Bickerdike Allen Partners
Architecture Acoustics Technology

FARNBOROUGH AIRPORT

NOISE MONITORING REPORT

CHURCH CROOKHAM

3 JANUARY 2024 – 2 APRIL 2024

Report to

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Bickerdike Allen Partners LLP is an integrated practice of Architects, Acousticians, and Construction Technologists, celebrating over 60 years of continuous practice.

Architects: Design and project management services which cover all stages of design, from feasibility and planning through to construction on site and completion.

Acoustic Consultants: Expertise in planning and noise, the control of noise and vibration and the sound insulation and acoustic treatment of buildings.

Construction Technology Consultants: Expertise in building cladding, technical appraisals and defect investigation and provision of construction expert witness services.

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1.0 INTRODUCTION

Bickerdike Allen Partners LLP (BAP) were instructed by Farnborough Airport Ltd. (FAL) to analyse measured noise data from a survey undertaken in Church Crookham, with the aim of quantifying and understanding the typical noise levels created in the community by aircraft operations at Farnborough Airport.

An unattended noise monitoring terminal (NMT) was installed by FAL at a community centre on Boyce Rd, Church Crookham, Fleet GU52 8AQ. The NMT is part of the noise and track monitoring system at the airport and operated at the location from 3 January 2024 to 2 April 2024.

The noise monitoring location, illustrated in Figure 1, is situated approximately 2.5 mi (4 km) southwest of the airport.

FAL provided BAP with the schedule of flights that occurred in the monitoring period, the flight track radar data from the airport's permanent track-keeping system, and noise measurements from the NMT.

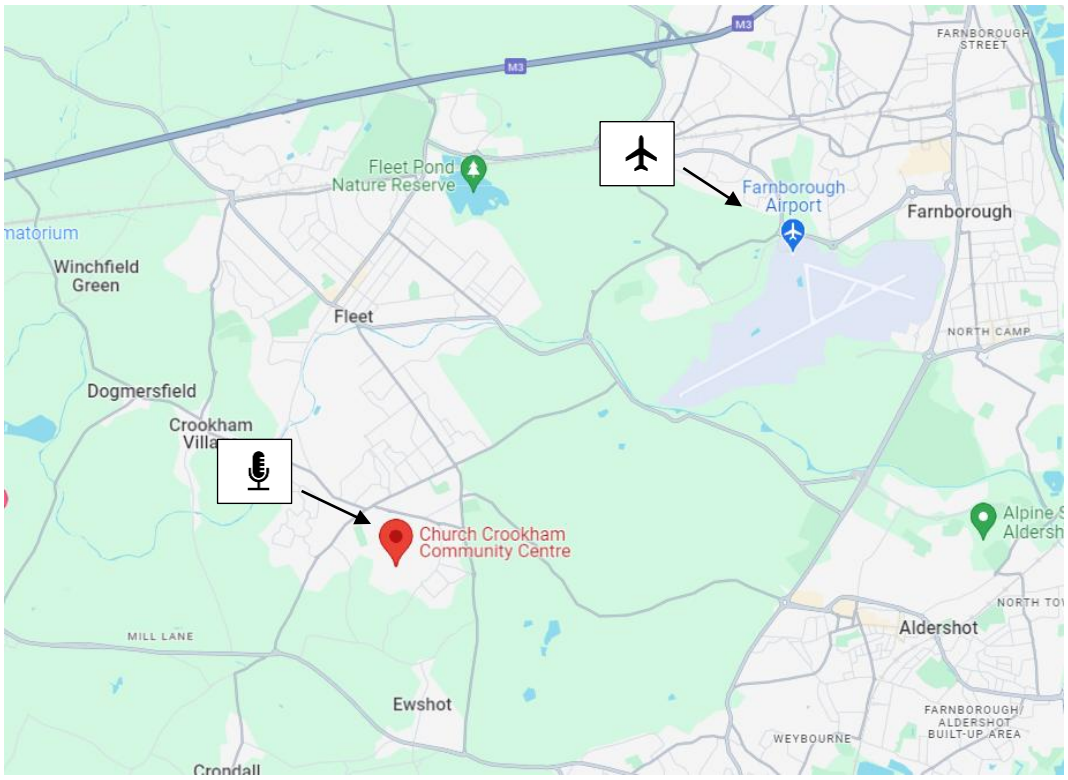

Figure 1: Noise monitoring location ( ) relative to Farnborough Airport ( ). Map data: Google, © 2024.

2.0 AIRCRAFT OPERATIONS

2.1 Direction

Aircraft operations at Farnborough Airport are either easterly operations using Runway 06 (R06) or westerly operations using Runway 24 (R24). During easterly operations aircraft approach from west of the airport and take-off to the east. During westerly operations the situation is reversed. The wind direction determines when easterly or westerly operations occur, as aircraft take-off and land into the wind for performance and safety reasons. Consequently, the split between easterly and westerly operations varies with time and the areas overflown by aircraft can correspondingly change.

During the 14 week period that covered the noise monitoring period there were a total of 7,117 flights logged at Farnborough Airport, distributed 16%/84% between R06/R24. Figure 2 shows the distribution of operations by runway week by week. Overall, the usage of Runway 24 was greater than the annual average for 2023, where it was 75%.

