Assessment of the ANEEM system at Heathrow

Introduction

Heathrow's ANOMS noise and flight track monitoring system (provided by EMS Brüel & Kjær) currently uses a threshold-based system of noise event recognition. To qualify as a noise event, the continuous time-varying sound level measured by a noise monitor must exceed a *threshold level* for a *minimum duration*. Both parameters are defined by the system user and can vary from monitor to monitor.

For each measured noise event, the ANOMS system software then determines whether an aircraft passed within a defined zone around the noise monitor close to the time of L_{Amax} (the maximum sound level measured during the event). If an aircraft is identified then the software correlates the noise event with that particular flight, otherwise the event is classified by the system as community noise (i.e. non-aircraft noise).

If the threshold level is set too low, then the system can become swamped with non-aircraft noise events which could make the identification of genuine aircraft noise events more difficult (for example, if the aircraft event and non-aircraft event occur within a few seconds of each other) and can increase the overall uncertainty of average measured aircraft noise levels. However, if the threshold is set too high then genuine quieter aircraft noise events can be missed and result in an overestimation of average measured aircraft noise levels.

At locations where the background noise level is frequently varying (for example, due to local road traffic), it can be difficult selecting an appropriate threshold level that is low enough to capture quieter aircraft noise events but high enough to ensure that extraneous (non-aircraft) noise is not continually recorded. Whilst the threshold levels can also be varied over different times of the day and night, the effort to manage time-varying thresholds for 50+ monitors at Heathrow would be so great as to be impractical.

In November 2019 ERCD was commissioned by Heathrow Airport to undertake an assurance piece of work on the effectiveness of a new noise source classification methodology developed by Heathrow's ANOMS system developer, Brüel & Kjær, called ANEEM[1] (Aircraft Noise Event Extraction Methodology), prior to any wider deployment into Heathrow's ANOMS system.

[1] https://www.emsbk.com/anoms-aneem/

The ANEEM system is intended to eliminate the need to manually set a threshold level and minimum duration in response to the varying background noise level and to be better suited for monitoring at locations that have multiple and varying noise sources. It is also claimed[2] that ANEEM is able to detect significantly more aircraft events than existing threshold-based systems while improving accuracy rates through the reduction in false positives[3] being classified.

Methodology

Baseline noise event data was extracted from the ANOMS system for two of Heathrow's mobile noise monitor locations, Camberwell and Richings Park, covering a one-month period at each site. The choice of locations and the periods of study were agreed with Heathrow Airport based on previous monitoring experience at locations that were known to be problematic for collecting aircraft noise event data; more information is given in the following sections. A comparison was then made with ANEEM event classification processing over the same study periods, using noise monitor data from each location that had been post-processed by the system supplier, independently from ANOMS.

Audio recordings are also captured by the ANOMS noise monitors for every measured noise event (aircraft and non-aircraft), allowing the user to play back and listen to the noise event audio for further analysis. This made it possible to listen to the audio recordings for a representative subset of noise events at each site, enabling a qualitative assessment to be made of the noise source classification methodology of both systems. However, this only covered events that were originally recorded by the threshold-based ANOMS monitors. Audio recordings were not available for noise events that were exclusively detected by the ANEEM system, therefore we could not determine whether ANEEM had incorrectly classified those particular noise events. This is a weakness in the study.

Camberwell noise monitor (NMT 511)

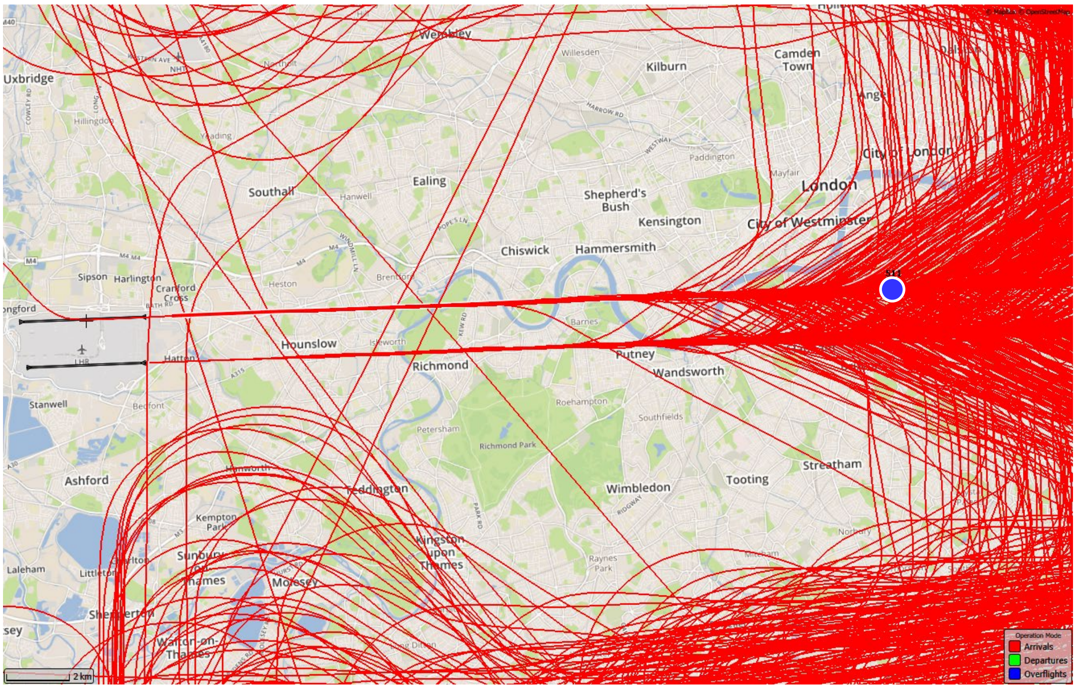
Monitor location and setup

The Camberwell noise monitor is installed in the grounds of the Ark All Saints Academy in Camberwell. The monitor is located under the westerly approach path to Heathrow's northern runway and is also overflown by aircraft joining the approach to the southern runway from the north (Figure 1). Heathrow arrivals over this location are typically at a height of around 4,000 ft.

