Bickerdike Allen Partners
Architecture Acoustics Technology

FARNBOROUGH AIRPORT

NOISE MONITORING REPORT

CHURT

30 AUGUST 2023 – 31 OCTOBER 2023

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 monitor aircraft noise in Churt for two months, 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 at a residence on Churt Road, Churt, Farnham, Surrey, GU10 2NY and was operational from 30 August 2023 to 31 October 2023. The measurement instrumentation comprised a 01dB CUBE (IEC 61672 Class 1 sound level meter) which was calibrated in November 2022. The calibration was field tested on installation of the NMT.

The measurement location, illustrated in Figure 1, is situated approximately 10 mi (16 km) due south of the airport.

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

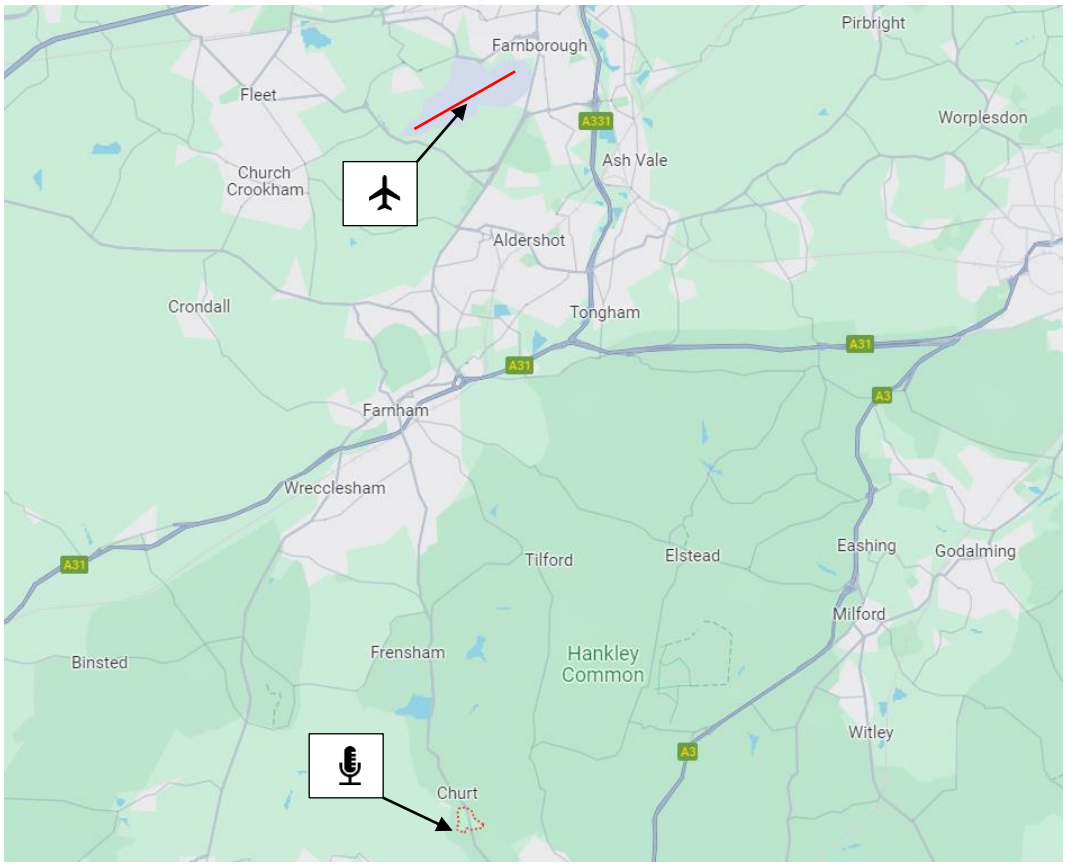

Figure 1: Noise monitoring location (🎙) relative to Farnborough Airport (✈) and Runway (／). Map data: Google, © 2024.

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 noise monitoring period there were a total of 6,301 flights logged at Farnborough Airport, distributed 22%/78% between R06/R24. Figure 2 shows the distribution of operations week by week over the noise monitoring period. This is comparable to the annual average for 2023 of 25%/75%.

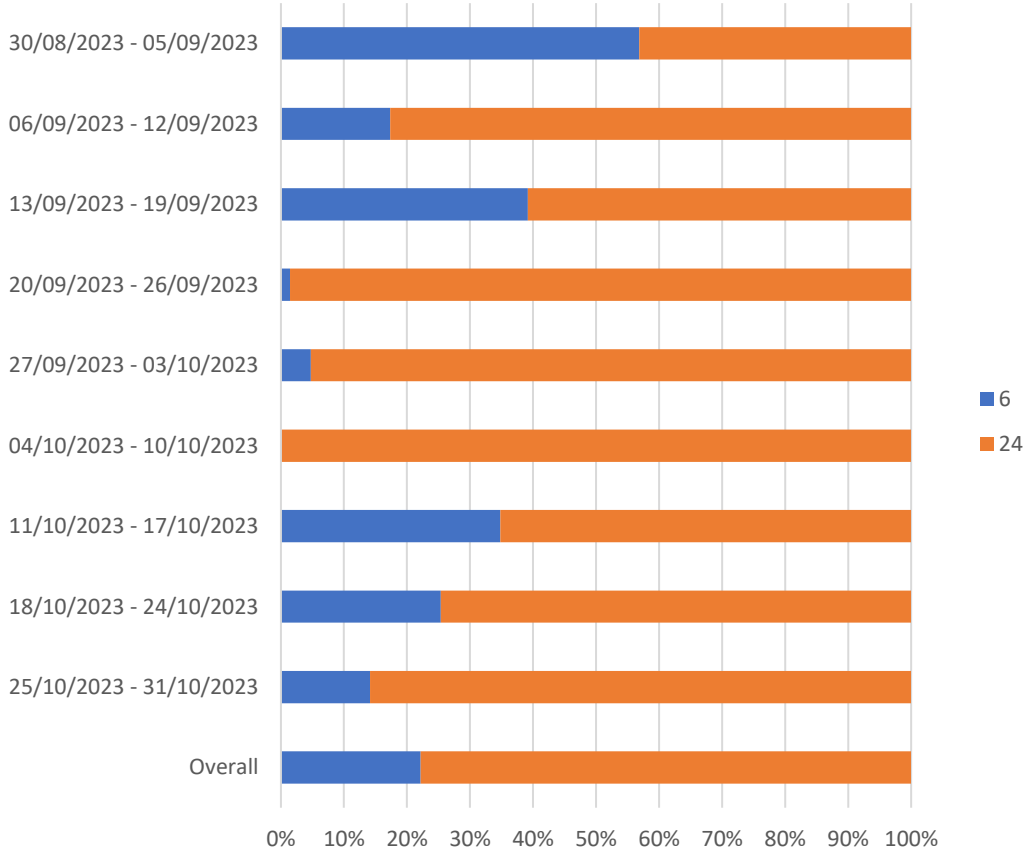

Figure 2: Distribution of aircraft operations

2.2 Overflights

Of the 6,301 flights logged at Farnborough Airport during the noise monitoring period, radar data was available for 5,888 (93%). For the remainder there may have been issues with the radar data not being complete, or with the correlation to specific movements. Using the radar data, overflights of the measurement location were identified.

