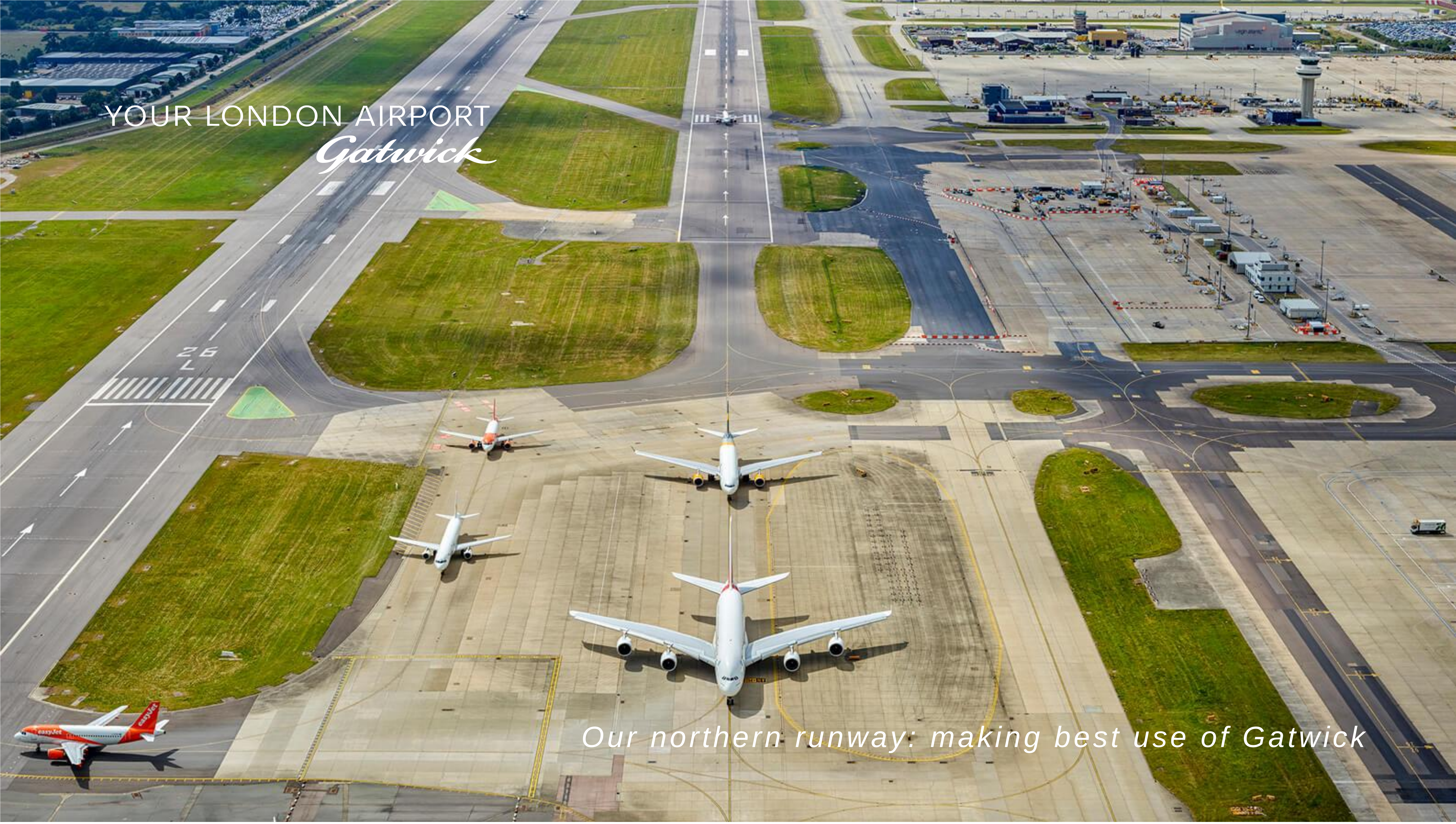

Preliminary Environmental Information Report
Appendix 14.9.3: Ground Noise

September 2021

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1 Introduction

1.1 General

1.1.1 This document forms Appendix 14.9.3 of the Preliminary Environmental Information Report (PEIR) prepared on behalf of Gatwick Airport Limited (GAL). The PEIR presents the preliminary findings of the Environmental Impact Assessment (EIA) process for the proposal to make best use of Gatwick Airport's existing runways (referred to within this report as 'the Project'). The Project proposes alterations to the existing northern runway which, together with the lifting of the current restrictions on its use, would enable dual runway operations. The Project includes the development of a range of infrastructure and facilities which, with the alterations to the northern runway, would enable the airport passenger and aircraft operations to increase. Further details regarding the components of the Project can be found in the Chapter 5: Project Description.

1.1.2 This document provides details of the ground noise modelling for the Project.

2 Baseline Study

2.1 Baseline Receptor Noise Survey

2.1.1 For the assessment of ground noise, around the perimeter of the airport, long term average L_{Aeq} noise levels over the day (07:00-23:00) and night (23:00-07:00) periods have been calculated with reference to the results of a 2-week baseline noise survey in 2016. The 12 sites surveyed are shown in Figure 14.4.1. The overall average daytime and night-time measured L_{Aeq} sound levels, including all noise sources, are shown at Table 2.1.1. The pattern of ground operations on the airfield is different between the two runway modes of operation (26 and 08) so the survey results for the two runway modes are reported separately.