[2] Myles Harding and Douglas Ferrier. (2014). *Using Post analysis of a noise sample stream in place of noise monitor based thresholds in the detection of aircraft noise*. Inter-Noise 2014. https://www.acoustics.asn.au/conference_proceedings/INTERNOISE2014/papers/p809.pdf

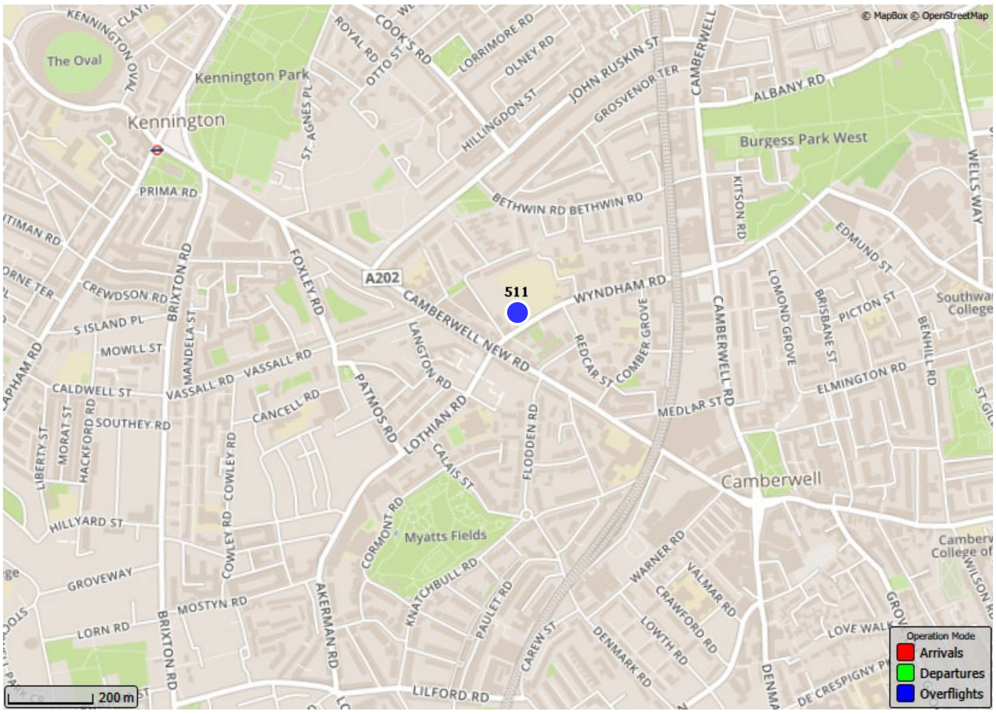
[3] False positives are non-aircraft noise events being incorrectly classified as aircraft noise events.

Figure 1 Camberwell monitor location in relation to typical westerly arrival tracks



Due to its location, the monitor also records events from helicopter overflights and from aircraft operating into London City Airport when it is operating in an easterly direction[4]. The site is located approximately 100 metres from Camberwell New Road, which is the nearest main A road, (Figure 2).

Figure 2 Camberwell monitor location relative to Camberwell New Road (A202)



[4] Easterly arrivals operating into London City Airport fly past the Camberwell noise monitor at a height of approximately 2000 ft.

The monitor was set up to record noise events above a threshold level of 58 dBA, lasting for 10 seconds or longer.

Noise event summary

Table 1 summarises the total daily numbers of noise events that were detected using each method of noise event classification during September 2018. These include noise events from any type of aircraft operation in the vicinity of the monitor, including non-Heathrow aircraft. The main Heathrow runway direction on each day is also shown for information.

Table 1 Comparison of threshold-based events and ANEEM events at Camberwell

Date	Count of threshold-based ANOMS noise events			Count of ANEEM noise events (see note 2)	Runway direction
	Correlated	Uncorrelated (see note 1)	Grand Total		
01/09/2018	235	4	239	638	Westerly
02/09/2018	42	3	45	164	Easterly
03/09/2018	54	7	61	148	Easterly
04/09/2018	39	2	41	137	Easterly
05/09/2018	42	1	43	109	Easterly
06/09/2018	244	5	249	650	Westerly
07/09/2018	303	7	310	683	Westerly
08/09/2018	273	8	281	629	Westerly
09/09/2018	216	7	223	669	Westerly
10/09/2018	231	18	249	648	Westerly
11/09/2018	183	13	196	619	Westerly
12/09/2018	236	1	237	477	Mixed
13/09/2018	300	5	305	658	Westerly
14/09/2018	302	10	312	643	Westerly
15/09/2018	285	4	289	634	Westerly
16/09/2018	235	13	248	676	Westerly
17/09/2018	185	13	198	633	Westerly
18/09/2018	268	13	281	635	Westerly
19/09/2018	320	27	347	641	Westerly
20/09/2018	282	29	311	642	Westerly
21/09/2018	354	57	411	650	Westerly
22/09/2018	250	9	259	370	Mixed
23/09/2018	62	5	67	355	Mixed
24/09/2018	240	8	248	651	Westerly
25/09/2018	243	11	254	622	Westerly
26/09/2018	166	10	176	553	Westerly
27/09/2018	136	5	141	568	Westerly
28/09/2018	53	4	57	154	Easterly
29/09/2018	233	13	246	627	Westerly
30/09/2018	222	8	230	659	Westerly

Note 1: Uncorrelated events are classified by the system as Community Noise (i.e. noise events not associated with any type of aircraft operation).
Note 2: ANEEM results exclude (uncorrelated) Community Noise events.

The results in Table 1 indicate that the ANEEM system has classified a significantly greater number of noise events at this location as aircraft noise events than the existing threshold-based system. The analysis did however also highlight a very small number of Heathrow arrival events (29 in total, over the entire month) that were detected by the threshold-based system, but were not detected by the ANEEM system. Whilst a detailed analysis of the audio recordings was not undertaken for these cases, some of these events appeared to be genuine uncontaminated aircraft events whereas others were likely to have been contaminated by extraneous noise.

Analysis of the radar data for each flight revealed that approximately half of all ANEEM noise events were from flights that did not fly directly overhead of the monitor, i.e. they flew outside a 60-degree cone[5] above the monitor. By comparison, less than a quarter of flights that were detected by the threshold-based ANOMS system did not fly directly overhead.

Further analysis of the data was undertaken specifically for Heathrow arrivals that overflew the Camberwell monitor within the 60-degree cone, since these flights should have been more easily detectable by the monitor than arrivals that flew outside the cone[6]. The results showed that the current threshold-based system detected noise events for approximately 63% of westerly arrivals that overflew the monitor, meaning that more than a third of overflights were missed (because the monitor threshold level was not set low enough to capture them).

