Bickerdike Allen Partners
Architecture Acoustics Technology

AIRCRAFT NOISE SURVEY

OVERFLIGHT MEASUREMENTS

Report to

London City Airport
City Aviation House
London City Airport
The Royal Docks
London E16 2PB

A11327_12_RP056_3.0
24 November 2023

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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) have been commissioned by London City Airport (LCA) to carry out a survey to measure the noise of aircraft while in level flight. The survey measured aircraft noise in August, September and October 2023 at two locations; one in Lambeth under the flight path for Runway 09 arrivals and one in Ilford under the flight path for Runway 27 departures. The locations are shown on a map in Figure A11327_12_DR001, along with the locations of the airport's six permanent noise monitoring terminals (NMTs).

This report provides a summary of the noise measurements and a comparison of current generation and next generation aircraft, in particular it compares the measurements for the current generation Embraer E190 with those for the new generation Embraer E190-E2 and Airbus A220-100.

A glossary of acoustic terminology is provided in Appendix 1.

2.0 SURVEY DETAILS

2.1 Locations

2.1.1 Lambeth Location

The measurement location in Lambeth was at Roots and Shoots, Walnut Tree Walk, Lambeth SE11 6DN. This location is around 11 km west and 1.5 km south of LCA. It is typically overflown by aircraft on an easterly approach to LCA, as they turn to line up with Runway 09 for their final approach. Some aircraft using London Heathrow Airport also pass close to this location when arriving during periods of westerly operations. The monitor in Lambeth was installed on a roof terrace, approximately 10m above the ground.

2.1.2 Ilford Location

The measurement location in Ilford was at Avanti Court Primary School, Carlton Drive, Ilford IG6 1LU. This location is around 9 km north and 2 km east of LCA. It is typically overflown by a proportion of aircraft which depart LCY on Runway 27 during westerly operations.

2.2 Methodology

Long-term unattended noise monitors were set up in each location, where environmental noise measurements were carried out in general accordance with BS 7445-1:2003[1].

[1] British Standards Institute, BS 7445-1:2003 Description and measurement of environmental noise, 2003

The monitors recorded noise data continuously while they were operational. There were some periods during which the monitors were not operational, for example while batteries were changed.

2.3 Equipment

The equipment used for the long-term surveys were Norsonic Type 140 sound level meters, with their microphone mounted on poles so they were approximately 3 m above the roof terrace in Lambeth and 3m above the ground in Ilford, and clear of reflecting surfaces. The monitor installation is shown in Figure 1 for Lambeth and Figure 2 for Ilford. The monitors were checked for correct calibration at the start and end of the measurements, and no significant drift was observed.

Figure 1: Noise Monitor Location, Lambeth

Figure 2: Noise Monitor Location, Ilford

3.0 SURVEY RESULTS

3.1 Flight Tracks

LCA has provided BAP with the aircraft movement data and flight track data for the monitoring period. BAP have reviewed the flight tracks to determine only those flights which passed close to the monitor locations.

3.2 Noise Measurements

The noise monitoring data was processed by BAP to correlate the measured noise levels with the aircraft movement data, provided by the airport. Measurements of the same aircraft operations were also extracted from the noise monitoring system at the airport.

All noise levels and differences presented in the tables in this section have been rounded to 1 decimal place. The differences are based on the unrounded values and therefore in some cases may differ by 0.1 from the difference between the values in the tables.

3.2.1 Lambeth Measurements - Arrivals

During the measurement period there were 1,198 arrivals which used Runway 09 and passed close to the monitor. Of these 1,190 (99%) were correlated with a noise event at the monitor. The correlated aircraft noise events for the key types are summarised in Table 1.

Aircraft Type	No. Correlated	Average L_{Amax} (dB)	Average SEL (dB(A))
Embraer E190	944	71.8	81.6
Airbus A221	33	68.3	78.4
Embraer E290	47	69.9	80.3
Next Gen Avg	80	69.2	79.5
Next Gen Avg Improvement	-	**2.5**	**2.1**

Table 1: Summary of Arrival Noise Results – Lambeth Survey Location

The results of the similar analysis undertaken for the fixed Noise Monitoring Terminals (NMTs) for the same flights is summarised in Table 2.

