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COMMENTARY ON AIRCRAFT NOISE LEVEL MONITORING AT OAKWOOD HILL JANUARY 1998 TO DECEMBER 2018

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ACKNOWLEDGEMENT – Dr R J Peters

We are heavily indebted to the work of the late Dr Bob Peters in the discovery, formulation and processing of data from two NTK platforms covering the 20-year period of this study. His untimely passing towards the conclusion of this work demonstrated to his successors, whilst completing this document, the enormity of the data analysis effort he had accomplished. Undertaking any such similar task in the future, in the absence of his experience and knowledge, would be approached with trepidation.

Bob will be long remembered and missed for both his professional dedication and his open and approachable personality.

0.0 Executive Summary

0.1 Gatwick airport has employed independent consultants to measure long-term aircraft noise climates in five community locations around the airport for the past 20 years and continues to do so. Where keen interest in aircraft noise prevails elsewhere, noise climates are measured in additional locations. During this 20-year period, Gatwick has commissioned the publication of a number of Community Noise Reports, each with oversight by local authority Environmental Health Officer contributions regarding particular scopes of work and many reports have been commissioned during this time. Until this report there has, however, been no single-site long-term view.

0.2 The purpose of this report is to present findings in the context of a 20-year review; it is aimed at anybody interested in how airport noise is monitored and in what differences there may be in aircraft noise over that time. The site at Oakwood Hill has been selected by Gatwick Airport as a suitable candidate for this purpose.

0.3 This report presents the results of noise monitoring at the Oakwood Hill site for the period of 20 years of complete seasonal cycles of aircraft movements between 1st January 1998 and 31st December 2018.

0.4 The Noise Monitoring Terminal (NMT) at Oakwood Hill is situated on the margins of a field adjacent to the boundary with a nearby farm house. There are few cars passing the site but there is occasional noise from a tractor (and similar agricultural vehicles) which occasionally move along a path close to the site. Subjectively, apart from the noise from passing aircraft and birdsong in spring and summer, noise is also audible from occasional domestic and agricultural activities.

0.5 This report presents analysis and description of the following aspects of data gathered during the 20 year period: the number of aircraft noise events recorded by the noise monitor; the maximum noise levels of these aircraft noise events and the daytime and night-time noise climates at the site, including mean levels of aircraft noise, levels of total and residual noise at the site.

0.6 Expanded information regarding technical aspects of the report are given in the Appendices.

<u>Findings</u>

0.7 Analysis of data over the 20 year period has produced a number of findings, which are set out below;

a) *About 31% of the total number of aircraft movements at Gatwick airport pass near to the Oakwood Hill NMT site and the number of aircraft noise events captured at the site is about 30% of the total number of aircraft movements at Gatwick.*

b) *During the period of this study there has been an increase of about 14% in the number of annual aircraft movements.*

c) *The mean level of daytime aircraft noise exposure at Oakwood Hill has reduced from about 58 dB $L_{Aeq,\ 16hr}$ to about 54 dB $L_{Aeq,\ 16hr}$ and night-time aircraft noise exposure has reduced from about 50 dB $L_{Aeq,\ 8hr}$ to about 48 dB $L_{Aeq,\ 8hr}$. The $L_{Amax,\ s}$ level has reduced from about 71 dB $L_{Amax,\ s}$ to about 66 dB $L_{Amax,\ s}$.*

d) *Whilst aircraft noise exposure and $L_{Amax,\ s}$ have reduced at Oakwood Hill over the 20-year period, the 2012 National Noise Incidence Study[1] (NNIS) sets out that between 2000 and 2012 the percentage of people bothered/annoyed/disturbed by aircraft noise has increased from 20% to 31% (an increase of more than 50%).*

e) *The NNIS finding of an increased trend of disturbance/annoyance caused by aircraft noise from 2000 to 2012, despite newer aircraft being quieter, would tend to indicate that there should be no reason to believe that this trend will not continue even if the trend towards quieter aircraft continues.*

f) *It is likely therefore that there will be a continuing commitment to monitor community aircraft noise in some form or another in order to provide an objective response to a subjectively reducing tolerance of aircraft noise.*

Limitations

0.8 There are two main areas from which limitations arise; the first is the intrinsic uncertainty in the measurement process and the second is the uncertainty intrinsic in the process of mathematical subtraction of aircraft noise from total noise to calculate residual noise.

0.9 Whilst there is uncertainty in the measurement of anything, given a large number of samples, with each sample being obtained under the same, or similar circumstances, the uncertainty of the sample mean tends towards zero and can effectively be ignored.

0.10 The uncertainty in the separation of aircraft noise from the total noise generated by sources other than aircraft is an uncertainty for which there is limited scope to reduce. This matter was subjected to study during 2003 and set out in Appendix C are the results from an exercise undertaken to determine the levels of residual noise at the Oakwood Hill site. Findings from this study led to a reduction, where practicable, of noise event trigger level at a number of sites.

1.0 Introduction

1.1 Noise from aircraft is of interest and possibly of concern to residents living and working nearby to airports and near aircraft flightpaths. In order to understand the levels of noise to which communities can be exposed, Gatwick Airport have, for the past 20 years, employed Applied Acoustic Design Ltd. (AAD) to measure long-term aircraft noise climates in five community locations nearby the airport. This noise monitoring commitment is ongoing.

1.2 During this time Gatwick Airport Ltd. have commissioned a number of Community Noise Reports (which are available on the Gatwick Airport Ltd website), with oversight contributions by local authority Environmental Health Officers (EHO's) regarding particular scopes of work. These reports were with respect to noise over discrete periods of time with no single long-term view.

1.3 In order for NMTs to measure aircraft noise reliably (i.e. with low risk of notable contributions from road and/or rail traffic, commercial/industrial or other local activity related noise) they are sited with a clear view of Gatwick air traffic in locations not otherwise unduly exposed to noise. One such location is at Oakwood Hill and this is the location chosen as the subject for this report.

1.4 The ambition of this report is to present a review and analysis of noise measurements at Oakwood Hill over a continuous period from January 1998 to December 2018. These measurement therefore cover 20 years of seasonal cycles of aircraft movements.

1.5 The Noise Monitoring Terminal (NMT) at Oakwood Hill is presently situated on soft ground in an open field close to the boundary of a residential property on Ruckmans Lane. The adjacent parking area serves only the cottages at the boundary of the estate. Noise arises locally from car-parking and occasional agricultural vehicle movements along a nearby dirt-track.

1.6 During 2005 the NMT, for domestic reasons, was moved by about 30m from the garden of the nearby farm house to a location north. It is not considered this minor change in position made a material difference to the noise levels measured by the NMT. A photograph of the current NMT installation is shown in Figure 1 below.

Figure 1: Current Oakwood Hill NMT

1.7 Other than from aircraft, the noise climate at Oakwood Hill is one of birdsong, notably in spring and summer, with occasionally audible noise from domestic and/or agricultural activities. From subjective observation at the site therefore, other than for aircraft noise, the site is notably quiet.

2.0 Noise Parameter Descriptions

2.1 In order to capture aircraft noise events, each NMT is configured to capture all noise events, regardless of source, which are subsequently passed to the Noise and Track Keeping (NTK) system for correlation with simultaneously occurring radar tracks. A detailed description of the Noise Monitoring Terminal (NMT) is given in Appendix A

2.2 Table 1 below sets out core parameters describing noise measured at NMT sites. These were developed by Dr Bob Peters in his community noise reports and are summarised below:

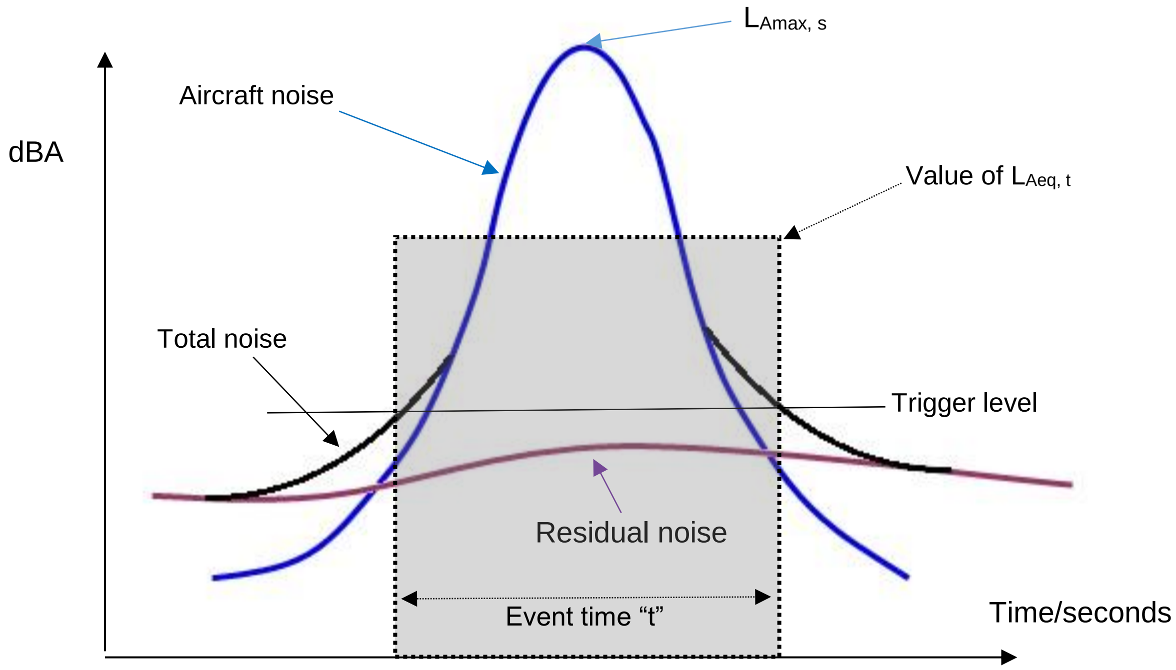
Table 1: Description of noise parameters

Parameter	Description
Total noise	A **measurement** of all of the noise present at the location
Aircraft noise	A **measurement** of a noise qualified as due to aircraft
Residual noise	A **calculation** arrived at by subtracting aircraft noise from total noise
Noise Climate	A **measured**, or a **calculated**, mean of 16-hr or 8-hr duration noise

2.3 Each NMT measures and records all of the noise present at its location regardless of source. The measured noise levels are consequently an aggregation of noise from aircraft and other noise sources such as from transportation, birdsong, farming activities etc. These measurements of all noise sources present around the NMT are designated the **Total** noise level.

2.4 The **Aircraft** noise level at the NMT site is calculated from the noise event data measured during all aircraft noise events. The **Residual** noise level is obtained by disaggregating the calculated aircraft noise level from the total noise level.

Figure 2: Graphic showing aircraft noise parameters



2.5 Each noise event qualified, by the noise to track process, as due to Gatwick aircraft includes the measured maximum instantaneous noise level ($L_{Amax, s}$). The $L_{Amax, s}$ term describes the maximum level of noise that instantaneously existed during the pass-by. As noise is experienced subjectively as a sequence of instantaneous noise levels, and not as an average over time, it is the instantaneous $L_{Amax, s}$ measurement which is the noise metric most related to the subjective experience of the aircraft noise.