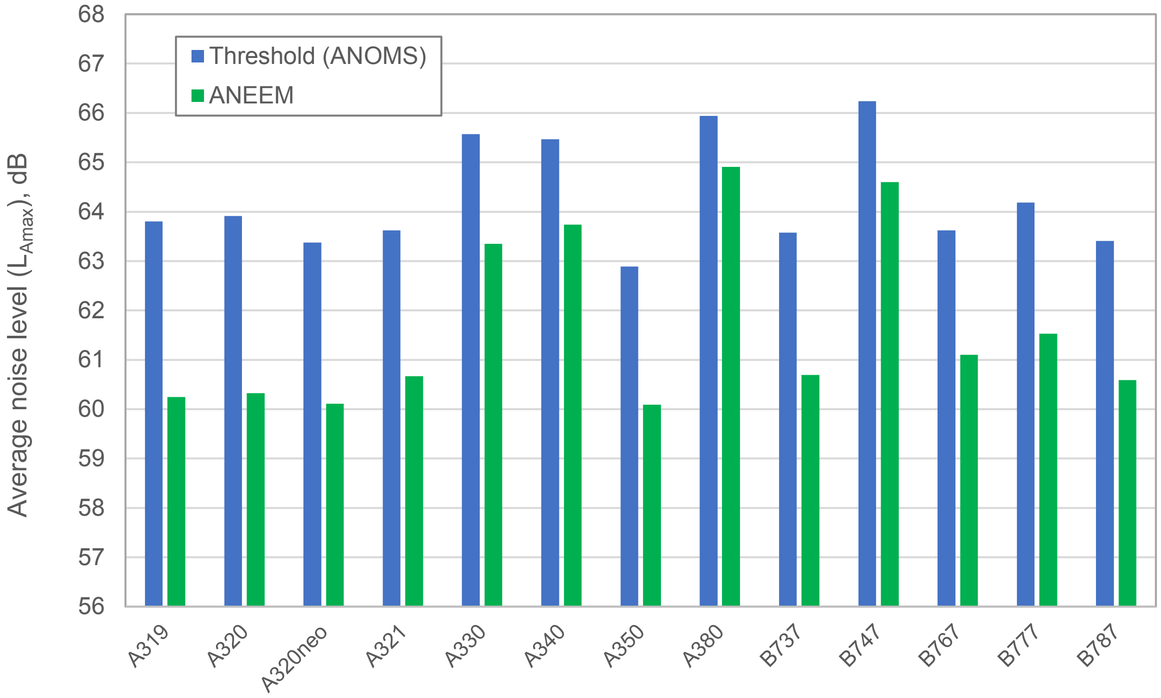
ANEEM on the other hand detected noise events for approximately 99% of all arrivals that flew overhead of the monitor, providing further evidence that ANEEM is detecting a greater number of quieter aircraft events than the threshold-based system. The lack of audio recordings however meant that there was no way of determining whether the additional 36% of events detected by ANEEM were aircraft noise events.

Comparison of average noise levels by aircraft type

Figure 3 presents the average measured (L_{Amax}) arrival noise levels for different types of aircraft operating into Heathrow (for all angles of elevation relative to the monitor). Results are shown separately for each method of noise event classification.

[5] See CAP1498, *Definition of overflight*, Civil Aviation Authority, March 2017. Since most arrivals over this location are at approximately the same height, aircraft that flew outside the 60-degree cone would generally be further from the monitor, and therefore quieter, than arrivals inside the cone.
[6] Although CAP1498 also defines an overflight cone of 48.5 degrees, a 60-degree cone was used for this particular comparison to ensure that aircraft noise events were at their highest levels when comparing both noise event classification systems (therefore maximising the likelihood of either system detecting aircraft noise events).

Figure 3 Average measured noise levels for Heathrow arrivals at Camberwell, September 2018



The results in Figure 3 show that the average measured noise level for each type of aircraft in the ANEEM dataset is consistently between 1 to 3 dB lower in level than that measured by ANOMS. This suggests that average measured noise levels are being overestimated at the Camberwell monitor using the current threshold method of detection, due to the fact that a proportion of quieter aircraft events remain undetected.

However, it should also be noted that, despite any improved event detection rate in ANEEM, the level of residual noise (ambient noise, in the absence of any aircraft noise) may introduce additional uncertainty for some of the quieter aircraft events.

The average daytime background noise level at the Camberwell location during the study period was approximately 52 dB L_{A90}[7]. Best practice guidance published by ISO[8] states that for an acoustically reliable measurement, noise monitors should only be installed at sites where the maximum sound pressure levels (L_{Amax}) of aircraft events of interest are at least 15 dB greater than the level of the average residual sound.

At sites where such a difference is not achievable, additional measurement uncertainty is introduced and aircraft noise levels may be slightly overestimated. For example, the ISO guidance notes that a level difference of 6 dB (between the measured aircraft level and the residual level) introduces a measurement uncertainty of more than 1 dB.

[7] This noise level quoted is the L_{A90} level, which is often used as an indicator of the background noise level and a reasonable proxy for the residual noise level.
[8] ISO 20906:2009, *Acoustics – Unattended monitoring of aircraft sound in the vicinity of airports*, International Organisation for Standardization (ISO).

Analysis of the ANEEM dataset for the relatively quiet A320neo aircraft, for example, indicates that nearly 25% of measured events levels were lower than 58 dBA (i.e. less than 6 dBA above the average background level). Care should therefore be taken when interpreting results from sites where measured aircraft levels are not clearly distinguishable from the residual sound.

During the analysis it was also noted that a small proportion of the ANEEM events were unusually short in duration and in some cases lasted for 5 seconds or less, compared to an average duration of around 30 seconds. A shorter duration noise event means less noise energy being recorded by the noise monitor and a lower measured Sound Exposure Level (SEL) as a result. Even assuming the L_{Amax} value was correctly recorded in such cases, the likelihood that the corresponding SEL may be significantly underestimated should be recognised. SEL measurements are fundamental to the calculation of a measured L_{Aeq} and validation of aircraft noise models.

Audio analysis of Camberwell noise events

A qualitative assessment was made of the noise source classification methodology of both systems by listening to a sample of nearly 300 audio recordings for a subset of noise events from the Camberwell monitor, selected on days with low wind speeds[9]. The intention was to determine to what extent noise events had been correctly identified as uncontaminated aircraft events[10].