An overflight was taken to be any Farnborough aircraft passing the measurement location at an elevation angle (approximately the angle between the horizon and the aircraft) of at least 48.5 degrees, as shown in Figure 3. This is generally in accordance with the Civil Aviation Authority (CAA) definition (CAP 1498), the difference being that any aircraft above 7,000 ft were also included. An angle of 48.5 degrees was used in preference to the alternative 60 degree angle detailed in CAP 1498, as using an angle of 48.5 results in a larger "cone" and therefore more Farnborough aircraft measurements being included in the survey results.

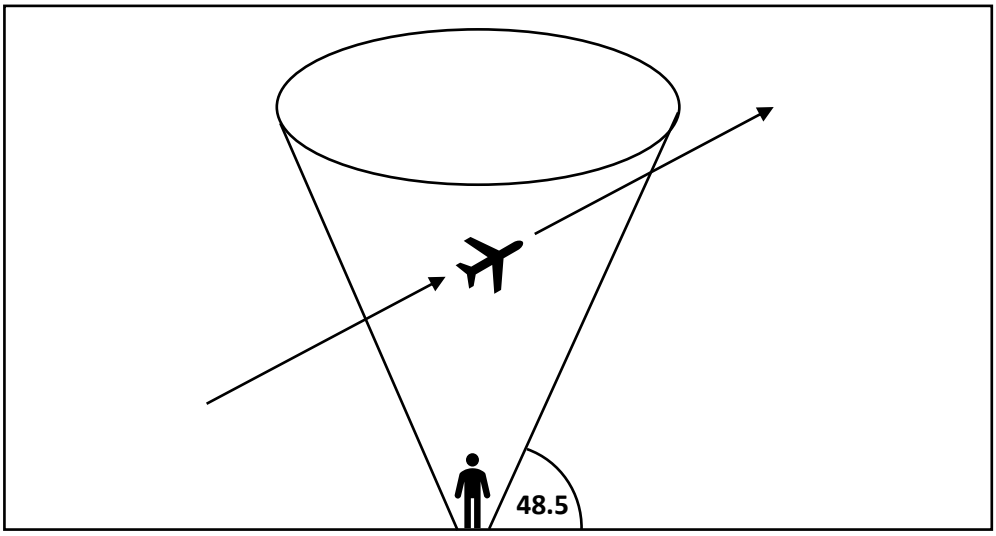

Figure 3: Illustration of an overflight. Any aircraft passing through the cone defined by the 48.5° angle was classed as an overflight.

In total, 1,208 Farnborough flights were identified as overflights of the measurement location, the majority of which were Runway 24 arrivals. Table 1 summarises the total number of overflights. Figure 4 shows the number of overflights that occurred each day.

Runway	Arrivals	Departures	Total
06	145	17	162
24	1,035	11	1,046
Total	**1,180**	**28**	**1,208**

Table 1: Number of flights identified as overflights of the measurement location.

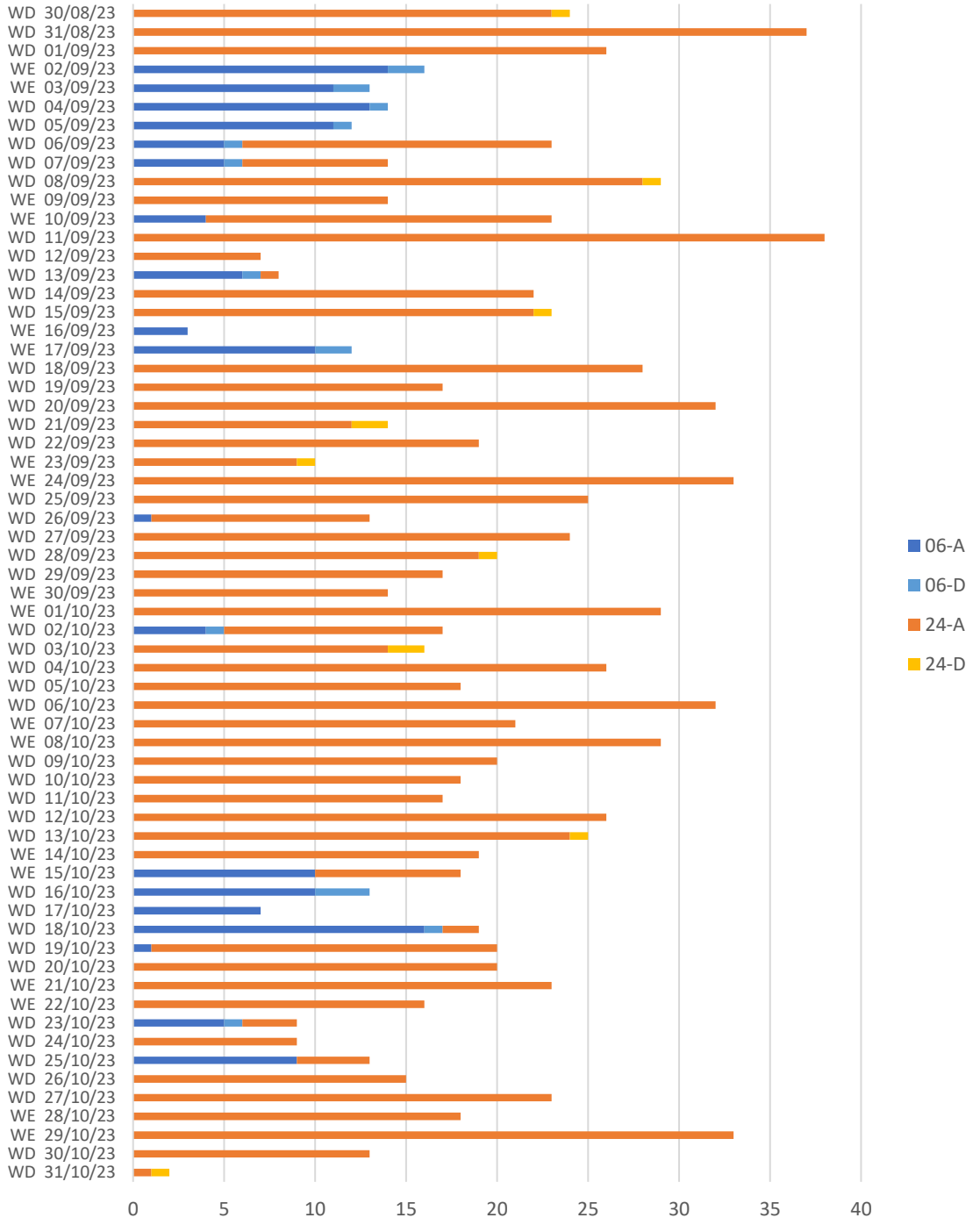

Figure 4: Number of overflights per day. WD is Weekday, WE is Weekend.