3.0 Aircraft Movements over the 20 Year Period

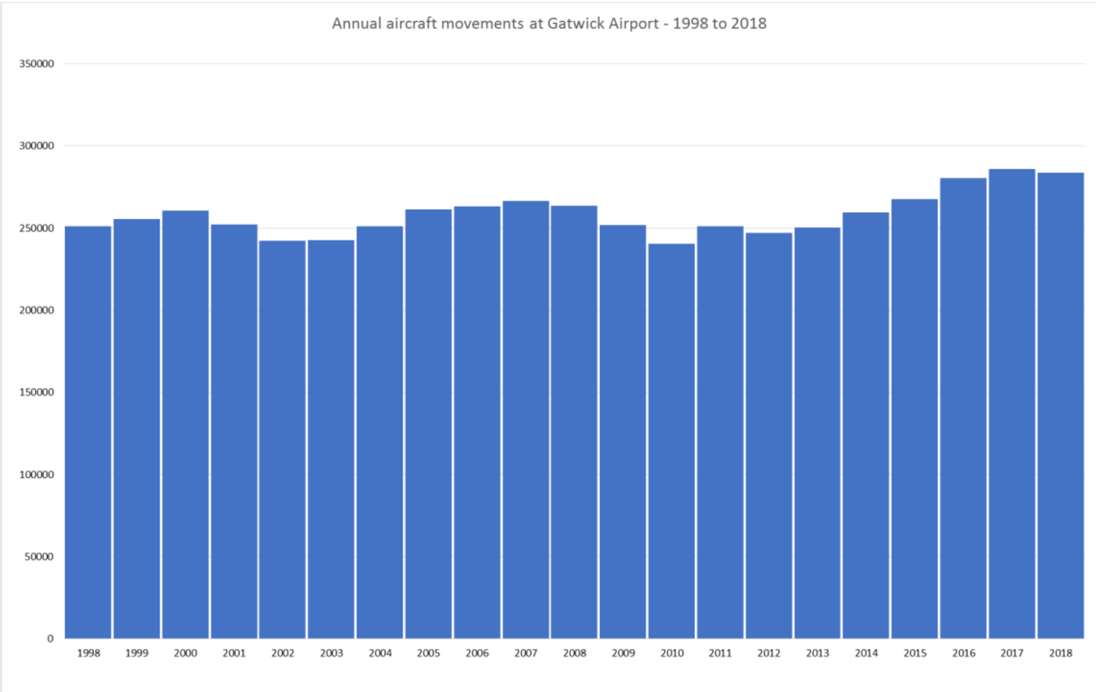
3.1 Annual aircraft movement data, published by the Civil Aviation Authority (CAA) for the years 1998 to 2014 and published by Gatwick Airport Ltd. for the years 2015 to 2018, indicates there were approximately 251,000 air traffic movements during 1998, rising to approximately 284,000 movements during 2018, a 20-year increase of about 14%. Against this long term background trend of increased annual aircraft movements, there was a reduction of 9% in the number of movements between 2007 and 2010. Subsequent to this was a return in trend with a steady year by year increase to the number of movements since 2012.

3.2 Figure 3 below shows the annual aircraft movements at Gatwick from 1998 to 2018 including two periods when, contrary to trend, there were reductions in annual air traffic movements from one year to the next.

3.3 There was a year on year reduction in air traffic movements from 2000 to 2003, a subsequent year on year increase in air traffic movements from 2003 to 2007 with a second period of year on year reduction air traffic movements from 2007 to 2010. From 2010 there has been a return to the earlier trend of year on year increase in air traffic movements at Gatwick.

3.4 The period from 2000 to 2002 is coincident with a recession in Europe and the aftermath of the 9/11 terrorist events in the United States of America and the period from 2007 to 2010 (the more significant and long lasting period) is coincident with the global financial crisis brought about by banking crises initiated by the sub-prime lending market.

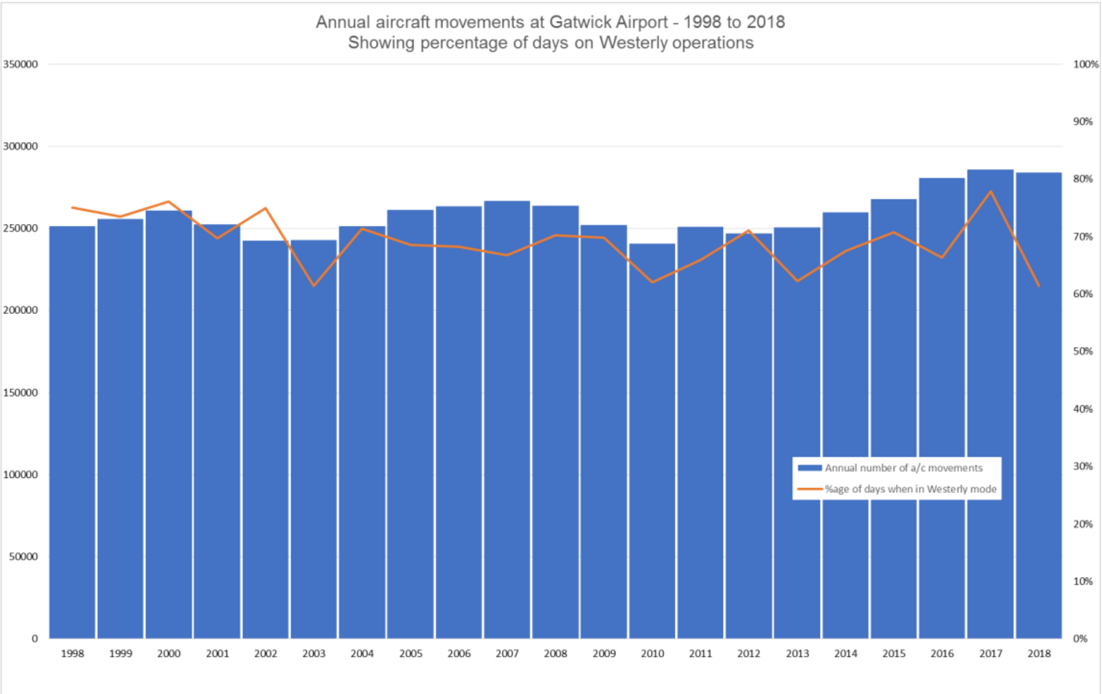
Figure 3: Annual aircraft movements at Gatwick from 1998 to 2018.



3.5 Aircraft take-off and land into the wind and consequently depending upon wind direction the direction in which aircraft take-off must change as wind direction changes. Operationally there are two modes of operation at most airports, including Gatwick airport, where the modes of operation are "westerly" and "easterly". As the prevailing weather in the UK comes from the south and west, there are a greater number of days when aircraft take off towards the west (westerly operations) than days when they take off to the east.

3.6 Figure 4 below shows air traffic movements from Figure 4 overlaid with percentage of days annually when the airport was operating westerly operations.

Figure 4: Annual number of air traffic movements from 1998 to 2018 showing percentage of days on Westerly operations.



3.7 As can be seen, for approximately 75% of the time aircraft are taking off towards the west, which is also towards the Oakwood Hill noise monitoring location.

3.8 Gatwick Airport operates Noise Preferential Routes (NPRs). These are departure routes along which aircraft are obliged to fly until, depending upon which NPR is being used, a flight altitude of 3,000 ft or 4,000 ft has been attained. Once the appropriate flight altitude has been attained, the NPR's can be departed. The actual tracks of aircraft arriving and departing for a typical day are shown by radar tracks for both westerly and easterly operations as shown in Figure 5 and Figure 6 below.

Figure 5: Typical radar tracks – Westerly operations (NPR indicated in pink)

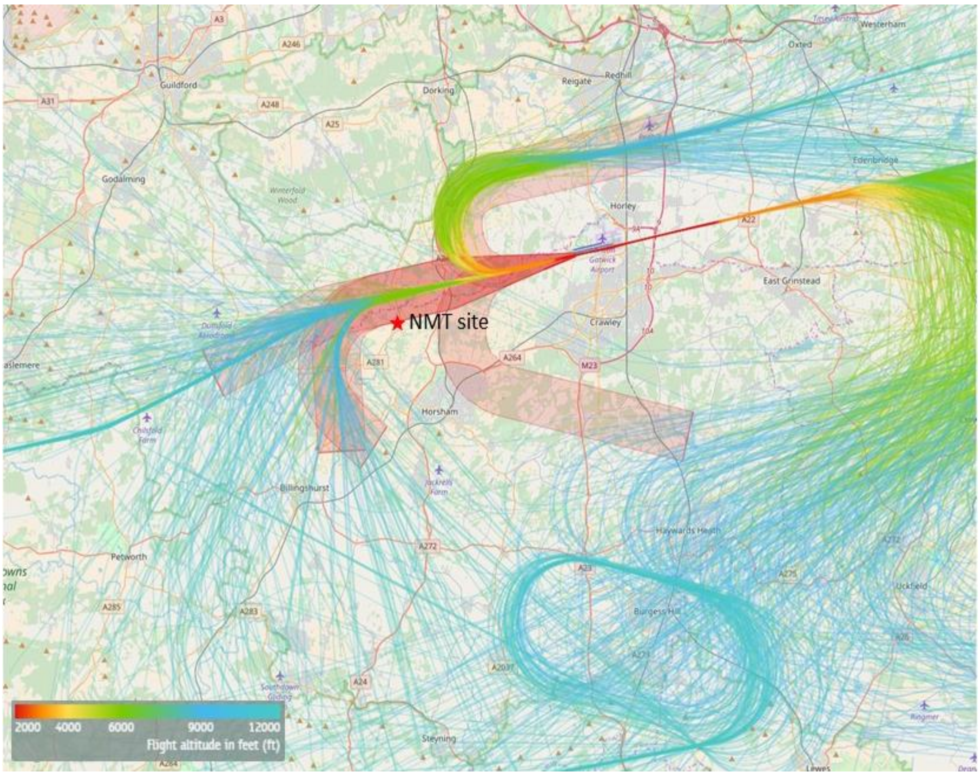
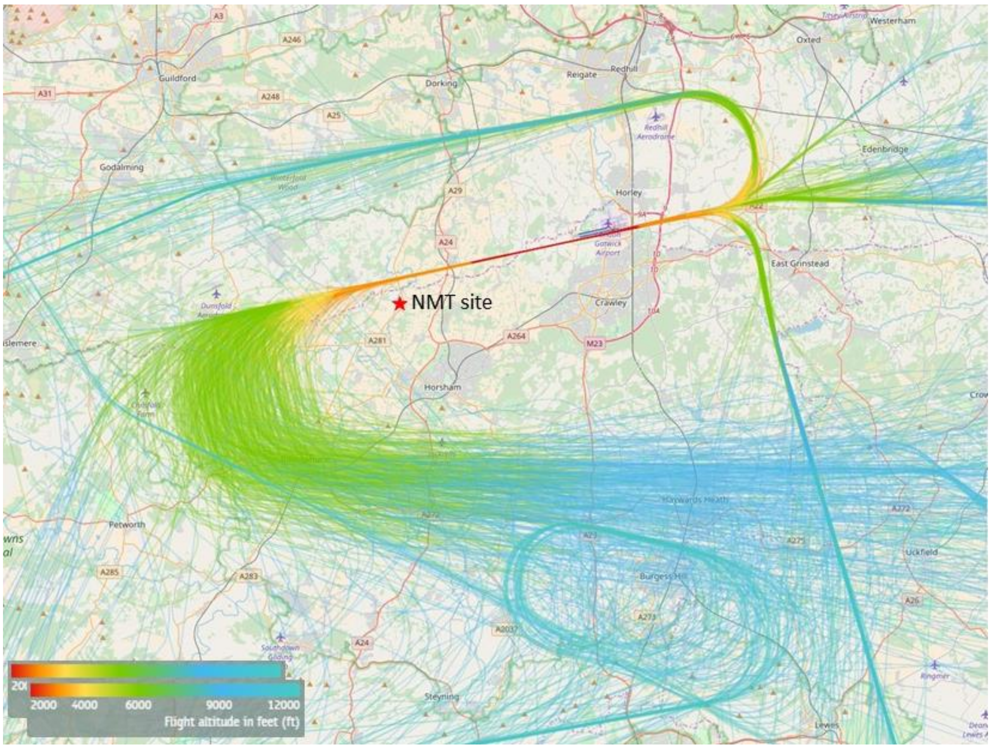


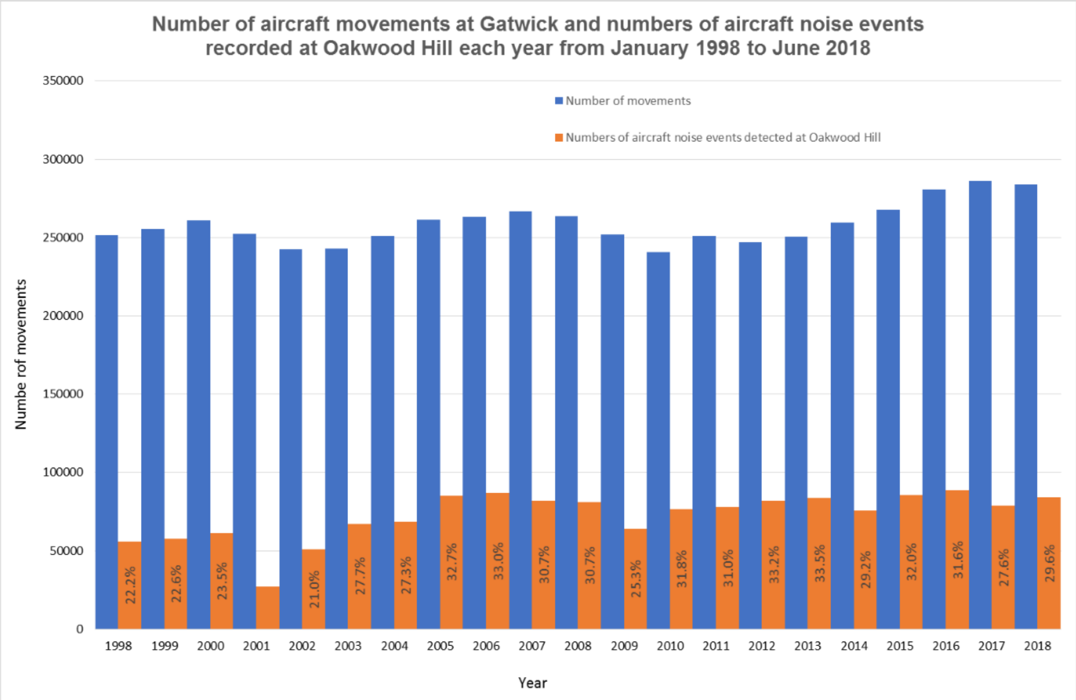
Figure 6: Typical radar tracks – Easterly operations



3.9 At Oakwood Hill the level of noise from aircraft taking off is greater than when aircraft are landing. During take-off the engines are at high power levels to gain altitude quickly so as to provide best separation distances to receivers on the ground as fast as possible. On arrival, aircraft settle in to a descent approach path at distance from the runway with engines providing just enough power to maintain the approach path with occasional power changes to combat atmospheric conditions.