The following periods were chosen for analysis:

- 7 September 2018, 04:30–11:00 and 17:00–23:00
- 27 September 2018, 04:30–12:00 and 15:00–23:00

On both days Heathrow was operating in a westerly direction and weather conditions were generally favourable for noise monitoring, with a moderate westerly wind on 7 September and a light westerly wind on 27 September.

The analysis period covered nearly 900 separate ANEEM noise events in total, although audio recordings were only available in the ANOMS system for approximately 300 of those. In some cases the audio samples (limited by the noise monitoring equipment to 20 seconds in duration at this site) were not long enough to confirm the sound source at the time of the L_{Amax}.

For approximately 85% of noise events classified as aircraft noise events by both systems, review of the audio sample confirmed that the event had been correctly identified as an uncontaminated aircraft event, although for 15% of events some degree of sound contamination was heard, most commonly from police sirens. In a

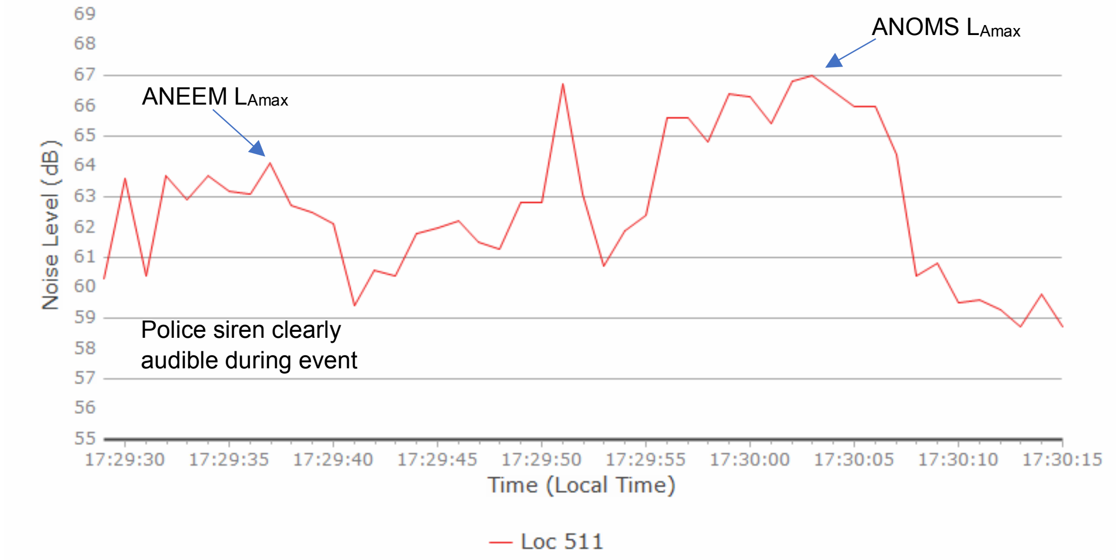
[9] ISO 20906 notes that data acquired under windy conditions (e.g. above 10 m/s) increase the uncertainty of the data.

[10] When determining whether an aircraft noise event was contaminated, a subjective judgement had to be made regarding the extent to which any non-aircraft noise source might have influenced the overall event level. For example, low-level birdsong that may have been audible in the background often may not have been judged as contamination. A police siren, however, that could be clearly heard over the majority of the aircraft event would be likely to have affected the noise event level and considered as contamination.

small number of cases ANEEM correctly identified an aircraft noise event but appeared to consider only part of the actual noise level time history, logging a different L_{Amax} level compared to ANOMS.

For example, ANEEM considered the initial part of the event time history shown in Figure 4 as an uncontaminated aircraft event, with an L_{Amax} of 64.1 dBA and a duration of 12 seconds. However this event was contaminated by a police siren which was clearly audible. (Whilst ANOMS classified the entire 47 second profile as the aircraft noise event, the audio recording ended after 20 seconds, before the other secondary peaks visible in the time history could be heard.)

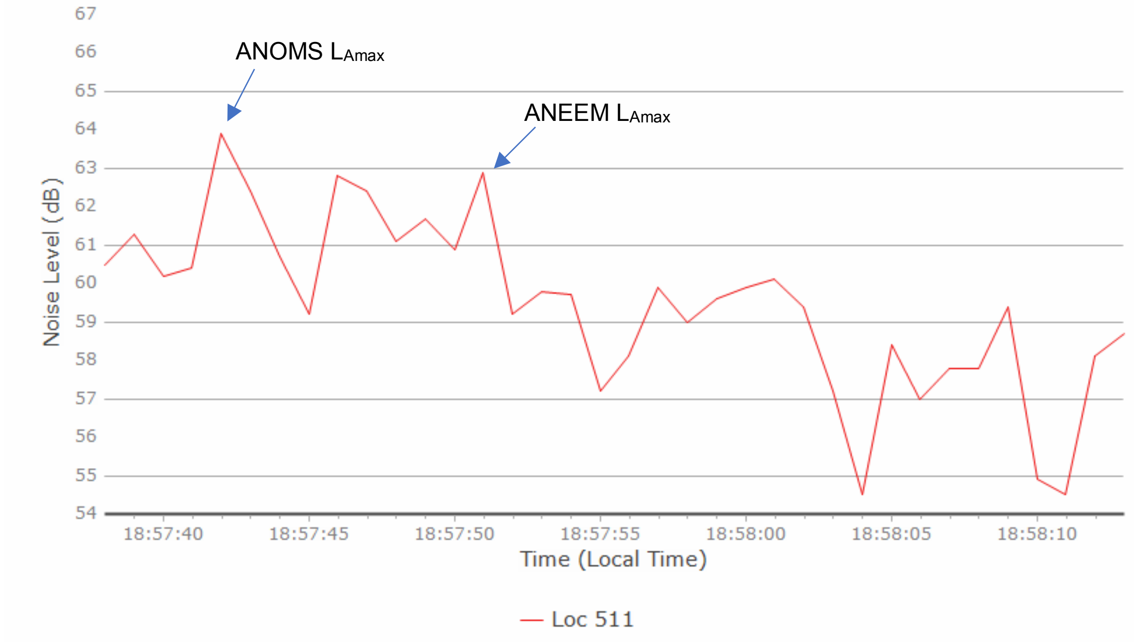
Figure 4 Noise event profile for an A320 arrival (Operation No.[11] 2015217497, 7 Sept 2018)



In another example shown in Figure 5, ANEEM ignored the first (genuine) maximum arrival noise level of 63.9 dB L_{Amax}, and instead determined that the event L_{Amax} value was the lower level peak of 62.9 dB that occurred a few seconds later. The event duration for the ANEEM event was also only 6 seconds long, compared to 36 seconds for the ANOMS event.