NB: data for 30/08/23 and 31/10/23 does not represent the whole day due to installation and removal of the NMT.

Figure 5 shows the average number of overflights 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 overflights per hour. There were no overflights recorded outside those hours.

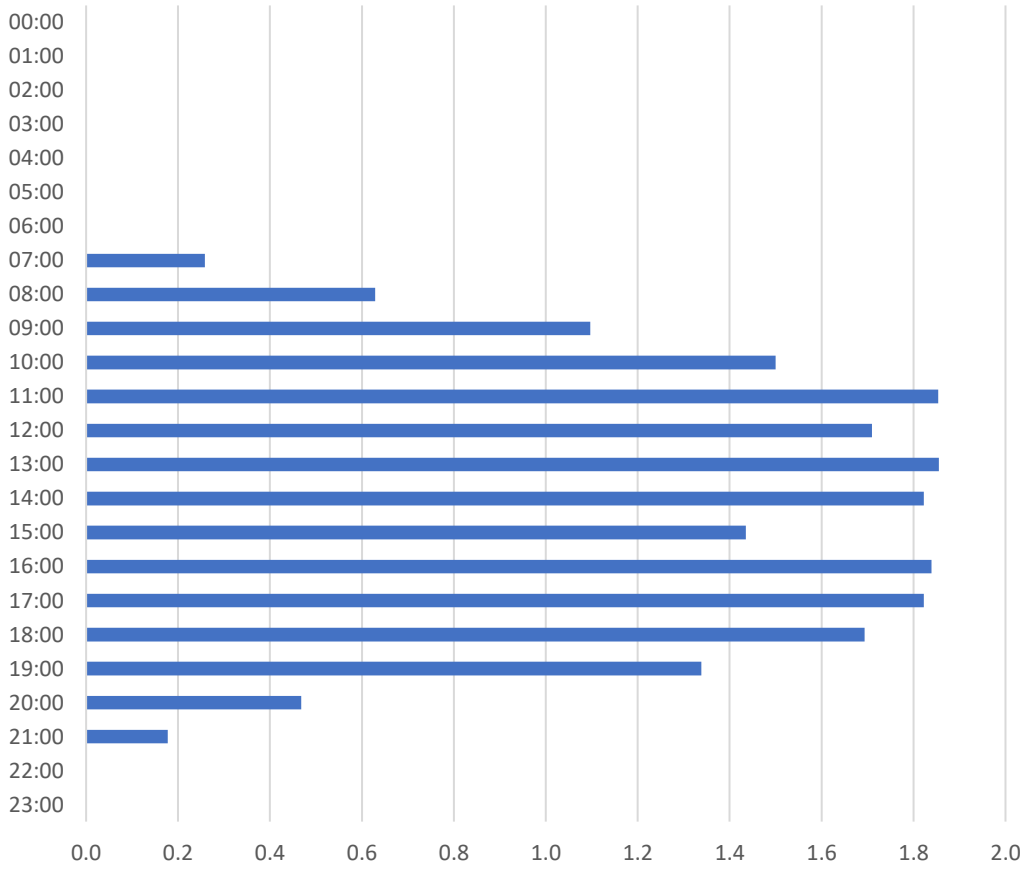

Figure 5: Average number of overflights per hour.

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

Figure 6 and Figure 7 show the actual number of overflights per hour that occurred on the busiest day (11/09/23) and quietest day (16/09/23) in the monitoring period. On the busiest day there were a total of 38 overflights and a maximum of 9 in any hour. On the quietest day there were a total of 3 overflights and a maximum of 1 in any hour.

On average, arrivals to both Runway 06 and Runway 24 were at a height above the airport of around 3,800 ft at their closest lateral distance to the measurement location. Departures, in direct contrast, were on average at over twice the height at around 8,100 ft. Figure 8 shows the height of each overflight in the measurement period.

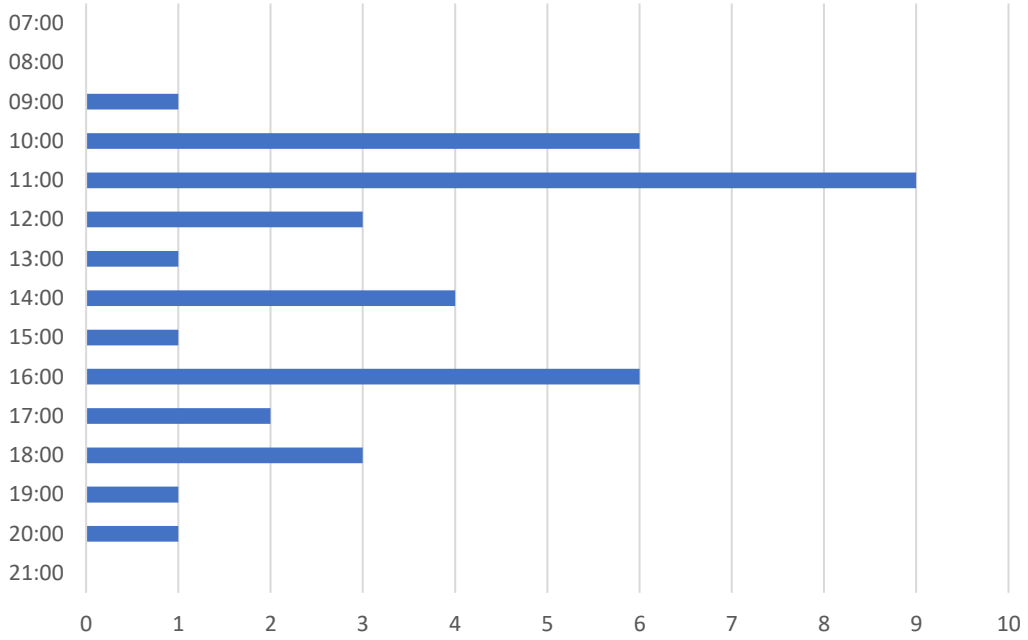

Figure 6: Actual number of overflights per hour, busiest day (11/09/23).