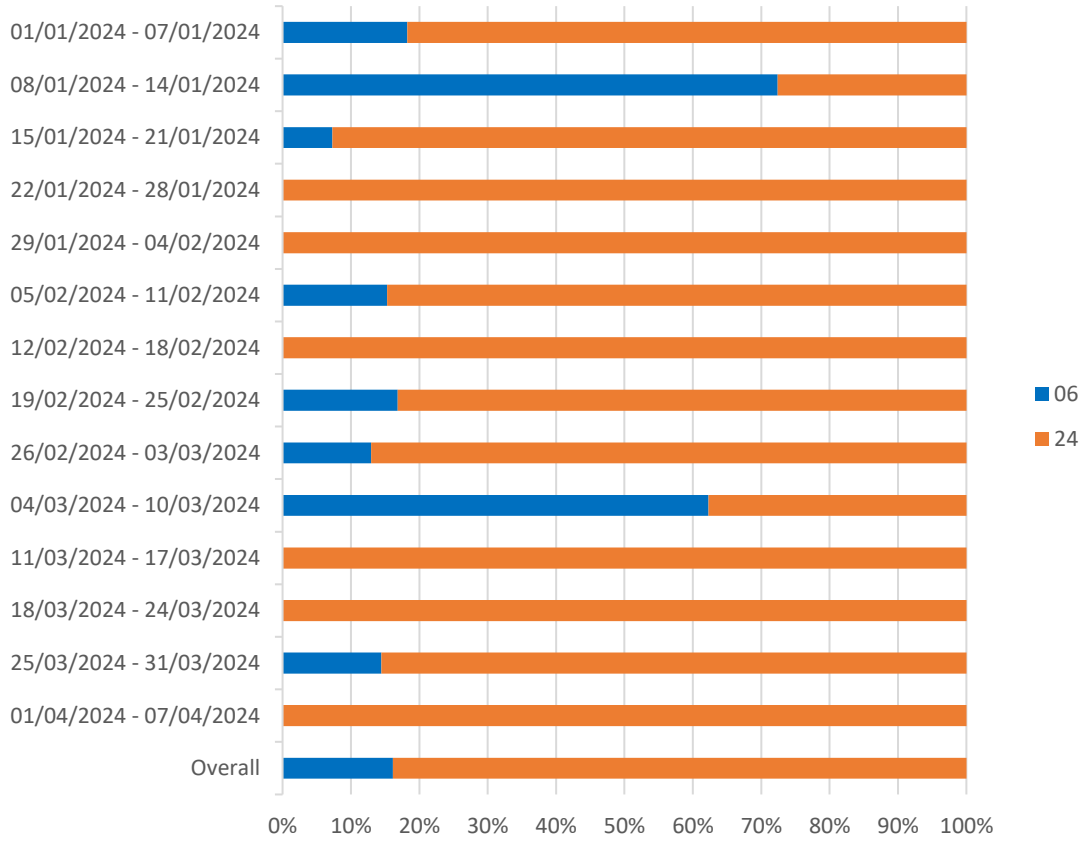

Figure 2: Distribution of aircraft operations by runway.

For this survey location, the aircraft that overflew the monitor at lower altitudes were departure movements from Runway 24 (24-D) and arrival movements onto Runway 06 (06-A). There were 3,352 of these flights, which equates to approximately 50% of total flights over the noise monitoring period.

The noise monitoring terminal recorded noise events when the noise level was above a set threshold. BAP used a time-based correlation with the schedule of flights that occurred to assign the events to specific movements.

It's not practical to achieve a 100% correlation rate with an unattended noise monitor. Factors such as high wind speeds and local noise events introduce measurement uncertainty and aircraft that are particularly quiet may not produce a distinct noise event relative to ambient noise levels. However, 578 of 592 R06 arrivals (98%) in the schedule were correlated with a measured noise event.

For the R24 departures, many of the aircraft turned off the extended runway centreline before the monitoring location. Some of these aircraft therefore did not fly close to the noise monitor. The departures that did generate a noise event will therefore be a combination of the aircraft that turned slightly later and those producing a higher noise level. In total 1,370 of 2,970 (46%) R24 departures were correlated with a measured noise event.

There were 2,905 noise events that were not correlated with a flight. These were events that did not occur within 1 minute of a flight and therefore are expected to be caused by various non-aircraft noise sources. The noise monitor was situated in a suburban location at a community centre on Boyce Rd, Church Crookham. Sources contributing to the overall ambient noise, besides airborne aircraft, therefore included road traffic and community activities.

Figure 3 shows the number of correlated flights operations that occurred each day.

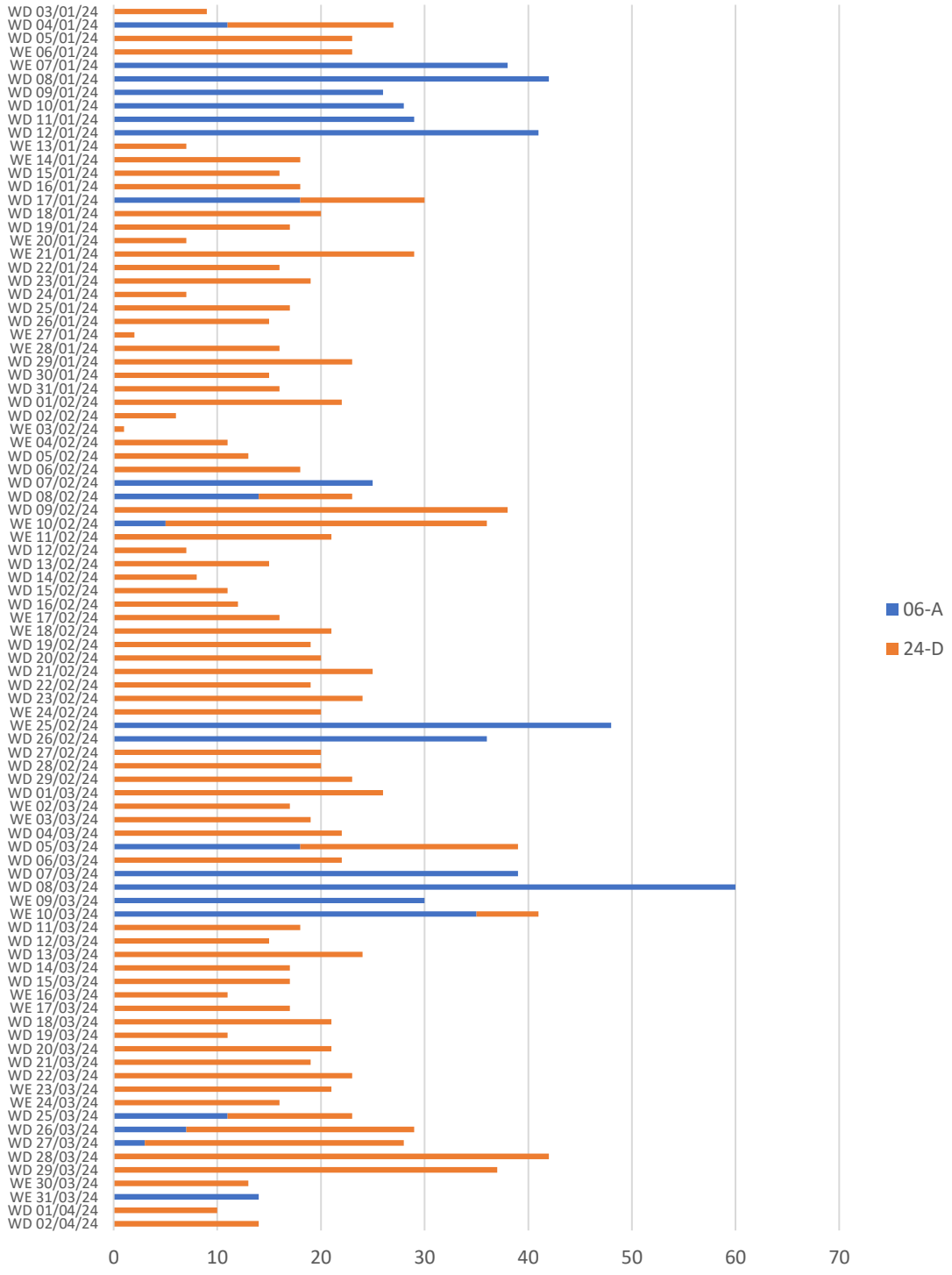

Figure 3: Number of correlated flights per day. WD is Weekday, WE is Weekend.

NB: data for 03/01/24 does not represent the whole day due to installation of the NMT.