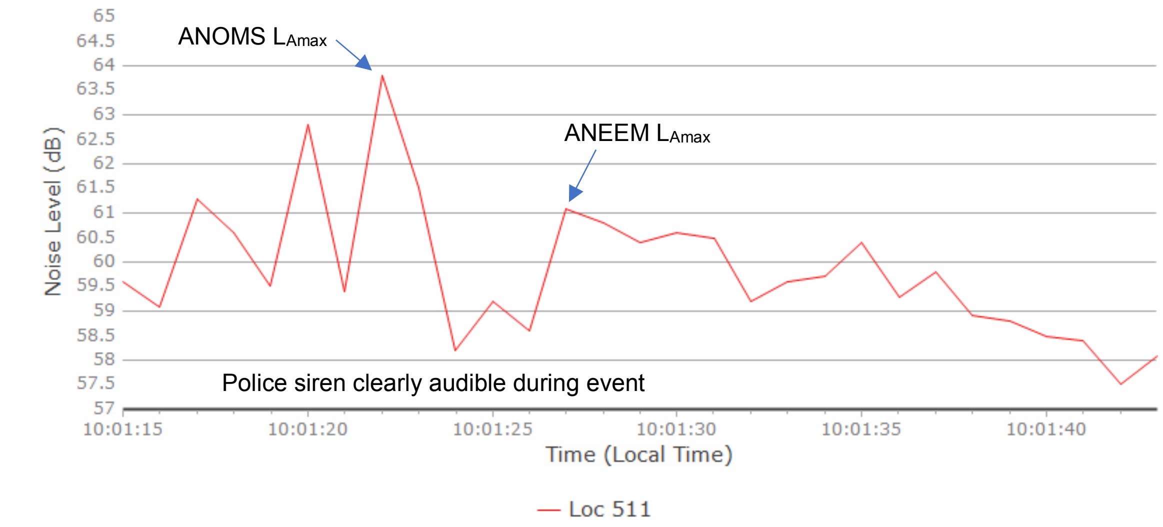
[11] Operation Number is a unique ID assigned by the ANOMS system to each aircraft operation.

Figure 5 Noise event profile for a B787-9 arrival (Operation No. 2015218137, 7 Sept 2018)



Finally, Figure 6 shows another example of a noise event profile for an aircraft event that was contaminated by a police siren for at least the first 20 seconds of the event. In this case the two event detection methods recognised different L_{Amax} values, 63.8 dB for ANOMS and 61.1 dB for ANEEM, both of which were likely to have been influenced to some degree by the audible police siren. The ANEEM event was again, also much shorter in duration than the ANOMS event (11 seconds vs. 29 seconds).

Figure 6 Noise event profile for a B777 arrival (Operation No. 2015344153, 27 Sept 2018)

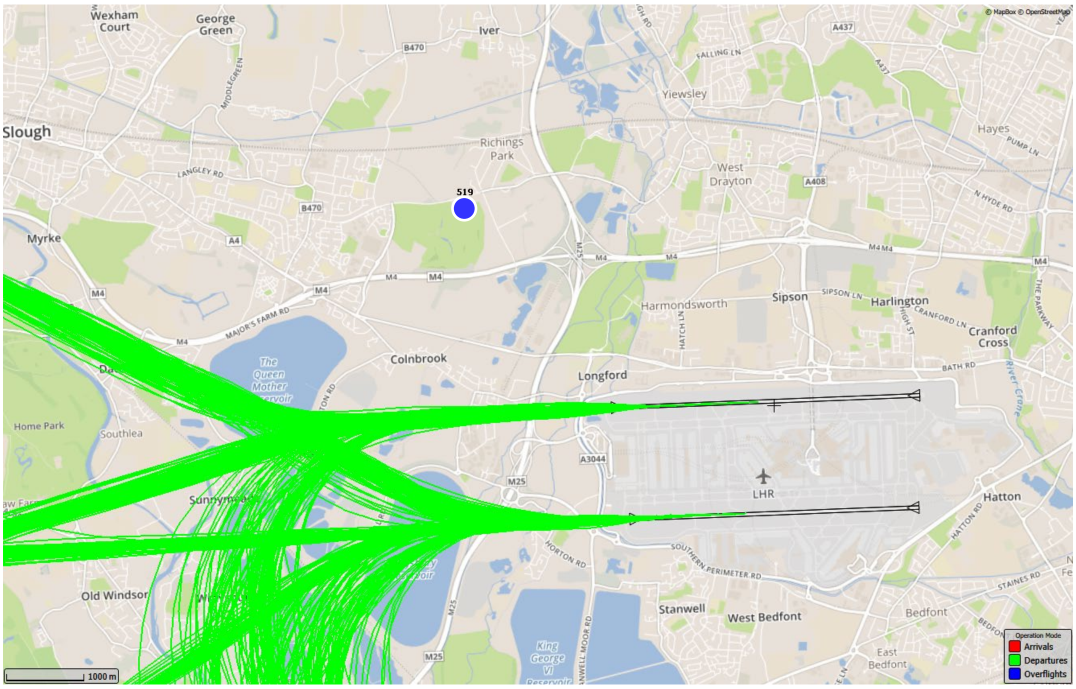


Richings Park noise monitor (NMT 519)

Monitor location and setup

The Richings Park noise monitor is installed in the grounds of Richings Park Golf Club. The monitor is located approximately 2.5 km north of the initial westerly departure route from Heathrow's northern runway and approximately 1 km from the M4 and M25 motorways (Figure 7). Heathrow westerly departures passing directly south of the monitor location are typically at a height of between 1,000 and 2,000 ft.

Figure 7 Richings Park monitor location in relation to typical westerly departure tracks



When Heathrow is operating in an easterly direction the Richings Park monitor also records noise events associated with aircraft landing on the northern runway, which are at a height of 400 ft when directly south of the monitor location.

The monitor was set up to record noise events above a threshold level of 53 dBA, lasting for 10 seconds or longer. On some days the varying background noise level can cause multiple long events to be continually recorded by the monitor, each lasting for a maximum duration of 120 seconds.