Table 2.1.1: Summary of Average 2016 Baseline Measurements

Descriptor	Location ($L_{Aeq, T}$ dB)											
	1	2	3	4	5	6	7	8	9	10	11	12
26 Daytime	56	60	61	58	51	55	60	60	67	60	56	61
26 Night	50	54	55	50	44	52	56	56	61	54	51	56
08 Daytime	53	56	57	56	48	57	60	61	66	60	59	68
08 Night	52	54	55	53	47	54	55	56	61	56	54	61

2.1.2 It should be noted that the long-term average results of the 2016 baseline survey are generally representative of neutral weather conditions (typically characterised by low wind speeds) which have relatively little effect on the propagation of noise.

2.1.3 The 2016 baseline ground noise has been predicted at the same receptor locations that were used for the measurements. The results are presented at Table 14.6.4 in Chapter 14 of the PEIR. It is noted that these do not include road traffic or air noise.

2.1.4 The predicted 2016 baseline noise levels (presented in Chapter 14 of the PEIR) are, in some cases, higher than the average measured 2016 baseline noise levels. For locations where ground noise is dominating the ambient noise environment, this is not unexpected since although the predictions represent have been corrected for average wind conditions, this is a conservative correction and can still be considered to represent a realistic worst-case scenario. The noise propagation methodology used in the ground noise modelling is carried out according to ISO9613-2 and within the scope of this standard it states:

> *'The method predicts the equivalent continuous A-weighted sound pressure level (as described in parts 1 to 3 of IS0 1996) under meteorological conditions favourable to propagation from sources of known sound emission. These conditions are for downwind propagation, as specified in 5.4.3.3 of IS0 1996-21987…'*

2.1.5 Since the current version of ISO9613 was published in 1996, the other standard referred to (ISO1996) has been updated and the latest version published in 2017 includes details about expected propagation under downwind conditions at Annex G. Annex G discusses an example of traffic noise predicted at 200 m from a road providing a figure which demonstrates 7-10 dB increase between neutral weather conditions and 'very favourable' downwind weather conditions. In order to consider downwind propagation of ground noise at Gatwick, the results of the 2016 baseline survey have been analysed to find the maximum measured $L_{Aeq, 1\text{-}hour}$ levels at each location (for day and night periods separately). The long-term average levels have then been subtracted from the maximum 1-hour averages to show the maximum upward variance in measured noise levels as shown below.

Table 2.1.2: Summary of Maximum Variance in measured 2016 Baseline Levels above the mean (dB L_{Aeq})

Descriptor	Location ($L_{Aeq, T}$ dB)											
	1	2	3	4	5	6	7	8	9	10	11	12
26 Daytime	7	7	5	6	10	8	4	5	3	6	6	4
26 Night	8	8	8	7	8	7	6	5	8	9	9	4
08 Daytime	10	7	7	5	14	15	12	6	4	5	4	2
08 Night	11	11	12	9	9	6	5	7	10	9	9	7

2.1.6 It can be seen that the variation in the measured 2016 baseline noise, in terms of the maximum variance above the long-term average, generally shows some 1-hour periods over the baseline survey where favourable downwind conditions occurred resulting in a 7-10 dB increase in ground noise.

2.1.7 Allowing for this variation in the baseline noise measurements, and expected increase due to favourable downwind conditions, the 2016 predicted ground noise levels (presented at Chapter 14 of the PEIR) are within the expected range.

2.2 Model Review

2.2.1 Hayes Mckenzie has developed an equivalent point source noise model for predicting airport ground noise, and this has previously been used for ground noise assessment at Gatwick Airport. Whilst the acoustic propagation within this model is based on methodology within ISO9613-2, the parameters which are used for defining the equivalent point sources have been developed over a number of years by Hayes McKenzie. A review of the existing ground noise model parameters was carried out and it was identified that source noise data for aircraft were quite out of date and required updating if possible. A study carried out at Madrid Airport (Ansensio *et al*., 2007) provided some useful source noise data for comparison with the data used in previous ground noise modelling exercises (most recently for the 2019 master plan). A brief review of the derived source noise data from the Madrid Airport study confirmed that data used in previous ground noise modelling carried out for Gatwick were appropriate, if slightly conservative by comparison. However, the data are now more than 10 years old and do not include next generation aircraft such as the Airbus A320 Neo. The methodology used in the Madrid Airport study provides a useful measurement protocol for estimating the sound power of taxiing aircraft and this was used as a basis for a survey of taxiing aircraft noise at Gatwick carried out in March/April 2019 (see Section 2.3).

2.2.2 More recently, some work sponsored by the Federal Aviation Administration (FAA) was published by the National Academy of Science as a web-based document (National Academies of Sciences, Engineering, and Medicine, 2013) and this builds on the work carried out at Madrid Airport. This National Academy of Science document presents measurements carried out by Wyle Laboratories at Washington (Dulles) Airport and provides comparison with the data from Madrid Airport. The data in this document are more difficult to interpret in relation to the data used in previous Gatwick modelling as they are not provided in a comparable format. The document was written with the view to developing the FAA’s noise modelling software for use in ground noise modelling and noise levels are represented in dB Sound Exposure Levels (SELs) for standard distances from aircraft as defined and used in the FAA models. Whilst the presented noise levels are not directly comparable, the results do provide more confidence in the results of the Madrid Airport aircraft taxi noise measurements. In addition, the measurement protocol used by the Wyle Laboratories is very similar to that used in the Madrid Airport study.

