Environmental Research and Consultancy Department

Quota Count validation study at Heathrow Airport

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Summary

Night-time aircraft movements at Heathrow, Gatwick and Stansted airports are restricted by movement limits and noise quotas that are set by the Department for Transport (DfT). The noise quotas are designed to encourage the use of quieter aircraft. Movements at each airport count against the airport's noise quota according to their Quota Count (QC) classifications, which are based on ICAO certificated noise levels.

The QC classification system was introduced by the government in 1993. To date there has been no alternative system proposed that is both consistent with the government's legal obligations (to base noise-related operating restrictions on ICAO certification data) and superior in practice to that currently in place.

This report presents the results of a study that was undertaken at Heathrow between June 2018 and March 2019 to monitor the noise performance of aircraft in relation to their QC classifications. Operational noise levels, measured in EPNdB at locations equivalent to the ICAO noise certification measurement positions, were acquired and analysed for a large range of aircraft types.

For the majority of aircraft types monitored, including new aircraft designs such as the Airbus A350 and Boeing 787, the operational noise levels correlated well with the QC classifications. However, large differences between the operational noise levels and the QC classifications were observed for some aircraft types.

Despite any differences that may exist between operational and certification noise, it should be noted that ANCON, the UK civil aircraft noise model, is validated using noise measurements at the London airports. Operational noise levels are therefore reflected in any noise management controls linked to any published ANCON contours.

Chapter 1

Introduction

Background

The Night Flying Restrictions at Heathrow, Gatwick and Stansted airports specify a night period (2300-0700 hours) during which the noisiest types of aircraft may not be scheduled to land or take off. In addition, between 2330 and 0600 hours (the night quota period) aircraft movements are restricted by movement limits and noise quotas that are set by the Department for Transport (DfT) for each summer and winter season.

The noise quotas are designed to encourage the use of quieter aircraft. Movements at each airport count against the airport's noise quota according to their Quota Count (QC) classifications.

The QC classifications are intended to indicate each aircraft's relative contribution to the total impact of aircraft noise on the airport surroundings. Noisier aircraft types carry a higher QC classification. The classification of aircraft for this purpose is based on their ICAO certificated noise levels and each aircraft type is classified separately for arrival and departure.

QC classification and operational noise levels

In the July 2004 consultation on Night Flying Restrictions, the DfT reported that most aircraft have operational (in-service) noise levels that accord with their QC classification[1]. This finding was based on the results of a large-scale UK noise monitoring study published by the CAA's Environmental Research and Consultancy Department in ERCD Report 0205[2].

However, it was noted that some types were noisier than their classification, and some quieter. The key aircraft found to be noisier was the Boeing 747-400 powered by Rolls-Royce engines which, at that time, was the main type used by airlines during the night quota period at Heathrow[3].

The original intention of the study was that if an aircraft type was shown to produce operational noise levels significantly higher or lower than the average for its category, its QC classification would be reconsidered. However, in 2004 the DfT confirmed that

[1] *Night Flying Restrictions at Heathrow, Gatwick and Stansted*, Department for Transport, (Stage 1) July 2004.

[2] ERCD Report 0205, *Quota Count Validation Study: Noise Measurements and Analysis*, Civil Aviation Authority, April 2003.

[3] Although a number of airlines at Heathrow have since retired the B747-400 from their fleets, British Airways remains the largest operator of this type and is expected to continue flying the aircraft until 2024 (and, on average, still operates at least once per night during the night quota period).

Article 4(4) of Directive 2002/30/EC[4] (which came into effect after the study had commenced) precluded the use of any system of noise classification other than that based on ICAO certification data, and it therefore had no discretion to substitute measurements of operational noise as an alternative to ICAO certification data. Operational noise levels were however taken into account by setting specific noise abatement objectives based on noise contours, and in determining the boundary of new night noise insulation schemes at each airport[5].

