **overhead** cone (upper chart) or on the **Detling** route (lower chart).

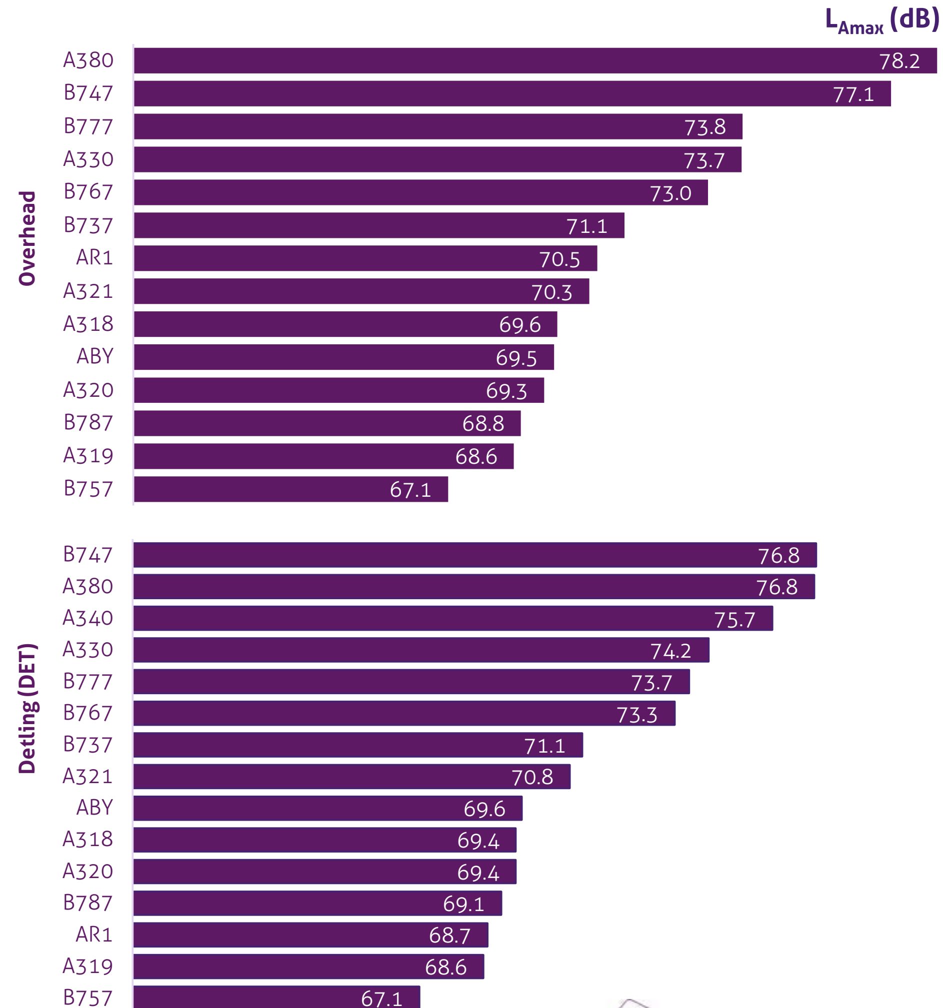
Note that some aircraft on the DET route are not overhead and vice versa (see heat maps on p14 to further understanding).

Overhead aircraft

- The average measured noise level of the B747 was marginally lower than that from the A380 - most of the B747s were at greater distances from the monitor than the A380s.
- The B777 and A330 (twin-engine aircraft) generated average L_{Amax} values of around 3-5 dB less than larger 4-engine aircraft.
- The B787 (the newest aircraft in service in a twin engine medium category) produced, on average, L_{Amax} around 5 dB less than the A330 aircraft and more than 2dB less than the B737.

Aircraft using the DET route

- When comparing aircraft on the DET route only, the average L_{Amax} of the A380 and the B747 was the same; 76.8dB for both. The A340 (another 4 engine aircraft) was on average around 1 dB less.
- The A330, B777 and B767 comprise the next loudest group of aircraft with noise levels generally falling between 73-76dB.
- In general, the noise levels of the aircraft decrease with size, the 3 quad-engine types are shown to the noisiest.
- The B787, (a twin engine medium aircraft), is a notable exception being quieter than many of the twin-engine small (And medium) aircraft registering an L_{Amax} of around 69dB (more than 3dB less than the B767).



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

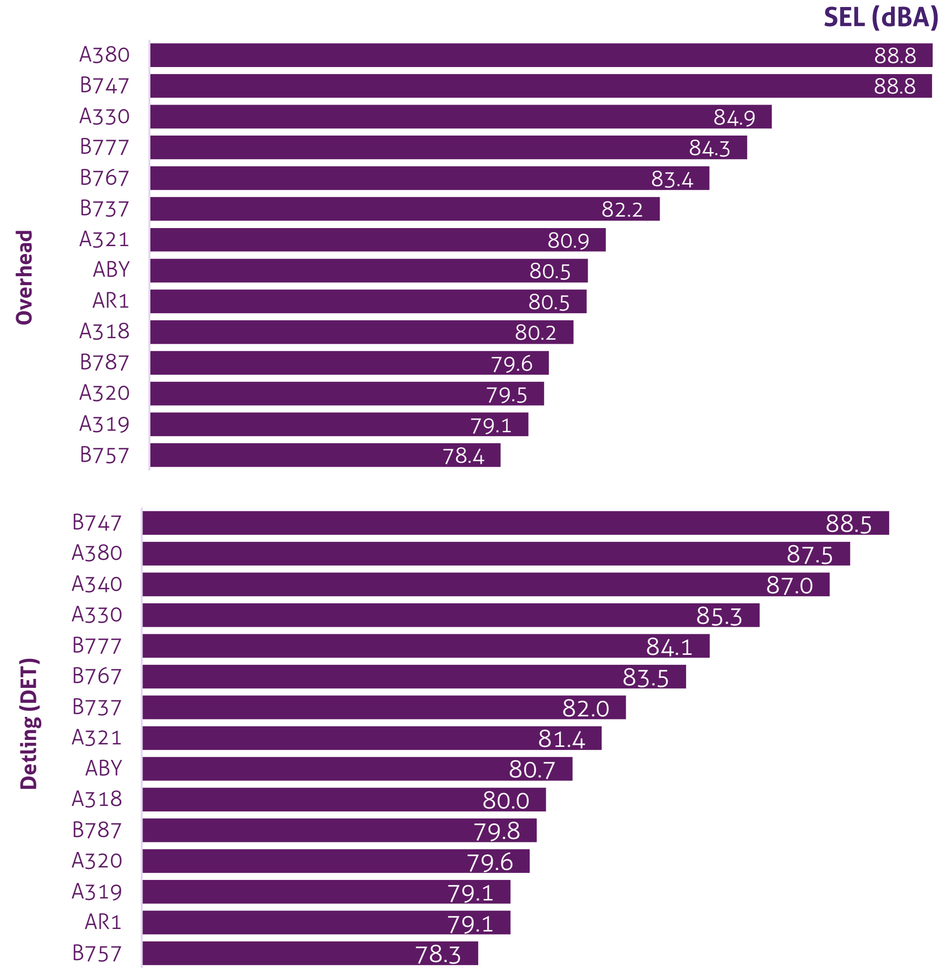
The plots to the right show the average (arithmetic mean) SEL of each aircraft type for which at least 20 movements were registered within the **overhead** cone (upper chart) and on the **Detling** route (lower chart).

Overhead aircraft

- The highest average SEL noise levels for aircraft considered within the 60° cone above the noise monitor are from the A380 and B747 at 88.8dBA.
- Below that the B777 and the A330 (both twin-engine aircraft) generated average SEL values around 4-5 dB less than the larger 4-engine aircraft.
- The B787 (the newest aircraft in service) was on average 5dB less than the A330 aircraft and more than 2dB less than the B737.

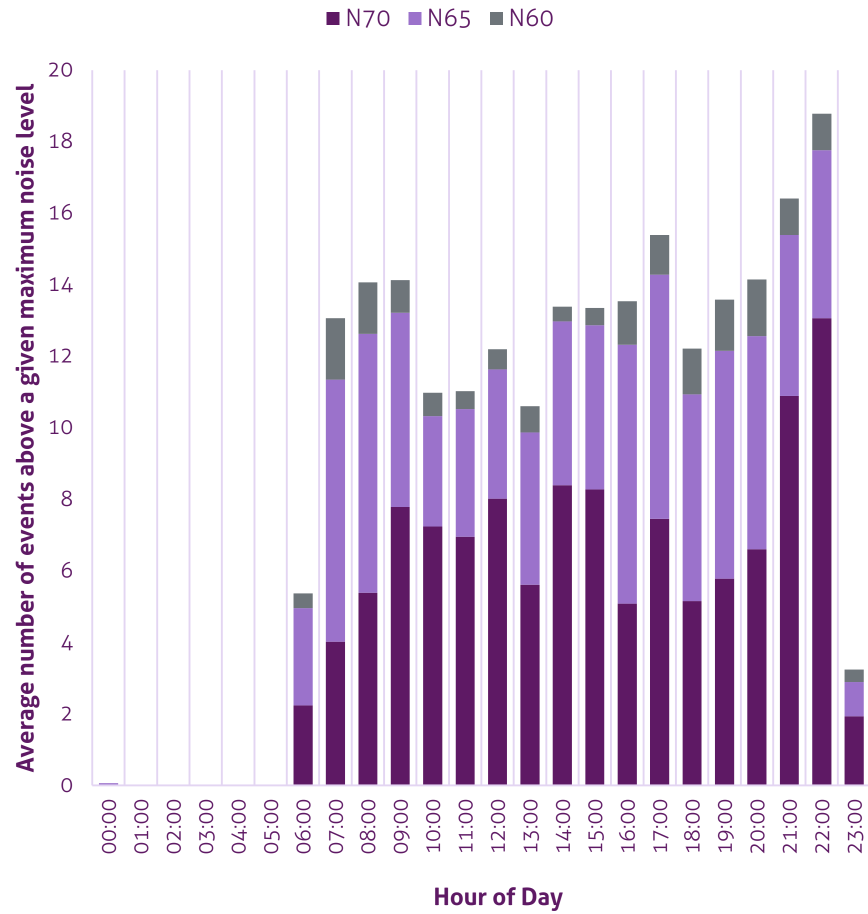
Aircraft using the DET route

- When comparing aircraft on the DET route only, the average SEL of the B747 was about 1dB greater than the A380. The A340 (another 4 engine aircraft) was on average around 1.5 dB less than the B747.
- The A330, B777 and B767 comprise the next loudest group of aircraft generally falling between 83-86dB.



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 are recognised to describe 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 easterly operations**.
- The N70 peaks in the evening period between 21:00 and 23:00hrs. This is indicative of the number of aircraft and the noisier aircraft operating in those periods. It is noted that the N65 and N60 also peak during this time period.
- On an average easterly day, the N65 during the 16h day period (07:00-23:00) was over 200; the N60 during the 8h night (23:00-07:00) was less than 10.
- The N60 during the night period on easterly days was less than 10 made up of scheduled departures in the 06:00-07:00 hour and late runners between 23:00 and 00:00.
- On easterly days, there are an average of 3 noise events occurring in the hour from 23:00 to 00:00 reaching a maximum of 11 events on two days. On 181 of the 221 days, there were no noise events recorded from late runners.