The geographic location of the Richings Park noise monitor relative to Heathrow's flight paths results in significantly lower angles of elevation[12] than is typical for other noise monitors around Heathrow. At the Richings Park monitor, elevation angles are approximately 10 to 15 degrees for westerly departures and less than 5 degrees for easterly arrivals.

ISO guidance[8] on the selection of sites for airport noise monitors states that in order to avoid excessive 'ground effects' (the interaction of sound with the ground) and to minimise any measurement uncertainty, the elevation angle should be greater than

[12] The angle between the ground plane and the straight line between the aircraft and the microphone.

30 degrees. However, the ISO guidance also recognises for practical reasons that some sound-monitoring sites may not always conform fully to the stated requirements (and the user therefore accepts any associated increase in uncertainty at such sites).

Noise event summary

Table 2 summarises the total daily numbers of noise events that were detected using each method of noise event classification during September 2019. These include noise events from any type of aircraft operation in the vicinity of the monitor. The main Heathrow runway direction on each day is also shown for information.

Table 2 Comparison of threshold-based events and ANEEM events at Richings Park

Date	Count of threshold-based ANOMS noise events			Count of ANEEM noise events (see note 2)	Runway direction
	Correlated	Uncorrelated (see note 1)	Grand Total		
01/09/2019	46	130	176	287	Westerly
02/09/2019	71	260	331	237	Westerly
03/09/2019	98	395	493	206	Westerly
04/09/2019	68	504	572	259	Westerly
05/09/2019	60	203	263	298	Westerly
06/09/2019	85	430	515	251	Westerly
07/09/2019	30	107	137	230	Westerly
08/09/2019	66	155	221	294	Westerly
09/09/2019	64	316	380	118	Westerly
10/09/2019	35	168	203	141	Westerly
11/09/2019	95	330	425	141	Westerly
12/09/2019	112	369	481	212	Westerly
13/09/2019	43	132	175	274	Mixed
14/09/2019	22	191	213	2	Mixed
15/09/2019	41	145	186	279	Westerly
16/09/2019	44	120	164	277	Westerly
17/09/2019	1	59	60	-	Mixed
18/09/2019	15	87	102	2	Easterly
19/09/2019	30	116	146	-	Easterly
20/09/2019	55	179	234	-	Easterly
21/09/2019	67	213	280	3	Easterly
22/09/2019	132	303	435	165	Mixed
23/09/2019	99	436	535	198	Westerly
24/09/2019	104	402	506	112	Mixed
25/09/2019	92	363	455	174	Westerly
26/09/2019	115	394	509	182	Westerly
27/09/2019	81	435	516	134	Westerly
28/09/2019	79	241	320	272	Westerly
29/09/2019	113	296	409	211	Westerly
30/09/2019	112	304	416	159	Westerly

Note 1: Uncorrelated events are classified by the system as Community Noise (i.e. noise events not associated with any type of aircraft operation).
Note 2: ANEEM results exclude (uncorrelated) Community Noise events.

Again, like the Camberwell analysis, the results in Table 2 suggest that the ANEEM system is able to detect a greater number of aircraft noise events at this location than the existing threshold-based system. The high numbers of daily uncorrelated ANOMS noise events (relative to the numbers of correlated noise events) shown in Table 2 also highlights the difficulties in detecting aircraft noise events at the

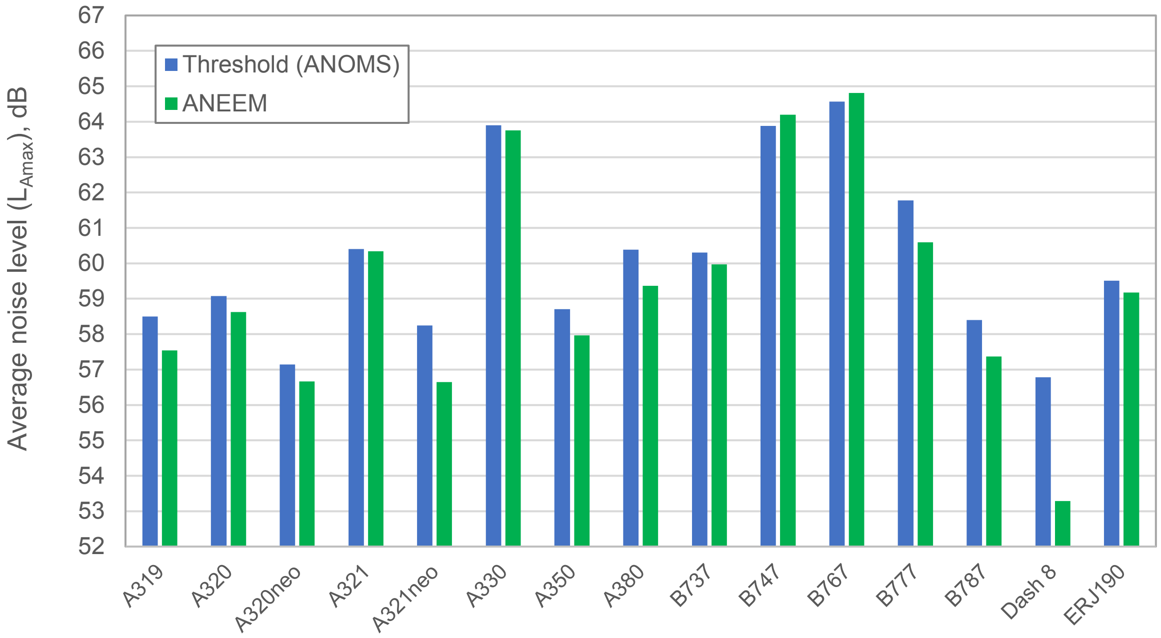
Richings Park location, which is susceptible to road traffic noise from the M4 and M25 motorways.

It is also worth noting that on the four days of dominant easterly operations between 18 to 21 September, the ANEEM system detected just three events[13] associated with arrivals on the northern runway, whereas the ANOMS system recorded 167 noise events over those four days. In view of this finding, and as part of the audio analysis of the Richings Park noise events provided below, a qualitative assessment was undertaken on a sample of the ANOMS events recorded on 18 and 20 September to investigate whether ANEEM might have missed some genuine aircraft events (see the audio analysis section below).

Comparison of average noise levels by aircraft type

Figure 8 presents the average measured (L_{Amax}) departure noise levels for different types of aircraft departing from Heathrow's northern runway. Results are shown separately for each method of noise event classification.