Wind Speed and Direction

2.2.3 Another aspect of the noise model that has been reviewed is the inherent effect of wind speed and direction on predicted noise levels. Since the wind direction determines whether the airport operates in runway 08 or runway 26 mode, it would seem appropriate to allow for wind conditions in the noise model. As discussed at paragraph 2.1.4, the ISO 9613-2 methodology results in an absolute worst-case “downwind” predicted noise level and although there is some discussion about a meteorological correction, there is no detailed methodology for implementing this and the standard does not provide clear guidance on how to correct predicted noise levels for average wind conditions.

2.2.4 In order to make an allowance for the average wind conditions experienced during the typical 92-day summer period, various methodologies were considered. A potentially suitable meteorological correction was found within a road traffic noise model published by the Acoustical Society of Japan (ASJ RTN 2018) and this was investigated further to understand the relevance to airport ground noise. Section 3.6 on the road traffic noise model is relatively brief and provides a simple formula for correcting overall A-weighted L_{Aeq} levels to account for meteorological effects. The model is based around determining predicted noise levels for neutral wind conditions over relatively short distances so the correction can be positive or negative depending on whether the conditions are favourable (downwind) or unfavourable (upwind).

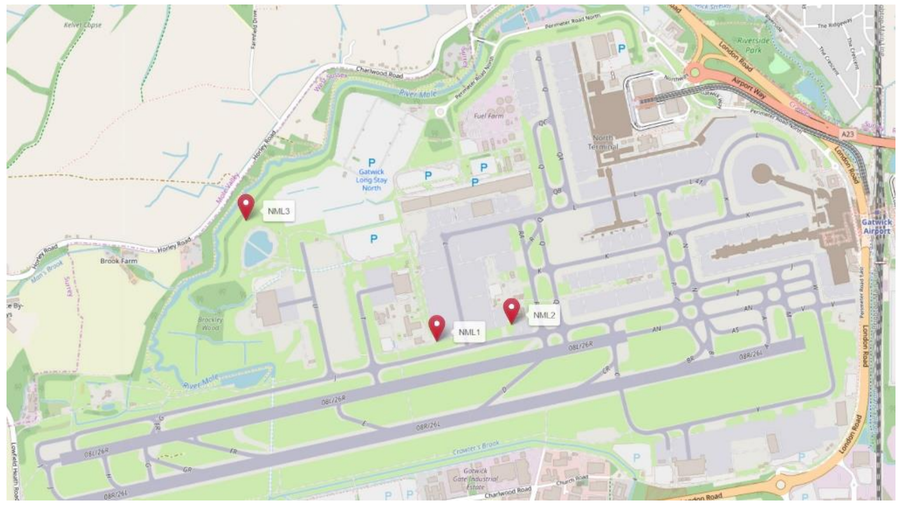
2.2.5 The origin of the meteorological correction in the road traffic noise model is referenced to a study published in 1983 and written by H. Tachibana, (Study on the practical prediction of the effect of wind on noise propagation) which describes the setup of a scale model experiment carried out in a wind tunnel that accurately reflects the results of field measurements presented in another study. The field measurements used for comparison were carried out by P. H. Parkin and W. E. Scholes and published in the Journal of Sound and vibration in 1965 (The Horizontal Propagation of Sound from a Jet Engine Close to The Ground, at Hatfield). These comprehensive measurements carried out by Parkin and Scholes are of particular relevance since they were carried out to measure propagation of noise from an aircraft jet engine under a range of wind conditions measured over long distances with the furthest measurement positions being in excess of 1 km from the noise source (jet engine).

2.2.6 Whilst the meteorological correction is presented within a road traffic noise model that corrects a prediction for neutral wind conditions (rather than correcting a worst-case downwind prediction), it is still considered to be relevant to the airport ground noise model. The fact that the research carried out to derive the meteorological correction has been verified through comparison with measurements of jet engine noise over long distances, gives confidence that the correction will provide a reasonable estimate of the effect of average wind conditions on long term average ground noise predictions.

2.3 Source Noise Survey

2.3.1 In order to provide more current data for Gatwick Airport, unattended sound level measurements were conducted over a period of 32 days between 21 March and 22 April 2019. Equipment was installed at three noise monitoring locations (NMLs) considered to be appropriate for measuring noise from aircraft taxi movements. The measurement locations are labelled NML 1, NML 2 and NML 3 and are shown at Diagram 2.3.1.

Diagram 2.3.1: NML Location Plan



2.3.2 At each NML, a Rion NL-52 Sound Level Meter fitted with a ½ inch microphone complying with the Class 1 standard in IEC 61672-1 (IEC, 2013) was installed, mounted on a tripod, at approximately 1.2 metres height, as shown at Diagram 2.3.2 to Diagram 2.3.4. At each NML, the microphone was located within a double-skinned windshield consisting of a 45 mm foam ball surrounded by a 125 mm radius secondary windshield of 40 mm thickness. The equipment was set up to measure the L_{Aeq} and L_{A90} noise level in 10-minute intervals along with 1-second Leq data in ⅓-octave bands and audio recording to allow further analysis of the measurements as necessary.

2.3.3 Calibration was carried out on all meters using a B&K type 4231 Acoustic Calibrator (s/n 2699280) with a level of 94.06 dB at the start of the survey and checked at the end with the same field calibrator. A drift of no more than 0.3 dB in the calibration was observed in any of the meters which is within normal tolerances and no correction was therefore required (or made) to the measured levels. All equipment was within its relevant laboratory calibration period.

2.3.4 Meteorological data including rainfall and wind speeds in 10-minute intervals were collected from the on-site runway midpoint meteorological station. Obtaining this weather data enabled periods of rainfall and high wind speeds to be considered and excluded from the derivation of the representative sound levels as necessary. These factors are less significant for aircraft pass-bys at NML 1 and NML 2 but could potentially increase the measured background sound levels at NML 3.