Aircraft Type	NMT1/2 average			NMT5		
	No. Correlated	Avg L_{Amax} (dB)	Avg SEL (dB(A))	No. Correlated	Avg L_{Amax} (dB)	Avg SEL (dB(A))
Embraer E190	938	79.0	86.9	938	74.5	83.8
Airbus A221	33	75.9	84.3	32	70.9	80.8
Embraer E290	47	75.8	84.4	46	71.3	81.2
Next Gen Avg	80	75.8	84.3	78	71.2	81.0
Next Gen Avg Improvement	-	**3.2**	**2.5**	-	**3.4**	**2.7**

Table 2: Summary of Arrival Noise Results – NMTs

3.2.2 Ilford Measurements - Departures

During the measurement period there were 773 departures which used Runway 27 and passed close to the monitor. Of these 725 (94%) were correlated with a noise event at the monitor. The correlated aircraft noise events for the key types are summarised in Table 3.

Aircraft Type	No. Correlated	Average L_{Amax} (dB)	Average SEL (dB(A))
Embraer E190	534	64.9	74.7
Airbus A221	30	61.3	71.1
Embraer E290	34	61.8	71.5
Next Gen Avg	64	61.6	71.3
Next Gen Avg Improvement	**-**	**3.4**	**3.4**

Table 3: Summary of Departure Noise Results – Ilford Survey Location

The results of the similar analysis undertaken for the fixed NMTs for the same flights is summarised in Table 4.

Aircraft Type	NMT1/2 average			NMT5		
	No. Correlated	Avg L_{Amax} (dB)	Avg SEL (dB(A))	No. Correlated	Avg L_{Amax} (dB)	Avg SEL (dB(A))
Embraer E190	524	89.4	97.8	524	76.0	86.2
Airbus A221	30	84.0	92.0	30	71.8	81.2
Embraer E290	33	84.2	91.7	33	70.9	81.2
Next Gen Avg	63	84.1	91.8	63	71.3	81.4
Next Gen Avg Improvement	**-**	**5.3**	**6.0**	**-**	**4.7**	**4.8**

Table 4: Summary of Departure Noise Results – NMTs

4.0 ANALYSIS OF RESULTS

Noise in the UK is typically assessed using the L_{Aeq} metric, which averages the noise energy over a specified period (e.g. 16 hours for daytime). The SEL metric is most directly related to such assessments, when measuring individual aircraft. However, the L_{Amax} metric is easier to understand, simply being the highest noise level measured during an aircraft overflight.

In the recent planning application, the assumptions regarding the noise level of the next generation aircraft currently operating at the airport are given in Table 5.

Aircraft Type	Change in Noise Level Compared to Embraer E190, dB(A) SEL	
	Arrival	Departure
Airbus A221	-2.8	-5.1
Embraer E290	-3.2	-5.4

Table 5: New Generation Aircraft Noise Levels Compared to Embraer E190

These assumptions were derived from the results at the NMTs in the period 2019-2021 and are based on the average improvement measured across the airport's six fixed NMTs. The latest NMT results are similar, with a slight reduction in the improvement for arrivals, and very similar improvement for departures.

Comparing the overflight survey results, for both arrivals and departures the improvements for next generation aircraft are not as large as those measured at the NMTs, however it is still clear that the next generation aircraft are quieter and therefore represent a benefit in noise terms compared to the current generation.

For departures, it is to be expected that the benefits of the next generation aircraft, which primarily relate to improved engine performance, would be reduced during sections of level flight. This is due to the engines being at a lower thrust and so the noise from them is a relatively smaller component of the total aircraft noise. The lower thrust also contributes to significantly lower noise levels at the Ilford location than at the fixed monitors closer to the airport. The measured levels in Ilford under the level flight path were over 10 dB quieter than those measured at NMT5 and over 20 dB quieter than those measured at NMTs 1 and 2.

For arrivals, the difference in the improvements is smaller between the locations. However, absolute noise levels are also lower further from the airport. The measured levels in Lambeth under the level flight path were around 2 dB quieter than those measured at NMT5 and around 5 dB quieter than those measured at NMTs 1 and 2.