3.10 Not all aircraft movements at Gatwick Airport will give rise to noise events at the Oakwood Hill NMT site. We estimate from our study that around 31% of the total Gatwick annual aircraft movements will pass close to the Oakwood Hill NMT site and, as shown in Appendix B and in Figure 7 below, the average number of aircraft noise events captured annually is about 30%. The actual number of noise events captured is consistent with expectation.

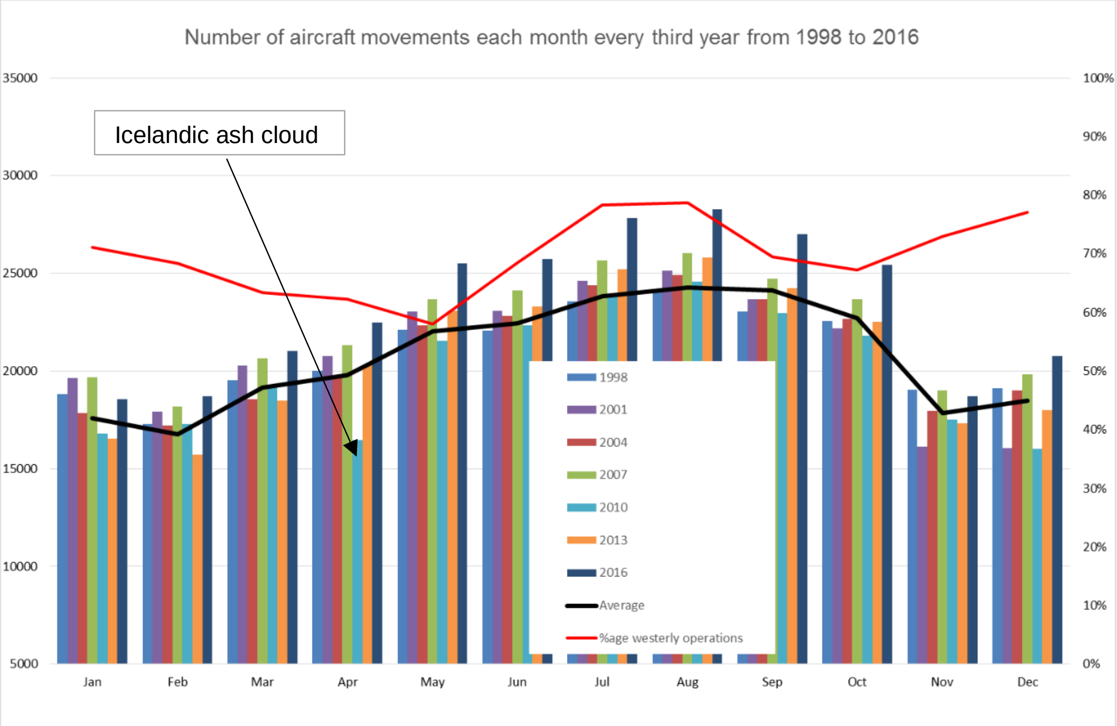
Figure 7: Annual movements showing percentage recorded noise events at Oakwood Hill 1998 to 2018.



Note: the number of recorded noise events in 2001 is artificially low as the site could not be accessed to extract data due to the foot and mouth epidemic during that year

3.11 There is a regular pattern to the number of aircraft movements month by month throughout each year, with numbers rising from lowest values in winter, reaching a maximum in August each year, reducing to November with a slight increase in December into January. As the general distribution of aircraft movements month by month is proportionally similar, and so as to not clutter the chart, we have chosen to investigate and compare the number of monthly aircraft movements every third year for the years 1998 to 2016 shown in Figure 8 below.

Figure 8: Monthly total movements, samples shown for every 3rd year



3.12 The reduction in aircraft movements during April 2010 occurred during the five day duration of the UK moratorium on flying caused by the Icelandic ash cloud from volcano Eyjafjallajökull.

4.0 Measured Noise Levels over the 20 Year Period

4.1 Two particular measurement parameters used to describe aircraft noise are $L_{Aeq,\,T}$ and $L_{Amax,\,S}$. $L_{Aeq,\,t}$ is the noise exposure value for an event and $L_{Amax,\,S}$ is the highest measured instantaneous noise level during the event. Both measurement parameters vary from one aircraft noise event to another but, averaged out over a large number of events, representative annual values can be calculated for both $L_{Aeq,\,T}$ and $L_{Amax,\,S}$. Annually the average $L_{Aeq,\,T}$ is derived from, at Oakwood Hill, in excess of 80,000 aircraft noise events which over the 20 year period is in excess of 1.6 million aircraft noise events. A Glossary of Terms is attached as Appendix G.

4.2 From 1998 to 2018 there has been an increase in annual aircraft movements at Gatwick from about 251,000 in 1998 to about 286,000 in 2018. Such an increase in the number of aircraft movements (14%) would give rise to a minimal change in the annual $L_{Aeq,\,T}$ of no more than about 0.6 dB. The $L_{Aeq,\,T}$ noise parameter is not particularly sensitive to changes in the number of events, a doubling of the number of aircraft events would only give rise to an increase of measured $L_{Aeq, T}$ of 3 dB, an increase in noise level which is barely subjectively audible.

4.3 It is a different matter with respect of the measured $L_{Amax, s}$ noise levels for aircraft events. The noise levels of the $L_{Amax, s}$ of aircraft events is an instantaneous measurement and consequently immediately reflects any increase or decrease of noise from aircraft events. The $L_{Amax, s}$ noise parameter is also closely related to the subjectively audible noise experience (at the time).

4.4 The yearly arithmetic mean of the maximum level of **aircraft noise events** at Oakwood Hill has fallen from around 71 dBA $L_{Amax, s}$ in 1998 to around 66 dBA $L_{Amax, s}$ in 2018 with the arithmetic mean of the daytime level of **aircraft noise** falling from around 58 dB $L_{Aeq, 16 hr}$ to around 54 dB $L_{Aeq, 16 hr}$, a drop of about 5 dBA for the $L_{Amax, s}$ and a drop of about 4 dBA for the $L_{Aeq, 16hr}$. The mean level of daytime **total noise** at the site fell somewhat less from 1998 to 2018, reducing from around 59 dB $L_{Aeq, 16 hr}$ in 1998 to around 57 dB $L_{Aeq, 16 hr}$ in 2018, a reduction of 2 dB.

4.5 The yearly arithmetic mean of the night-time level of **aircraft noise** has fallen from around 50 dB $L_{Aeq, 8hr}$ in 1998 to around 48 dB $L_{Aeq, 8hr}$ in 2018 with the mean level of night-time **total noise** at the site reducing from around 52 dB $L_{Aeq, 8hr}$ in 1998 to around 50 dB $L_{Aeq, 8hr}$ in 2018. A reduction by 2 dB for both indice.

4.6 Over the 20 year period the mean level of **aircraft noise** changed from 1dBA to 3 dBA below that of the total noise during the day but remained the same, at about 2 dBA below total noise, during the night.

4.7 The summarised results are tabulated below:

Table 2A: Summary of measured noise levels for 1998

Descriptor	Aircraft noise level	Total noise level
$L_{Aeq,16h}$	58 dB	59 dB
$L_{Aeq,8h}$	50 dB	52 dB
Mean $L_{Amax, s}$ (DAY and NIGHT)	71 dB	
Aircraft noise events	55774	

Table 2B: Summary of measured noise levels for 2018

Descriptor	Aircraft noise level	Total noise level
$L_{Aeq,16h}$	54 dB	57 dB
$L_{Aeq,8h}$	48 dB	50 dB
Mean $L_{Amax, s}$ (DAY and NIGHT)	66 dB	
Aircraft noise events	84152	

Table 2C: Differences from 1998 to 2018

Descriptor	Aircraft noise level	Total noise level
$L_{Aeq,16h}$	-4 dB	-2 dB
$L_{Aeq,8h}$	-2 dB	-2 dB
Mean $L_{Amax, s}$ (DAY and NIGHT)	-5 dB	
Aircraft noise events	+28378	

4.8 The gradual reduction in the measured mean monthly $L_{Aeq,\ 16hr}$, $L_{Aeq,\ 8hr}$ and $L_{Amax,\ s}$ aircraft noise levels are shown on Figures A1 and A2, with the mean yearly values being show in Tables A4 and A5. The Figures and Tables being in Appendix A.

5.0 Subjective Response to Measured Noise Levels

5.1 Although sound is captured by the ear, the interpretation of the sound and the actual "hearing" of the sound happens in the brain and the brain is very good at pattern recognition. The mechanical components of the ear are good at discriminating frequencies but not so good at discriminating changes in the level of sound.

5.2 Although, as discussed in the DORA Report 9023 "*The use of L_{eq} as an Aircraft Noise Index*"[5], it has been shown that levels of subjective annoyance and disturbance can be related to measured $L_{Aeq,\ t}$ noise levels, subjectively we cannot rank order $L_{Aeq,t}$ noise levels from one event to another. What we hear are instantaneous noise levels such as those described by the measured L_{Amax} noise levels and consequently we can subjectively rank order how noisy one L_{Amax} level is from another.

5.3 Although the reduction in mean instantaneous $L_{Amax,\ s}$ by 5 dB shown in Table 2C (page 15) is equivalent to a reduction in source sound energy of about 60% the subjective (or human) response, for an otologically normal person, is that a 5 dB difference is at the level of being clearly detectable. This is a consequence of the human response to sound.

5.4 A change in sound of 3 dB is the minimum change in sound level readily discernible by the brain as a change in sound level. However such a change would have to occur instantaneously, or over a very short period of time, for the change in sound level to be apparent to the human ear. An increase in sound of 3 dB over a period of time of say a few hours, is unlikely to be subjectively noticed.

5.5 Given the extended period of time over which the 5 dB reduction in $L_{Amax,\ s}$ has occurred it is highly unlikely that observers would have noticed any change in the level of noise from aircraft movements.

6.0 Findings from 20 Years of Data

6.1 On average about 31% of the total number of aircraft movements at Gatwick airport pass near to the Oakwood Hill NMT site and the number of aircraft noise events captured at the site is about 30% of the total number of aircraft movements at Gatwick. It is apparent therefore that most aircraft movements over the Oakwood Hill NMT site are being captured by the noise monitor.

6.2 There has been an increase of about 14% in the number of aircraft movements during this period of time.

6.3 The mean measured level of daytime and night time noise from aircraft has reduced by around 4 dB during the day (58 dB $L_{Aeq,\ 16\ hr}$ reducing to 54 dB $L_{Aeq,\ 16hr}$) and by around 2 dB at night (50 dB $L_{Aeq,\ 8hr}$ reducing to 48 dB $L_{Aeq,\ 8hr}$).

6.4 The mean level of $L_{Amax,\ s}$ noise from aircraft movements at Oakwood Hill has reduced from about 71 dB $L_{Amax,\ s}$ to about 66 dB $L_{Amax,\ s}$.

6.5 Due to the period of time that the reduction in aircraft $L_{Amax,\,s}$ noise level has taken place, it is likely that observers would, subjectively, be unaware of the reduction in the objectively measured instantaneous noise levels from aircraft events.