NML 1

2.3.5 At NML 1, the monitoring equipment was installed on an area of grass beside an access road near to some disused maintenance hangers at the end of Larkins Road. The sound level meter was positioned at approximately 3 metres from the edge of the access road, 40 metres from the edge of Taxiway Juliet and 123 metres from the edge of the northern runway. The noise environment at NML 1 was dominated by taxiing aircraft passing on Taxiway Juliet and take-offs on the main runway. Aircraft landing on the main runway, more distant taxiing aircraft and occasional vehicles on the access road could also be heard.

Diagram 2.3.2: Photographs of NML 1

NML 2

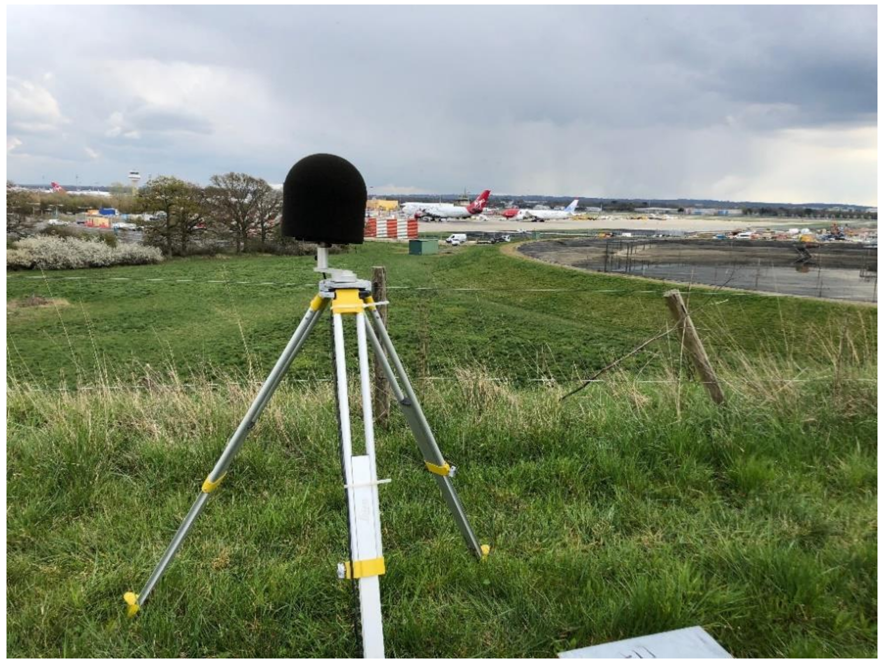
2.3.6 At NML 2, the monitoring equipment was installed on an area of grass in front of the operations building. The sound level meter was positioned at approximately 44 metres from the edge of Taxiway Juliet and 127 metres from the edge of the northern runway. The noise environment at NML 2 was dominated by taxiing aircraft passing on Taxiway Juliet and take-offs on the main runway. Aircraft landing on the main runway, more distant taxiing aircraft and occasional vehicle movements related to the operations building could also be heard.

Diagram 2.3.3: Photographs of NML 2

NML 3

2.3.7 At NML 3, the monitoring equipment was installed on top of the north bund near to a holding pond behind the Boeing hangar development site. The sound level meter was positioned at the following latitude/longitude coordinates: 51.156737, -0.200590. The noise environment at NML 3 included take-offs and landings on the main runway, distant taxiing aircraft and reversing beepers/other sporadic noises from the Boeing hangar construction site (under construction at the time of survey).

Diagram 2.3.4: Photographs of NML 3



Aircraft Logging

2.3.8 In addition to the noise data, it was also necessary to keep a log of aircraft passing the microphones at NML 1 and NML 2 in order to allow detailed analysis of noise levels generated by particular types of taxiing aircraft.

2.3.9 Initially, when the equipment was installed in March (2019), a manned survey of the aircraft was carried out over 2-3 hours from the observation room in the operations building using GPS time and binoculars to note down aircraft registration and times. During this manned survey, the surveyors (Hayes McKenzie) were also provided access to the Gatwick situational awareness tool which provides live (and historical) radar data showing the exact location of aircraft taking off, landing and taxiing around the airport. The manned survey log sheets correlated perfectly with information obtained from the situational awareness tool and it was decided that all further information required for the aircraft log sheets could be obtained remotely through access to the situational awareness tool.

2.3.10 For the purposes of calculating source noise data used in the model for this assessment, approximately two weeks of aircraft log data was processed representing a large dataset of recorded aircraft pass-bys.

Results

2.3.11 The survey results were filtered to only include measurements where no take-offs or landings were happening whilst taxing aircraft travelled along the section of Taxiway Juliet that was used in the measurements. Results were also filtered to ensure that no measurements were included where a taxiing aircraft passing a microphone was within one minute of another aircraft passing the same microphone. Based on the two weeks of aircraft log data, a total of 1460, 98, 36, and 130 samples were obtained for the A320, A320 Neo, B747 and B787 aircraft respectively. Following the filtering described above the total numbers reduce to 484, 35, 9 and 49 for the A320, A320 Neo, B747 and B787 aircraft respectively. It was also decided that since the A320N and the A321N both use the same GE engine, results of these two aircraft types would be combined in order to provide a greater dataset for the sound power level assumed to be representative of the majority of small (Category C) next generation aircraft. Combining the two datasets provided a total of 58 samples from A320N and A321N aircraft after filtering. Some manual filtering was also made where it was considered that particular recordings appeared to be outliers based on the recorded noise profile not fitting with the expected trend.