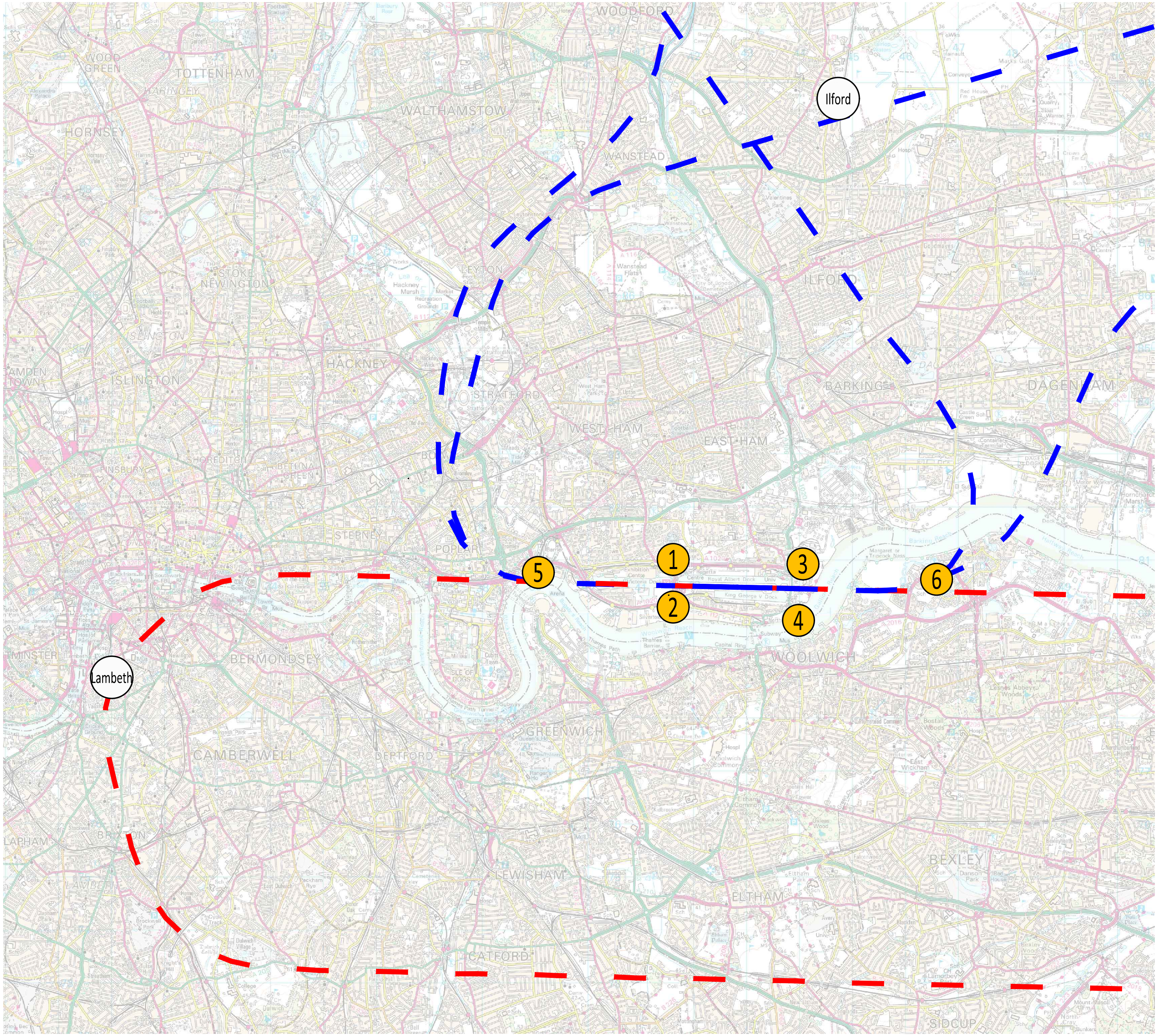
5.0 SUMMARY

BAP have carried out long-term noise surveys at two locations to measure the aircraft noise levels and have reported the results. A comparison has been carried out between current generation and next generation aircraft, in particular comparing the measurements for the Embraer E190 with those for the Embraer E190-E2 and the Airbus A220-100.

The measurements find the next generation aircraft are quieter than the current generation aircraft, although the improvement is slightly lower than that measured at the airport's fixed Noise Monitoring Terminals.