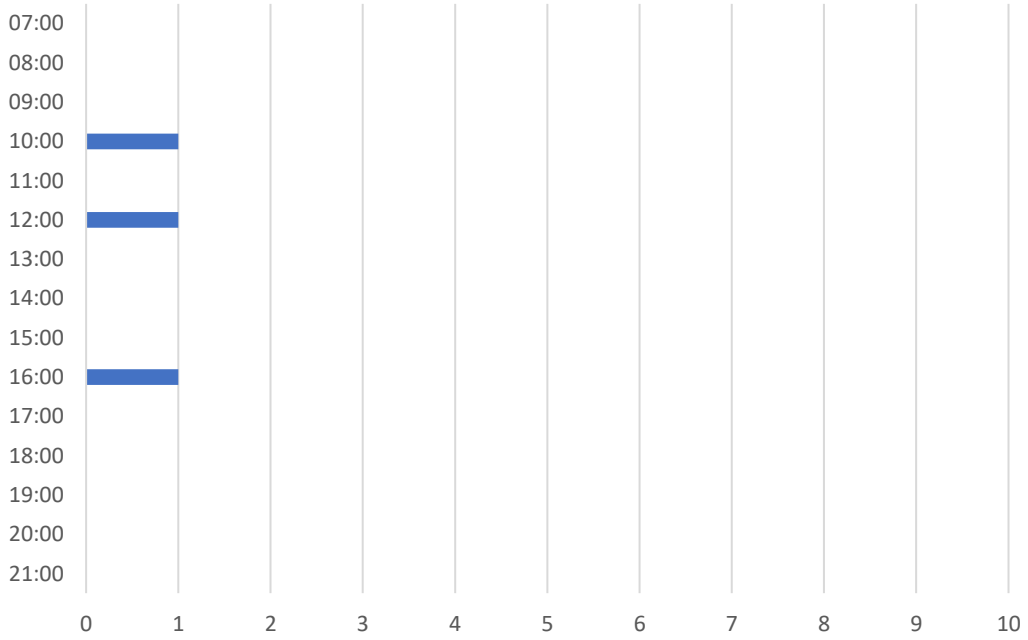

Figure 7: Actual number of overflights per hour, quietest day (16/09/23).

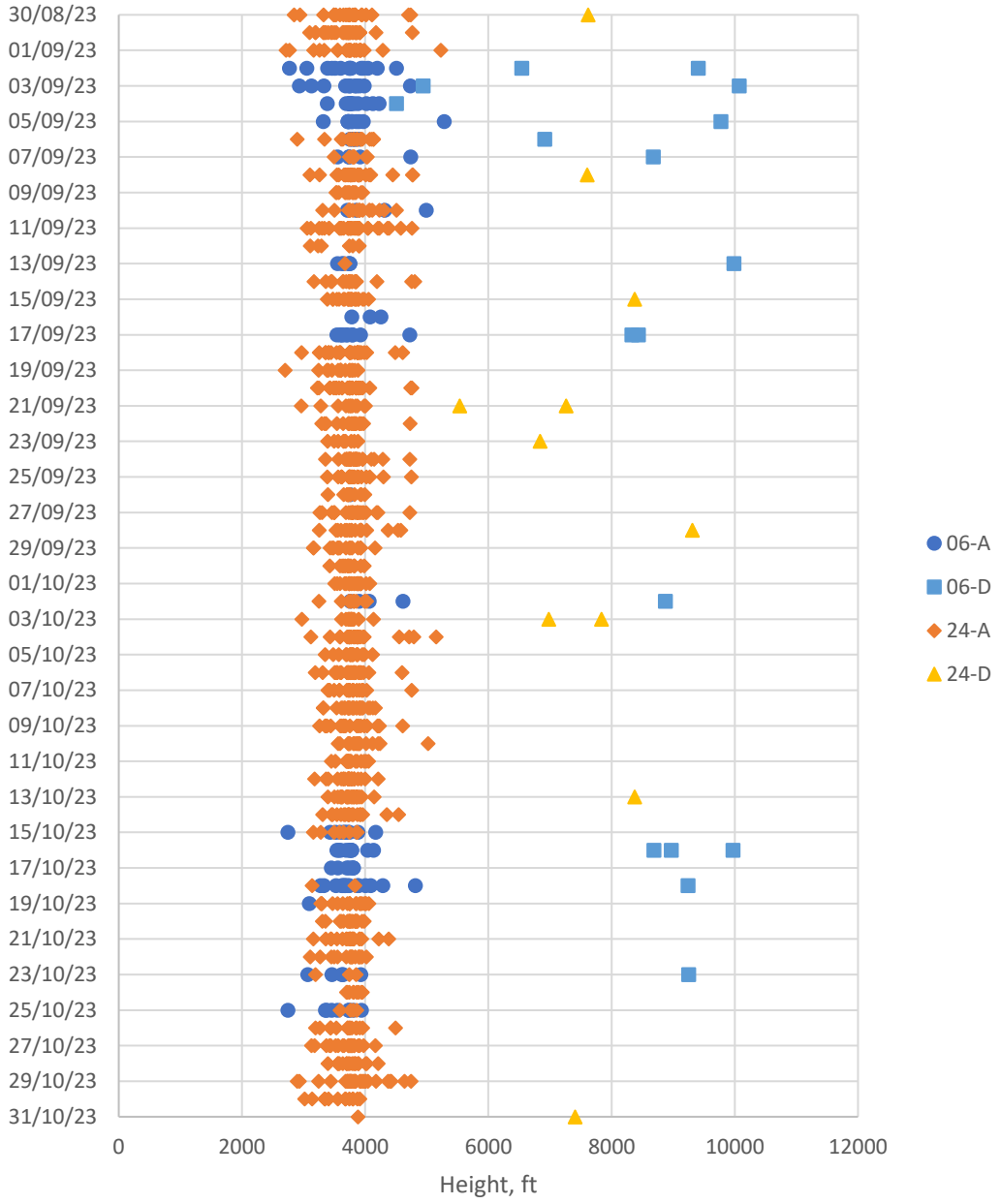

Figure 8: Height above the airport of overflights at their closest lateral distance to the NMT

NB: data for 30/08/23 and 31/10/23 does not represent whole day due to installation and removal of the NMT.