3 Updated Source Terms

3.1.1 Detailed analysis of the results of the source noise survey revealed overall A-weighted maximum sound power levels (varies significantly with directivity) of 133 dBA, 130 dBA, 142 dBA and 137 dBA for the A320, A320 Neo, B747 and B787 aircraft respectively. This indicates that the next generation aircraft are 3 – 5 dB quieter than older aircraft (at source) when taxiing and this has been taken into account within the noise model.

3.1.2 The calculated sound power levels for each aircraft type are presented in octave bands at Table 2.3.1 below. It should be noted that due to difficulties with accurately measuring in the 31.5 Hz octave band, calculated levels in the 63 Hz band have been assumed to be representative of levels in the 31.5 Hz band.

Table 2.3.1: Calculated Sound Power Levels

Aircraft Type	Octave Band Sound Power dB L_{wA}									Overall L_{wA}
	31.5	63	125	250	500	1k	2k	4k	8k	
B747	125	125	130	135	133	135	133	136	128	142.2
B787	126	126	132	132	127	120	120	120	119	137
A320	124	124	128	125	123	123	122	121	117	133.2
A320 Neo	118	118	121	123	123	121	118	120	117	129.9

4 Prediction Model

4.1.1 Aircraft ground noise is assessed by carrying out predictions of noise levels arising from the proposed change in taxi routes and number and type of aircraft using the taxi routes. The accuracy of the ground noise predictions depends on the quality of the input noise data and the assumptions used in the prediction model.

4.1.2 Predictions of aircraft ground noise have been carried out in the noise modelling software CadnaA. Modelling has been carried out for the existing baseline situation comprising actual traffic data covering the 92-day summer period (as used for air noise). This modelling was initially carried out as part of the 2019 Gatwick Master Plan but the model has been used as a basis for future baseline predictions and it is considered that the key assumptions relating to aircraft taxi routes are also valid for this purpose. It should also be noted that the predicted ground noise levels provided for the 2019 masterplan have been updated based on the revised sound power data calculated as part of the survey discussed above within section 2.

4.2 Baseline Noise Model

4.2.1 For the 2019 master plan modelling, the total numbers of arrivals and departures for the relevant taxiways were derived from recorded movements supplied by GAL. Actual taxiways that were used have not been recorded in the recorded traffic data but the stand location is provided, and the taxiway on which a stand is located has been used to define the assumed taxi route for each individual movement (for the purposes of the model a single movement is considered to encompass both the arrival and departure of an aircraft). Movements were summed and averaged over the 92 day period to provide typical movements for the 16 hour day (07.00 to 23.00), and 8 hour night (23.00 to 07.00). The process of creating this model for the 2019 masterplan also provided information on the proportions of different aircraft using each of the defined taxiways for the daytime and night-time periods. These proportions of aircraft types on each of the defined taxiways have then been taken as representative of the current airport operation and used for interpretation of the predicted traffic data across all of the future baseline noise modelling.

4.2.2 Taxiing routes between the ‘defined taxiways’ which are marked on the airport plan (Quebec, Romeo, Sierra etc), and the runway have been interpreted from analysis carried out by London City Airport Consulting. The analysis shows the normal routes taken for aircraft arriving and departing under easterly and westerly operations separately. Based on routing diagrams provided by London City Airport Consulting, the most efficient routes between taxiways have been selected for inclusion in the baseline noise model.

Project Model

4.2.3 Modelling of the ‘with Project’ scenario has been based on specific arrival and departure routes around the airport supplied by GAL. The taxi routes are defined for Category C and Category E aircraft (small and large) travelling to six individual areas of the airport apron that are separated equally into three associated with the North Terminal and three associated with the South Terminal. These taxi routes are defined for day and night, separated into easterly and westerly operations. This results in 74 individual arrival and departure routes for daytime operation and 60 individual arrival and departure routes for night-time operation that are included within each run of the noise model.

Generic Aircraft Types

4.2.4 For the purposes of the 2019 master plan aircraft ground noise model, the many different aircraft types recorded were classed as either ‘large’ or ‘small’ generic types using the International Civil Aviation Organization (ICAO) wake category. The ‘heavy’ wake category has been used to indicate the first generic type (large), which is representative of the 'jumbo' size aircraft taxiing sound levels as first measured for the Heathrow Terminal 5 Public Inquiry. The ‘medium’ and ‘light’ wake categories have been used to indicate the second generic type which is representative of the majority of small standard size category twin-jet aircraft currently operating at Gatwick.

Source Noise Levels

4.2.5 Historically, source noise levels for the ‘jumbo’ size aircraft measured for Heathrow Terminal 5 Public Inquiry have been used to model large aircraft and measurements of an Airbus A319 aircraft carried out at Stansted Airport on 29 January 2007 have been used to model small aircraft. The small and large aircraft sizes correspond to GAL categories C and E respectively.

4.2.6 The taxiing noise source sound power levels used, in the pre-existing model (pre-2019 survey), for both large and small generic types were measured at 150 metre radius for both idle and breakaway thrust settings which were assumed to be typical for normal taxiing. There is sufficient residual thrust even at idle power settings to maintain forward motion during normal taxiing, but pilots can choose to use higher breakaway thrust settings for a few seconds to assist the aircraft to accelerate rapidly from rest or to negotiate a particularly sharp bend. Sound levels are not directly affected by the speed of taxiing but only by the thrust setting needed to maintain that speed.