APPENDIX A

20 YEARS AT OAKWOOD HILL

Description and Results from the Noise Monitoring Terminal

A01 Each NMT is a “precision grade” Class 1 sound level meter (SLM) housed within a tripod supported field station cabinet with the power supply separately accommodated and where mains power is unavailable, the system is powered by batteries, often solar assisted. Atop the tripod is an outdoor/all-weather microphone and associated pre-amplifier, wind-shield and bird deterrent (current NMT shown in Figure 2, page 6).

A02 The SLM in all NMTs is set up to measure the total level of noise by hour and also to “capture” noise from aircraft events. The trigger noise level and duration at which the noise from an aircraft event is measured is “tailored” to each site. As there are varying degrees of community ambient noise events at each site, there is an initial period of noise monitoring to determine the levels of noise from both aircraft and community sources.

A03 Based upon this initial data, a trigger noise level is chosen that minimises the risk of capturing a significant number of community ambient noise events that would have to be systematically investigated and then rejected as not being aircraft noise events. The selection of the threshold conditions (noise level and time period) which trigger the capture of a noise event is a compromise judgement designed to include as much of the noise from passing aircraft as possible whilst at the same time excluding, as far as possible, noise from other sources. At Oakwood Hill site originally a trigger level of 60 dBA for a duration of at least 10 seconds was set but, due to the quiet nature of the site, this was reduced during September 2003 to the current threshold trigger level 50 dBA.

A04 An aircraft (pass-by) noise event is characterised by the event trigger and other parameters. The $L_{Amax,\ s}$ term describes the maximum level of noise that instantaneously existed during the pass-by. As noise is experienced subjectively as a sequence of instantaneous noise levels, and not as an average over time, it is the instantaneous $L_{Amax,\ s}$ measurement which is the noise metric most related to the subjective experience of the aircraft noise.

A05 In addition to gathering data about noise events the NMT also collects and stores information on an hourly basis about the total level of noise at the site from all sources (including that from aircraft movements), including individual noise events. See Appendix G Part 2 for a Glossary of Terms.

A06 By using the Sound Exposure Level (SEL) for each aircraft noise event it is possible to calculate the average, or equivalent aircraft noise level (L_{Aeq}) over a period of time (hour, day or month). Although this average noise level bears little relationship to the aircraft noise as heard it is, nevertheless, a useful parameter for calculation purposes, and is an internationally recognised parameter for the measurement of environmental noise, including aircraft noise.

A07 The NMT records a number of noise levels for each aircraft event captured with three recorded noise levels, $L_{Aeq,\,T}$, SEL and instantaneous $L_{Amax,\,s}$ being used to describe aircraft noise events as follows:

Table A1: Description of measured noise levels

Measured noise level	Description
"A" frequency weighted, slow time weighted, maximum level	L_{Amax},s dB
"A" frequency weighted noise, equivalent continuous level over time T	$L_{Aeq,T}$, dB
"A" frequency weighted noise, $L_{Aeq,\,T}$ corrected to a 1 second period	SEL dB

A08 When the information stored in the NMT is downloaded (either by attendance or by remote command) it is uploaded into the airports Noise and Track Keeping (NTK) system. The NTK system also has a radar feed and, from the historical records of that radar feed, the system compares, for each noise event, the time at which the maximum noise level occurred with the radar track of aircraft to match (or otherwise) aircraft locations at that same time. Gatwick aircraft near the NMT at the same time are thereby likely to be linked to each such noise event.

A09 There are occasions when the NTK system identifies a noise event, which although it occurred at the time of a matching Gatwick aircraft radar track, is anomalous perhaps due to a high $L_{Amax,\,s}$ level or event length inconsistent with an aircraft noise event. These anomalous events are highlighted and are manually reviewed to determine if the shape of the noise envelope is consistent with an aircraft event or if there was clear contamination by a community noise source. If the profile of the noise event is consistent with an aircraft event it is recorded as such otherwise it is excluded from the record of aircraft noise events.

A10 If no Gatwick aircraft were nearby at the time of a captured noise event, no aircraft is linked to it. Such events become attributed by the NTK system as community noise events which might include lawn mowing, tractor passages, high level (i.e. non-Gatwick) overflights, and the like.

A11 Any noise arising from aircraft travelling to or from any other airport (i.e. an overflight) will be included as residual noise. Therefore, wherever reference is made to aircraft noise events within this document it should be understood that these relate only to aircraft using Gatwick Airport.

A12 Noise events that are matched to aircraft are combined to provide a measure of 'aircraft noise' and noise events that are not matched to aircraft are included with 'all other noise' (i.e. that noise which is not captured as noise events, because it fails to meet the capture conditions), and is called residual noise.

A13 Therefore, with respect of the community noise reports produced with respect of the NMT's, the parameters used are as shown below:

Table A2: Description of noise parameters

Parameter	Description
Total noise	A **measurement** of all of the noise present at the location
Aircraft noise	A **measurement** of a noise event triggered by an aircraft
Residual noise	A **calculation** arrived at by subtracting aircraft noise from total noise
Noise Climate	A **measurement**, or a **calculation**, of 16-hr or 8-hr duration noise

A14 What we hear is instantaneous noise, like that indicated by the measured $L_{Amax,\ s}$ noise level, whereas both the $L_{Aeq,\ T}$ and the SEL values are measurements of average noise energy over time. There has been shown to be a relationship between measured $L_{Aeq,\ T}$ values and community annoyance as confirmed recently in the February 2017 CAA document CAP 1506 "*Survey of noise attitudes 2014: Aircraft*"[3].

A15 Figures 1A and 1B below show the monthly mean values of total noise, aircraft noise, residual noise, background ($L_{A90,\ t}$) noise and mean instantaneous aircraft $L_{Amax,\ s}$ values each year from 1998 and 2018 at Oakwood Hill.

Figure A1: Monthly mean measured $L_{Aeq,\ 16\ hr}$ daytime noise climate.

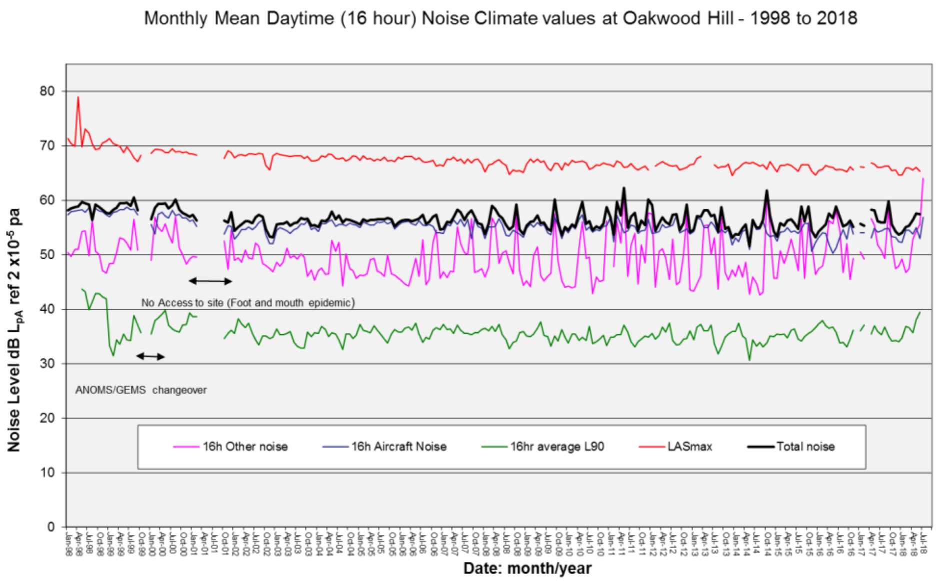
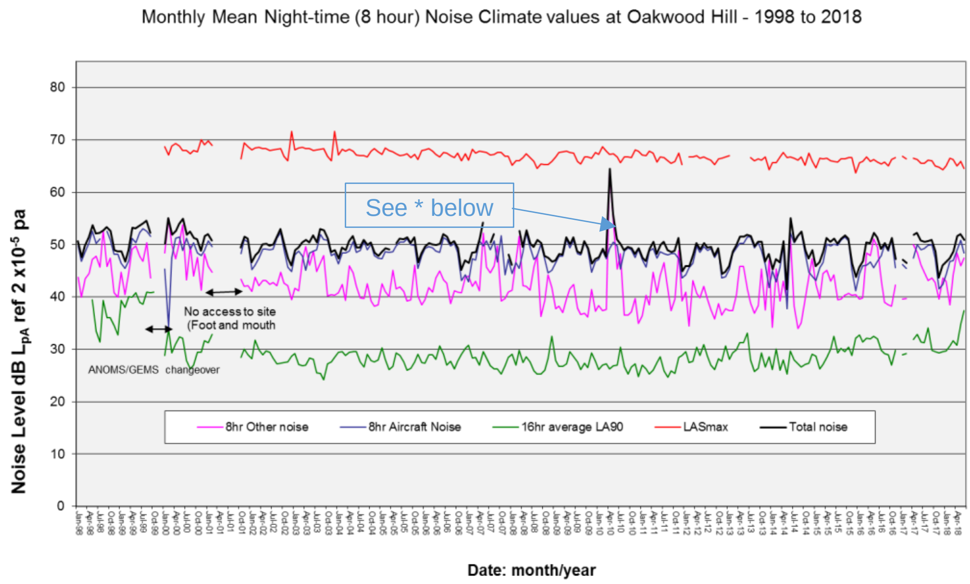


Figure A2: Monthly mean measured $L_{Aeq,\ 8\ hr}$ night time noise climate.



* These data is affected by periods of high hourly noise levels in April, May and June 2010. Noise from aircraft events have been reconciled with flight track data and the "spike" in noise levels are not due to aircraft but, it is surmised, due to periods of high noise from the workshop where the tractor was stored and so will have picked up "events" from tractor movements, equipment cleaning etc.

Table A3: Summary of data for Oakwood Hill

Survey period	1998 to 2018
Aircraft noise event trigger level	60 dBA for 10 seconds (1998 to Sept 2003) 50 dBA for 10 seconds (Sept 2003 to present)
Length of noise monitoring period	20 years
Number of aircraft noise movements	There were approximately 251,000 movements in 1998, rising to approximately 284,000 in 2018 (an increase of about 14%).
Number of aircraft noise events detected by the NMT at Oakwood Hill	As shown in Appendix B, the number of aircraft events captured at Oakwood Hill are consistent with what would be expected. (30% of annual Gatwick Airport movements captured compared to a theoretical best estimate of 31% of annual Gatwick Airport movements)
Mean maximum noise level of aircraft noise events	71 dBA reducing to 66 dBA
Mean total noise level	59 dBA reducing to 57 dBA (Day) 52 dBA reducing to 50 dBA (Night)
Mean aircraft noise level	58 dBA reducing to 54 dBA (Day) 50 dBA reducing to 48 dBA (Night)
Mean residual noise level	About 52 dBA (Day); about 47 dBA (Night)
Background noise (L_{A90})	About 35 to about 36 dBA (Day) About 28 to about 30 dBA (Night)
Day-evening- night level, L_{den},	Aircraft noise: about 58 dBA reducing to about 55 dBA

A16 In summary, the annual mean level of **total noise** at the site reduced by about 2 dBA over the 20 year period from about 59 dB $L_{Aeq,\ 16hr}$ to about 57 dB $L_{Aeq,\ 16hr}$ in the daytime and from about 52 dB $L_{Aeq,\ 8hr}$ to about 50 dB $L_{Aeq,\ 8hr}$ at night.

A17 The annual mean level of **aircraft noise** was typically between 1 and 3 dBA below that of the total noise, reducing, over the 20 year period, from about 58 dB $L_{Aeq,\ 16hr}$ to about 54 dBA in the day and from about 50 dB $L_{Aeq,\ 8hr}$ to about 48 dB $L_{Aeq,\ 8hr}$ at night.

A18 The annual mean level of **residual noise** typically being about 52 dBA in the day and about 47 dBA at night.

A19 As discussed earlier in this report mean levels of $L_{Amax,\ s}$ for aircraft noise events reduced from about 71 dBA at the beginning of the 20 year period to about 66 dBA at the end.

A20 Tables setting out the measured and calculated annual $L_{Aeq,\ t}$, $L_{Amax,\ slow}$, total, residual and $L_{A90,\ t}$ values over the 20 year period for Oakwood Hill are shown overleaf.