It is to be expected that some differences will exist between operational and certificated noise levels. Nonetheless, results from the UK noise monitoring study (and similar measured noise data from other ICAO Member States) were provided to a noise expert Working Group tasked with examining the ICAO noise certification requirements. The Working Group concluded that, despite some differences between certification noise and operational noise at some airports, there was no compelling need to change the certification scheme[6].

In January 2017, the DfT published[7] additional data collected by the CAA to confirm whether the operational approach noise levels for several new aircraft types that were previously not covered in ERCD Report 0205 accord with their QC classification. These included variants of the Airbus A350, A380 and Boeing 787. The CAA's analysis indicated that whilst some aircraft were quieter than expected, the A380 with Rolls-Royce Trent 900 engines appeared noisier in operation than its QC/0.5 classification[8].

For practical reasons, the 2017 analysis was limited to arrivals noise from one of Heathrow's existing noise monitors. It would not have been possible to collect suitable departure measurements without first deploying specially-equipped noise monitors at the appropriate locations, which was not feasible at that time. However, in early 2018 the DfT requested that the CAA carry out a new full-scale QC validation study that would also include departure noise. This report presents the results of that study.

[4] Directive 2002/30/EC was replaced by Regulation (EU) No 598/2014 on 13 June 2016.

[5] *Night Flying Restrictions at Heathrow, Gatwick and Stansted*, Department for Transport, June 2006.

[6] Report of the Committee on Aviation Environmental Protection, Seventh Meeting Montréal, 5-6 February 2007 (Doc 9886, CAEP/7).

[7] *Night flight restrictions at Heathrow, Gatwick and Stansted Consultation Document*, Department for Transport, January 2017.

[8] The DfT's January 2017 consultation document also noted that the engine manufacturer Rolls-Royce, with assistance from the CAA where necessary, subsequently carried out an investigation to better understand the relatively high monitored arrival noise levels. Rolls-Royce has since indicated it would not be possible to resolve the arrival noise issue with the current A380/Trent 900 model without significant redesign of the engine.

Report contents

This report is structured as follows:

- Chapter 2 explains the rationale behind the use of certificated noise data for the QC system.
- Chapter 3 provides a summary of the data collection process for the study.
- Chapter 4 presents the results of the study and discusses some of the factors that can cause differences between operational and certificated noise levels.
- Chapter 5 presents the conclusions of the study.