Figure 8 Average measured noise levels for Heathrow departures at Richings Park, Sept. 2019



The results show that in several cases the average measured noise level is slightly lower (by up to 1 dB) in the ANEEM dataset than that measured by ANOMS. In the case of the quieter Dash 8 aircraft, the ANEEM result is more than 3 dB lower. For the noisier aircraft types on the other hand the average difference in level between the two datasets is minimal (within ±0.5 dB). The results suggest that average measured noise levels for some quieter aircraft types are at risk of being overestimated at the Richings Park monitor using the current threshold method of detection, due to the fact that a proportion of quieter aircraft events remain undetected.

[13] The two ANEEM events recorded on 18 September were both correlated with overflights.

However, it should again be noted that, despite any improved event detection rate in ANEEM, the level of residual noise (in the absence of any aircraft noise) may introduce additional uncertainty for some of the quieter aircraft events. For example, the average measured L_{Amax} of 53 dB for the Dash 8 aircraft in the ANEEM dataset should be considered in the context of the typical daytime residual noise level at that location; the background noise level, used as a proxy for residual noise level, was measured at approximately 52 dB over the study period. Care would need to be taken when interpreting results where measured aircraft maximum levels are not sufficiently greater than the level of residual sound.

During the analysis it was again noted that a small proportion of the ANEEM events were unusually short in duration and in some cases lasted for 5 seconds or less, compared to an average duration of around 20 seconds. Even assuming the L_{Amax} value was correctly recorded in such cases, the likelihood that the corresponding SEL may be significantly underestimated should be recognised.

Audio analysis of Richings Park noise events

A qualitative assessment was made of the aircraft noise events from the Richings Park monitor by listening to a sample of 250 audio recordings for a subset of noise events to determine the extent to which the events had been correctly identified as uncontaminated aircraft events by both systems.

The following periods were chosen for analysis:

- 4 September 2019, 15:00–17:00 and 22:00–23:30
- 8 September 2019, 17:00–23:00
- 18 September 2019, 05:00–22:00
- 20 September 2019, 05:00–10:00

On 4 and 8 September Heathrow was operating in a westerly direction and weather conditions were generally favourable for noise monitoring, with a moderate westerly wind on 4 September and a light variable wind on 8 September.

On 18 and 20 September Heathrow was operating in an easterly direction, with a light north-easterly wind and a moderate easterly wind respectively. As noted previously, these two dates were chosen for further analysis because ANEEM did not detect any arrival noise events whereas the ANOMS system recorded several or more arrival events on each of those days.

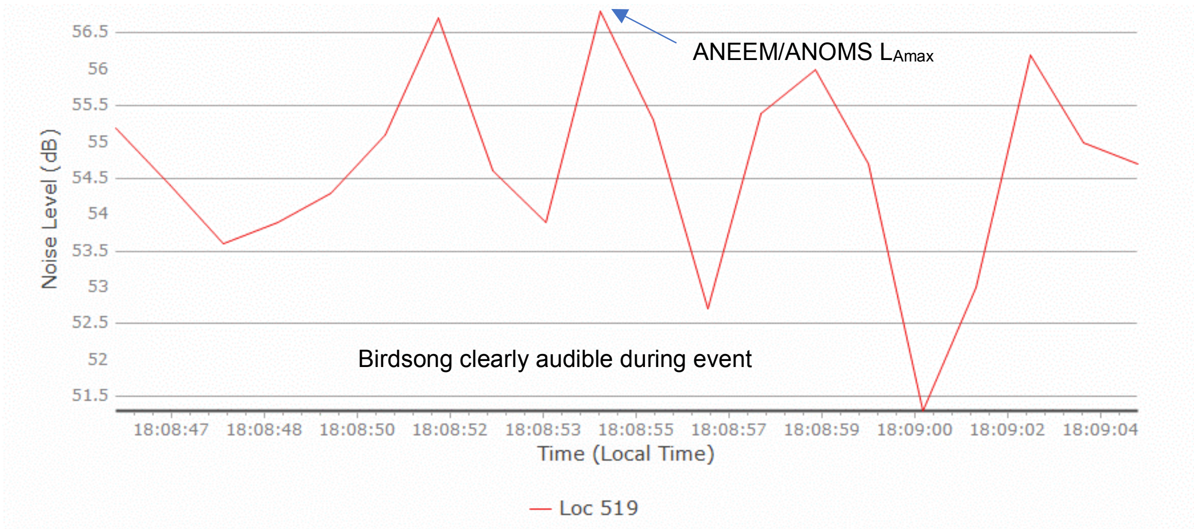
The analysis periods on 4 and 8 September covered more than 300 separate ANEEM departure noise events in total, although audio recordings were only available in the ANOMS system for 205 of those. An additional 45 audio recordings on 18 and 20 September were also listened to (which covered arrival noise events detected by ANOMS but not by ANEEM).

For approximately 75% of departure noise events listened to, the audio samples confirmed that ANEEM had correctly identified the event as uncontaminated aircraft noise, although for around 15% of events, birdsong and other non-aircraft sound sources were also audible to some degree. Whilst in most cases the non-aircraft sound source was unlikely to have influenced the measured aircraft event level, in a few cases the birdsong was considered more likely to have contaminated the measurement (although again, this was a subjective judgment). For the remainder of the departure noise events listened to, the audio samples (limited by the noise monitoring equipment to 40 seconds in duration at this site) ended before the time of the L_{Amax}, so the sound source at the time of the L_{Amax} could not be confirmed.

Of the 45 easterly arrival events that were listened to (which were events detected by ANOMS but not by ANEEM), only 7 were considered to have been possible arrival noise events (all were barely distinguishable above the general background sound of road traffic noise and/or airport ground noise). Of the remaining events, 23 were judged to have either been (i) contaminated to some degree, (ii) non-aircraft events, or (iii) associated with a different aircraft on the airfield other than the arrival aircraft[14]. Finally, in 15 cases the audio samples were not long enough to determine whether the noise event had been caused by an arrival.

In Figure 9 for example, it is likely that the L_{Amax} level of 56.8 dB recorded for an A319 departure event (by both ANEEM and ANOMS) was contaminated by birdsong, which was clearly audible throughout the event.