HELIOS

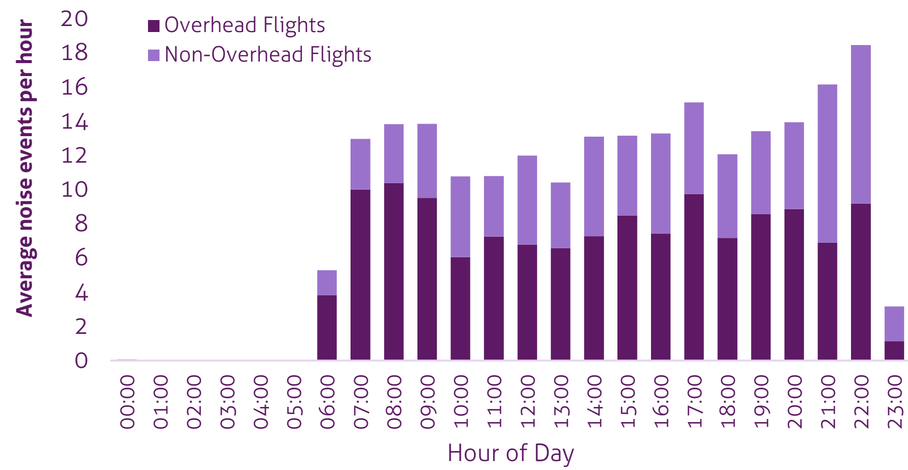
How does the number of aircraft noise events vary across a day?

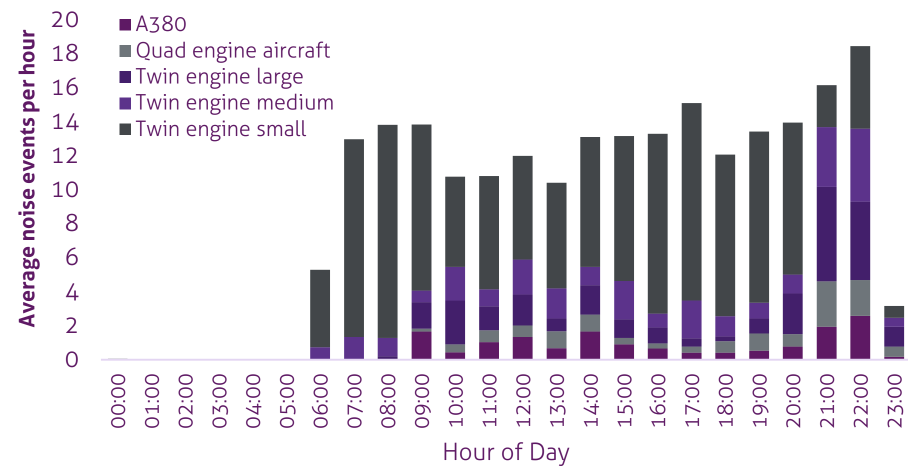
The top right figure shows the average number of noise events during each hour of the day for days of full easterly operations.

- During daytime hours, there were typically between 10 and 18 aircraft noise events flights per hour of which between 3 and 10 were overhead (passing within the 60° cone above the monitor).
- The two busiest hours of the day in terms of aircraft noise events from both overhead and non-overhead flights fell between 21:00 and 23:00, with 16-18 flights per hour, 10 of which were overhead.

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

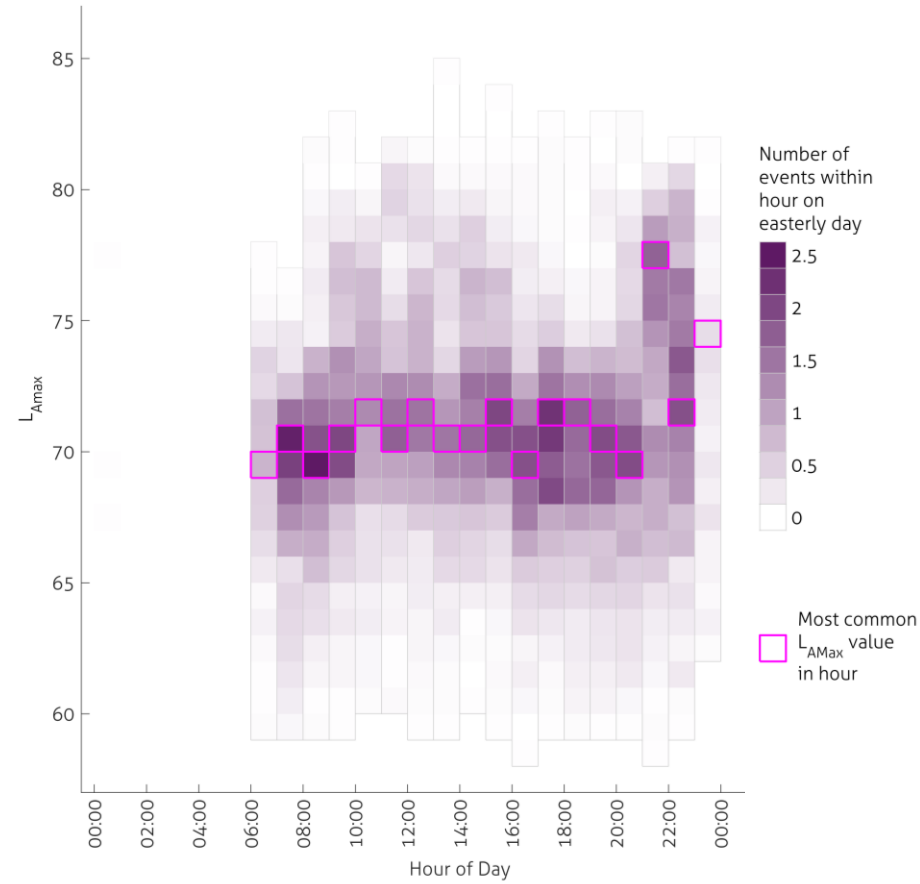
- Before 09:00, 90% of noise events were from smaller aircraft with less than twin-engine medium and small – predominantly the A320 family.
- Although there is some variation, the aircraft mix between 09:00 and 21:00 is fairly consistent - smaller, medium and larger aircraft at 66%, 23% and 11% of noise events respectively.
- The proportion and number of large twin, quad and A380 increases between 21:00 and 23:00 when compared with the rest of the day. This is driven in particular B777 movements which account for 30% of noise events during these hours.
- On average, there were between 3-4 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 11 for this hour. Of the total 221 days in the 2015/16 monitoring period, 49 days were 100% easterly operations, there were no delayed departures on 10 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 (p27).





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

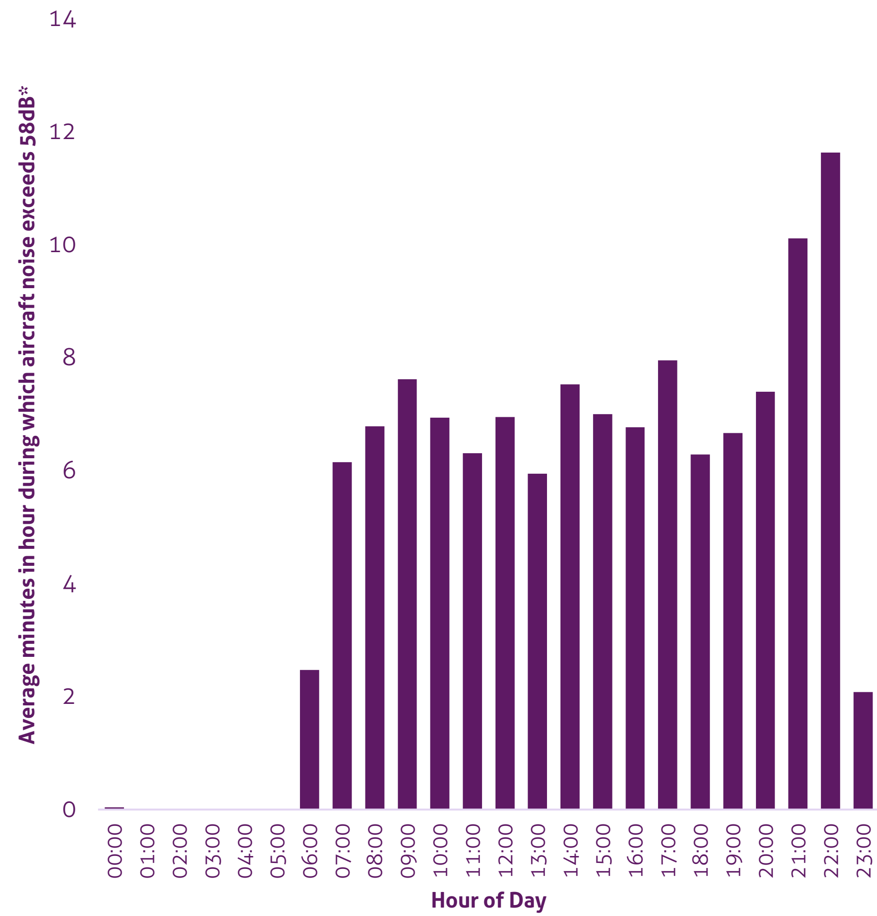
- The figure to the right shows the range of L_{Amax} values of aircraft noise events for each hour of the day. The average number of aircraft events in each decibel interval and hour on a typical easterly day is shown by the colour of each square; the darker the square, the more aircraft events occurred 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 69 and 72dB. The lowest average L_{Amax} occured between 07:00 and 08:00 when movements are dominated by smaller aircraft - 90% of the noise events are caused by smaller twin engine aircraft.
- The increase in larger aircraft between 09:00 and 15:00, as seen on the previous page, is reflected in the larger number of noise events between 75 and 81dB.
- The highest average L_{Amax} of aircraft events was typically highest between 21:00 and 00:00 due to the greater proportion of B777 and A380s departing in this period.



HELIOS

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

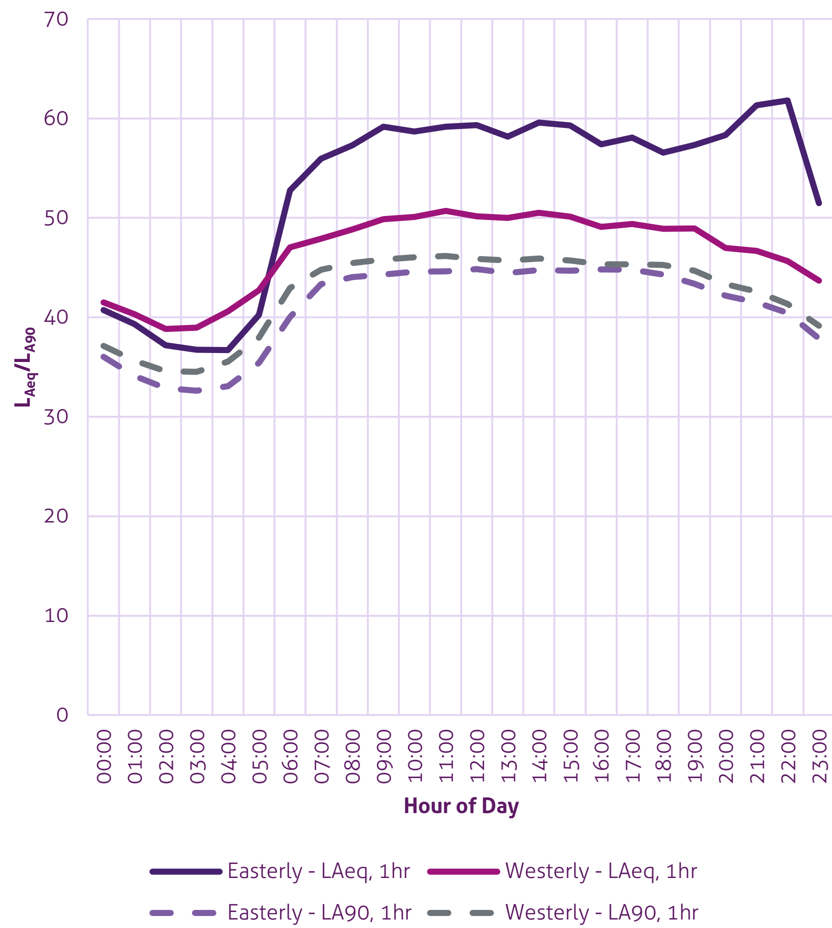
- The figure to the right shows the average number of minutes in each hour when the sound level within an aircraft noise event exceeding the measured noise event threshold - in this case 58dBA – on a day of full easterly operations. At this location this could be described as the amount of time (in minutes) that the aircraft noise level exceeds 58 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% easterly days aircraft noise exceeded the monitor threshold for a total of between 6 and 8 minutes in each hour (10-12% of the hour) between the hours of 7am and 9pm.
- Between 9pm and 11pm this increased to 10 and 12 minutes. As with other analysis, this increase is because of the A380 and B777 movements, 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 easterly operations?