3.0 AIRCRAFT NOISE

Noise data was logged continuously over the measurement period and the overflights identified were correlated with measured noise events. For each overflight the time was determined when the aircraft was at its closest lateral distance to the measurement position. This time was then used to analyse the noise data and find the corresponding noise event. Where there were multiple possible noise events around the time of the overflight it was assumed that the event with the highest maximum noise level corresponded to the overflight.

It is 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 in total, 1,038 of the 1,208 overflights (86%) were correlated with a measured noise event. This is comfortably above the requirement[1] for an automatic sound-monitoring system to correctly classify 50% of aircraft sound events. It is also above the target of 80% applied to the permanent monitoring system around London City Airport.

The noise monitor was situated in a semi-rural location at a property adjacent to the A287 Churt Road. Sources contributing to the noise environment, besides airborne aircraft, therefore included road traffic and domestic activities. The daytime average noise level from all sources throughout the measurement period was 54 dB $L_{Aeq,16h}$ and the corresponding background daytime noise level was 36 dB L_{A90}. The average overflight produced a maximum noise level of 58 dB L_{ASmax}.

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 overflight produced an SEL of 68 dB(A).

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 overflights are those measured by the monitor and as such have not been modified with respect to weather or distance.

Table 2 summarises the number of overflights that were correlated with a noise event by aircraft type, runway and operation. Aircraft types with fewer than 10 measurements have been grouped as 'Other' aircraft. The exceptions are the Piaggio P180 and Bombardier Challenger

[1] BS ISO 20906:2009+A1:2013 Acoustics — Unattended monitoring of aircraft sound in the vicinity of airports

300, as despite the low number of movements particular concern has been expressed regarding these types.

Figure 9 shows the measured noise maximum of all overflight noise events against the ambient and background daytime noise levels.

The radar data shows that the measurement location is primarily overflown by Runway 24 arrivals, and this is reflected in the number of noise measurements collected.

The results for Runway 24 arrivals for aircraft types that were measured at least 10 times and the Piaggio P180 and Bombardier Challenger 300 are presented in detail in Table 3 and Figure 10. On average the Bombardier Challenger 350 aircraft type was around 8 dB(A) noisier than other common aircraft types operating at Farnborough Airport. The Piaggio P180 and Bombardier Challenger 300 aircraft types were measured fewer than 10 times, however the available results indicate a similar noise level to the Bombardier Challenger 350.

Although there were 122 noise correlated overflights for Runway 06 arrivals, only the Cessna Citation Excel was measured at least 10 times. No aircraft types were measured more than 10 times on departure.

Figure 12 replicates Figure 9 while also highlighting overflights by the CL35 aircraft type.

In the figures and tables below, only aircraft measured at least 10 times and the Piaggio P180 and Bombardier Challenger 300 have been considered in detail. As can be seen in 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; the exact position of each aircraft and its distance to the monitor, how each aircraft is being operated, and atmospheric conditions such as temperature, wind speed and direction. The results presented are those measured at the survey location and have not been modified to attempt to allow for these factors. Results for aircraft types with few measurements may not be representative.

Figure 13 summarises the number of overflights that were measured to exceed 65 dB L_{ASmax} each day (N65). On average there was at least 1 such overflight each day, up to a maximum of 4.

Figure 14 shows representative sound levels for a number of non-aircraft activities and situations to aid in comparison with the measured aircraft noise levels.

Aircraft Type			Runway 06		Runway 24	
Code	Description	MTOW[2]	Arrivals	Departures	Arrivals	Departures
C25A	Cessna Citation CJ2	5.6-5.7T	3	1	24	0
C25B	Cessna Citation CJ3	5.7-6.3T	2	0	22	0
C510	Cessna Citation Mustang	3.9T	1	1	13	1
C56X	Cessna Citation Excel	9.1-9.2T	10	1	84	0
C680	Cessna Citation Sovereign	13.6-14.0T	3	0	18	0
C68A	Cessna Citation Latitude	14.0T	7	1	43	1
CL30	Bombardier Challenger 300	17.5-17.6T	0	0	8	0
CL35	Bombardier Challenger 350	18.4T	8	0	66	0
CL60	Bombardier Challenger 600	17.2-21.9T	9	0	37	0
CRJ2	Bombardier CRJ200	20.6-24.0T	6	0	26	0
E35L	Embraer Legacy 600	22.2-22.5T	8	1	35	0
E550	Embraer Legacy 500	17.2-19.4T	2	0	44	0
E55P	Embraer Phenom 300	8.2-8.3T	9	1	67	1
F2TH	Dassault Falcon 2000	16.2-19.4T	7	3	55	2
FA7X	Dassault Falcon 7X	31.3-31.8T	4	1	43	0
FA8X	Dassault Falcon 8X	33.1T	1	1	17	0
GL5T	Bombardier Global 5000	39.8-42.0T	3	0	13	0
GL7T	Bombardier Global 7000	52.1T	1	0	13	0
GLEX	Bombardier Global Express	42.4-45.1T	4	0	49	0
GLF5	Gulfstream V	34.0-41.2T	5	0	28	0
GLF6	Gulfstream G650	34.0-47.0T	2	1	36	0
HDJT	HondaJet	4.8-5.0T	2	0	10	0
P180	Piaggio P180	5.2-5.5T	0	0	3	0
PC12	Pilatus PC-12	4.1-4.7T	2	0	13	0
PC24	Pilatus PC-24	8.0-8.5T	1	0	32	2
Other			17	4	109	1
Total			**117**	**16**	**897**	**8**

Table 2: Number of correlated overflight noise events at the measurement location.