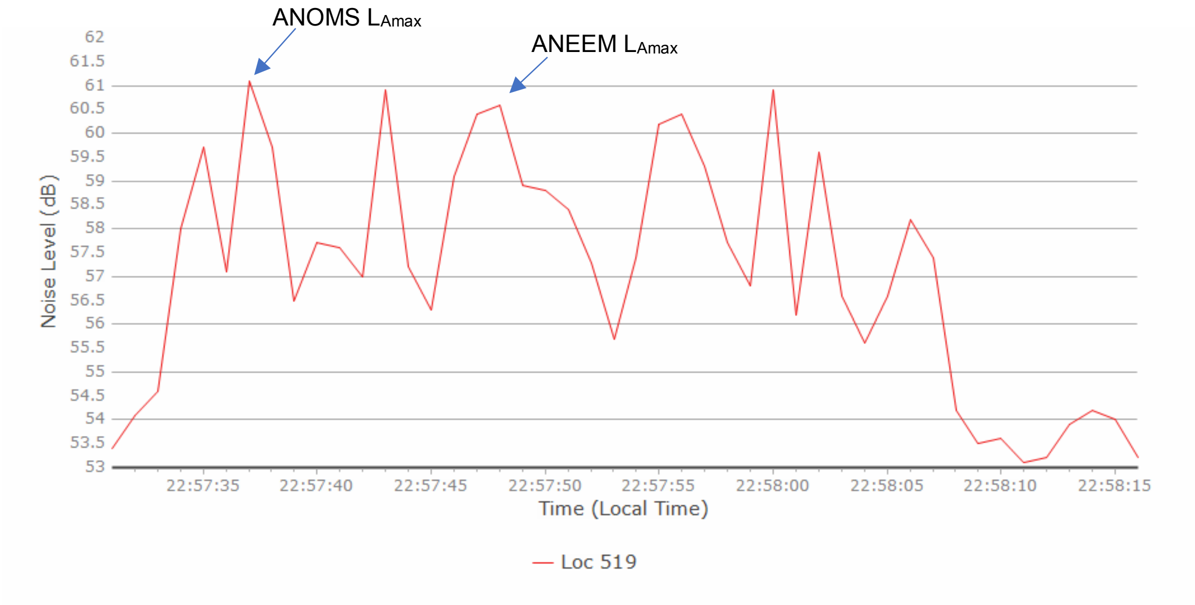
Figure 9 Noise event profile for an A319 departure (Operation No. 2017342462, 8 Sept 2019)



[14] For example, it is considered likely that on some occasions, noise events correlated by ANOMS to arrivals landing on the northern runway are actually associated with start-of-roll noise from departures on the southern runway.

Figure 10 provides another example where ANEEM correctly identified a departure noise event but considered only part of the event noise profile, resulting in a different L_{Amax} level compared to ANOMS. In this case, the L_{Amax} recorded by ANOMS was 61.1 dB whereas ANEEM only considered a 7-second portion of the audible event, where the L_{Amax} was 60.6 dB.

Figure 10 Noise event profile for an B777 departure (Operation No. 2017343849, 8 Sept 2019)



Conclusions

Heathrow's ANOMS noise and flight track monitoring system currently uses a threshold-based system of noise event recognition, as is common practice for most airport noise and track-keeping monitoring systems. At locations where the background noise level is frequently varying, it can be difficult to select an appropriate threshold level that is low enough to capture quieter aircraft noise events but high enough to ensure that extraneous (non-aircraft) noise is not classified as aircraft noise.

Noise event data recorded at two of Heathrow's mobile monitors were extracted from the ANOMS system and compared with equivalent noise event data processed using the system supplier's new ANEEM event classification system, which is intended to eliminate the need to manually set a threshold level.

The choice of monitor locations for this study was based on previous monitoring experience at locations that were known to be problematic for collecting aircraft noise event data. As part of the study, audio recordings captured by the ANOMS noise monitors were listened to, allowing a qualitative assessment to be made of the noise source classification methodology of both systems. The main findings were as follows:

- Based on data from two of Heathrow's monitor locations, the results indicate that the ANEEM system is able to detect a significantly greater number of quieter aircraft noise events than the existing threshold-based system.
- Where the level of residual noise is comparable to aircraft noise levels, additional uncertainty will always be present when categorising aircraft noise events. Care should be taken when interpreting results from sites where measured aircraft levels are not clearly distinguishable from the residual sound.
- ANEEM improves aircraft noise event classification where the residual noise level at a monitoring site is sufficiently lower than the previously used threshold levels. In this sense, ANEEM has the effect of optimising the threshold level at each monitoring site.
- A small proportion of the ANEEM aircraft noise events were found to be unusually short in duration and in some cases lasted for 5 seconds or less, compared to an average duration of between 20 to 30 seconds. Even assuming the L_{Amax} value was correctly recorded in such cases, the likelihood that the corresponding SEL may be significantly underestimated should be recognised. SEL measurements are fundamental to the calculation of a measured L_{Aeq} and validation of aircraft noise models.
- At both monitor locations, non-aircraft sound sources such as police sirens or birdsong were audible to varying degrees in approximately 15% of ANEEM aircraft events that were listened to. In some cases, the extraneous noise was considered likely to have influenced the measured aircraft event level.

Recommendations

It is recommended that:

i) Heathrow Airport deploy ANEEM on a longer-term basis at one or more noise monitor sites and work with the ANOMS system supplier to fine-tune the ANEEM event detection parameters to minimise the occurrence of very short noise events (i.e. noise events that start late and/or terminate early).

ii) Heathrow Airport explore with the ANOMS system supplier other opportunities for improved aircraft noise event detection, leveraging processing and analysis of the audio signal now recorded using the latest noise monitoring and other technologies.

ERCD
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Glossary of terms

dB	Decibel units describing sound level or changes of sound level.
dBA	Units of sound level on the A-weighted scale, which incorporates a frequency weighting approximating the characteristics of human hearing. If the noise metric is A-weighted, and clearly shown with a subscript ‘A’ (e.g. L_{Amax}), the ‘A’ can be omitted from the unit (i.e. dB).
L_{A90}	The A-weighted sound level exceeded for 90 percent of the measurement period, which is often used as an indicator of the background noise level.
L_{Aeq}	Equivalent sound level of aircraft noise in dBA, often called ‘equivalent continuous sound level’.
L_{Amax}	The maximum A-weighted sound level measured during an aircraft fly-by.
SEL	The Sound Exposure Level generated by a single aircraft at the measurement point, measured in dBA. This accounts for the duration of the sound as well as its intensity.