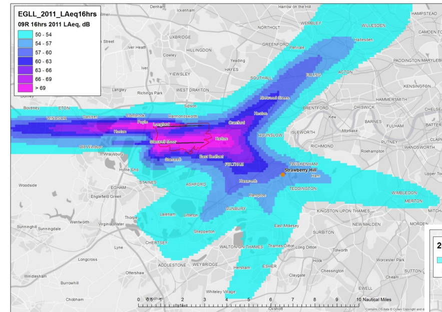
- The figure to the right shows the average (arithmetic mean) hourly $L_{Aeq,1hr}$ and $L_{A90,1hr}$ on days where 100% of operations were either westerly or easterly. It should be noted that these metrics describe the overall noise environment including all noise sources, not just aircraft noise.
- During days of full easterly operations daytime $L_{Aeq,1hr}$ values were typically around 10dB higher when compared with the same hour during a full westerly day. This indicates that the overall noise environment for each hour is governed by aircraft noise when on easterly operations.
- During the period the monitor was in place, the average daytime $L_{Aeq,16hr,1hr\ average}$ between 07:00 and 23:00 was 50dB on westerly operations and 59dB on easterly operations from all noise sources8. During the night, the average $L_{Aeq,8hr,\ 1hr\ average}$ between 23:00 and 07:00 was 43dB on westerly operations and 49dB on easterly operations.
- The contribution of aircraft noise to the noise environment is most discernible during the period 21:00 and 23:00. This is shown by a difference of more than 15dB between easterly and westerly $L_{Aeq,1hr}$ values. The $L_{Aeq,1hr}$ peaks between 21:00-23:00 reaching 62dB on easterly operations. The ambient noise levels are highest at this time during easterly operations but (across the day period) are the lowest at this time during westerly operations.
- On westerly operations, the background noise ($L_{A90,1hr}$) is, on average, 1.4dB higher than during easterly operations.

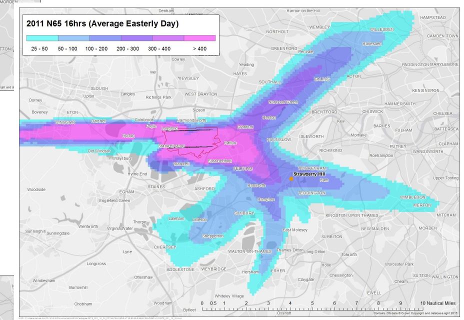


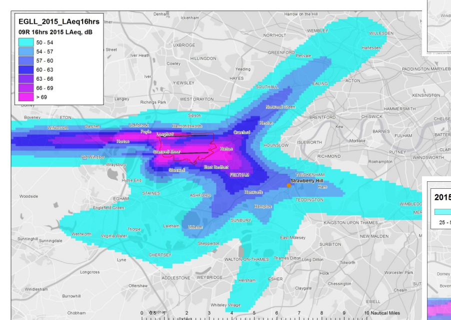
*Note: The $L_{Aeq,16hr,1hr\ average}$ has been derived by taking the logarithmic average of the 16 daytime hours where each day is an (arithmetic) average of each hour the in the day when the airport is on westerly or easterly operations. A similar calculation has been performed for the $L_{Aeq,8hr,1hr\ average}$

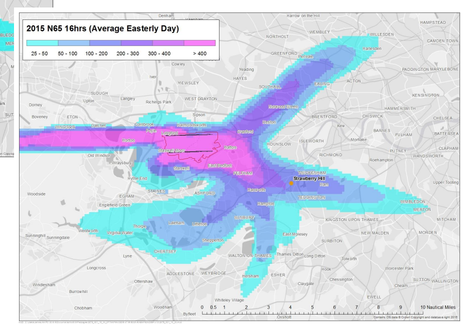
Comparing longer term average daytime ($L_{Aeq, 16hr}$ /N65) and night-time ($L_{Aeq, 8hr}$ /N60) aircraft noise levels around the airport using modelling.

- 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 easterly operations** across the summer in each of these years.
- Note that these contours are specific to easterly 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 easterly 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.







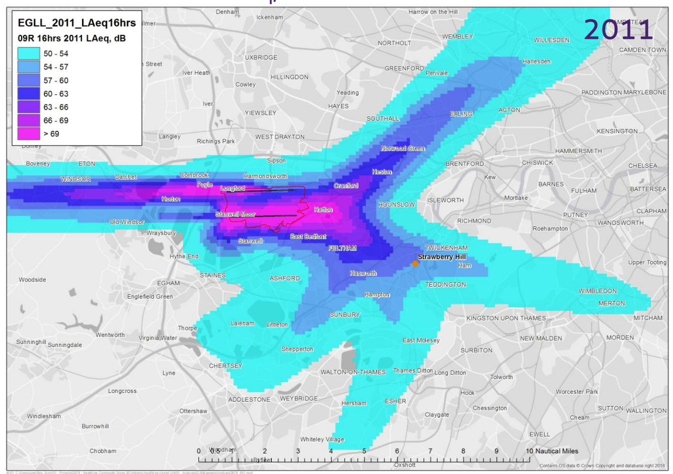


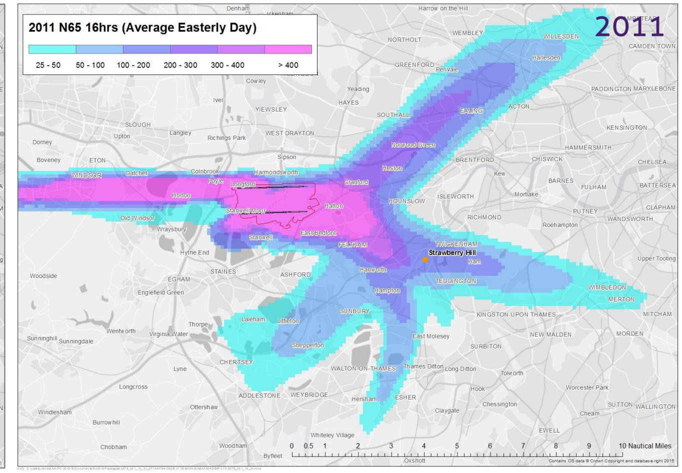
Modelled average **daytime** $L_{Aeq, 16\,hour}$ and N65 aircraft noise levels

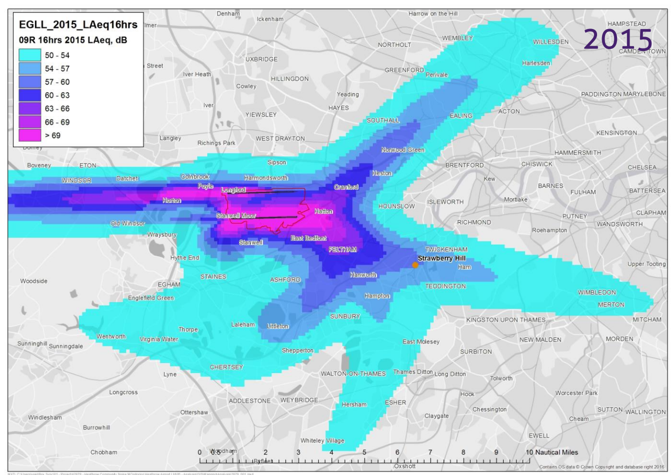
- The figures to the right show the 2011 and 2015 daytime $L_{Aeq, 16hr}$ bands in the left column and N65 bands in the right column for **an average easterly summer day when the airport is on 100% easterly operations**.
- The position of the noise monitor is marked by the orange dot.
- The N65 is defined 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.

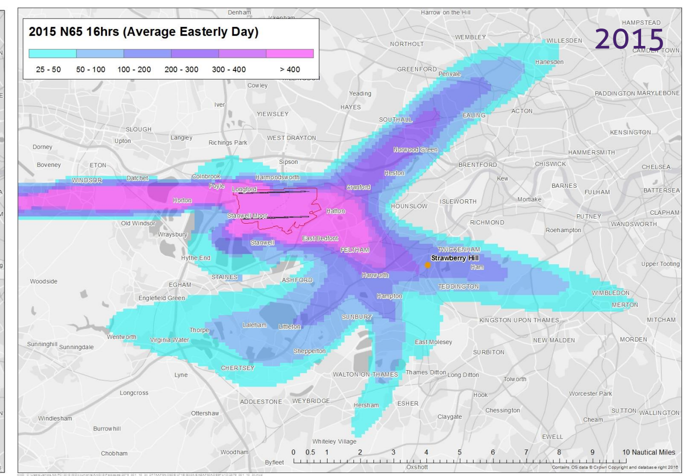
$L_{Aeq,16hr}$

N65, Daytime





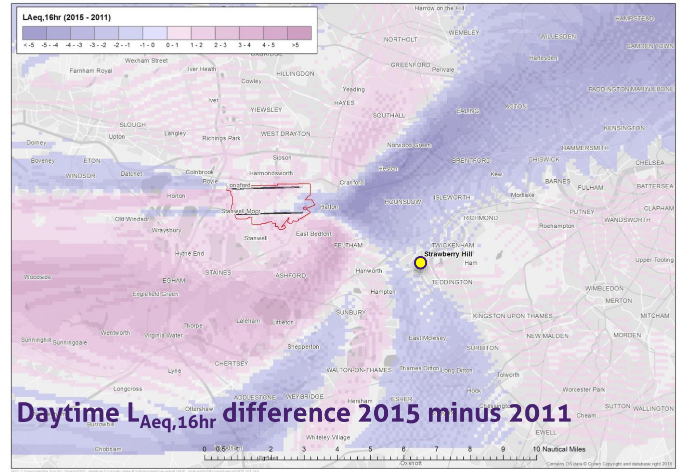


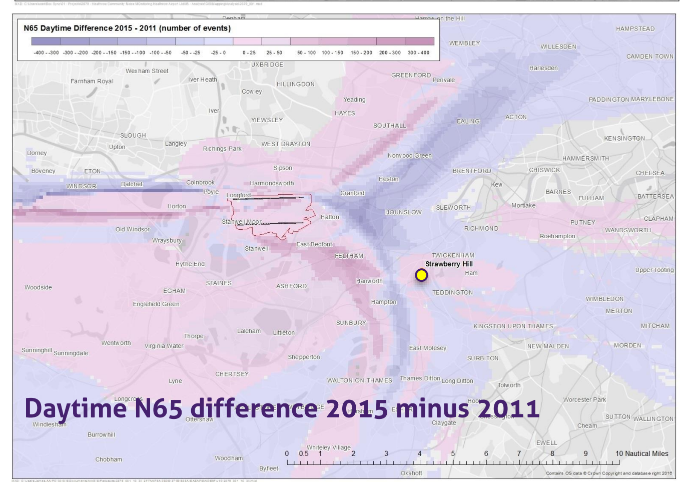


Modelled **daytime** $L_{Aeq,\,16\,hour}$ and $N65_{(16\,hour)}$ differences - 2011 to 2015

- 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 easterly 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 Strawberry Hill there was less than a 1dB difference in average modelled daytime noise level $L_{Aeq,16hr}$ between 2011 and 2015 at 58dB.
- The modelling indicates an increase of upto around 25 (+12%) daytime N65 events.
- It should be noted that, all other variables remaining constant, a difference in 26% of noise events, would correspond to about a 1dB increase/decrease in $L_{Aeq,16hr}$.