4.2.7 The extent to which newer aircraft types may be quieter than those previously measured and used for the ground noise calculation model generated a significant uncertainty within the model. Since the fleet of aircraft at Gatwick will be changing over the coming years in terms of the number of next generation aircraft, it was deemed necessary to gather up-to-date source noise measurements that could be used to take this into account. As set out in Section 2.1, a survey was therefore conducted based on the principles set out in the research carried out at Madrid Airport (Ansensio *et al.,* 2007).

4.2.8 Historically (pre-2019 survey) the calculation model required an average sound power level to be calculated for taxiing operations based on the proportion of small and large aircraft types. The majority of air traffic at Gatwick falls into the small category and a statistical analysis of the supplied 2016 traffic data indicated that the lowest proportion of small aircraft using any of the defined taxiways for both easterly and westerly operation was 80.1% on Taxiway Lima. However, in order to further improve the accuracy of the modelling, each aircraft type included in the modelling for EIA purposes has now been modelled separately. The four aircraft types measured in the survey have been used to represent older small and large aircraft and next generation small and large aircraft accordingly. Forecast traffic numbers falling into each of these four categories of aircraft have been used to model noise from each aircraft category individually, producing a more accurate overall prediction of airport ground noise.

Directivity

4.2.9 Historical directivity patterns of small and large aircraft were determined by direct measurements at ten-degree increments around each of the two aircraft measured, with constant operating conditions throughout each measurement whilst the aircraft were stationary. The measurements of taxiing aircraft have been used to estimate the directivity pattern of each aircraft type following methodology used the research at Madrid Airport (Ansensio *et al.,* 2007). Frequency dependent directivity corrections have been applied within the model in 15-degree increments, based on the results of the measurements.

Calculation Method

4.2.10 The acoustic propagation model implemented within the CadnaA software is as set out in ISO 9613 Part 1 (ISO, 1993) and Part 2 (ISO, 1996), with point noise sources for taxiing noise assumed along a string of potential source locations covering the length of each of the baseline taxi routes and each of the 74 daytime and 60 night-time taxi routes for the development case scenarios. Ground absorption is assumed to be 0 for 'hard ground' over the airport apron and a coefficient of 0.6 has been used for all other ground absorption within the model.

4.2.11 The historical source sound power levels only offered overall A-weighted levels which was another factor affecting the accuracy and therefore the uncertainty of the previous model. Since updated source sound power levels have been obtained through measurements of taxiing aircraft in March and April 2019 it has been possible to derive octave band sound power levels which are considered to provide greater accuracy and lower overall uncertainty in the calculation. Remaining uncertainties that cannot be removed relate to environmental conditions and the effect these have on noise propagation. Air turbulence caused by cross winds or upwind obstructions can have a much bigger effect on A-weighted front end fan sound levels than any increases associated with breakaway thrust. It should be noted that ISO 9613 states that the methodology provides a nominal accuracy of ± 3 dB and the predicted noise levels can therefore be expected to vary this much due to the accuracy of the acoustic propagation model. In light of these known uncertainties in the modelling of environmental noise propagation it is best practice to conservatively allow for this to ensure that impacts are not underestimated. The inputs that are used for the modelling have been developed over a number of years (specifically in relation to ground noise at Gatwick) to ensure that results provide a conservative prediction. It should therefore be noted that the model is more likely to over-predict ground noise than under-predict it.

4.2.12 Whilst there should be some caution exercised to ensure that the noise model does not underpredict ground noise, it is also considered that assuming worst-case downwind conditions at all receivers for both easterly and westerly operations is simply too conservative. Following the review of the noise model (discussed at section 2.2 above), it is considered that a conservative estimate of the effects due to typical or average wind conditions can be obtained by using a meteorological correction outlined in a Japanese road traffic noise model (see paragraphs 2.2.3 - 2.2.6). The Japanese meteorological correction is derived so as to be applied to a prediction of noise under neutral wind conditions rather than a correction to be applied to a downwind noise prediction. The formula gives a correction ($\Delta L_{m,line}$) to overall A-weighted levels that is directly proportional to both wind speed and distance from the source and can be both positive or negative depending on wind direction as follows:

$$\Delta L_{\mathrm{m,line}} = \begin{cases} 0.88\,\lg\left(\dfrac{l}{15}\right)\cdot U_{\mathrm{vec}} & l > 15 \\ 0 & l \leq 15 \end{cases},$$

Where l is the distance from the source in meters;

U_{Vec} = U.Cos(θ)

where U is the wind speed in m/s and

θ is the angle between the wind direction and the line perpendicular to the road through the prediction point.

4.2.13 In order to apply this meteorological correction to the worst-case downwind ground noise predictions, it is first necessary to convert from a worst-case downwind condition to something closer to neutral wind conditions. This has been conservatively estimated by calculating the correction for a downwind condition and subtracting this prior to applying the correction. This approach means that if a receiver is actually downwind of a noise source then the downwind correction would then be added back on and there would be no change to the predicted noise level.

4.2.14 It is also necessary to obtain representative values for typical wind conditions during easterly and westerly operations and for this purpose hourly meteorological observations from a centrally located weather station on the airfield at were obtained for the 92-day summer period in 2018. The wind speeds have been arithmetically averaged and the wind directions have been arithmetically averaged for day and night under easterly and westerly conditions separately. The averaged 2018 wind conditions used for the calculation of the meteorological correction (in all years) are summarised in the table below:

Table 4.2.1: Summary of 2018 92-day summer period typical wind conditions

Description	Ave wind speed	Ave wind direction
East Day	2.7	69.5
East Night	2.0	65.4
West Day	2.9	243.1
West Night	2.0	239.3

Taxiing Assumptions

4.2.15 All taxiing noise sources have been assumed to be at a height of 3 metres above ground level; this is based on the average centreline height of the jet engines on larger aircraft types. The taxiways have then been split into a series of segments represented by point sources and the locations of these taxiing noise sources have been agreed with GAL.