Figure 4 shows the average number of correlated flights per hour across the seven-day week. During the airport's operational hours (07:00 – 22:00 weekday and 08:00-20:00 weekend) there were generally on average between 1 and 2 correlated flights per hour. There were no correlated flights recorded outside those hours.

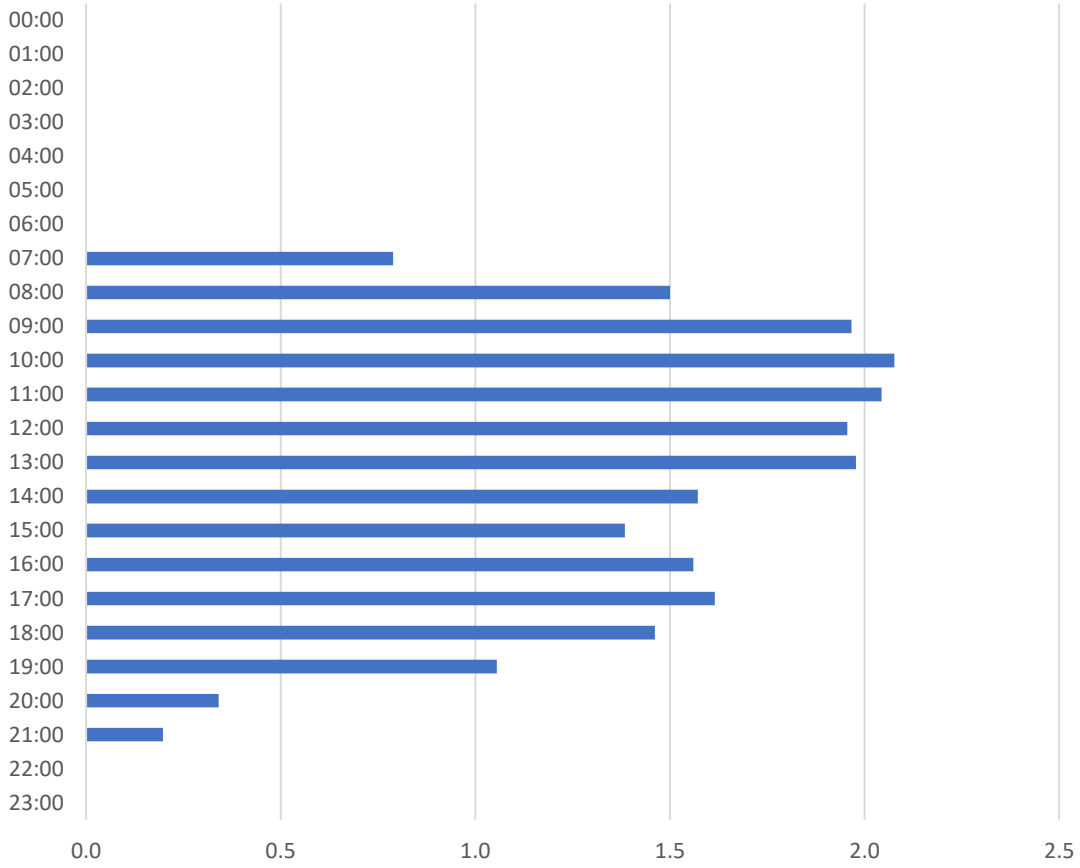

Figure 4: Average number of correlated flights per hour.

NB: The time stated is the start of the hour, e.g. 07:00 refers to 07:00 – 07:59.

Figure 5 and Figure 6 show the actual number of correlated flights per hour that occurred on the busiest day (08/03/24) and quietest day (03/02/24) in the monitoring period. On the busiest day there were a total of 60 correlated flights and a maximum of 7 in any hour. On the quietest day there was a single correlated flight.

On average, arrivals to Runway 06 were at a height above the airport of around 900 ft at their closest lateral distance to the measurement location. Departures were on average over twice the height at around 2,300 ft. Figure 7 shows the height of each correlated flight in the measurement period.

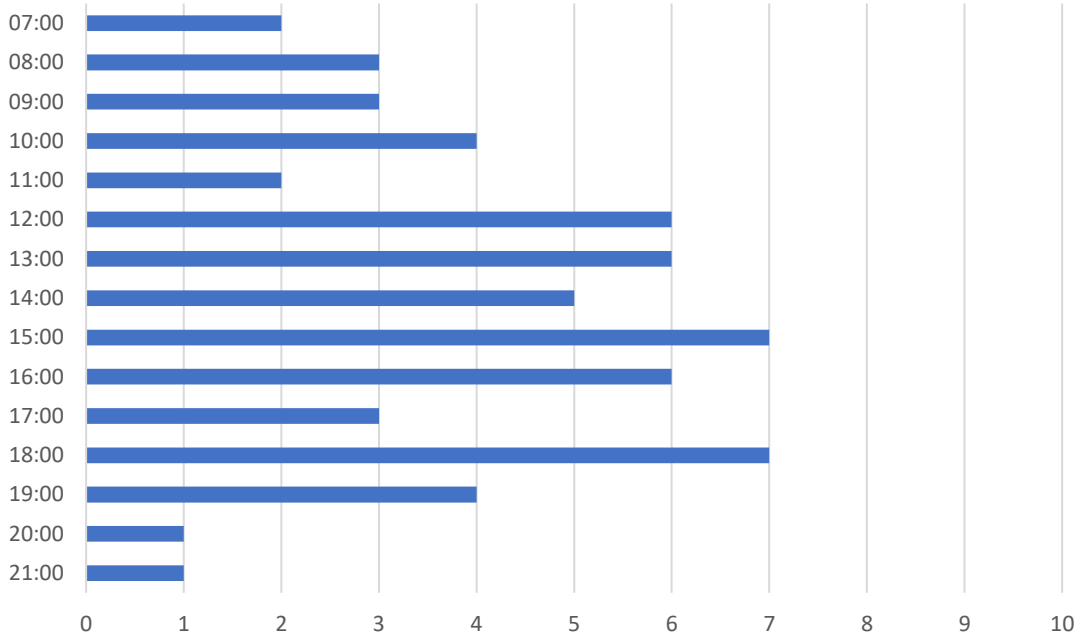

Figure 5: Actual number of correlated flights per hour, busiest day (08/03/24).