- Larger figures are shown in Appendix A.





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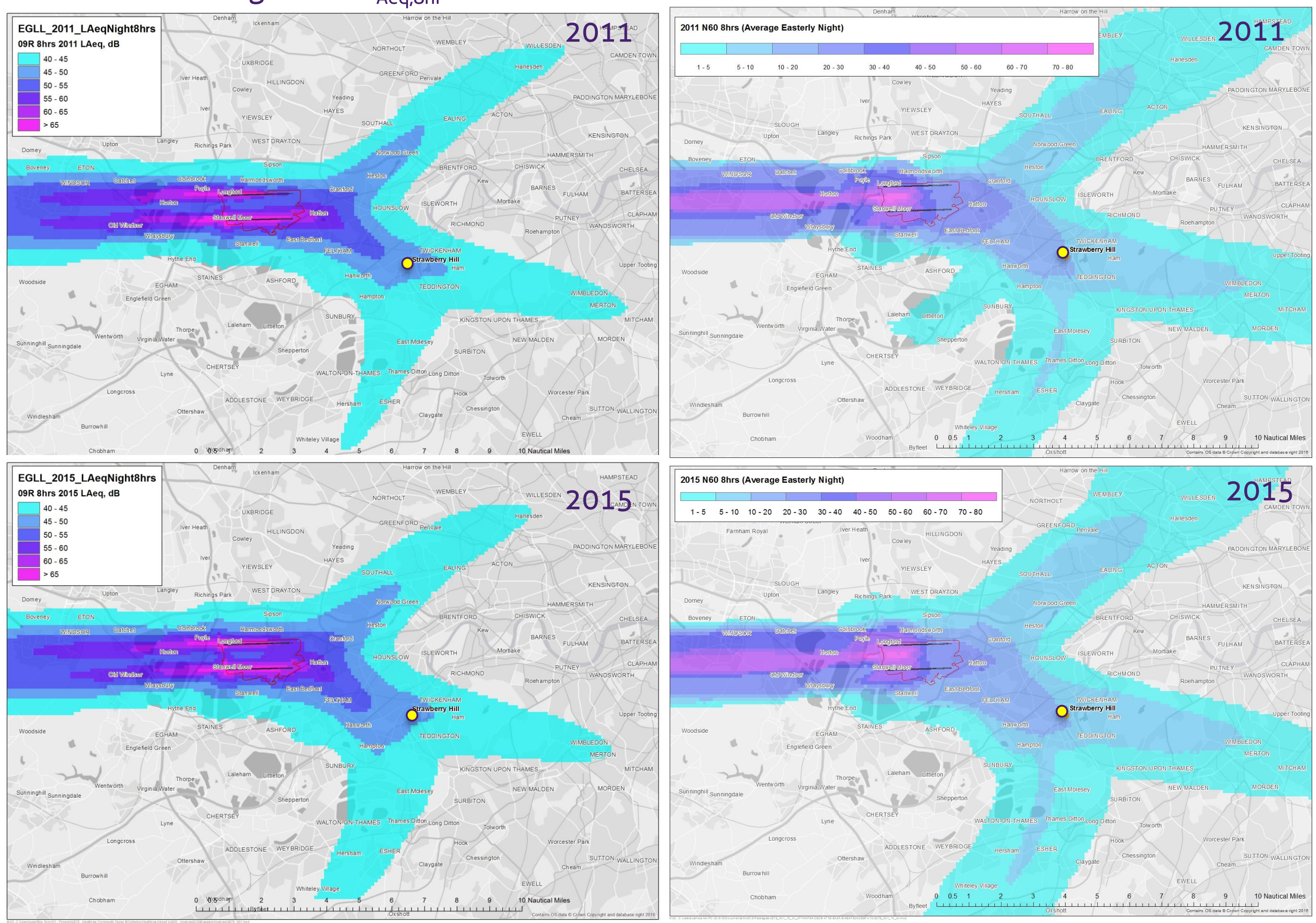
Modelled average **night time** $L_{Aeq, 8hr}$ and N60 aircraft noise levels.

- 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 easterly summer night between 11pm and 7am when there are 100% easterly operations. Generated from **an average easterly summer day when the airport is on 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 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 easterly operations.
- Larger figures are shown in Appendix A.

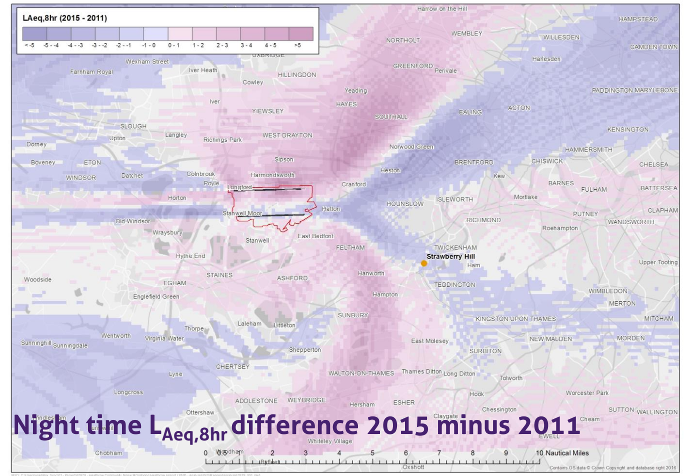
Night-time $L_{Aeq,8hr}$ | N60, night-time

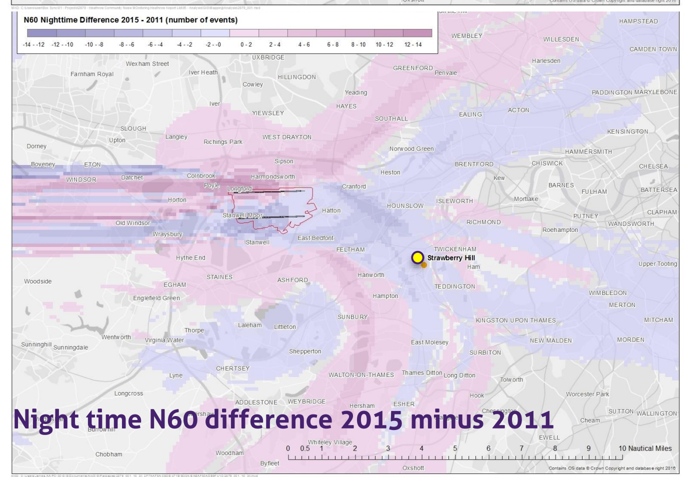


Modelled average **night-time** $L_{Aeq, 8hr}$ and N65 differences - 2011 to 2015

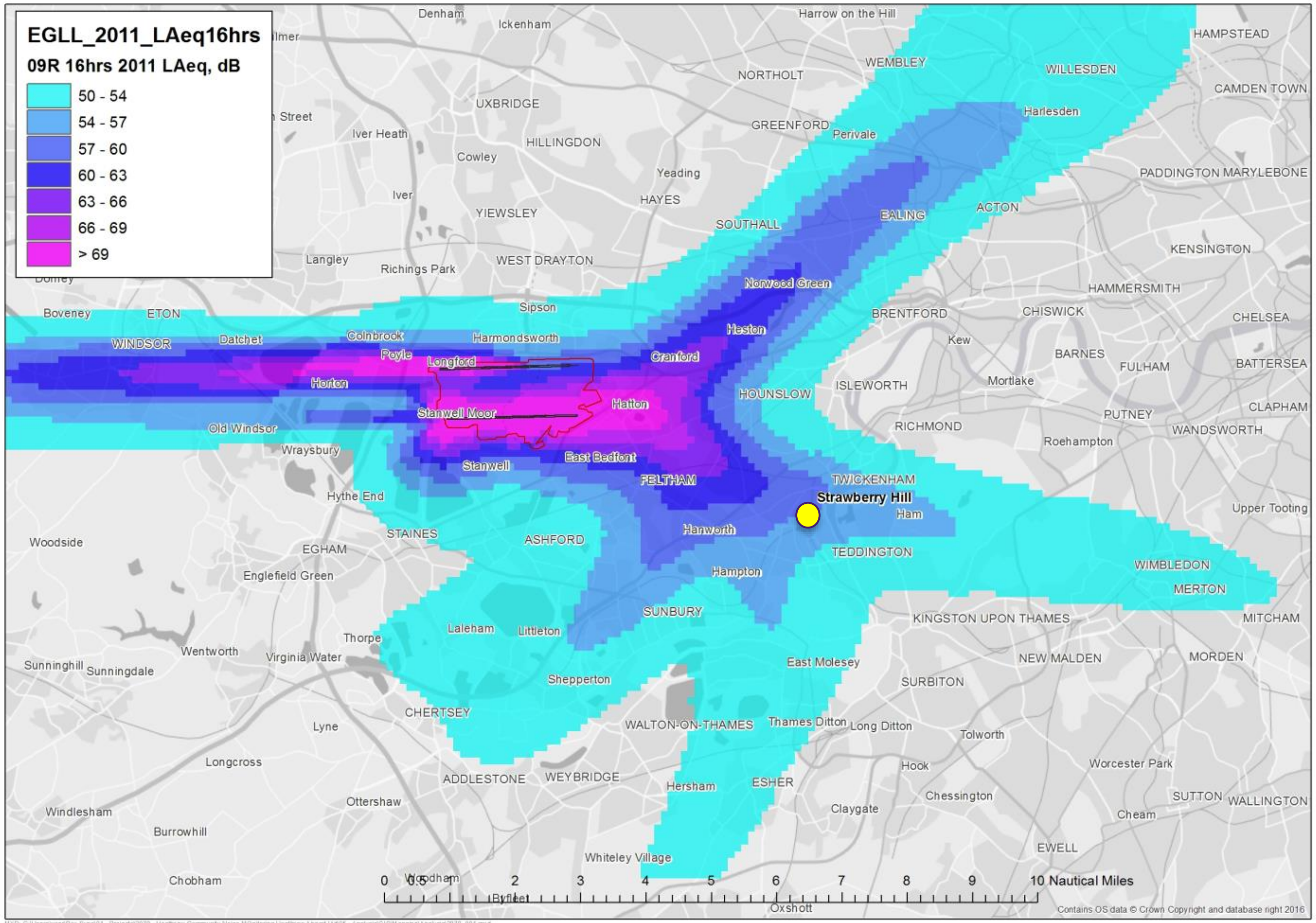
- The difference in the modelled average $L_{Aeq, 8hr}$ (upper figure) and $N60_{(8\ hr)}$ (lower figure) values around Heathrow between 2011 and 2015 are shown in the figures to the right.
- Areas with an average decrease are shown in blue and those areas with an average increase in pink.
- The results indicate a marginal reduction in average night-time aircraft noise levels (both $L_{Aeq,8hr}$ and N60) at Strawberry Hill from 2011-2015.

- Larger figures are shown in Appendix A.