Table A4: Summary of measured and calculated annual Daytime noise levels

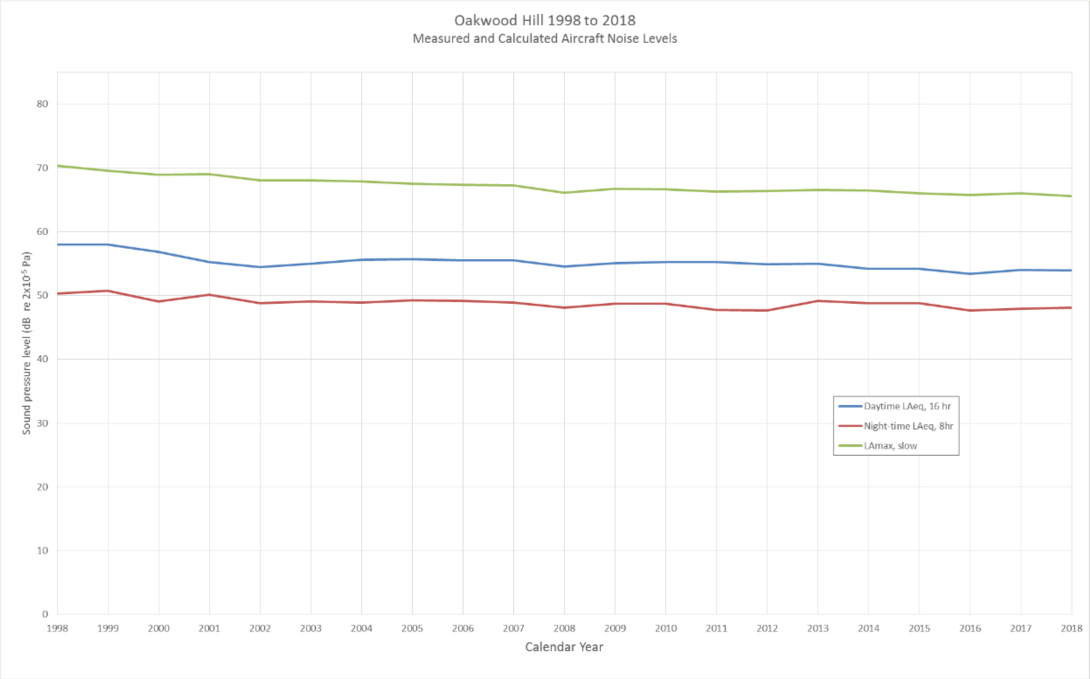
Year	Aircraft noise level (dB $L_{Aeq, 16 hr}$)	Maximum noise level (dB $L_{Amax, slow}$)	Total noise level (dB $L_{Aeq, 16 hr}$)	Residual noise level (dB $L_{Aeq, 16 hr}$)	Background noise (dB $L_{A90, 16 hr}$)
1998	58.0	70.4	58.6	51.9	42.4
1999	58.0	69.5	59.0	52.2	35.1
2000	56.9	69.0	58.6	53.7	37.7
2001	55.3	69.0	56.8	51.5	38.6
2002	54.4	68.0	55.7	49.5	35.9
2003	55.0	68.0	55.9	48.9	35.0
2004	55.6	67.9	56.4	48.9	35.3
2005	55.7	67.5	56.3	47.4	35.9
2006	55.5	67.4	56.4	49.2	36.0
2007	55.5	67.3	56.8	51.0	36.1
2008	54.6	66.1	56.6	52.2	35.6
2009	55.1	66.7	56.2	49.8	35.4
2010	55.2	66.7	56.5	50.5	34.8
2011	55.2	66.3	57.9	54.9	35.0
2012	54.9	66.4	56.7	51.9	35.3
2013	55.0	66.6	56.6	51.5	35.5
2014	54.1	66.5	56.3	52.1	34.7
2015	54.2	66.0	56.1	51.7	35.5
2016	53.4	65.8	56.3	53.2	36.0
2017	54.0	66.1	56.6	53.1	35.7
2018	53.9	65.6	56.2	52.2	37.2

Table A5: Summary of measured and calculated annual Night-time noise levels

Year	Aircraft noise level (dB $L_{Aeq, 8 hr}$)	Maximum noise level (dB $L_{Amax, slow}$)	Total noise level (dB $L_{Aeq, 8 hr}$)	Residual noise level (dB $L_{Aeq, 8 hr}$)	Background noise (dB $L_{A90, 8 hr}$)
1998	50.3	69.8	51.5	46.5	36.3
1999	50.7	69.3	52.4	47.3	39.8
2000	49.1	68.5	52.5	49.9	30.5
2001	50.1	70.6	51.0	43.8	32.7
2002	48.8	68.4	49.7	42.6	28.9
2003	49.1	68.4	50.8	45.8	27.3
2004	48.9	67.6	49.7	41.8	28.7
2005	49.3	67.4	50.0	42.0	28.0
2006	49.1	67.4	49.9	42.2	28.6
2007	48.9	67.4	50.7	45.9	28.0
2008	48.1	65.9	49.9	45.3	28.2
2009	48.7	67.0	49.2	39.1	27.7
2010	48.7	67.3	55.2	54.1	27.0
2011	47.8	66.7	49.1	43.2	26.8
2012	47.7	66.5	48.3	39.6	28.8
2013	49.2	66.7	50.1	42.7	29.5
2014	48.8	66.5	50.1	44.3	27.8
2015	48.8	66.0	49.7	42.1	29.8
2016	47.6	66.0	49.9	45.9	31.0
2017	47.9	65.8	49.7	45.1	31.0
2018	48.1	65.6	50.0	45.6	33.4

A21 The calculated aircraft event noise and aircraft $L_{Amax, slow}$ values over the 20 year period are also shown in the chart below;

Figure A3: Annual calculated $L_{Aeq, T}$ and measured $L_{Amax, slow}$ noise levels.



Factors that affect the noise climate:

A22 The mean ($L_{Aeq, T}$) aircraft noise level over any period, T (e.g. months or years) is dependent upon the length of time over which the noise event trigger is exceeded and the levels of noise measured throughout the period of the noise event. This is also the case for the SEL value of each event, the difference being the fixed time period of 1 second irrespective of how long the actual noise event was.

APPENDIX B

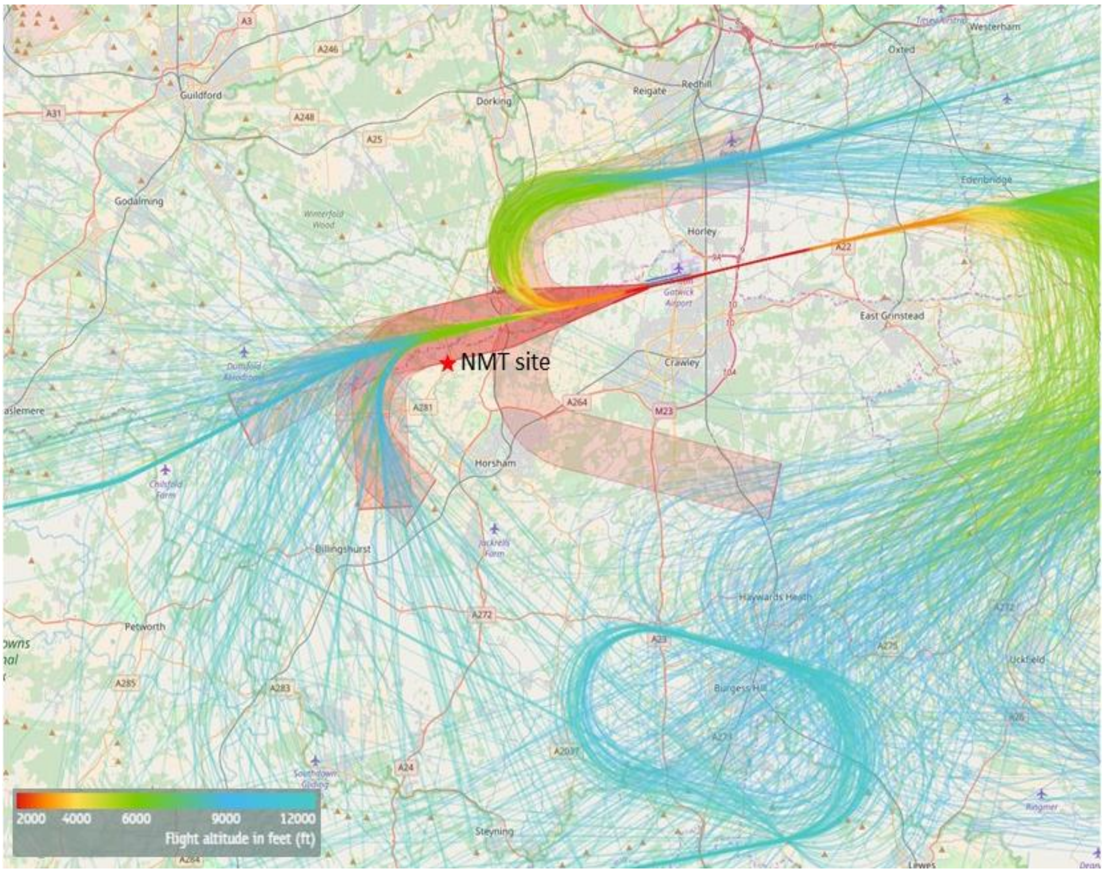
AIRCRAFT MOVEMENTS NEARBY OAKWOOD HILL

Aircraft Movements

B01 Data from Gatwick Airport sets out the total number of air traffic movements at the airport each year, which includes both arrivals and departures. Over the year there is an even split between the number of aircraft movements on departure and the number on arrivals. The Gatwick data also shows that there is an uneven split between westerly and easterly operations of 75% westerly operations and 25% easterly.

B02 On easterly operations, aircraft arrive over Oakwood Hill from the west and on westerly operations aircraft depart over Oakwood Hill. On westerly departures there are five Noise Preferential Routes (NPR) of which four are regularly used with the fifth being rarely used as shown by the aircraft track data shown below for a typical days westerly operations (aircraft tracks shown in blue).

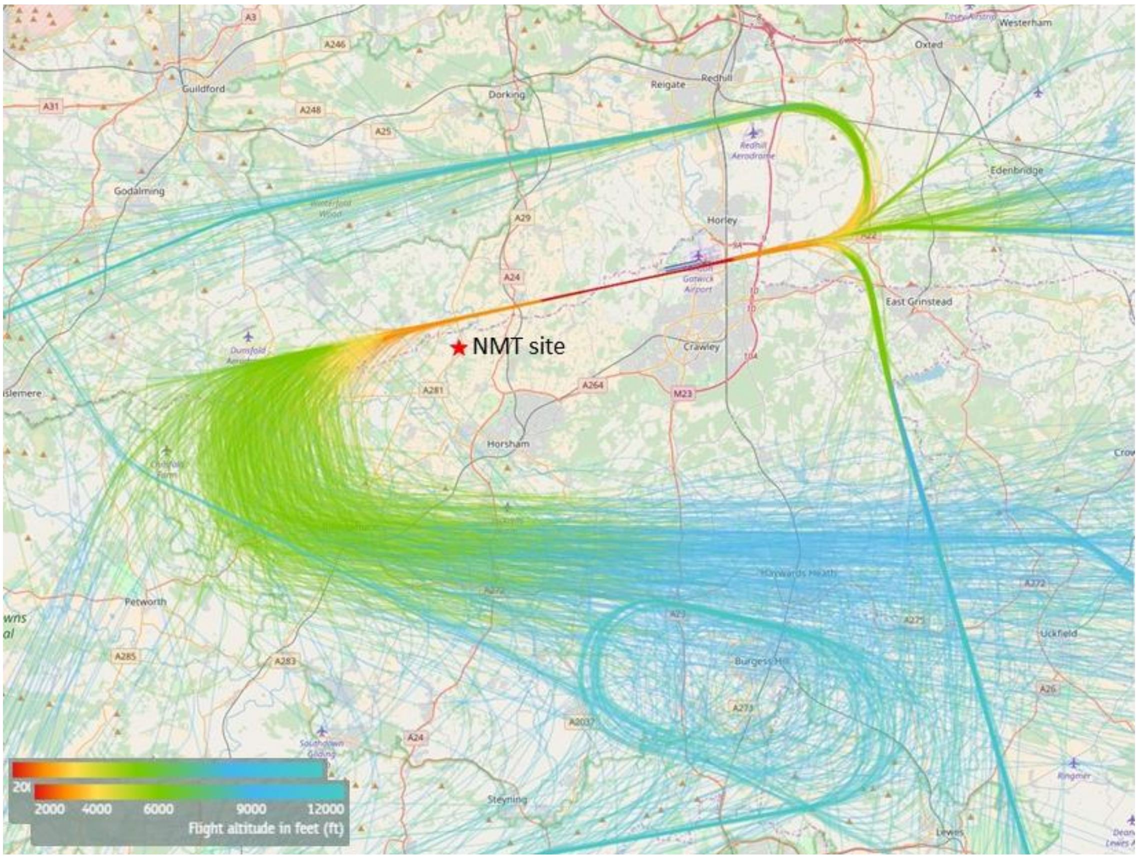
Figure B1: Typical radar tracks – Westerly operations (NPR indicated in pink)



B03 It would appear that there is about a 50/50 split in aircraft movements between the northerly NPR and the three westerly NPR's and subsequently only about half of the westerly departures pass the Oakwood Hill NMT site.