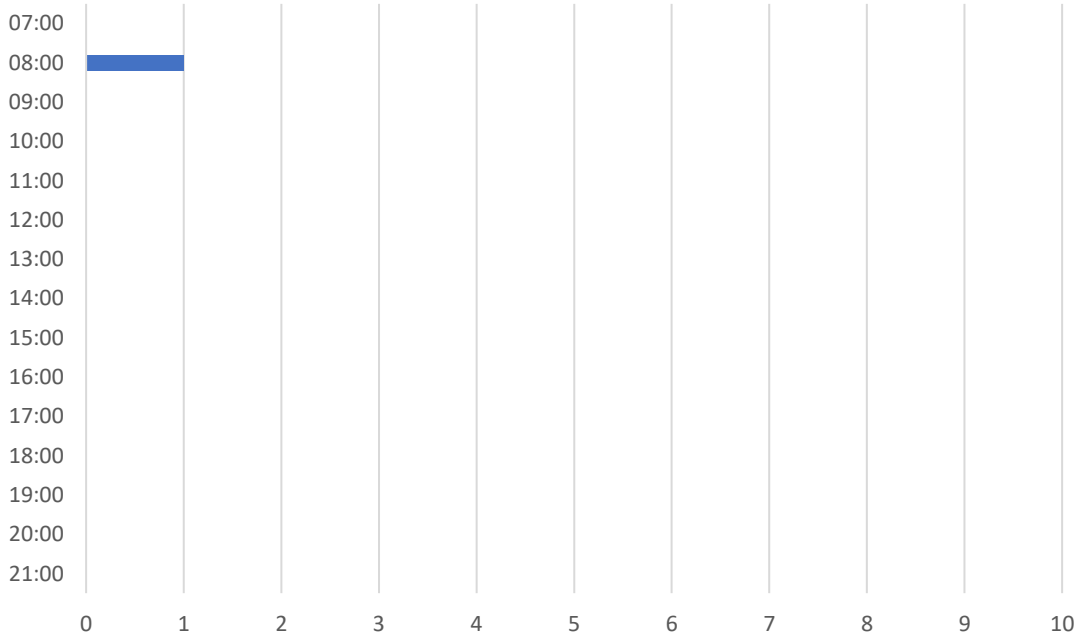

Figure 6: Actual number of correlated flights per hour, quietest day (03/02/24).

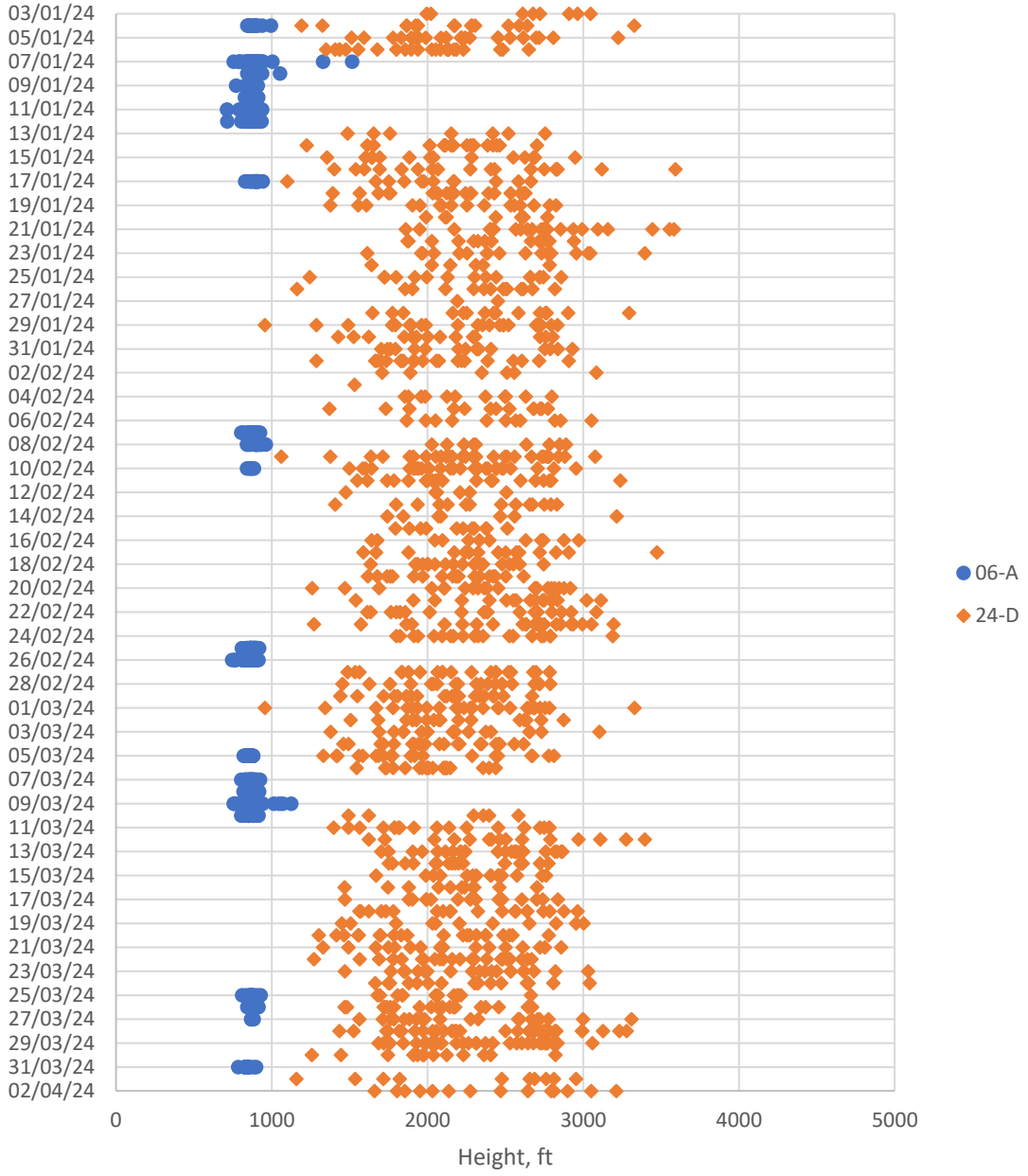

Figure 7: Height above the airport of correlated flights at their closest lateral distance to the NMT

NB: data for 03/01/24 does not represent the whole day due to installation of the NMT.

3.0 AIRCRAFT NOISE

Aircraft noise is often reported in terms of the Sound Exposure Level (SEL). Whereas the L_{ASmax} level refers to the single highest noise level of the event, the SEL represents the total sound energy of the whole event and accounts for the duration of the event as well as its intensity. The numerical value is typically around 10 dB higher than the equivalent L_{ASmax} value. In this case the average arrival produced an SEL of around 81 dB(A) and the average departure produced an SEL of around 75 dB(A).

In the figures and tables below, aircraft measured at least 10 times have been considered in detail. The Piaggio P180 has also been considered despite there being fewer than 10 movements, due to particular community concern regarding this aircraft type. There were 2 correlated departures by the P180 from Runway 24 and no Runway 06 arrivals during the survey period.

Table 1 summarises the number of flights that were correlated with a noise event by aircraft type, runway and operation. Aircraft types with fewer than 10 measurements, except for the Piaggio P180, have been grouped as 'Other' aircraft.

Figure 8 shows the measured noise maximum of all correlated noise events for R06 arrivals and R24 departures. The average maximum noise level produced by each R06 arrival was around 73 dB L_{ASmax}. The average maximum noise level produced by each R24 departure was around 67 dB L_{ASmax}.