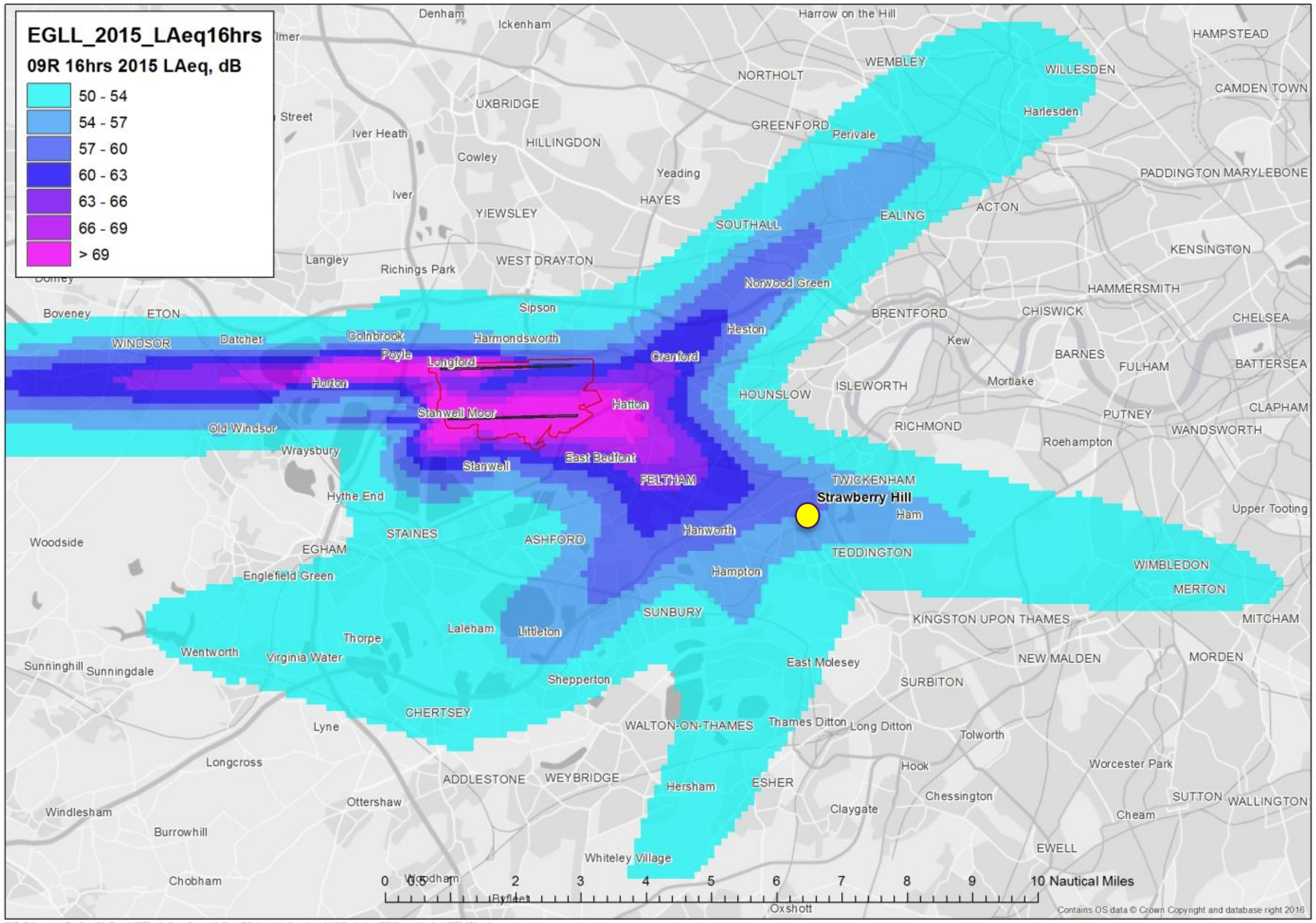




Appendix A: $L_{Aeq, 16hr}$ contours (2011)



Appendix A: $L_{Aeq,\,16hr}$ contours (2015)



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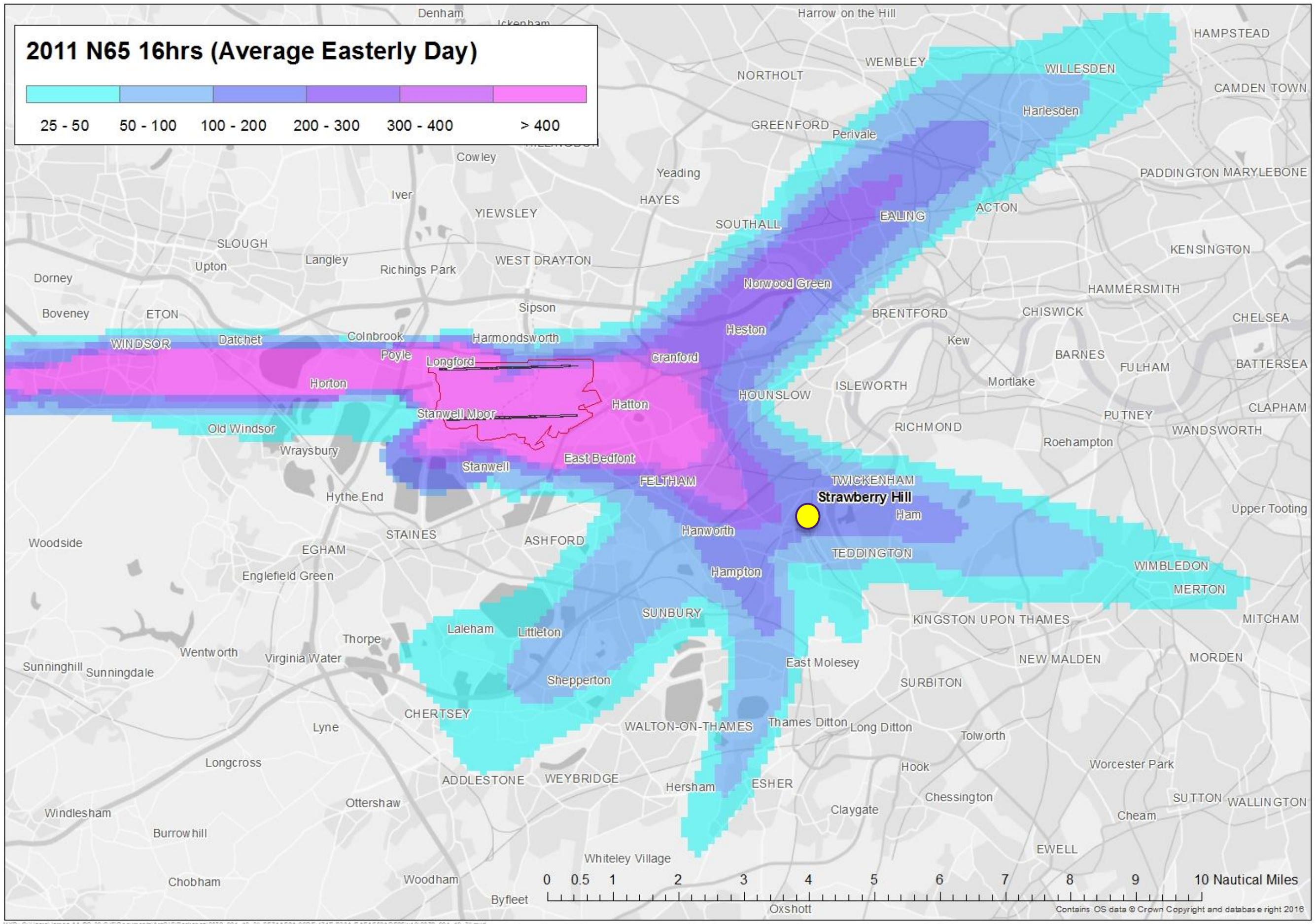
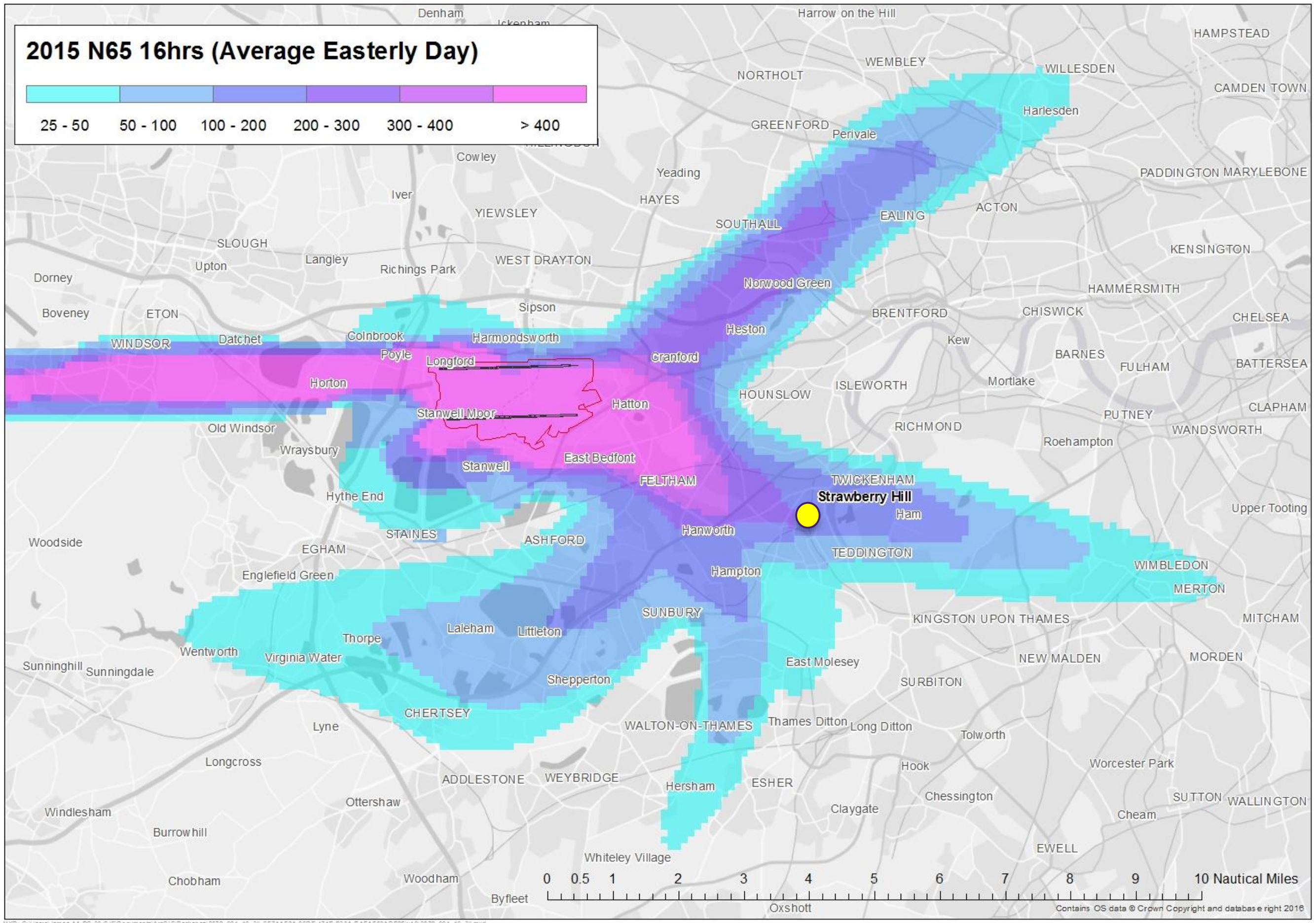
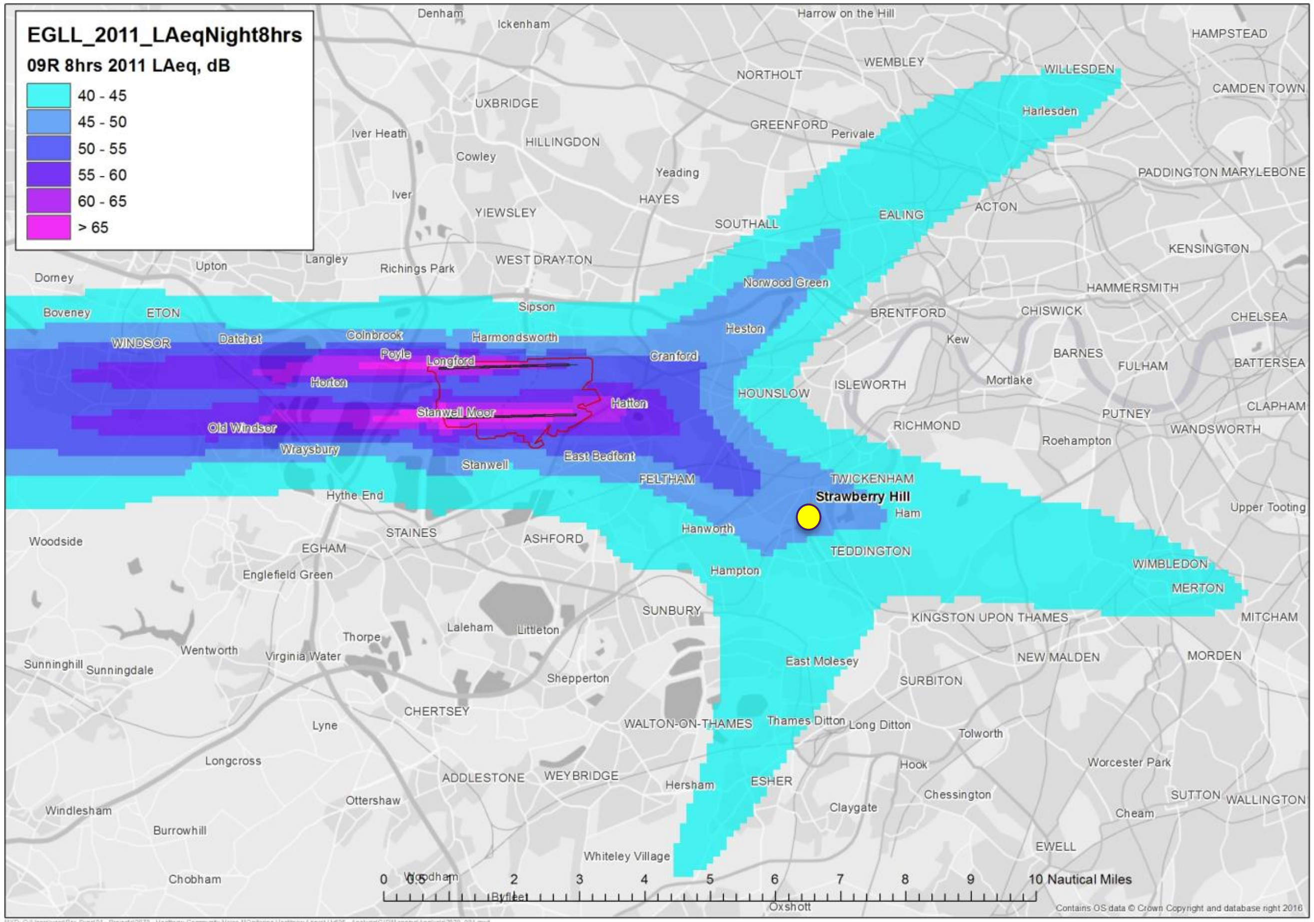
Appendix A: N65$_{16hr}$ contours (2011)