B04 With respect of easterly operations all arriving aircraft pass by the Oakwood Hill NMT site as shown by the aircraft track data for typical easterly operations.

Figure B2: Typical radar tracks – Easterly operations



B05 From the information above the expected percentage of aircraft movements over Oakwood Hill NMT can be calculated.

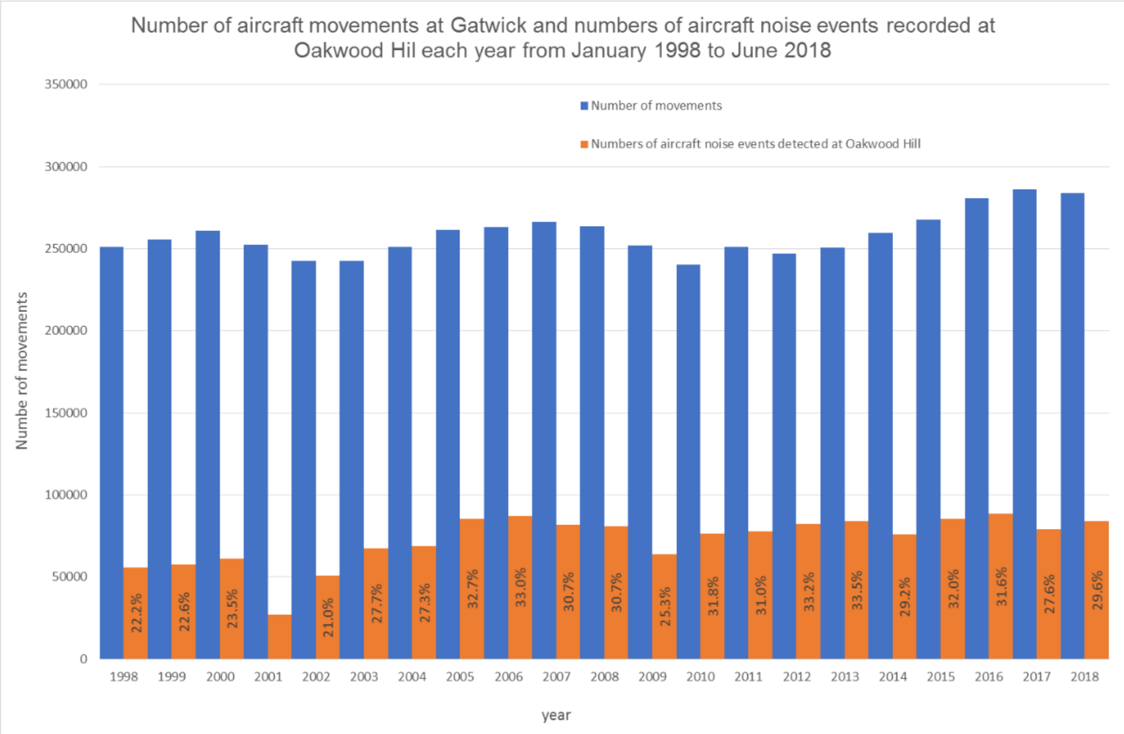
Table B1: Calculated percentage of movements over the Oakwood Hill NMT

Operation	Annual percentage of movements	Percentage of movements over NMT	Percentage of annual movements
Easterly	25%	50% (arrivals only)	12.5%
Westerly	75%	25% (50% of departures)	18.25%
Expected total			≈ 31%

B06 There would therefore be an expectation that the number of aircraft events captured Oakwood Hill should be about 31% of the total number of aircraft movements at Gatwick.

B07 The percentage of aircraft noise events captured at Oakwood Hill is shown in the figure below.

Figure B3: Annual number of recorded noise events at Oakwood Hill from 1998 to 2018.



Note: the number of recorded noise events in 2001 is artificially low as the site could not be accessed to extract data due to the foot and mouth epidemic during that year

B08 Averaging the percentage of captured aircraft events over the 20 year period (excluding 2001) gives an average of about 29% however, as discussed in Appendix A on page 18, the noise threshold for aircraft noise event capture was reduced in September 2003 from 60 dB L_{pA} to 50 dB L_{pA}.

B09 If the data are considered over two periods, pre and post change in noise trigger level, the percentage of events captured against total aircraft movements are 23% prior to the change to 30% after the change.

B10 As can be seen from a calculated expected aircraft pass-by capture rate of about 31%, the aircraft event capture rate is about 30% of total annual aircraft movements. It is likely therefore that most, if not all, aircraft movements over the Oakwood Hill NMT site are being captured by the noise monitor.

APPENDIX C

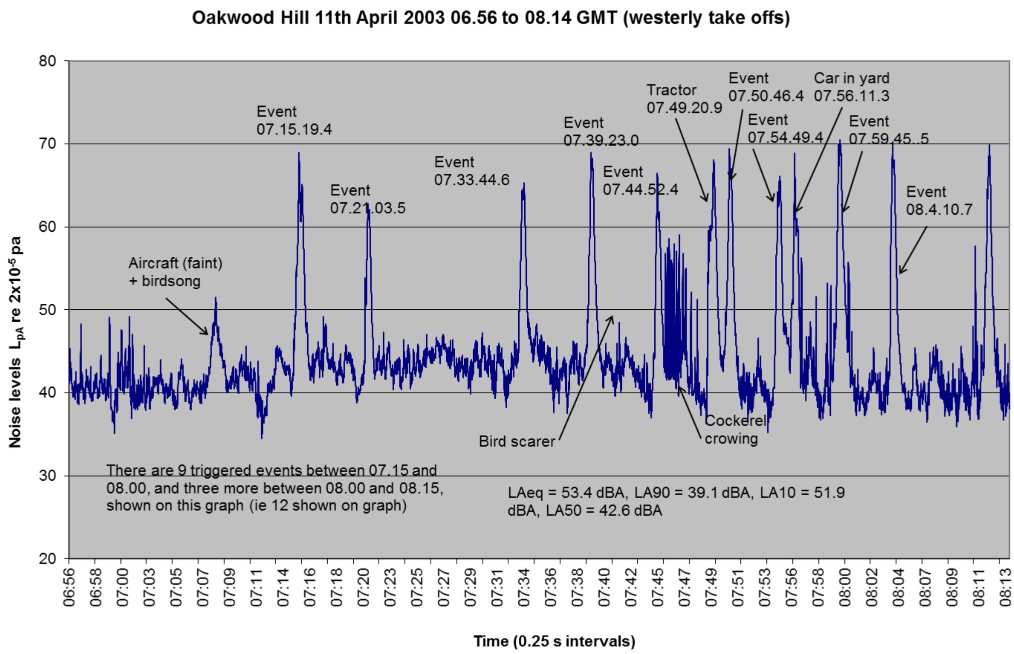
DETERMINATION of RESIDUAL NOISE LEVELS at OAKWOOD HILL

Measurements of residual noise at Oakwood Hill

C01 The residual noise levels reported and discussed in this report have been deduced from the measured levels of total noise and aircraft noise, by decibel subtraction. To verify the levels of residual noise at Oakwood Hill attended measurements were undertaken during the 20 year period discussed in this report. The attended measurements were carried out on three occasions, two when noise measurements were made ‘in between’ aircraft flights when aircraft noise was not audible, and the other when aircraft were not flying over the site.

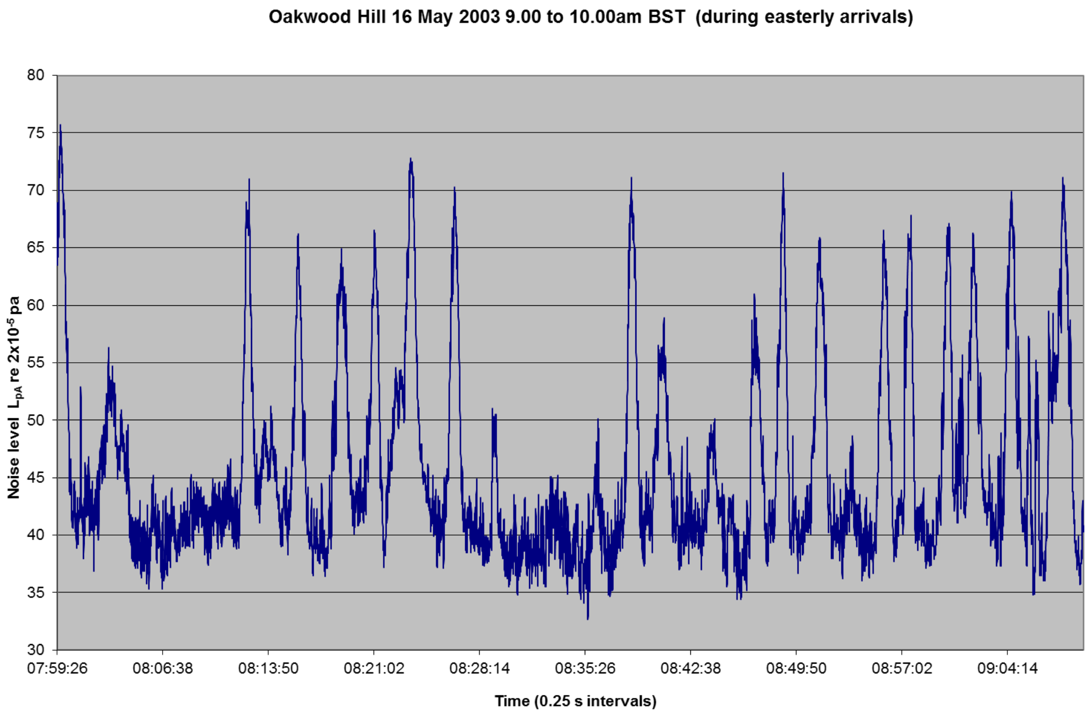
C02 Samples of the attended noise measurements made at the Oakwood Hill site on 11 April (Figure C1) and 16 May 2003 (Figure C2) when aircraft were taking off in a westerly and easterly direction respectively. During the period of enforced no flying caused by the Icelandic ash cloud the opportunity was taken to carry out noise measurements of the ambient noise levels and the data are shown in Figure C3.

Figure C1: Measured noise levels 11th April 2003



C03 The sharp peaks in noise level from departing aircraft flying overhead, together with one or two other noise events can be clearly seen, as can the level of residual noise in between these peaks. The aircraft noise events reached levels of between about 60 and 70 dBA. The level of residual noise, in between these peaks, can be seen to vary approximately between 35 dB L_{pA} and 45 dB L_{pA}.