The results for Runway 06 arrivals for aircraft types that were measured at least 10 times are presented in detail in Table 2 and Figure 9. The results for Runway 24 departures for aircraft types that were measured at least 10 times, and the 2 correlated departures by the Piaggio P180, are presented in detail in Table 3 and Figure 10.

As can be seen in Figure 9 and Figure 10, there is a wide spread of measured noise levels for each aircraft type. This variation is down to many factors that are unique to each individual aircraft operation including the exact position of each aircraft and its distance to the monitor, how each aircraft is being operated, and contributions from other sources of noise. The results presented are those measured at the monitoring location and have not been modified to attempt to allow for these factors. Results for aircraft types with few measurements may therefore not be representative.

While the propagation of noise, including aircraft noise, can be affected by the weather the survey was conducted over a relatively long period to capture a representative range of weather conditions. The reported noise levels for the correlated aircraft flights are those measured by the monitor and as such have not been modified with respect to weather or distance.

Figure 11 summarises the number of correlated flights that were measured to exceed 65 dB L_{ASmax} each day (N65). Almost all correlated arrivals (576 out of 578) exceeded this level. On the days where R06 arrivals overflew the monitor there were an average of around 26 such flights per day, with a maximum of 60 on a single day. Departures were less likely to exceed the level of 65 dB L_{ASmax}, around 68% (938 of 1,370) of correlated departures exceeded this level. On the days where R24 departures overflew the monitor there were an average of around 12 such flights per day, with a maximum of 40 on a single day.

Figure 12 shows representative sound levels for a number of non-aircraft activities and situations to aid in comparison with the measured aircraft noise levels. A noise level of 65 dB L_{ASmax} is slightly louder than the typical level for conversational speech, which is around 60 dB. 65 dB would therefore be equivalent to a slightly raised voice, or someone who's speech is naturally slightly louder.

Aircraft Type		MTOW[1]	Correlated Runway 06 Arrivals[2]	Correlated Runway 24 Departures
Code	Description			
BE20	Beechcraft Super King Air 200	5.7T	25	71
C25A	Cessna Citation CJ2	5.6-5.7T	n/a	15
C25B	Cessna Citation CJ3	5.7-6.3T	n/a	23
C525	Cessna 525 CitationJet	3.9T	n/a	12
C56X	Cessna Citation Excel	9.1-9.2T	46	56
C68A	Cessna Citation Latitude	14.0T	28	59
CL30	Bombardier Challenger 300	17.5-17.6T	n/a	13
CL35	Bombardier Challenger 350	18.4T	50	110
CL60	Bombardier Challenger 600	17.2-21.9T	16	23
CRJ2	Bombardier CRJ200	20.6-24.0T	12	24
E145	Embraer ERJ-145	20.0-22.0T	10	27
E35L	Embraer Legacy 600	22.2-22.5T	13	53
E550	Embraer Legacy 500	17.2-19.4T	32	21
E55P	Embraer Phenom 300	8.2-8.3T	36	130
F2TH	Dassault Falcon 2000	16.2-19.4T	24	43
F406	Cessna F406 Caravan	4.2-4.5T	n/a	23
F900	Dassault Falcon 900	20.6-22.2T	n/a	17
FA7X	Dassault Falcon 7X	31.3-31.8T	25	79
FA8X	Dassault Falcon 8X	33.1T	12	29
G280	Gulfstream G280	18.0T	13	n/a
GA6C	Gulfstream G600	42.9T	10	12
GALX	Gulfstream G200	16.1-16.2T	n/a	11
GL5T	Bombardier Global 5000	39.8-42.0T	15	33
GL7T	Bombardier Global 7000	52.1T	16	41
GLEX	Bombardier Global Express	32.2-33.8T	39	147
GLF4	Gulfstream IV	32.2-33.8T	n/a	10
GLF5	Gulfstream V	34.0-47.0T	19	33
GLF6	Gulfstream G650	39.8-42.0T	29	58
H25B	Hawker 800	12.2-12.7T	n/a	13
P180	Piaggio P180	5.5T	0	2
PC12	Pilatus PC-12	4.1-4.7T	11	18
PC24	Pilatus PC-24	8.0-8.5T	19	40
Other			78	126
Total			**578**	**1,370**

Table 1: Number of correlated flight noise events at the monitoring location.

[1] MTOW can vary between specific variants of the same aircraft type, ranges given where this is the case