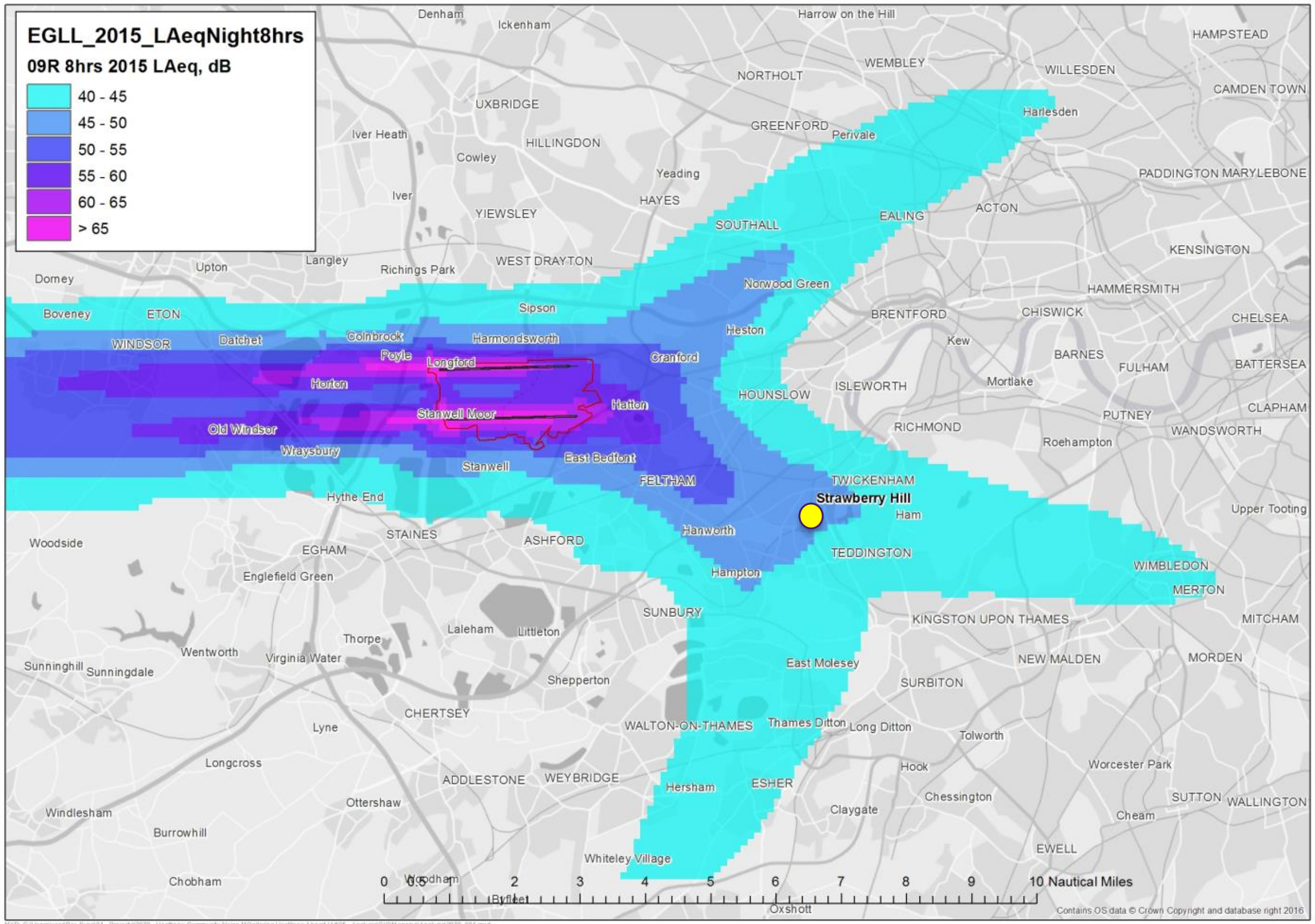
Appendix A: $N65_{16hr}$ contours (2015)



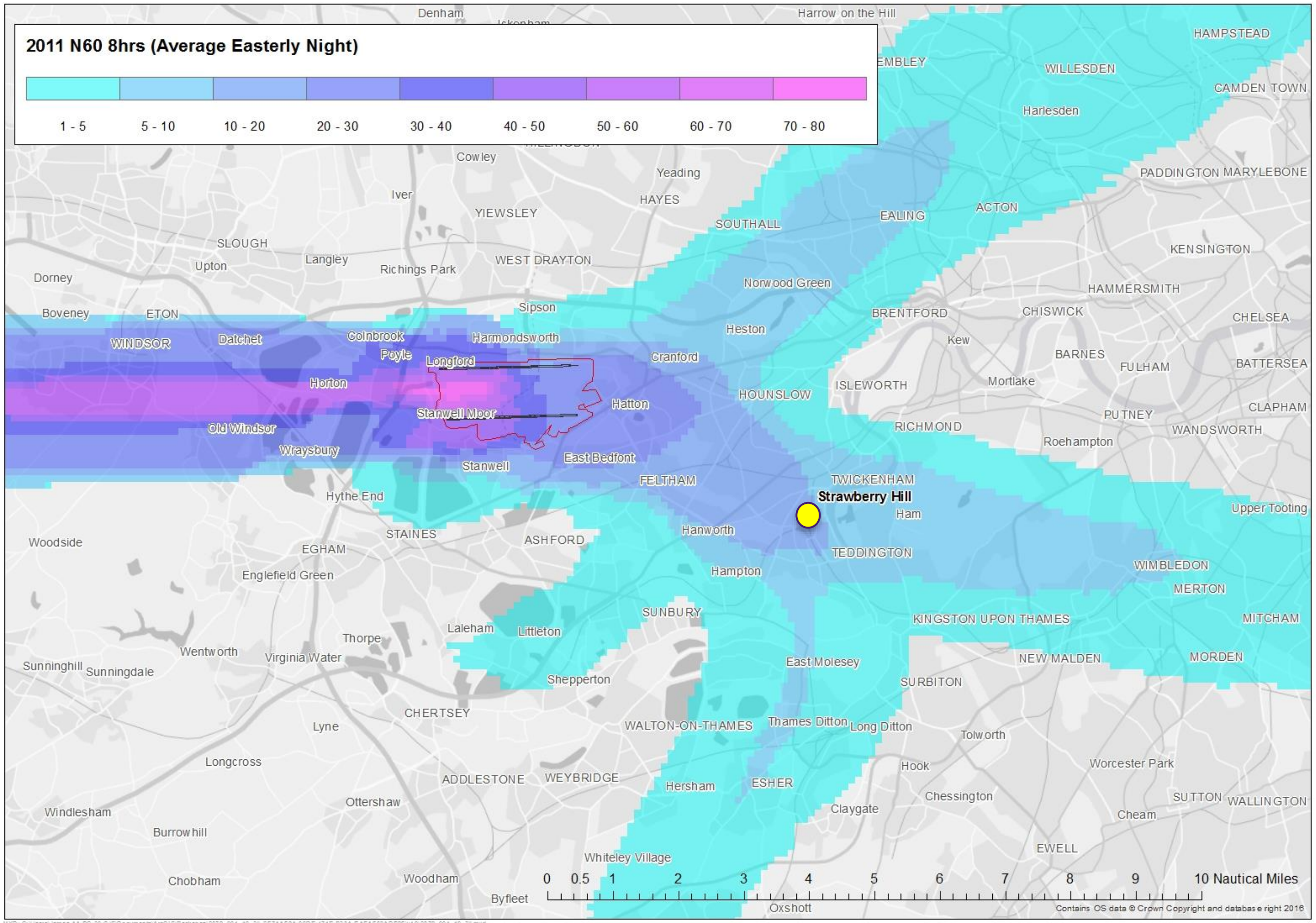
Appendix A: $L_{Aeq,8hr}$ contours (2011)