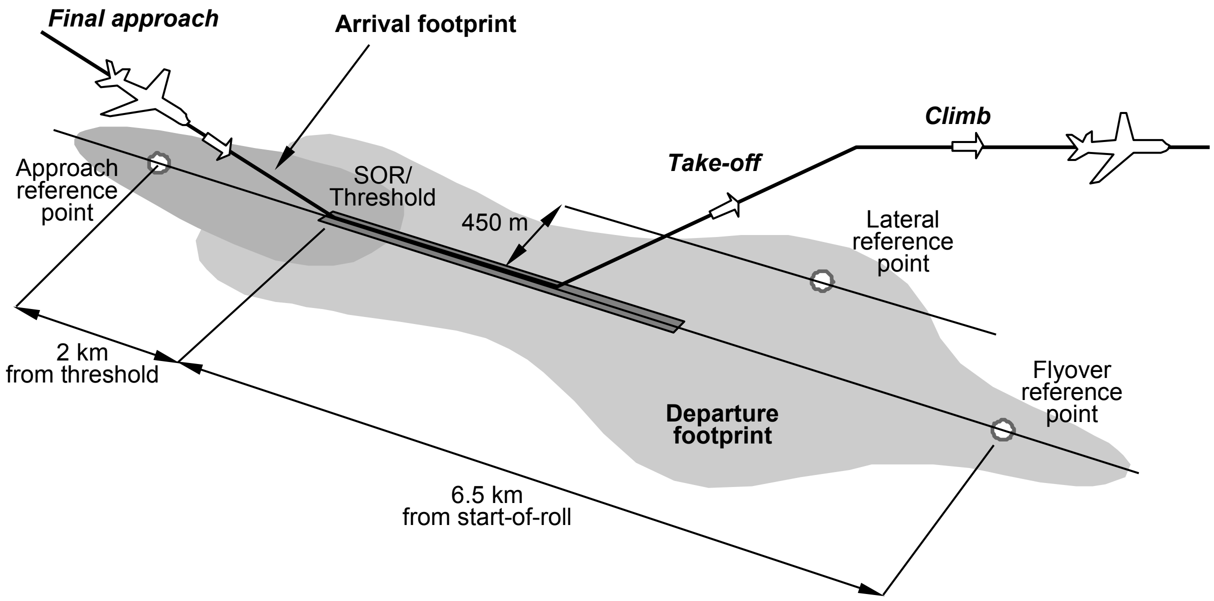
Chapter 2

The QC system

The government has historically set restrictions on the operation of aircraft at night at the London airports. Under the present Quota Count (QC) system, which was introduced in 1993, aircraft are classified into different categories depending on their ICAO noise certification data. Certificated noise levels are measured in Effective Perceived Noise Decibels (EPNdB), a specialised noise unit used for aircraft noise certification tests, and are referred to as Effective Perceived Noise Levels (EPNLs).

The certification procedure, specified in Chapter 3 of ICAO Annex 16[9], requires the determination of arrival and departure EPNLs, see Figure 1. Three reference measurement points are specified: *approach*, under a 3-degree descent path 2 km from the runway threshold; *lateral*, 450 m to the side of the initial climb after take-off, at the longitudinal position where noise is greatest; and *flyover*, under the departure climb path, 6.5 km from start-of-roll (SOR).

Figure 1 Aircraft noise reference points (in relation to illustrative noise footprints)



Classifications for departures are based on the average of the lateral and flyover EPNLs, and for arrivals after subtracting 9 EPNdB from the approach EPNL. Further technical details can be found in ERCD Report 0204[10].

[9] Annex 16 – Environmental Protection, Volume I – Aircraft Noise, ICAO, Eighth Edition, July 2017

[10] ERCD Report 0204, *Review of the Quota Count (QC) System: Re-analysis of the Differences between Arrivals and Departures*, Civil Aviation Authority, November 2002

The aircraft QC classifications were, as a matter of policy, based on official certificated noise levels because these are (i) generally considered to be reliable indicators of aircraft noise performance, (ii) available for practically every civil transport aircraft in current operation, (iii) openly published and therefore readily applied by administrators of the scheme, and (iv) correlated with noise footprint areas, which were taken to be appropriate measures of 'noise impact'.

The central feature of the classification system is that each aircraft is given a QC rating, which increases by a multiple of two in step with the 3-decibel doubling of noise energy principle (e.g. QC/1, QC/2, QC/4, etc.). The underlying principle of the scheme is to encourage the use of quieter aircraft by making each movement of a noisier type use more of the total available quota set for each airport.

It was the intention when the QC system was introduced in 1993 that it should be long lasting and would be reviewed only if an international or EU-wide system of aircraft classification for night restrictions purposes was in prospect[11]. To date there has been no alternative system proposed that is both consistent with the government's legal obligations (to base noise-related operating restrictions on ICAO certification data) and superior in practice to that currently in place.

Different types of aircraft (based on airframe, engine type and maximum take-off or landing weight) are classified separately for landing and take-off on the basis of their certificated noise levels into one of the following QC categories:

Noise Classification, EPNdB	Quota Count
Below 81	0
81 - 83.9	0.125
84 - 86.9	0.25
87 - 89.9	0.5
90 - 92.9	1
93 - 95.9	2
96 - 98.9	4
99 - 101.9	8
Greater than 101.9	16

When the QC system was first introduced, aircraft quieter than QC/0.5 were exempt from the restrictions. To incentivise the use of quieter aircraft whilst also preventing a proliferation of exempt jets, the QC/0.25 ("QC quarter") category was introduced in October 2006. This was followed by QC/0.125 ("QC eighth") in October 2018 to capture new quieter aircraft types that were expected to enter service in greater numbers over the next few years. Aircraft quieter than QC/0.125 are currently exempt from the noise quotas but count towards each airport's movement limits.