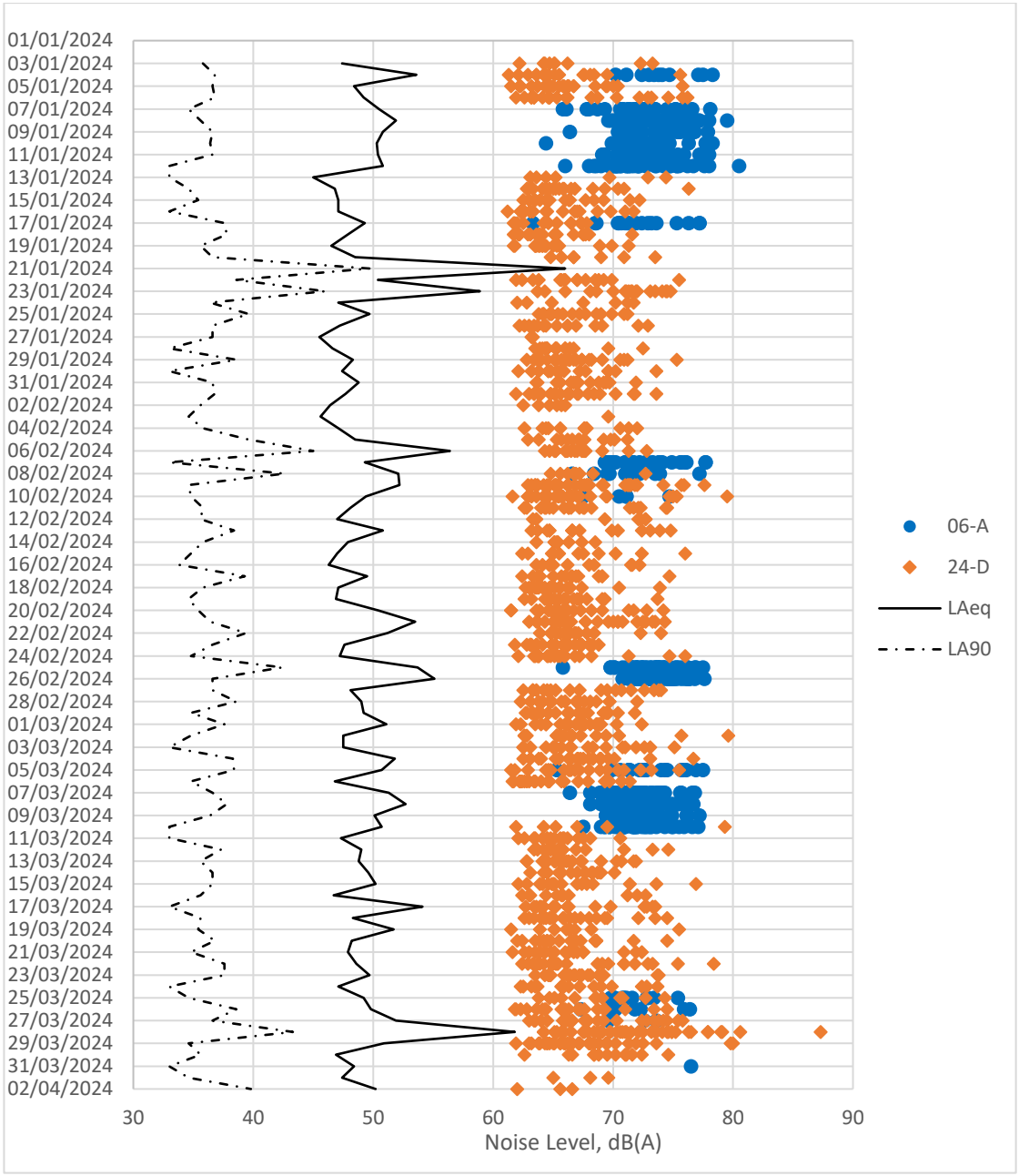

Figure 8: All correlated aircraft noise maxima against average ambient and background noise levels.

[2] n/a is shown where an aircraft type performed fewer than 10 arrivals or departures, the movements are grouped under "Other"

Figure 8 shows that the measured noise levels from the aircraft are well above the background noise level (L_{A90}) shown as a dashed line, this means the aircraft were likely to be clearly audible. Figure 8 also shows that the average noise level ($L_{Aeq,16h}$) shown as a solid line does not necessarily correlate with either the frequency of relative loudness of aircraft events. For instance, on 8th March there were many more correlated flights than on average and on 12th January there was a particularly loud arrival, but the average noise levels on these days were not particularly high. Similarly, on 21st January the average noise level at the monitor was much higher than normal, but there were relatively few correlated flights and none that were particularly loud. This suggests that aircraft, while clearly audible, are not the only and potentially not the primary source of noise at the survey location.

Aircraft Type		MTOW[1]	Number	Sound Exposure Level, dB(A)		
Code	Description			Average	Min	Max
BE20	Beechcraft Super King Air 200	5.7T	25	84	77	86
C56X	Cessna Citation Excel	9.1-9.2T	46	82	75	85
C68A	Cessna Citation Latitude	14.0T	28	80	78	83
CL35	Bombardier Challenger 350	18.4T	50	80	73	82
CL60	Bombardier Challenger 600	17.2-21.9T	16	83	82	85
CRJ2	Bombardier CRJ200	20.6-24.0T	12	84	81	86
E145	Embraer ERJ-145	20.0-22.0T	10	83	79	86
E35L	Embraer Legacy 600	22.2-22.5T	13	83	81	85
E550	Embraer Legacy 500	17.2-19.4T	32	80	78	82
E55P	Embraer Phenom 300	8.2-8.3T	36	81	79	86
F2TH	Dassault Falcon 2000	16.2-19.4T	24	81	75	83
FA7X	Dassault Falcon 7X	31.3-31.8T	25	82	74	85
FA8X	Dassault Falcon 8X	33.1T	12	82	81	85
G280	Gulfstream G280	18.0T	13	80	79	82
GA6C	Gulfstream G600	42.9T	10	81	78	84
GL5T	Bombardier Global 5000	39.8-42.0T	15	81	79	83
GL7T	Bombardier Global 7000	52.1T	16	82	78	85
GLEX	Bombardier Global Express	42.4-45.1T	39	81	78	83
GLF5	Gulfstream V	34.0-47.0T	19	80	78	84
GLF6	Gulfstream G650	39.8-42.0T	29	80	79	83
PC12	Pilatus PC-12	4.1-4.7T	11	85	83	86
PC24	Pilatus PC-24	8.0-8.5T	19	83	79	86

Table 2: Measured noise levels (SEL) of Runway 06 arrivals for aircraft types with at least 10 results.

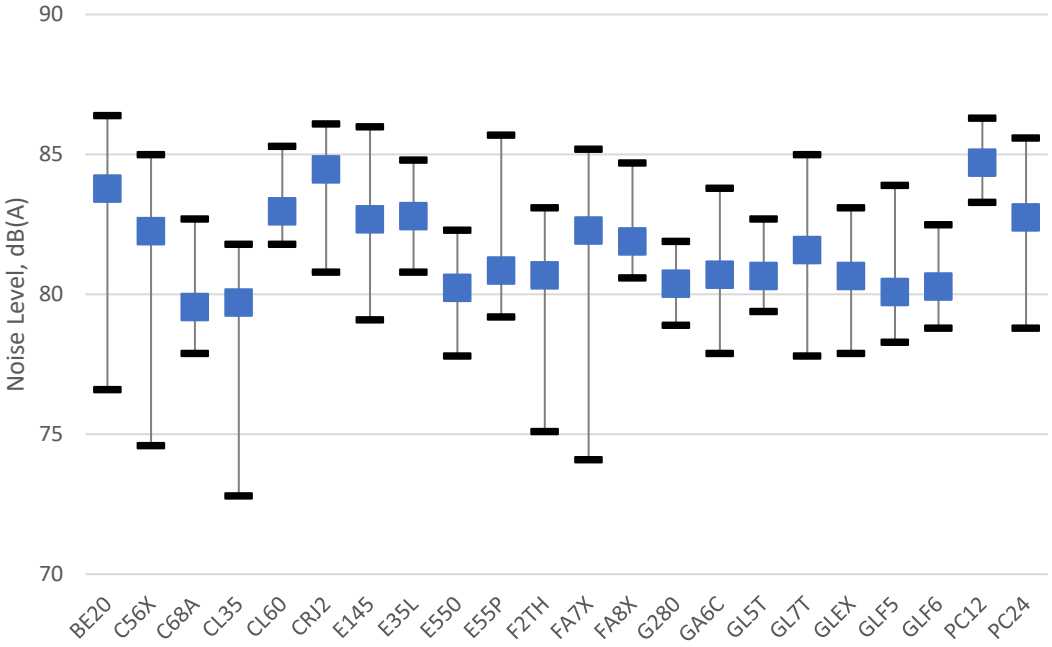

Figure 9: Measured noise levels (SEL) of Runway 06 arrivals for aircraft types with at least 10 results. Blue: average SEL. Black: minimum SEL and maximum SEL.