4.2.16 The model was set up with each straight length of taxiway divided into a series of short segments of around 100 metres. All bends in the main taxiways are represented by multiple short straight-line segments, which are assumed to be traversed at lower speed than for straight lengths of taxiway to represent typical queuing which occurs at sharp bends and at the pre-departure runway thresholds. Depending upon the time of day, the total numbers of aircraft along a given route can then be multiplied by the time spent on each separate segment represented by a point source. This provides an 'on time' which is dependent on the assumed speed at which each aircraft taxis across each taxiway segment and the assumed length of that segment.

4.2.17 Each aircraft travelling across each segment of taxiway is assumed to be positioned on the centre of each segment for as long as it would take to traverse that segment at the assumed standard taxiing speeds of 10 m/s for normal taxiing and 3 m/s when negotiating bends. At receiver locations outside the airport boundary this achieves exactly the same results as assuming continuous progression through each segment. Observations in the research at Madrid Airport and also the observations from the 2019 Gatwick Airport survey of taxi noise along Taxiway Juliet indicate that 10 m/s is a suitable assumption for constant speed along a straight section of taxiway.

Noise Barriers

4.2.18 Only those physical structures which make a significant contribution to screening in different directions within and around the airport are included in the model. For the baseline modelling, these are:

- the existing noise wall to the north east of the airport north of North Terminal Pier 4 and South Terminal Pier 3;
- the earth bunds around the end of the runway and North Terminal long stay car park;
- the existing terminal buildings and cargo sheds; and
- the existing piers at the North and South Terminals.

4.2.19 For the with Project case this is slightly different as follows:

- the existing earth bund at the end of the runway needs to be removed to allow for the development to take place; and
- an additional barrier would be built into the Project design to replace the functionality of the earth bund as much as possible as described within Section 14.8 of the PEIR Chapter 14: Noise and Vibration.

5 Primary Metric (L_{Aeq}) Results

5.1 Baseline

First Full Year of Opening: 2029

5.1.1 With reference to the 12 assessment locations listed in Chapter 14 and shown at Figure 14.4.1 (see Volume 2 of the PEIR), the predicted ground noise baseline levels are presented for each of the locations in Table 5.1.1

Table 5.1.1: Summary of Ground Noise 2029 Future Baseline Predicted Levels (dB L_{Aeq})

Descriptor	Location ($L_{Aeq, T}$ dB)											
	1	2	3	4	5	6	7	8	9	10	11	12
2029 - 026 Daytime	46	45	51	51	46	54	55	59	48	58	54	51
2029 - 026 Night	46	45	50	49	44	52	52	55	47	56	51	47
2029 - 08 Daytime	53	56	56	55	49	55	51	51	60	61	52	42
2029 - 08 Night	49	51	51	50	45	52	48	49	56	58	49	40

Design Year: 2038

5.1.2 The predicted ground noise baseline in 2038 is presented in Table 5.1.2.

Table 5.1.2: Summary of Ground Noise 2038 Future Baseline Predicted Levels (dB L_{Aeq})

Descriptor	Location ($L_{Aeq, T}$ dB)											
	1	2	3	4	5	6	7	8	9	10	11	12
2038 - 26 Daytime	44	43	49	49	44	52	54	57	46	56	52	49
2038 - 26 Night	44	43	49	47	43	50	50	54	46	55	49	45
2038 - 08 Daytime	51	54	54	53	48	54	49	50	58	60	50	41
2038 - 08 Night	47	49	50	49	44	50	47	48	55	57	47	38

5.2 With Project Scenario

First Full Year of Opening: 2029

5.2.1 As part of the Project, mitigation in the form of noise barriers has been proposed and has been included in the results presented in Table 5.2.1, with the difference between the predicted levels and the 2029 baseline shown in Table 5.2.2.

Table 5.2.1: Summary of Ground Noise 2029 Predicted Level (dB L_{Aeq})

Descriptor	Location ($L_{Aeq, T}$ dB)											
	1	2	3	4	5	6	7	8	9	10	11	12
2029 - 26 Daytime	50	50	56	54	48	55	56	59	51	61	53	51
2029 - 26 Night	48	48	54	51	46	52	52	54	50	59	51	46
2029 - 08 Daytime	55	58	58	56	50	55	51	50	59	60	53	42
2029 - 08 Night	48	51	50	50	45	51	47	47	54	56	50	40

Table 5.2.2: Summary of Ground Noise 2029 Predicted Project Level versus 2029 Baseline, Differences (dB L_{Aeq})

Descriptor	Location ($L_{Aeq, T}$ dB)											
	1	2	3	4	5	6	7	8	9	10	11	12
2029 - 26 Daytime	3	4	5	3	2	1	1	0	3	3	0	0
2029 - 26 Night	3	3	4	2	2	1	0	-1	3	3	0	0
2029 - 08 Daytime	2	2	2	1	1	0	0	0	-1	-1	1	0
2029 - 08 Night	-1	0	-1	-1	0	-1	-1	-1	-3	-2	1	0

Design Year: 2038

5.2.2 As part of the Project, mitigation in the form of noise barriers has been proposed and has been included in the results presented below in Table 5.2.3 with the difference between the predicted levels and the 2038 baseline shown in Table 5.2.4.