Appendix A: $L_{Aeq, 8hr}$ contours (2015)



Appendix A: $N60_{8hr}$ contours (2011)



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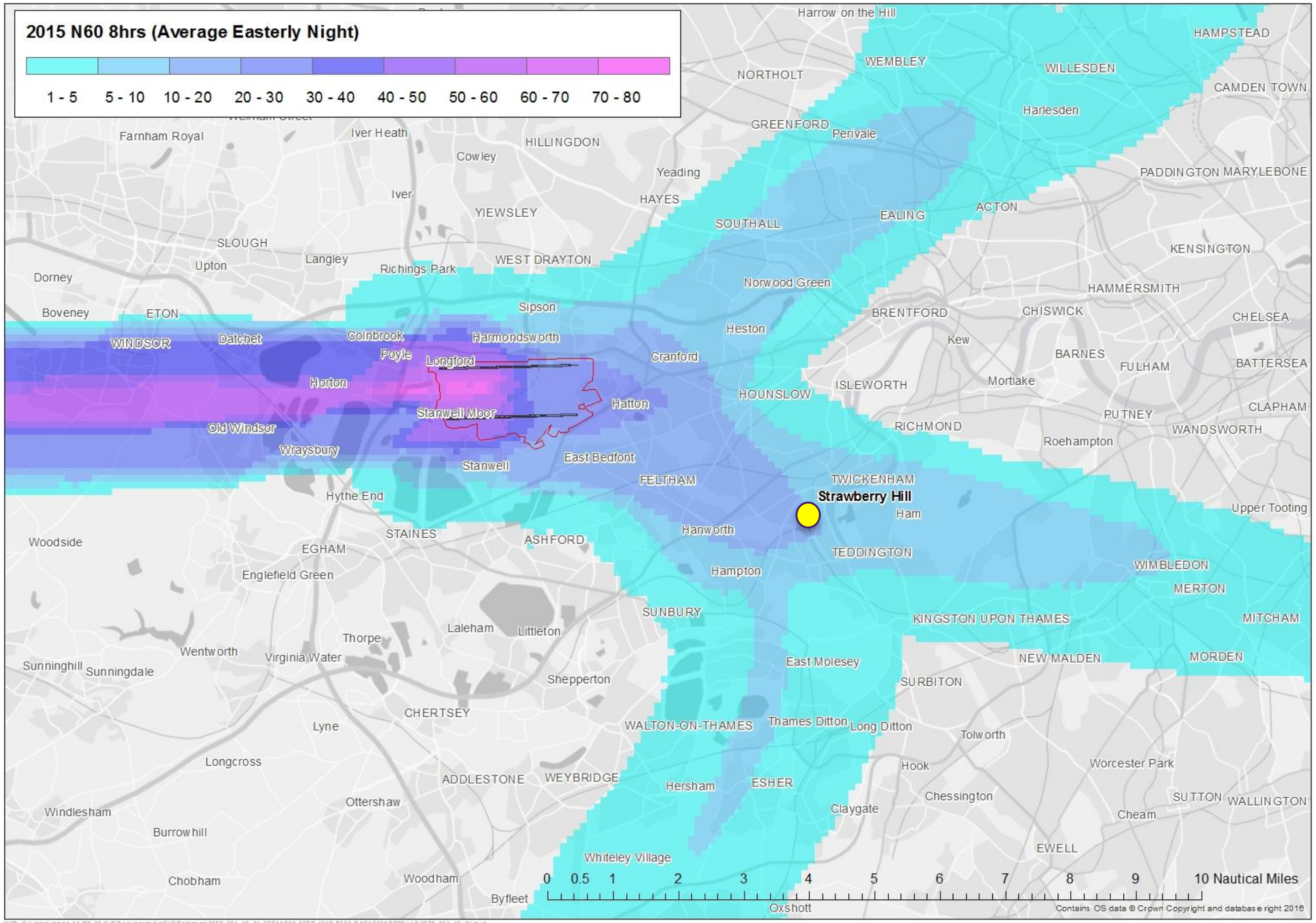
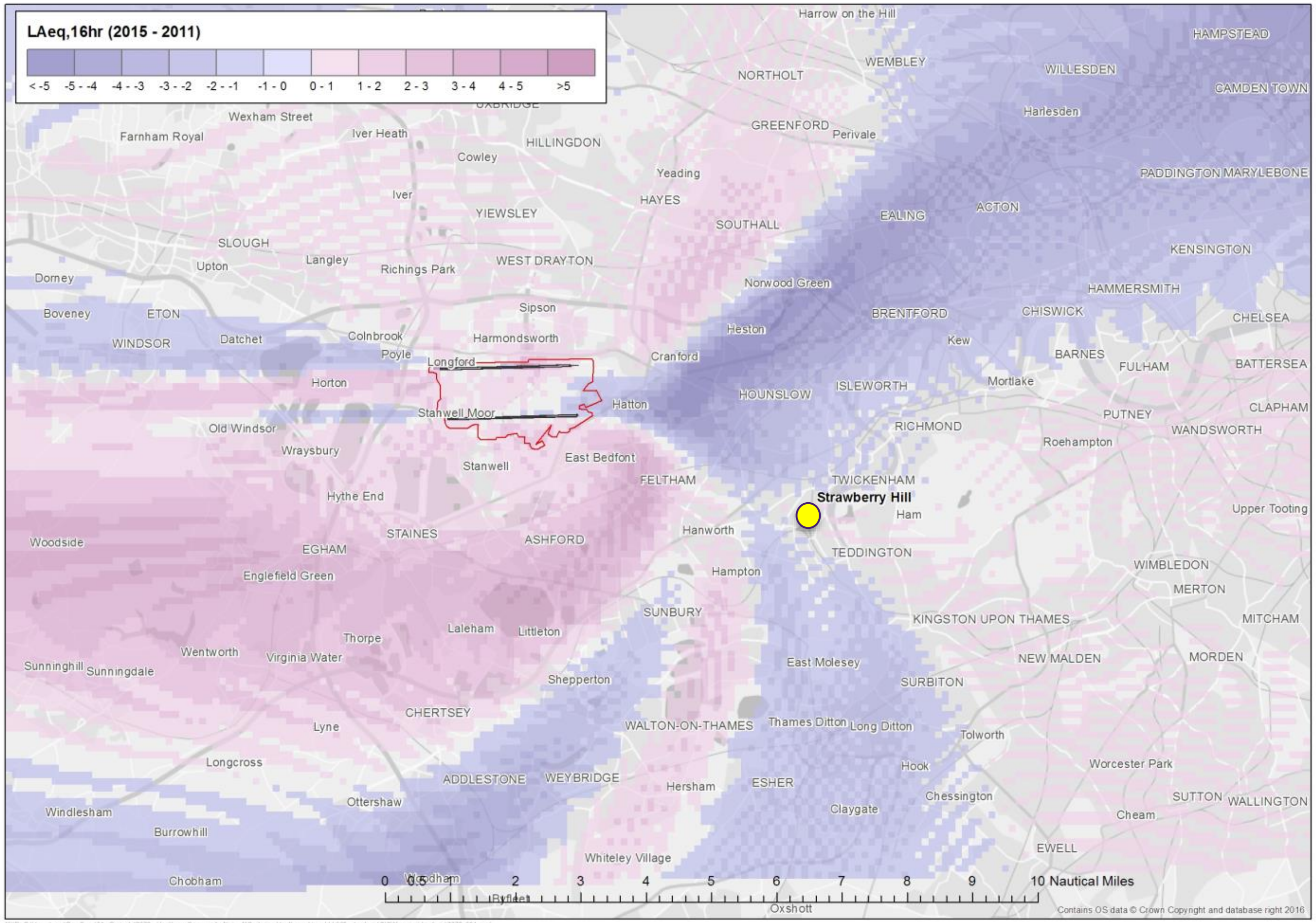
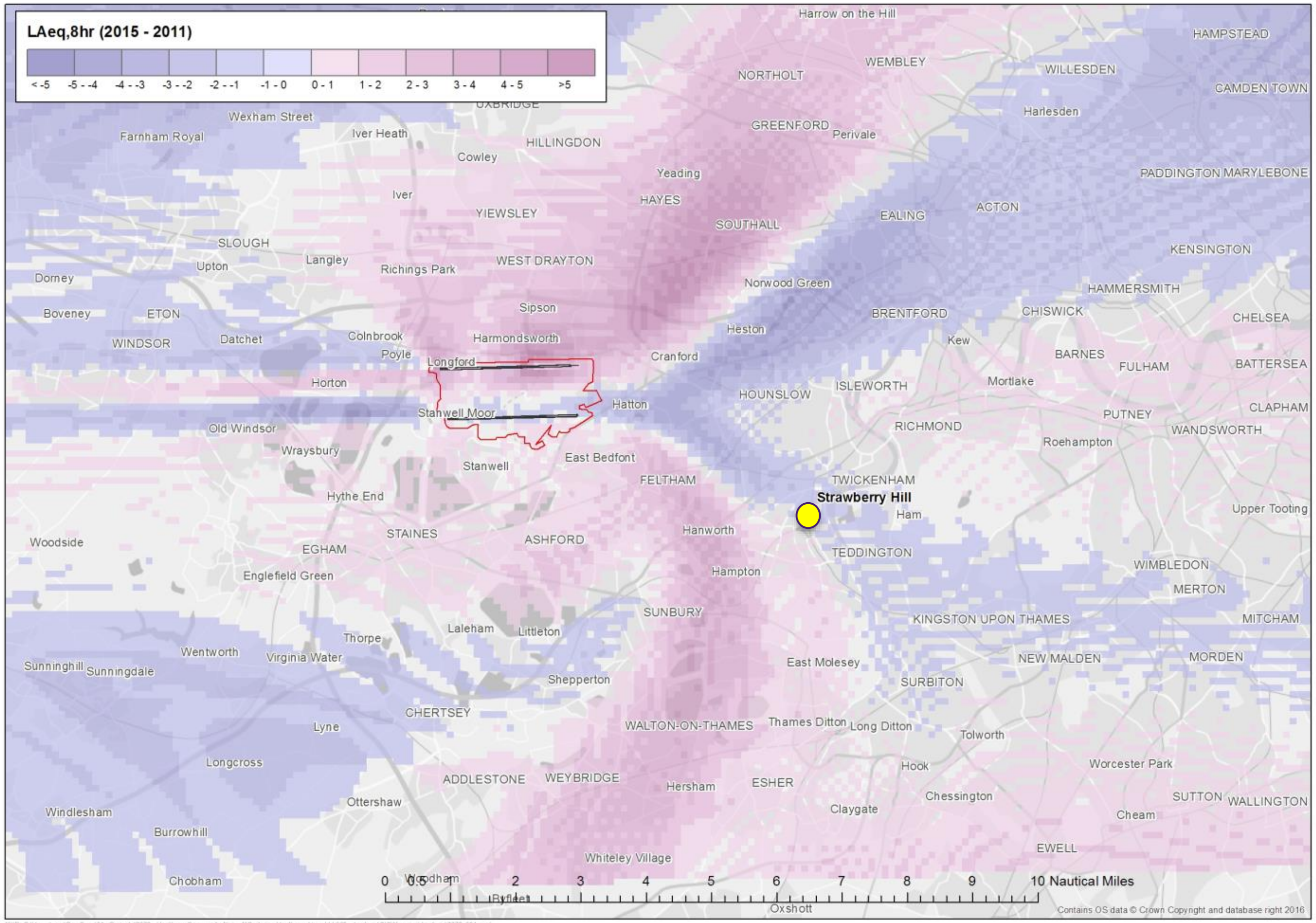
Appendix A: $N60_{8hr}$ contours (2015)