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

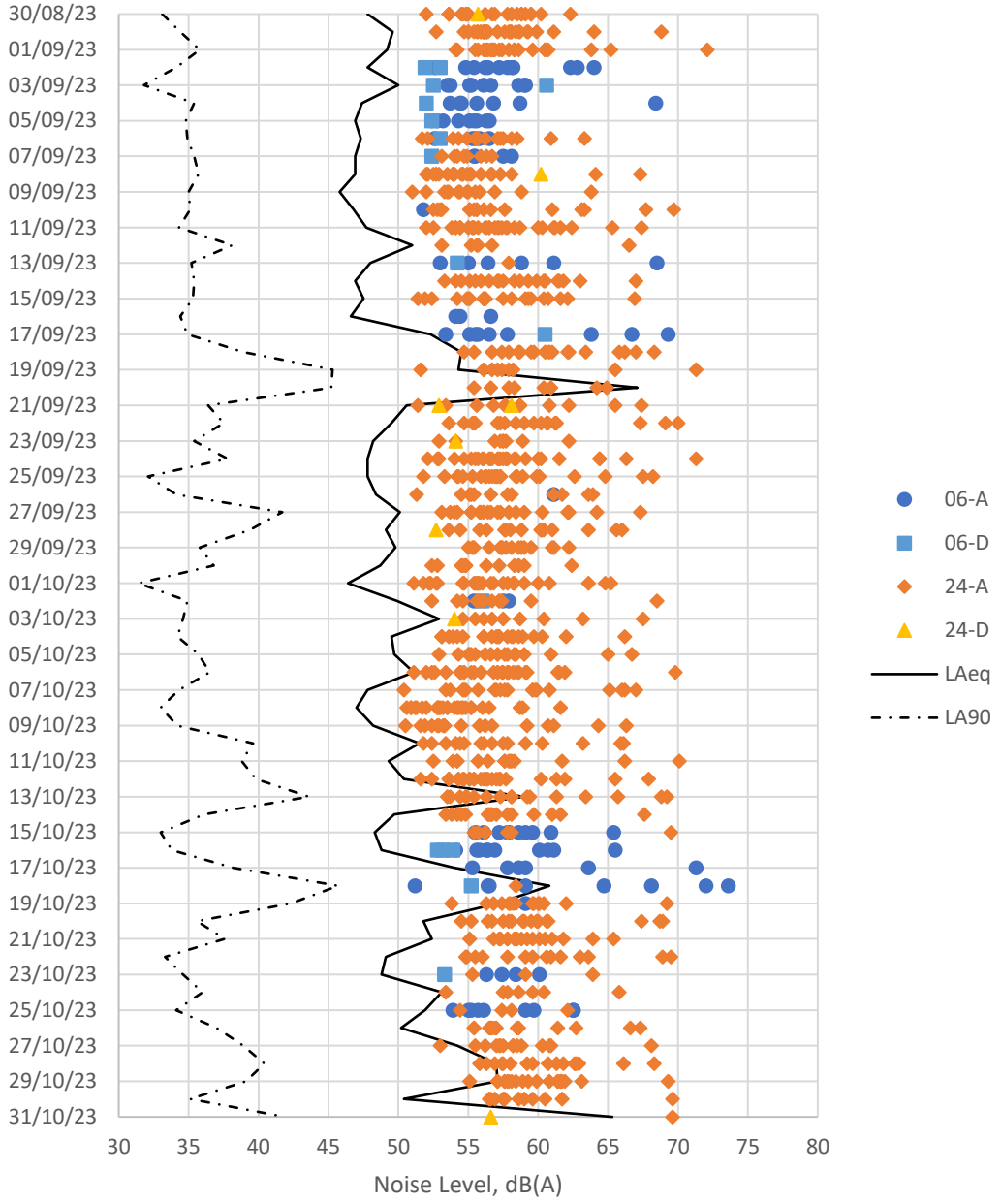

Figure 9: All correlated aircraft noise maxima against average ambient and background noise levels.

NB: data for 30/08/23 and 31/10/23 does not represent whole day due to installation and removal of the NMT.

Figure 9 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 9 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 31st August there were many more overflights than on average and on 1st September there was a particularly loud overflight, but the average noise levels on these days were not particularly high. Similarly, on 20th September the average noise level at the monitor was much higher than normal, but there were relatively few overflights 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[2]	Number	Sound Exposure Level, dB(A)		
Code	Description			Average	Minimum	Maximum
C25A	Cessna Citation CJ2	5.6-5.7T	24	67	59	71
C25B	Cessna Citation CJ3	5.7-6.3T	22	68	64	70
C510	Cessna Citation Mustang	3.9T	13	68	64	72
C56X	Cessna Citation Excel	9.1-9.2T	84	67	57	75
C680	Cessna Citation Sovereign	13.6-14.0T	18	68	64	72
C68A	Cessna Citation Latitude	14.0T	43	68	62	75
CL30	Bombardier Challenger 300	17.5-17.6T	8	77	74	81
CL35	Bombardier Challenger 350	18.4T	66	76	68	79
CL60	Bombardier Challenger 600	17.2-21.9T	37	68	59	77
CRJ2	Bombardier CRJ200	20.6-24.0T	26	66	63	72
E35L	Embraer Legacy 600	22.2-22.5T	35	66	57	72
E550	Embraer Legacy 500	17.2-19.4T	44	65	58	71
E55P	Embraer Phenom 300	8.2-8.3T	67	68	59	73
F2TH	Dassault Falcon 2000	16.2-19.4T	55	65	60	73
FA7X	Dassault Falcon 7X	31.3-31.8T	43	70	58	74
FA8X	Dassault Falcon 8X	33.1T	17	70	63	72
GL5T	Bombardier Global 5000	39.8-42.0T	13	69	58	73
GL7T	Bombardier Global 7000	52.1T	13	66	60	72
GLEX	Bombardier Global Express	42.4-45.1T	49	70	64	74
GLF5	Gulfstream V	34.0-41.2T	28	67	60	72
GLF6	Gulfstream G650	34.0-47.0T	36	68	62	75
HDJT	Honda HA-420	4.8-5.0T	10	65	60	73
P180	Piaggio P180	5.2-5.5T	3	76	75	77
PC12	Pilatus PC-12	4.1-4.7T	13	69	58	74
PC24	Pilatus PC-24	8.0-8.5T	32	69	60	72

Table 3: Measured noise levels (SEL) of Runway 24 arrivals for common aircraft types.