The absolute noise levels for all of the aircraft types are lower at the more distant locations from the airport under the level flight paths compared to the levels measured at the airport's NMTs, particularly for departures.

Nick Williams	**David Charles**
for Bickerdike Allen Partners LLP	**Partner**



LEGEND:

X Survey Locations

X Permanent Noise Monitors

Typical Departure Tracks

Typical Arrival Tracks

REVISIONS

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London City Airport

Survey Locations

DRAWN: DR CHECKED: DC

DATE: November 2023 SCALE: 1:100,000@A4

FIGURE No:

A11327_12_DR001_1.0

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

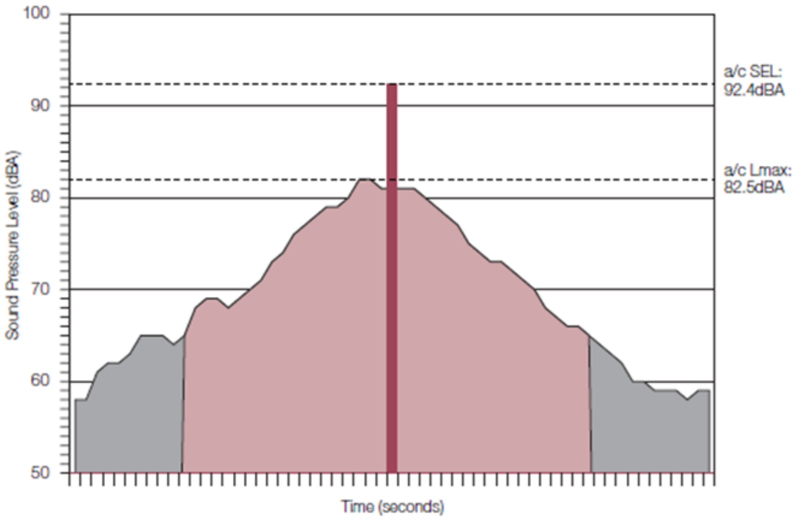
The sensitivity of the ear is frequency dependent. Sound level meters are fitted with a weighting network which approximates to this response and allows sound levels to be expressed as an overall single figure value, in dB(A).

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.
$L_{Amax,T}$	The maximum A-weighted sound pressure level, normally associated with a time weighting, F (fast), or S (slow)
Sound Exposure Level (SEL)	An SEL is a measure the total noise from an aircraft movement. The SEL noise level for an aircraft movement is the sum of all the noise energy for the event expressed as an average noise level for 1 second. This is shown in the graph below:

Figure 3.1: Aircraft time history, showing maximum level L_{Amax} and associated Sound Exposure Level (SEL)[41]



Source: CAA data

Sound Transmission in the Open Air

Most sources of sound can be characterised as a single point in space. The sound energy radiated is proportional to the surface area of a sphere centred on the point. The area of a sphere is proportional to the square of the radius, so the sound energy is inversely proportional to the square of the radius. This is the inverse square law. In decibel terms, every time the distance from a point source is doubled, the sound pressure level is reduced by 6 dB.

Road traffic noise is a notable exception to this rule, as it approximates to a line source, which is represented by the line of the road. The sound energy radiated is inversely proportional to the area of a cylinder centred on the line. In decibel terms, every time the distance from a line source is doubled, the sound pressure level is reduced by 3 dB.

Factors Affecting Sound Transmission in the Open Air

Reflection

When sound waves encounter a hard surface, such as concrete, brickwork, glass, timber or plasterboard, it is reflected from it. As a result, the sound pressure level measured immediately in front of a building façade is approximately 3 dB higher than it would be in the absence of the façade.

Screening and Diffraction

If a solid screen is introduced between a source and receiver, interrupting the sound path, a reduction in sound level is experienced. This reduction is limited, however, by diffraction of the sound energy at the edges of the screen. Screens can provide valuable noise attenuation, however. For example, a timber boarded fence built next to a motorway can reduce noise levels on the land beyond, typically by around 10 dB(A). The best results are obtained when a screen is situated close to the source or close to the receiver.

Meteorological Effects

Temperature and wind gradients affect noise transmission, especially over large distances. The wind effects range from increasing the level by typically 2 dB downwind, to reducing it by typically 10 dB upwind – or even more in extreme conditions. Temperature and wind gradients are variable and difficult to predict.