5.2.3 The predicted level differences in Table 4.2.4 show some slightly (1 dB) larger differences than for the design year (2032) presented at Chapter 14: Noise and Vibration. However, these predicted changes are in the context of an overall lower predicted noise levels with the Project in 2038 due to a larger proportion of next generation aircraft in the fleet.

Table 5.2.3: Summary of Ground Noise 2038 Predicted Level (dB L_{Aeq})

Descriptor	Location ($L_{Aeq, T}$ dB)											
	1	2	3	4	5	6	7	8	9	10	11	12
2038 - 26 Daytime	49	49	55	53	47	54	55	58	50	60	52	49
2038 - 26 Night	48	47	53	50	45	51	51	53	50	59	50	45
2038 - 08 Daytime	54	56	57	55	49	54	50	50	57	59	52	42
2038 - 08 Night	46	49	49	49	44	50	46	46	52	55	49	39

Table 5.2.4: Summary of Ground Noise 2038 Predicted Project Level versus 2038 Baseline, Differences (dB L_{Aeq})

Descriptor	Location ($L_{Aeq, T}$ dB)											
	1	2	3	4	5	6	7	8	9	10	11	12
2038 - 26 Daytime	4	6	6	4	3	1	1	1	4	4	0	1
2038 - 26 Night	3	4	4	2	2	1	1	-1	4	4	0	0
2038 - 08 Daytime	2	3	2	2	1	1	1	0	-1	-1	1	1
2038 - 08 Night	-1	0	-1	0	0	-1	-1	-2	-3	-2	1	1

6 Secondary Metric (L_{Amax}) Results

6.1 Baseline

6.1.1 The number of maximum noise level events exceeding the day and night criteria, for the 2029 and 2038 future baseline scenarios (not presented in the main chapter), are summarised below.

Table 6.1.1: Summary of 2029 Future Baseline Aircraft Taxiing Events exceeding L_{Amax} Criteria

Descriptor	Total number of L_{Amax} events at Location											
	1	2	3	4	5	6	7	8	9	10	11	12
2029 - 26 Daytime (>65 dB)	0	0	0	0	0	0	0	4	0	12	0	0
2029 - 08 Daytime (>65 dB)	0	0	0	0	0	3	0	0	15	7	0	0
2029 - 26 Night (>60 dB)	0	1	6	0	0	1	2	9	0	23	1	0
2029 - 08 Night (>60 dB)	0	0	0	0	0	2	3	3	23	28	0	0

Table 6.1.2: Summary of 2038 Future Baseline Aircraft Taxiing Events exceeding L_{Amax} Criteria

Descriptor	Total number of L_{Amax} events at Location											
	1	2	3	4	5	6	7	8	9	10	11	12
2038 - 26 Daytime (>65 dB)	0	0	0	0	0	0	0	4	0	2	0	0
2038 - 08 Daytime (>65 dB)	0	0	0	0	0	4	0	0	15	9	0	0
2038 - 26 Night (>60 dB)	0	1	5	0	0	1	2	8	0	20	2	0
2038 - 08 Night (>60 dB)	0	0	0	0	0	1	3	3	22	20	0	0

6.2 With Project Scenario

Taxiing Noise

6.2.1 The number of maximum noise level events exceeding the day and night criteria, for the 2029 and 2038 northern runway scenarios (not presented in the main chapter), are summarised below.

Table 6.2.1: Summary of 2029 Northern Runway Aircraft Taxiing Events exceeding L_{Amax} Criteria

Descriptor	Total number of L_{Amax} events at Location											
	1	2	3	4	5	6	7	8	9	10	11	12
2029 - 26 Daytime (>65 dB)	0	0	9	0	0	0	0	3	0	10	0	0
2029 - 08 Daytime (>65 dB)	0	0	0	0	0	2	0	0	3	4	0	0
2029 - 26 Night (>60 dB)	0	0	14	0	0	1	1	2	4	27	0	0
2029 - 08 Night (>60 dB)	0	1	0	0	0	1	0	0	5	12	0	0

Table 6.2.2: Summary of 2038 Northern Runway Aircraft Taxiing Events exceeding L_{Amax} Criteria

Descriptor	Total number of L_{Amax} events at Location											
	1	2	3	4	5	6	7	8	9	10	11	12
2038 - 26 Daytime (>65 dB)	0	0	1	0	0	0	0	2	0	14	0	0
2038 - 08 Daytime (>65 dB)	0	0	0	0	0	4	0	0	0	4	0	0
2038 - 26 Night (>60 dB)	0	0	14	0	0	1	0	2	7	20	0	0
2038 - 08 Night (>60 dB)	0	1	0	0	0	1	0	0	1	4	0	0

APU, EGR and EAT Maximum Noise Levels

6.2.2 Maximum noise levels produced by auxiliary power units (APU) noise and engine ground running (EGR) noise are independent of runway operation and do not differ for day or night as the stands and EGR areas are fixed locations. The end around taxiway (EAT) usage has been modelled independently of other taxi movements and since there are only two EATs proposed for the Project, this is only dependent on 08 or 26 runway operation.

Table 6.2.3: Predicted APU, EGR and EAT L_{Amax} Noise Levels

Descriptor	Predicted L_{Amax} at Location											
	1	2	3	4	5	6	7	8	9	10	11	12
EAT 26	64	65	60	48	43	55	39	40	67	68	54	37
EAT 08	33	39	36	40	38	42	49	49	46	54	50	49
APU	46	48	47	41	45	51	67	65	49	59	57	65
EGR	58	61	64	62	49	54	54	57	73	70	73	61

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