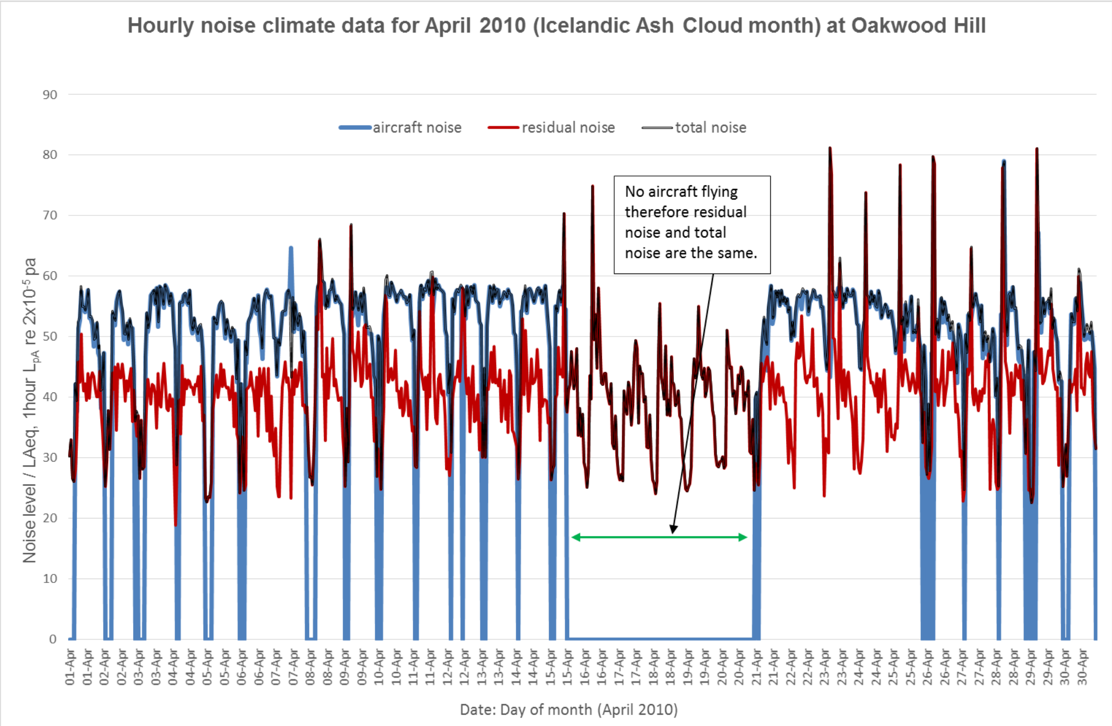
Figure C2: Measured noise levels 16th May 2003



C04 Figure C2 displays the corresponding noise level time history showing aircraft noise events for arrivals over Oakwood Hill, recorded on 16 May 2003, (aircraft were taking off to the east). Once again levels of residual noise can be clearly seen, in between the events, at levels of between about 35 dB L_{pA} and 45 dB L_{pA}.

C05 All aircraft movements were suspended at Gatwick Airport for about 5 days in mid-April 2010 because of the ash cloud in the atmosphere originating from a volcano in Iceland. Figure 3C below shows the hourly average noise levels at Oakwood Hill for the entire month of April 2010.

Figure C3: Measurement data during the Icelandic ash cloud incident



C06 It can be seen that for most days in the month the level of total noise at the site was between 50 and 60 dBA in the daytime, dropping to about 30 dBA at night. The level of aircraft noise during daytime on these days is very similar to the level of total noise, indicating that aircraft noise was the dominant source of noise in the daytime at this site (as previously indicated by Figures C1 and C2), but dropping to almost zero at night when there were no aircraft movements. The level of residual noise was about 40 dBA in the daytime falling to the same level as the total noise, at 30 dBA or below, at night-time. The five-day period, when aircraft movements were suspended, can be clearly identified because the level of total noise became the same as the residual noise, at about 40 dBA.

Residual noise levels

C07 Since the NMT also records hourly L_{Aeq} values of the total noise from the site it is possible, by subtracting the aircraft noise level from the total noise level (using the decibel (or logarithmic) subtraction process which is appropriate in this case) to calculate the remaining component of the total noise, i.e. the residual noise level.

C08 The residual noise is a combination of the noise from residual noise events (i.e. those captured noise events which did not match with aircraft movements) and from other residual noise, not captured as noise events, i.e. all other noise recorded by the monitor that did not exceed the trigger level for the required minimum time period.

C09 It is therefore possible that the residual noise could also include some noise from aircraft arriving at, or departing from Gatwick, as well as from overflights, which was below the trigger level. Conversely it will sometimes be possible that some non-aircraft noise, i.e. residual noise might be captured as part of aircraft noise event. This could happen for example if a burst of residual noise occurred at the same time as an aircraft was passing overhead. Where an anomalous event is detected by the NTK system they are highlighted for manual review.

C10 The first possibility, i.e. aircraft noise being counted as residual noise will lead to an increase in reported residual noise levels, and the second possibility, i.e. of residual noise being counted as aircraft noise, will lead to an increase in reported levels of aircraft noise level. Previous investigations have shown that in both cases these effects on the reported levels are small, and not considered to be significant, and are incorporated within the levels of uncertainty reported below.

Combined Uncertainty

C11 There is uncertainty in the measurement of individual noise events arising from the intrinsic variability in measuring noise. ISO 5752 “Accuracy (trueness and precision) of measurement methods and results” states that this intrinsic variability is a standard deviation of ± 1 dB.

C12 With respect of environmental noise measurement ISO 1996 “Acoustics – Description, measurement and assessment of environmental noise” advises that, for a 95% confidence limit, uncertainty should be 2 x the measurement variability standard deviation of ± 1 dB i.e. ± 2 dB.

C13 This variability relates to the instantaneous measurement of noise by a number of sound level meters at the same time in the same place, some meters will show higher noise levels than others but the variability across the measured values should be no more than ± 2 dB around the mean value.

C14 However, the comments above relate to individual noise measurements. Given a large number of noise measurements over time the averaged measured noise levels from all of the sound level meters will tend towards the same measured level.

C15 When discussing yearly average noise levels, both period $L_{Aeq,\ t}$ levels and instantaneous $L_{Amax,\ s}$ noise levels, due to the large number of aircraft noise events recorded, the uncertainty of the sample mean (Δx) tends towards zero. Δx being found by dividing the uncertainty in an individual measurement (x) by the square root of the number of measurements taken (N) i.e. $\Delta x = (x/\sqrt{N})$ (this is a standard and commonly used statistical function).

C16 For 100 samples the uncertainty reduces to one tenth of the uncertainty of a single sample, for 10,000 samples the uncertainty reduces to one hundredth of that of a single sample etc. Therefore, when discussing yearly average noise levels, both period $L_{Aeq,\ t}$ levels and instantaneous $L_{Amax,\ s}$ noise levels, the uncertainty in the measured noise levels tends towards 0 dB.

C17 Therefore, when discussing yearly mean noise levels, both period $L_{Aeq,\ t}$ levels and instantaneous $L_{Amax,\ s}$ noise levels, the uncertainty in the noise levels will tend towards 0 dB.

APPENDIX D

ATTITUDE TO AIRCRAFT NOISE

Attitude to Aircraft Noise

D01 During the 20 year period under consideration, the noise climate at Oakwood Hill has remained unchanged with daytime noise levels at about $L_{Aeq,\ 16hr}$ 57 dB and night time noise levels at about $L_{Aeq,\ 8hr}$ 50 dB. More importantly, the instantaneous $L_{Amax,\ s}$ noise levels have reduced, although not over a short enough period of time to be subjectively observable.

D02 As discussed above, the reduction in aircraft noise is typical and not exclusive to Gatwick and consequently it must be considered that, within the context of this study, similar reductions in instantaneous $L_{Amax,\ s}$ noise levels are likely to prevail elsewhere.

D03 Although, as also discussed above, the change in instantaneous noise level over a long period of time is unlikely to be subjectively observable there should be no subjectively observable increase either. There would therefore be an expectation that there should be no change in people's attitude to aircraft noise.

D04 This conjecture can be tested by consideration of the report on the National Noise Attitude Survey [1] commissioned by The Department for Environment, Food and Rural Affairs (Defra). This report sets out the results of a noise attitude study undertaken in 2012 which included comparisons with the results of a similar study undertaken in 2000. The results from the 2012 survey are discussed below.

National Noise Attitude Survey 2012

D05 The Department for Environment, Food and Rural Affairs (Defra) commissioned a survey to determine attitudes towards noise from a number of sources, including noise from aircraft. The results from this survey were compared with the results of a similar survey undertaken in 2000 by Defra and its professor body (the Department of the Environment).

D06 From these two surveys the following data emerged with respect of noise from aircraft, airports and airfields;

Table D1: Proportion of people bothered/annoyed by aircraft noise

Description	2000	2012	Comment
%age who could hear a/c noise	71%	72%	No statistical difference
%age bothered, annoyed or disturbed by a/c noise	20%	31%	Significant increase in reported disturbance and annoyance
%age very or extremely bothered by a/c noise	2%	4%	With such low numbers it is difficult to determine any true change in attitude

D07 As a national study it must be expected that the results from the surveys are applicable to all areas, including around Gatwick airport. For the same years the number of flights at Gatwick were about 261,000 in 2000 and about 247,000 in 2012 and consequently it is unlikely that the number of flights would be a factor in any change of the percentage of people disturbed.

D08 It is also the case, with respect to Gatwick, as shown by the measured aircraft noise levels over 20 years, that the level of noise from aircraft has not increased and consequently the level of noise from aircraft could not be the driver behind increased levels of noise disturbance.

D09 It is noted in the 2012 survey that there was an imbalance in the persons surveyed over those surveyed in 2000 with the 2012 survey report noting that;

- *Retired persons were over-represented with people in full time employment slightly under-represented.*
- *The higher and intermediate managerial/administrative/professional groups (A/B) were over-represented and consequently the semi-skilled and unskilled manual workers (D) were under-represented.*
- *The age group 23-35 were slightly under-represented while the age group 65-74 was slightly over-represented.*
- *Owner occupiers were over-represented*.

D10 With respect to these observed imbalances, it was stated in the survey that "*Sensitivity analysis showed that the over-representation was unlikely to skew the overall picture as the over-represented groups do not tend to differ significantly in attitudes on key questions from the overall average*". It would follow therefore that it is unlikely that any increase in disturbance is due to the number of people in the A/B socio-economic groups responding to the survey.

D11 The 2012 report confirms this as it is stated that "*The achieved sample was found to be broadly representative of the UK population in both 2000 and 2012. Therefore any changes in response between the two surveys can be considered to indicate changes in opinion of the population, rather than an artefact of the sampling*".

D12 The 2012 report also notes that "*the 'higher and intermediate managerial/administrative/professional' social groups are more likely to report a greater impact when being* bothered, annoyed or disturbed *by noise from 'aircraft, airports and airfields' compared to the overall sample. This may lead to an over-estimation of effects associated with noise from this source*".

D13 What falls from the NNAS 2012 study therefore is that the people most likely to use aircraft for both business and leisure, those in the A/B socio-economic groups, are also the people who are least tolerant of, and therefore more likely to be disturbed by (and presumably complain of), aircraft noise.

D14 Given the increase of reported disturbance due to aircraft noise between the 2000 and 2012 studies, and that all socio-economic groups tend not to "*differ significantly in attitudes on key questions*" it must be taken that the population as a whole has become increasingly, over the years, less tolerant of the presence of aircraft noise irrespective of measured aircraft noise levels remaining the same, or indeed reducing.

APPENDIX E

REDUCTIONS IN AIRCRAFT NOISE

Reductions in aircraft noise

E01 Due to the international nature of the aviation industry, for the need of shared standards, the International Civil Aviation Organization (ICAO) was set up. Part of the role of the ICAO is to establish aircraft specifications, including test and certification procedures. The information originally from the documents referenced below has been taken from the Department of Transport document "*Aviation 2050, The future of UK aviation*"[2].

E02 From its inception the ICAO has put effort into reducing the levels of noise from aircraft with aeroplanes and helicopters being required to meet the noise certification standards set out in Annex 16 to the Convention of International Civil Aviation (the Chicago Convention) extant at the time they are built.

E03 Over time, the maximum allowed levels of noise for aircraft and helicopters has been reduced by the inclusion of new "chapters" to Annex 16. First generation jet aircraft were not covered by Annex 16 (i.e. Boeing 707, Douglas DC-8) however, by 1977, chapter 2 of Annex 16 was extant and aircraft such as the Boeing 727 and Douglas DC-9 were required to achieve particular noise criteria.

E04 Between 2002 and 2006 chapter 3 was extant with further reductions in noise levels and aircraft flying today were designed to meet these reduced noise levels (i.e. aircraft types including Boeing 737-300/400, Boeing 767 and Airbus A319).

E05 In 2006 chapter 4 introduced an improvement in noise criteria for aircraft in that all aircraft built up to 2017, or those for which manufacturers requested re-certification to chapter 4 standards, are required to meet these noise criteria.

E06 According to the Civil Aviation Authority (CAA) in a document in 2014 *(Aircraft Noise and Emissions – Environmental Information Sheet no. 10*[4]) stated that modern aircraft are typically 75% quieter than jet aircraft used in the 1960s. A 75% reduction in noise would indicate a 6 dB reduction in sound pressure levels.

E07 Although the Oakwood Hill data are over a shorter period of time, (1998-2018) than the 50 year period (1960s – 2014) discussed in the CAA information sheet, there would not be a sudden removal from service of the older noisier aircraft types as the Annex 16 noise criteria became more stringent. Indeed, there were specific exemptions for developing nations allowing the use of older aircraft when chapter 3 was introduced in 2002.