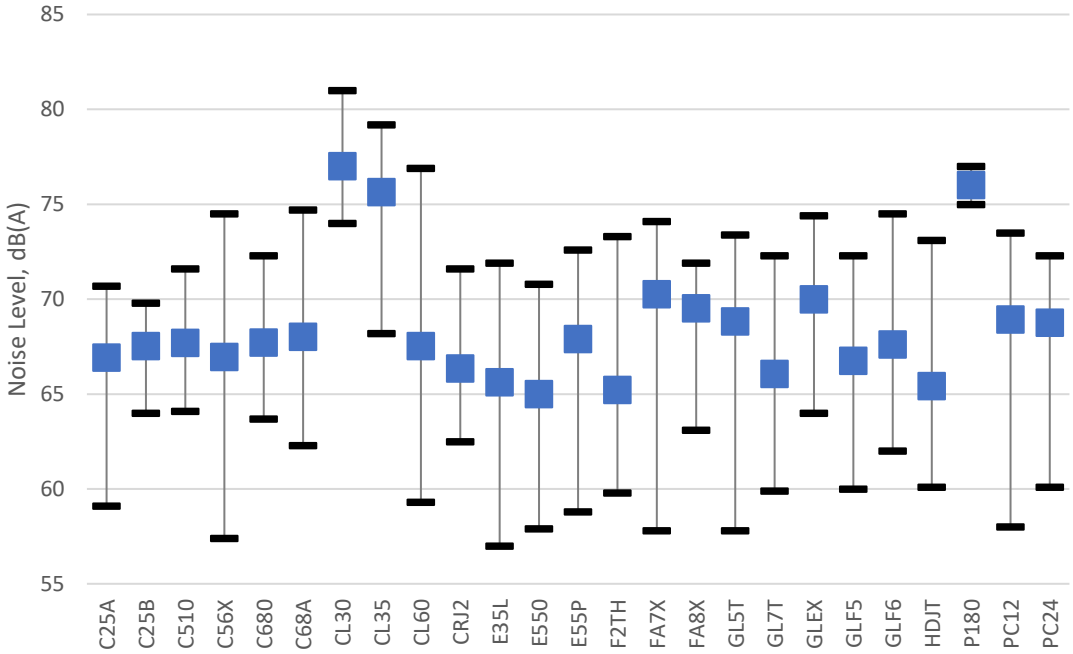

Figure 10: Measured noise levels (SEL) of Runway 24 arrivals for common aircraft types. Blue: average SEL. Black: minimum SEL and maximum SEL.

Although Figure 10 indicates a range of measured noise results for each aircraft type, each aircraft type typically shows a distribution around the average as shown in Figure 11 for the Bombardier Challenger 350.

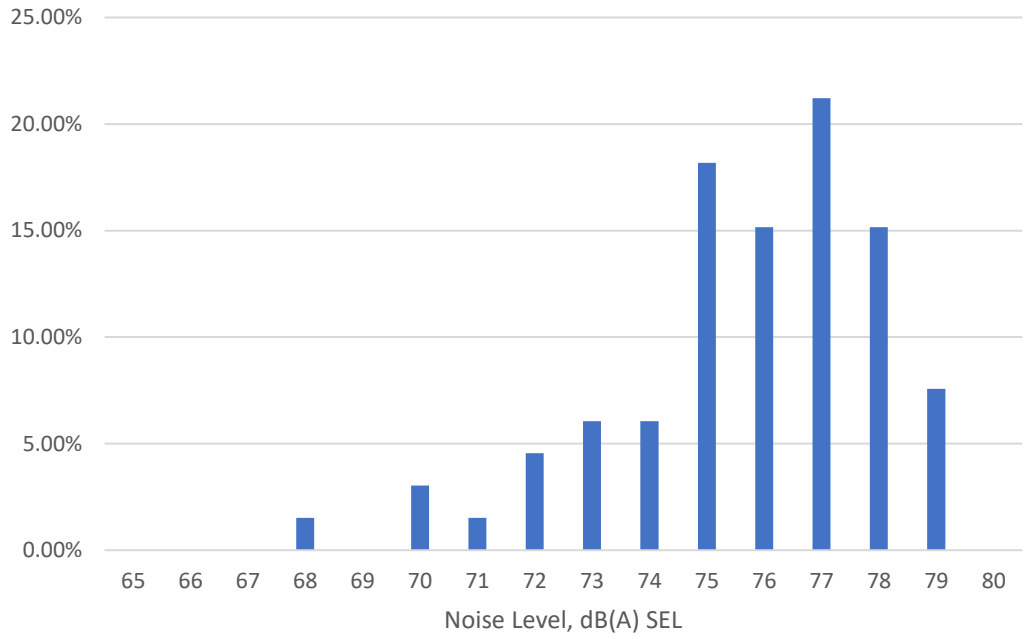

Figure 11: Distribution of measured noise levels (SEL) for Runway 24 arrivals by the Bombardier Challenger 350 aircraft type.

NB: the noise level refers to the lower threshold, that is 74 dB(A) refers to measurements in the range 74.0 – 74.9 dB(A).