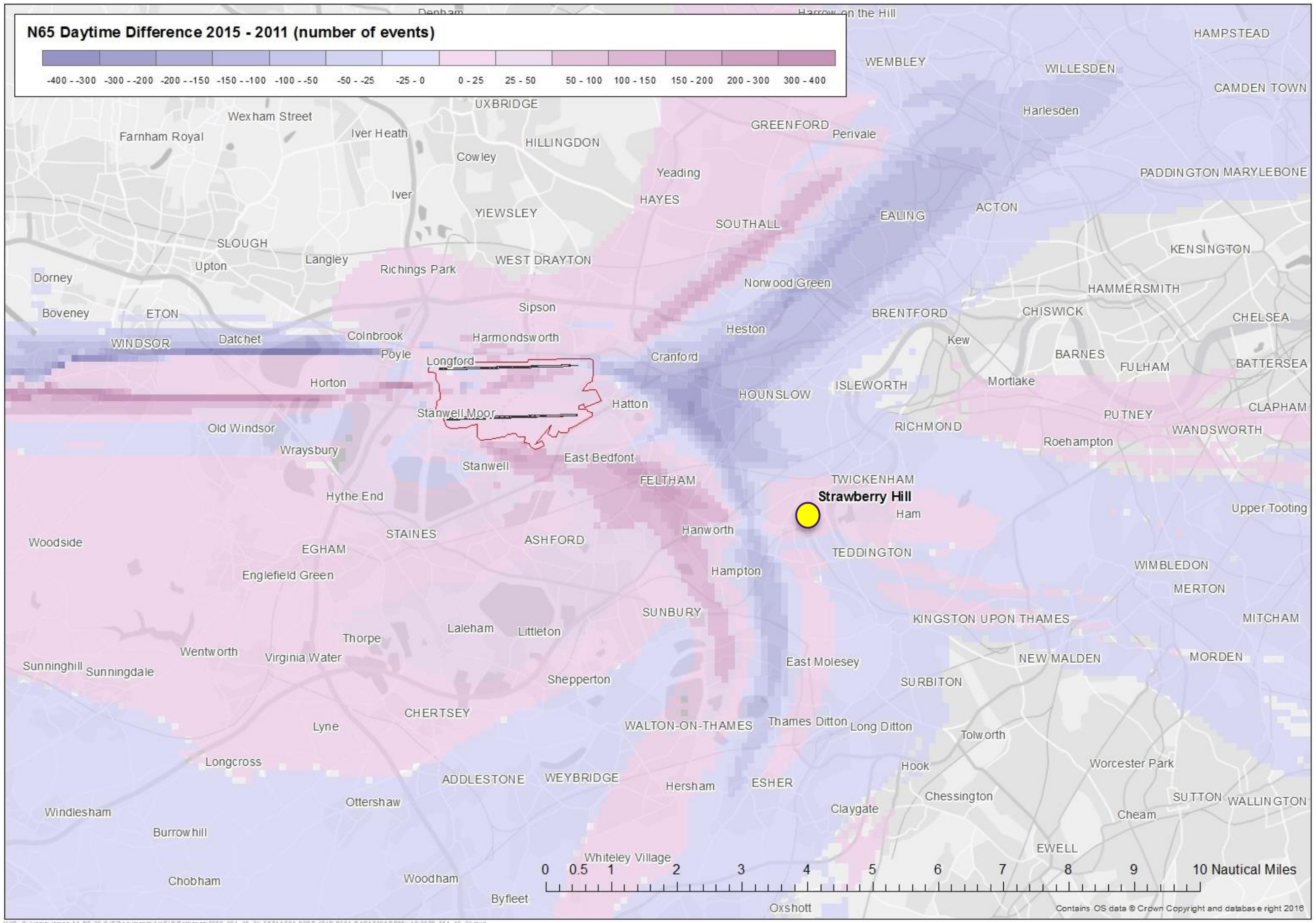
Appendix A: $L_{Aeq, 16hr}$ difference (2015 minus 2011)



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



Appendix A: N65$_{16hr}$ difference (2015 minus 2011)



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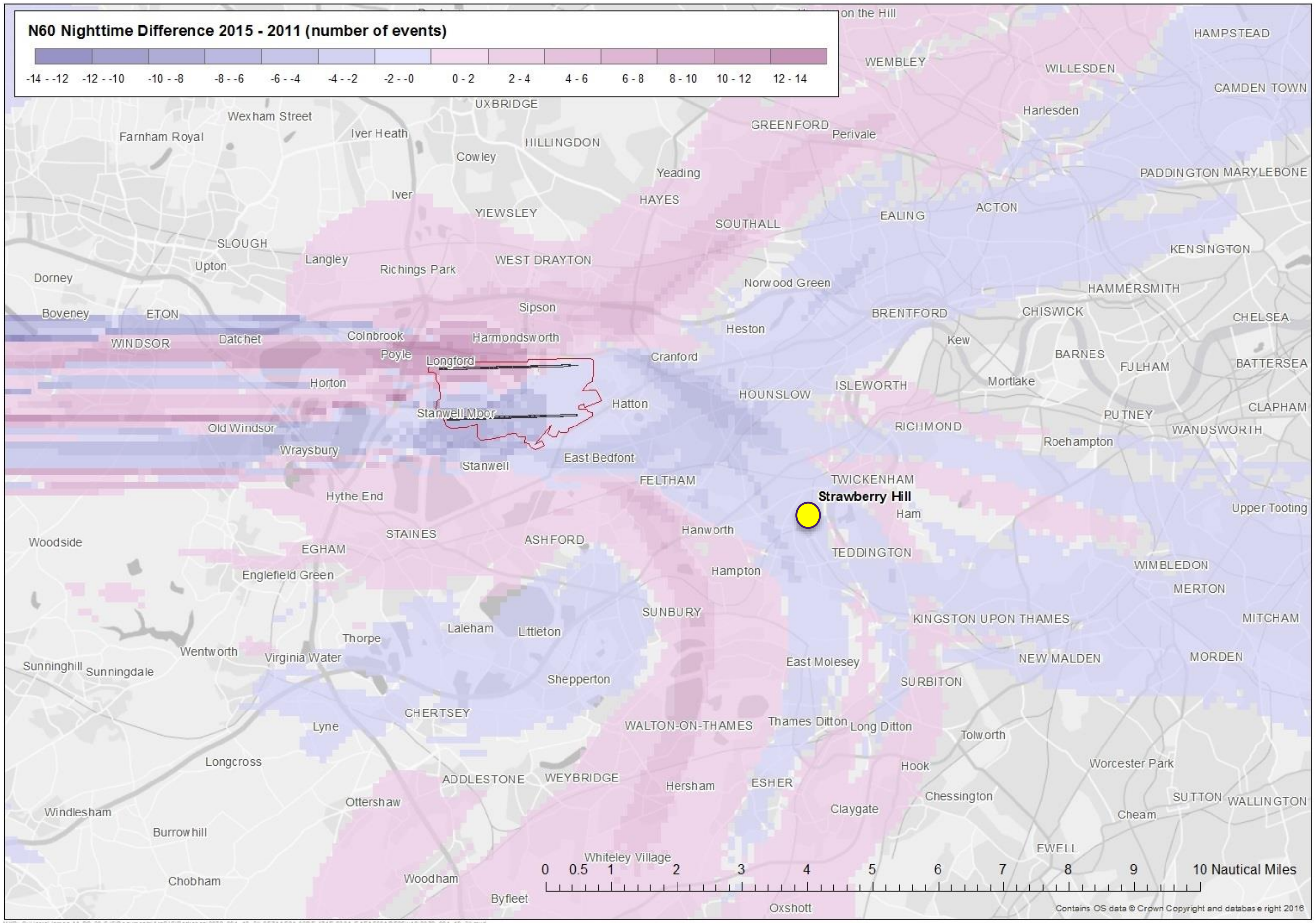
Appendix A: $N60_{8hr}$ difference (2015 minus 2011)



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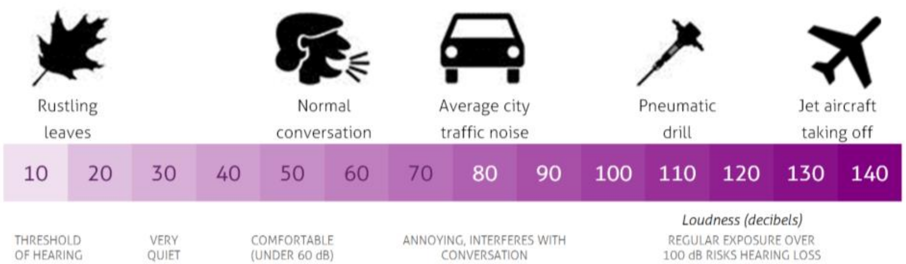
Appendix B: Noise Terminology

How is noise measured?

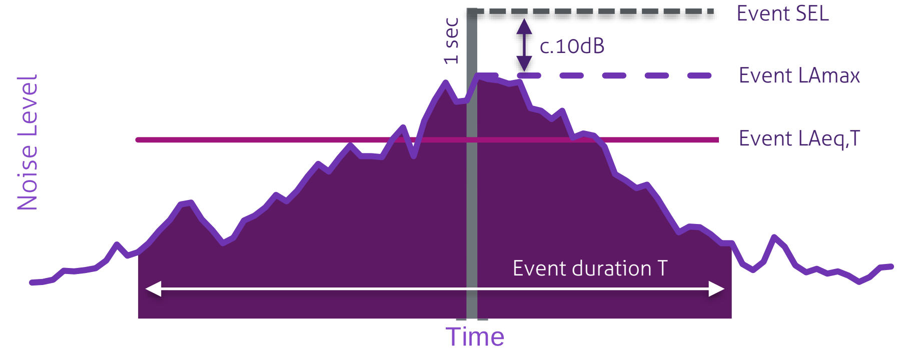
There is a million to one ratio between the threshold of hearing and the highest tolerable sound pressure. Noise is therefore measured using a logarithmic scale, to account for this wide range, called the decibel (dB). Typical noise levels of everyday sounds are shown in the figure below.



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.



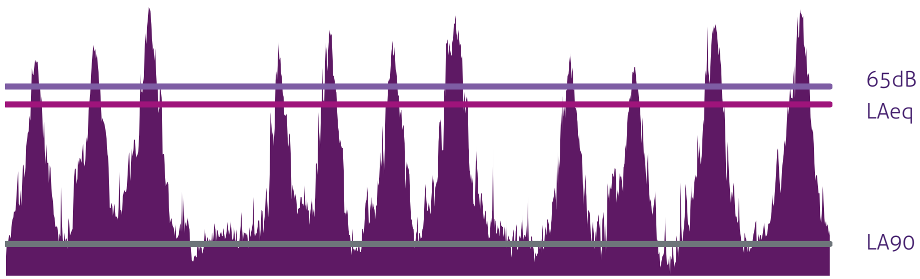
There are a number of metrics that can then be used to characterise a noise event all of which can be derived from modelling:

- 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

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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 ($L_{Aeq,T}$) 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 individual events are the same), the $L_{Aeq,T}$ will increase by 3dB. Likewise, a 26% increase in events will raise the $L_{Aeq,T}$ by 1dB. Further factors are shown in the table below.

Number of Events	Noise level difference
x4	+6dB
x2	+3dB
x1.58	+2dB
x1.26	+1dB
0	0
÷1.26	-1dB
÷1.58	-2dB
÷2	-3dB
÷4	-6dB