Aircraft Type		MTOW[1]	Number	Sound Exposure Level, dB(A)		
Code	Description			Average	Min	Max
BE20	Beechcraft Super King Air 200	5.7T	71	74	68	90
C25A	Cessna Citation CJ2	5.6-5.7T	15	75	69	88
C25B	Cessna Citation CJ3	5.7-6.3T	23	75	72	89
C525	Cessna 525 CitationJet	3.9T	12	74	69	79
C56X	Cessna Citation Excel	9.1-9.2T	56	73	68	82
C68A	Cessna Citation Latitude	14.0T	59	74	70	85
CL30	Bombardier Challenger 300	17.5-17.6T	13	76	72	81
CL35	Bombardier Challenger 350	18.4T	110	74	68	92
CL60	Bombardier Challenger 600	17.2-21.9T	23	73	68	82
CRJ2	Bombardier CRJ200	20.6-24.0T	24	74	71	79
E145	Embraer ERJ-145	20.0-22.0T	27	74	70	87
E35L	Embraer Legacy 600	22.2-22.5T	53	75	68	88
E550	Embraer Legacy 500	17.2-19.4T	21	74	69	81
E55P	Embraer Phenom 300	8.2-8.3T	130	74	68	86
F2TH	Dassault Falcon 2000	16.2-19.4T	43	74	68	83
F406	Cessna F406 Caravan	4.2-4.5T	23	72	68	80
F900	Dassault Falcon 900	20.6-22.2T	17	77	69	87
FA7X	Dassault Falcon 7X	31.3-31.8T	79	77	68	88
FA8X	Dassault Falcon 8X	33.1T	29	78	70	84
GA6C	Gulfstream G600	42.9T	12	76	70	90
GALX	Gulfstream G200	16.1-16.2T	11	77	72	84
GL5T	Bombardier Global 5000	39.8-42.0T	33	75	69	83
GL7T	Bombardier Global 7000	52.1T	41	76	70	85
GLEX	Bombardier Global Express	42.4-45.1T	147	79	68	92
GLF4	Gulfstream IV	32.2-33.8T	10	77	70	84
GLF5	Gulfstream V	34.0-47.0T	33	76	70	82
GLF6	Gulfstream G650	39.8-42.0T	58	75	69	86
H25B	Hawker 800	12.2-12.7T	13	77	72	86
P180	Piaggio P180	5.5T	2	80	79	80
PC12	Pilatus PC-12	4.1-4.7T	18	73	69	90
PC24	Pilatus PC-24	8.0-8.5T	40	75	71	86

Table 3: Measured noise levels (SEL) of Runway 24 departures for aircraft types with at least 10 results and the Piaggo P180.

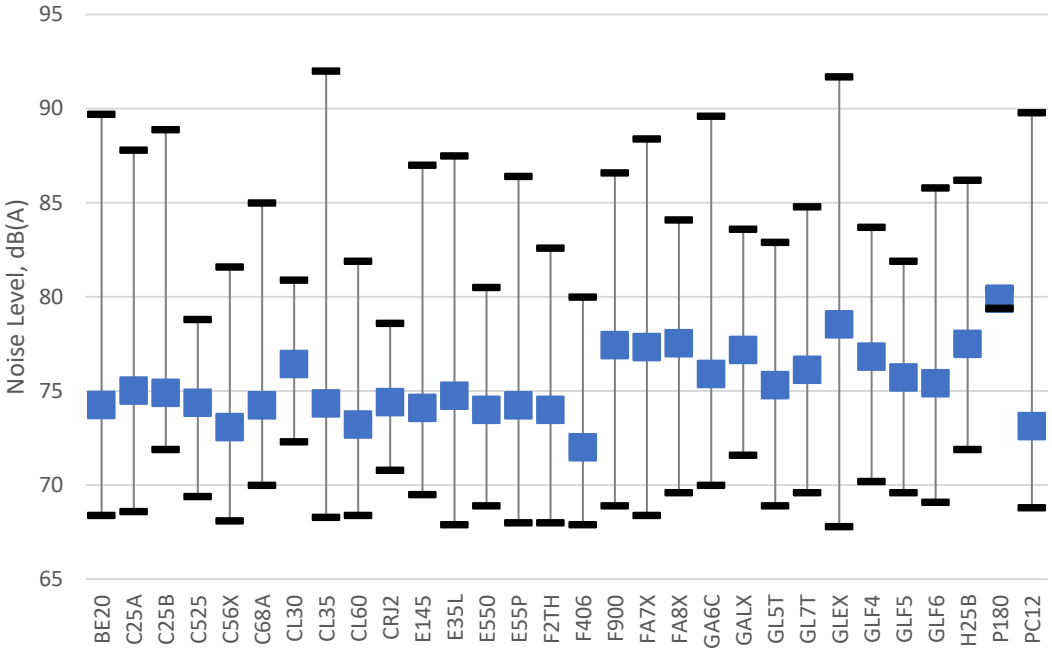

Figure 10: Measured noise levels (SEL) of Runway 24 departures for aircraft types with at least 10 results and the Piaggio P180. Blue: average SEL. Black: minimum SEL and maximum SEL.

The range of noise levels measured for Runway 24 departures is much larger than that measured for arrivals. This is primarily due to many of the departures turning before the monitoring location, their distance from the monitor therefore varies leading to a large variation in the noise levels measured. There may also be contributions from non-aircraft noise sources in some cases which could affect the maximum levels, however this shouldn't significantly affect the average levels.