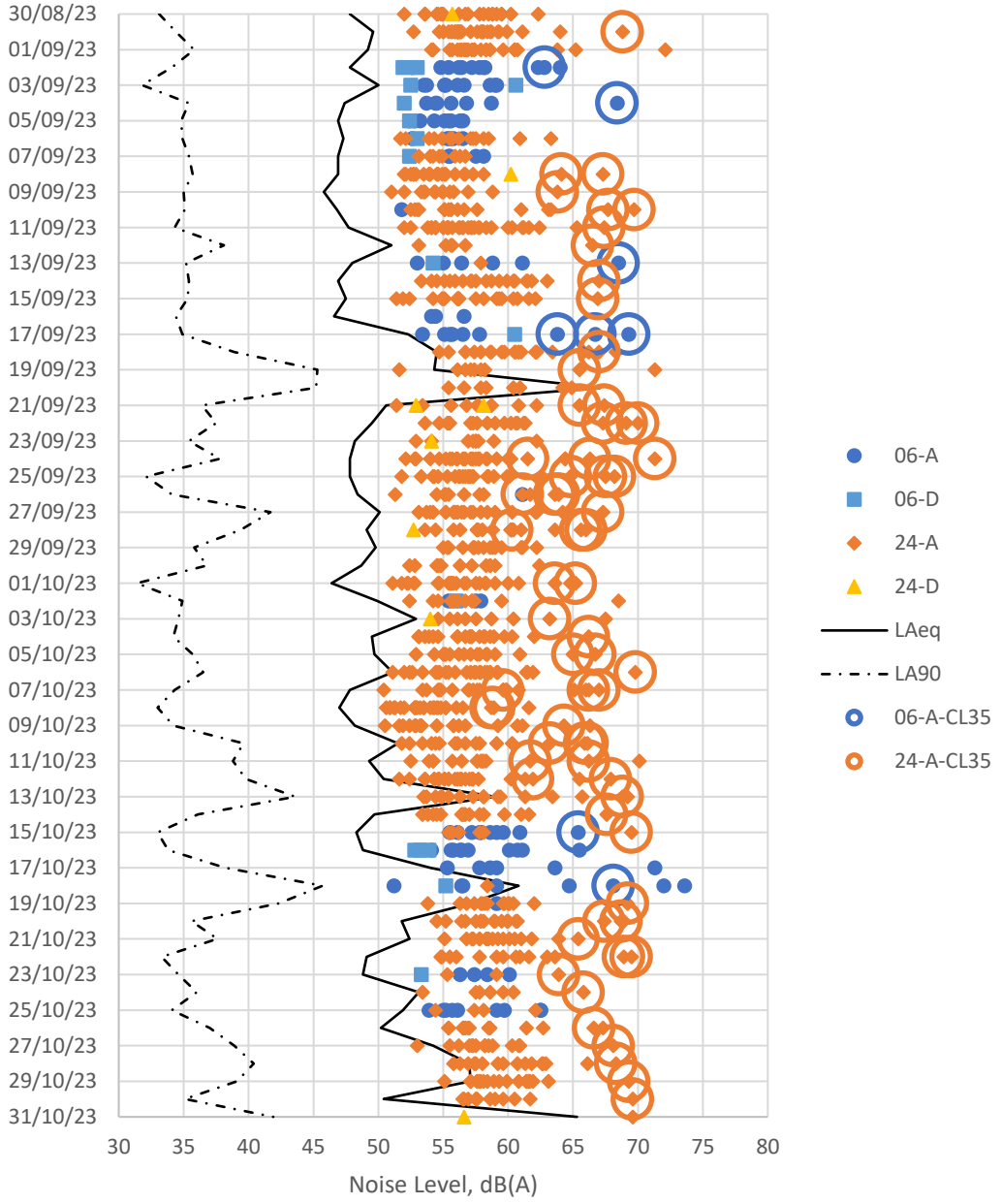

Figure 12: All correlated aircraft noise maxima against average ambient and background noise levels. Overflights by the CL35 aircraft type are circled.

NB: data for 30/08/23 and 31/10/23 does not represent whole day due to installation and removal of the NMT.

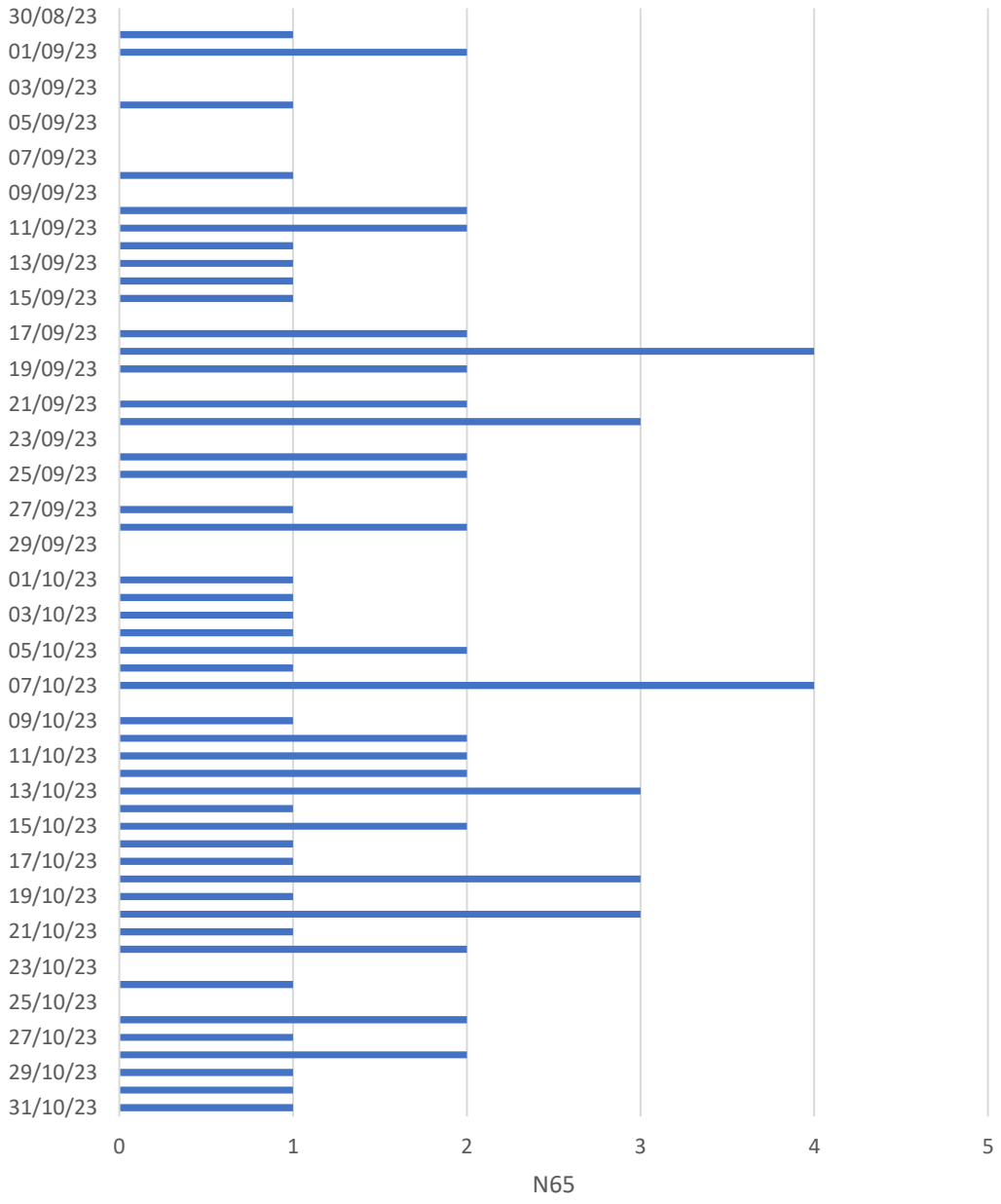

Figure 13: Number of overflights measured as exceeding 65 dB L_{ASmax} per day (N65).

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

4.0 SUMMARY

Aircraft operations and noise levels were monitored in Churt from 30 August 2023 to 31 October 2023. This found that:

- The majority of overflights (1,180 of 1,208, or 98%) were arrivals and the majority of these were Runway 24 operations (1,035 of 1,180, or 88%).
- The overall runway usage during the measurement period was 22%/78% between R06/R24. Compared to the 12%/88% split in overflights, this suggests that Runway 24 operations are more likely to overfly Churt than those on runway 06.
- There were a total of 2,430 Runway 24 arrivals in the measurement period. 43% of these were identified as overflying Churt.
- Across the airport's operational hours (07:00 – 22:00 on weekdays and 08:00-20:00 at the weekend) there were on average between 1 and 2 overflights per hour and none recorded outside those hours.
- The average maximum noise level produced by each overflight was around 58 dB L_{ASmax}, compared to the average ambient noise level of 54 dB $L_{Aeq,16h}$. The corresponding SEL, accounting for the duration of each overflight, was 68 dB(A) SEL.
- On average there was at least 1 and on occasion up to 4 overflights per day producing a maximum noise level of 65 dB L_{ASmax} or greater.
- Overflights by Bombardier Challenger 300 and Challenger 350 aircraft were on average noisier, by around 8 dB(A), compared to the average aircraft operating at Farnborough Airport. These aircraft types accounted for around 9% of overflights and 7% of all flights in the monitoring period.

Mike Pau	**Duncan Rogers**	**David Charles**
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.