E08 It would not therefore be expected that there would be an obvious "step" reduction in noise levels but a gradual change as older aircraft were replaced with newer quieter aircraft. The 4 dB reduction in instantaneous $L_{As\,max}$ noise levels measured at Oakwood Hill over the 20 years from 1998 to 2018 is consistent with the drive towards quieter aircraft being effective in reducing community aircraft noise levels.

E09 The latest Annex 16 noise criteria, chapter 14, introduced in 2017 introduces a 7 dB reduction in aircraft noise for new aircraft types submitted for certification after 31st December 2017. As older aircraft compliant with chapter 2 to chapter 4 requirements will continue in service, there would again be no expectation of a step change in instantaneous noise levels from aircraft events.

E10 However, as has been the case historically as shown above, as newer aircraft are introduced, a gradual reduction of $L_{Amax, s}$ noise levels can be expected over time. Again however, due to reductions in noise level being over an extended period of time, it is unlikely that there will be a subjective response to any such gradual change in aircraft noise.

E11 In December 2018 the Department for Transport published a consultation document "*Aviation 2050 – The future of UK aviation*" [2]. This document envisaged an increase in the total number of terminal passengers at UK airports from the 284 million in 2017 to 435 million by 2050, an increase of about 53%.

E12 Assuming that individual aircraft passenger capacity does not change during the period up to 2050 it would be expected that a 53 % increase in passengers would result in an increase in current aircraft movements by 53%.

E13 As discussed in section 4 above, the reduction in aircraft noise over the last 20 years can be demonstrated by the reduction in measured $L_{Amax, s}$ noise levels, but there is not a similar reduction in the calculated $L_{Aeq, 16 hr}$ and $L_{Aeq, 8 hr}$ noise levels as the increase in the number of aircraft events can mitigate the reduction in aircraft noise over 16 or 8 hours.

E14 As there would need to be an 800% increase in the number of aircraft movements to balance out the 7 dB noise reduction set out in chapter 14, it would be expected that, over time, as newer quieter aircraft replace older noisier aircraft, the calculated $L_{Aeq, 16 hr}$ and $L_{Aeq, 8 hr}$ aircraft noise levels should slowly reduce in the same way that the $L_{Amax, s}$ noise levels have.

Comments

E15 Current predictions are that air travel will continue to expand, increasing numbers of people will want to travel and, as a consequence, an increase in aircraft movements will result.

E16 There has been a process, which will presumably continue into the future, of setting more onerous design noise limits on new aircraft types, or existing aircraft types submitted for re-certification.

E17 As discussed above, given the current design noise limits set out in Chapter 14 and the level of air travel forecast to 2050, it should be that, possibly for the first time, mean aircraft $L_{Aeq, T}$ noise levels will reduce over time in the way that instantaneous $L_{Amax, s}$ noise levels have in the past (and should continue to do so in the future).

E18 The obverse side of the argument however is that, due to the nature of the human subjective perception of sound, reductions in aircraft noise, due to the extended period of time over which they are likely to occur, are set to pass undetected.

E19 Such a situation has already occurred in that relating the results from the UK attitude to noise study in 2000 to a similar noise attitude study in 2012 showed a 50% increase in people bothered, annoyed or disturbed by aircraft noise although instantaneous $L_{Amax, s}$ aircraft noise levels had decreased over that time.

E20 It may need to be accepted therefore that, despite reductions in aircraft noise and increased use of air travel, reported annoyance and disturbance may increase over time.

E21 Given the reported increase in annoyance/disturbance due to aircraft noise, it is likely that there will be a continuing requirement to monitor community aircraft noise in some form or another to provide objective noise measurement data against which any increase in complaints or community annoyance/disturbance can be compared.

APPENDIX F

ACOUSTIC TERMINOLOGY

ACOUSTIC TERMINOLOGY

This glossary is presented in two parts. The first part contains definitions relating specifically to the context of this report, followed, in the second part, by a more general glossary of acoustic terms.

Part 1

Definitions relating specifically to the context of this Report:

Aircraft movement

Every arrival and departure of an aircraft from an airport is an air traffic movement, or just aircraft movement. References therefore to aircraft movements, unless specifically referenced as an arrival or departure, is a reference to the combined number of arrivals and departures of aircraft from Gatwick Airport.

Aircraft Noise events	Noise events which have been matched by the airport's noise and track keeping system to radar tracks in the vicinity of the NMT from aircraft arriving at or departing from Gatwick airport.
Aircraft noise level	The average noise level derived from aircraft noise events, aggregated into hourly, daily or monthly average (L_{Aeq}) values.
ANOMS/ Casper BV	Airport Noise and Operations Monitoring System. The software data analysis system (incorporating the NTK system) which was in use at the airport until March 2013. The ANOMS system has been replaced by the Casper BV noise and track keeping system, which came into operation on 1 April 2013.

Applied Acoustic Design (AAD)

Acoustic consultants retained by Gatwick Airport Ltd.

Average $L_{Amax, s}$ level	The arithmetic average of the $L_{Amax, s}$ values of all the events (of a particular type i.e. either aircraft noise or community noise) which occur over a particular period of time (e.g. hour, day or month).

Chapter 14

National Noise Incidence Study 2000

A study carried out by the Building Research Establishment for Defra based on a survey of noise levels outside 1020 dwellings in England and Wales in 2000, and extended to the whole of the UK in 2001, giving proportions of the population exposed to various levels of environmental noise.
A second National Noise Incidence study was carried out in 2000. A comparison of the data from the two studies indicated that although there were some changes, much about the noise climate in England and Wales had not changed significantly over the 10 year period. Therefore the 2000

study remains a good basis for setting the noise levels from this study at Leigh into a wider context.

Noise Climate metrics

A small group of four selected noise metrics whose values collectively give a good description of the noise climate at a site:

($L_{Aeq.T}$,aircraft noise, $L_{Aeq.T}$,total noise, Average $L_{Amax,\,s}$ of aircraft noise events, L_{A90} (background noise level).

Noise event — A period of noise which satisfies the noise event capture conditions for a particular NMT, i.e. which exceeds the pre-set trigger noise level (in this report 50 dBA) for a pre-set time interval (in this report 10 seconds).

Noise events are detected, captured and stored by the NMT, and following subsequent processing by the NTK system are classified in this report as either aircraft noise events or community noise events

Noise Monitoring Terminal (NMT)

The noise measurement and analysis system installed at each site consisting of a precision grade sound level meter (Larson Davis type 870) inside a weather proof and tamper proof metal cabinet connected to an outdoor microphone located at a height of approximately 3.5 m above ground level.

NTK system Noise and Track Keeping system.

A software system able to match noise events recorded by the NMTs with aircraft tracks.

Residual noise — All noise arriving at the NMT microphone apart from aircraft noise events, i.e. comprising residual noise events and all other noise which does not satisfy the trigger conditions for capture as a noise event.

Residual Noise events

Those noise events which have not been matched by the NTK system to aircraft tracks using Gatwick Airport in the vicinity of the NMT.

Statistical frequency Analysis (of $L_{Amax,\,s}$ noise levels)

An analysis of a group of $L_{Amax,\,s}$ values giving the numbers of events (or percentages of total numbers) at different dBA levels

Total noise — All noise arriving at the NMT microphone, i.e. not only including all noise events (both aircraft and residual) but also all other noise which does not satisfy the trigger conditions for capture as a noise event.

Total noise level — The average or continuous equivalent level (L_{Aeq}) of the total noise at the site, recorded each hour by the NMT, which may also be aggregated into daily or monthly values.

Total noise climate — The level of the total noise at the NMT microphone varies with time. Over a particular period of time e.g. one hour, this variation maybe described in terms of a number of different noise indices including the average or equivalent noise level, maximum and minimum noise level values and various percentile levels.

Such a description constitutes the noise climate at the site over that period of time.

The NMT records the following total noise indices every hour:
L_{Aeq}, $L_{Amax, s}$, L_{AS10}, L_{A50}, L_{A90} and L_{A99}.

Part 2

<u>A general Glossary of acoustic Terms</u>:

A-weighting — A method of producing a single figure measure of a broad band noise (as opposed to the 8 or 9 figures which make up an octave band spectrum) which takes into account, in an approximate way at least, the frequency response of the human hearing system. The idea is that sound levels measured in this way should give an indication of the loudness of the sound.

A-weighted sound pressure level (dBA).

The value of the sound pressure level, in decibels, measured using an A-weighting electronic circuit built into the sound level meter. The vast majority of noise measurements are carried out in this way.

Decibel scale — The decibel scale is the scale on which sound pressure levels are commonly measured. It is a logarithmic scale and is used for convenience to compress the audible range of sound pressures into a manageable range, from 0 dB to 140 dB. The zero of the scale, 0 dB, corresponds to the notional threshold of hearing, 0.00002 Pa, and the upper limit, 140 dB, corresponds to 20 Pa, which would cause immediate damage to the ear.

Equivalent continuous sound level ($L_{Aeq, T}$), also called the Average noise level.

The $L_{Aeq, T}$ represents a measure of the 'average' sound level over the measurement period. It corresponds to the steady continuous level of sound which, over the same period of time, T, would contain the same amount of (A-weighted) sound energy as the time varying noise.
This is the most common method of measuring time varying noise, and within certain limits gives the best correlation with human response to noise, for example with annoyance.

Maximum sound pressure level ($L_{Amax, s}$)

This is the highest value of the time weighted sound pressure level, (measured using the A frequency weighting and the Slow time weighting) which occurred during the measurement period. It is commonly used to measure the effect of very short duration bursts of noise, such as for example sudden bangs, shouts, car horns, emergency sirens etc. which audibly stand out from the general level of, say, traffic noise, but because of their very short duration, maybe only a very small fraction of a second, may not have any effect on the $L_{Aeq,T}$ value.

In the context of this report the $L_{Amax, s}$ value for each aircraft noise event and community noise event is monitored

In this report, in line with standard practice for aircraft noise measurement, the Slow (S) time weighting has been used for measurement of maximum levels of aircraft noise, hence reference is made to $L_{Amax, s}$. (See under Time Weighting, Fast (F) and Slow (S)) below.

Noise — Unwanted sound

Sound exposure level (SEL)

This is a measure of the A-weighted sound energy used to describe single noise events such as the passing of a train or aircraft; it is the A-weighted sound pressure level which, if occurring over a period of one second, would contain the same amount of A-weighted sound energy as the event.

SEL values for events may be used to calculate the average noise level over a period of time (hour, day or month)

Sound pressure — sound is a disturbance or fluctuation in air pressure, and sound pressure, measured in Pascals (Pa), is used as a measure of the magnitude of the sound. The human ear can detect sound pressures in the range from 0.00002 Pa to 20 Pa. This is an enormously wide range and so for convenience sound pressures are commonly measured on a decibel (dB) scale.

Time varying noise — When the level of noise varies with time, as is often the case, for example with noise from road traffic, various measures or noise indices as they are called are used to give a single figure description of the noise over a given period of time. The three most commonly used noise indices are the $L_{Aeq, T}$ the $L_{A90,T}$ and the $L_{Amax,T}$ values.

In all three cases the ‘L’ stands for the level of the sound in decibels, the ‘A’ for the fact that it is the A- weighted value, and the ‘T’ for the time period over which the noise is measured, for example 5min, 1 hour, 24 hours etc.

Time weighting (Fast (F) and Slow (S))

An exponential function of time, of a specified time constant, that weights the square of the instantaneous sound pressure. (Defined in BS EN 61672 – 1:2003).

There are two time constants defined in BS EN 61672 – 1:2003, designated Fast (F) and Slow (S), and noise indices such as the maximum, or percentile noise levels which are based on instantaneous time-weighted sound pressure should indicate which time weighting has been used in the measurement.

In this report, in line with standard practice for aircraft noise measurement, the Slow (S) time weighting has been used for measurement of maximum levels of aircraft noise, hence reference is made to $L_{Amax, s}$. Because the sound level meter cannot measure using both Fast and Slow weightings simultaneously this necessarily means that the 90th percentile values have also been measured using the S weighting. Although it is more usual to measure L_{A90} using the F weighting, it is not considered that the use of the S weighting will make any significant difference to the L_{A90} values in this case.

References:

1 National Noise Attitude Survey 2012 (NNAS2012), DEFRA, December 2014

2 Aviation 2050 "The future of UK aviation (Cm9714), Department for Transport, December 2018

3 Survey of noise attitudes 2014: Aircraft (CAP 1506), CAA, February 2017

4 Aircraft Noise and Emissions "Environmental Information Sheet No. 10", CAA, 2014

5 DORA Report 9023 "The use of L_{eq} as an Aircraft Noise Index", CAA, September 1990