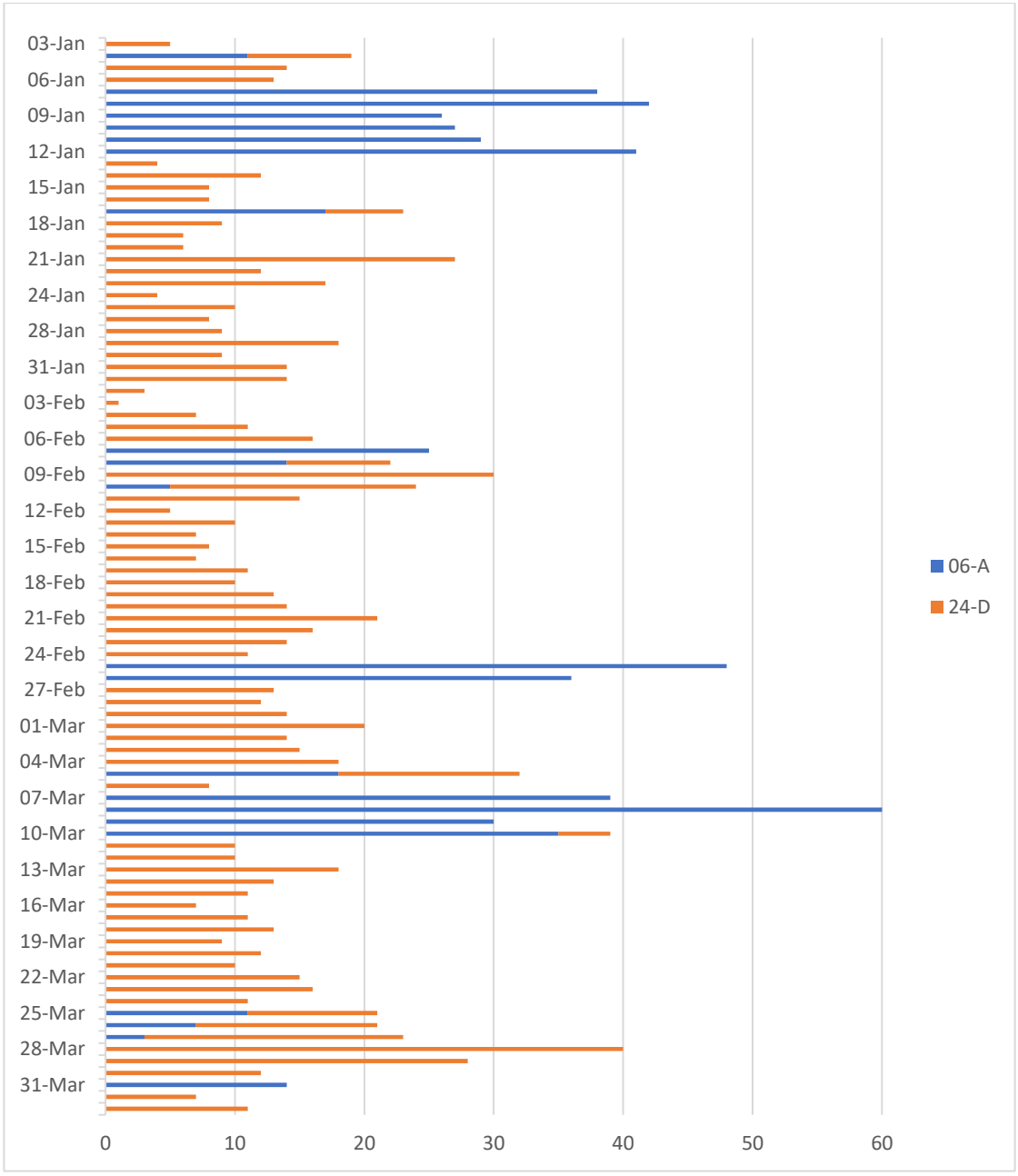

Figure 11: Number of correlated flights measured as exceeding 65 dB L_{ASmax} per day (N65).

Situation	Sound Pressure Level LpA dB(A)
Threshold of pain	130
Threshold of discomfort	120
Chainsaw, 1m distance	110
Disco, 1m from speaker	100
Diesel truck pass-by, 10m away	90
Kerbside of busy road, 5m away	80
Vacuum cleaner, distance 1m	70
Conversational speech, 1m	60
Quiet office	50
Room in quiet, suburban area	40
Quiet library	30
Background in TV studio	20
Rustling leaves in the distance	10
Hearing threshold	0

Source: Airports Commission, based substantially on http://www.sengpielaudio.com/TableOfSoundPressureLevels.htm

Figure 12: Approximate sound pressure levels (LpA) for different activities or situations

4.0 SUMMARY

Aircraft operations and noise levels were monitored in Church Crookham from 3 January 2024 to 2 April 2024. This found that:

- During the 14 week period that covered the noise monitoring period the overall runway usage was 16% on Runway 06 and 84% on Runway 24. This is a higher usage of Runway 24 compared to the annual average for 2023 when it was used by 75% of flights.
- There were 592 Runway 06 arrivals in the monitoring period, with 98% (578) being correlated with noise events. There were also 2,970 Runway 24 departures although not all of these flew close to the monitoring location. Therefore, only 46% (1,370) of the departures were correlated with noise events.
- The average maximum noise level produced by each Runway 06 arrival was around 73 dB L_{ASmax}. The corresponding SEL, accounting for the duration of each flight, was around 81 dB(A) SEL.
- The average maximum noise level produced by each Runway 24 departures was around 67 dB L_{ASmax}. The corresponding SEL, accounting for the duration of each flight, was around 75 dB(A) SEL.
- On the days where Runway 06 arrivals overflew the monitor there were an average of around 26 flights per day that exceeded a level of 65 dB L_{ASmax}. On the days where Runway 24 departures overflew the monitor there were an average of around 12 flights per day that exceeded a level of 65 dB L_{ASmax}.

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for Bickerdike Allen Partners LLP	**Senior Acoustic Consultant**	**Partner**

APPENDIX 1
GLOSSARY OF ACOUSTIC TERMINOLOGY

The Decibel, dB

The unit used to describe the magnitude of sound is the decibel (dB) and the quantity measured is the sound pressure level. The decibel scale is logarithmic and it ascribes equal values to proportional changes in sound pressure, which is a characteristic of the ear. Use of a logarithmic scale has the added advantage that it compresses the very wide range of sound pressures to which the ear may typically be exposed to a more manageable range of numbers. The threshold of hearing occurs at approximately 0 dB (which corresponds to a reference sound pressure of 2 x 10^{-5} Pascals) and the threshold of pain is around 120 dB.

The sound energy radiated by a source can also be expressed in decibels. The sound power is a measure of the total sound energy radiated by a source per second, in watts. The sound power level, L_w is expressed in decibels, referenced to 10^{-12} watts.

Frequency, Hz

Frequency is analogous to musical pitch. It depends upon the rate of vibration of the air molecules that transmit the sound and is measure as the number of cycles per second or Hertz (Hz). The human ear is sensitive to sound in the range 20 Hz to 20,000 Hz (20 kHz). For acoustic engineering purposes, the frequency range is normally divided up into discrete bands. The most commonly used bands are octave bands, in which the upper limiting frequency for any band is twice the lower limiting frequency, and one-third octave bands, in which each octave band is divided into three. The bands are described by their centre frequency value and the ranges which are typically used for building acoustics purposes are 63 Hz to 4 kHz (octave bands) and 100 Hz to 3150 Hz (one-third octave bands).

A-weighting

The sensitivity of the ear is frequency dependent. Sound level meters are fitted with a weighting network which approximates to this response and allows sound levels to be expressed as an overall single figure value, in dB(A).

Environmental Noise Descriptors

Where noise levels vary with time, it is necessary to express the results of a measurement over a period of time in statistical terms. Some commonly used descriptors follow.

Statistical Term	Description
$L_{Aeq, T}$	The most widely applicable unit is the equivalent continuous A-weighted sound pressure level (LAeq, T). It is an energy average and is defined as the level of a notional sound which (over a defined period of time, T) would deliver the same A-weighted sound energy as the actual fluctuating sound.
L_{A90}	The level exceeded for 90% of the time is normally used to describe background noise.
$L_{Amax,T}$	The maximum A-weighted sound pressure level, normally associated with a time weighting, F (fast), or S (slow)
SEL	The Sound Exposure Level (SEL) is the constant sound level that has the same amount of sound energy in one second as the total sound energy of an event over its entire duration. This is equal to $L_{Aeq,T}$ + 10 Log(T), where T is the duration in seconds.
N65	The number of aircraft noise events with a maximum noise level of 65 dB L_{ASmax} or greater at a specific location and in a defined time period. Typically, contours ranging from 10 events to 500 events are plotted.