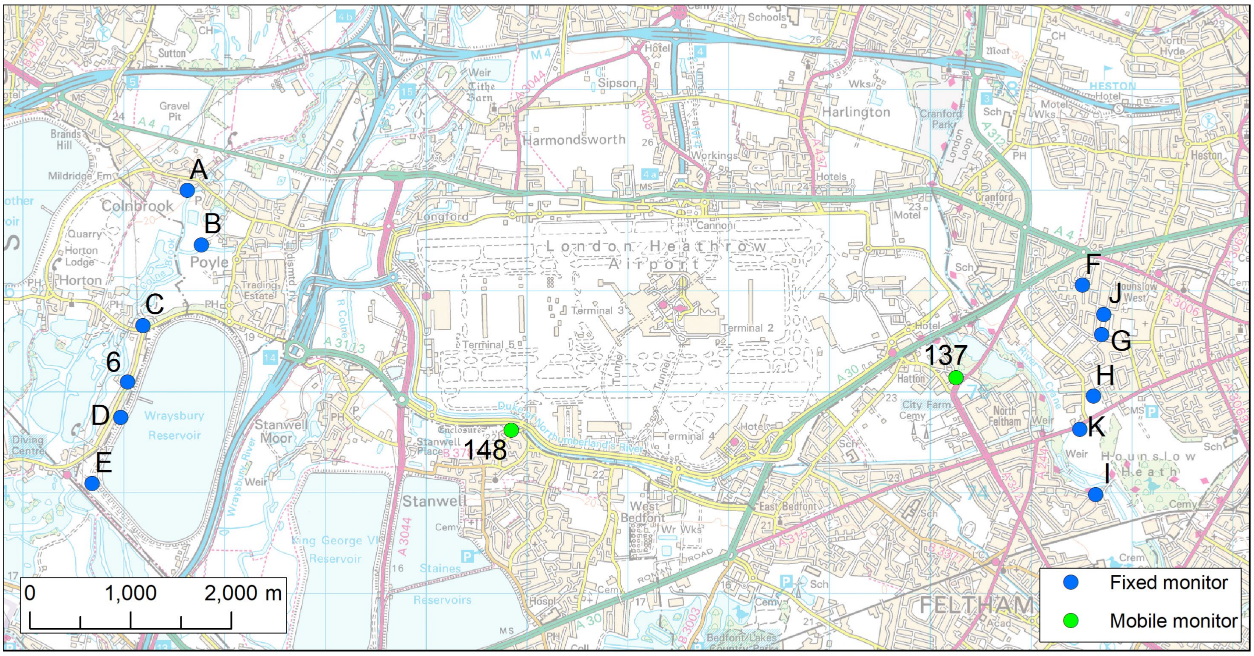
[11] *Review of the Quota Count (QC) System used for administering the night noise quotas at Heathrow, Gatwick and Stansted Airports*, Department for Transport, 2003

Chapter 3

Data collection

For this study, noise measurements from suitably positioned monitors were extracted and analysed from the Heathrow Noise and Track Keeping (NTK) system for the period June 2018 to March 2019. Figure 2 shows the layout of the noise monitors in relation to Heathrow's runways.

Figure 2 Heathrow EPNL noise monitoring locations



Since the numbers of movements at night (when the QC system applies) are relatively small, it would take an excessively long time to collect data for all the aircraft types of interest if relying on night-time measurements alone. Therefore, for this study, data collected both during the day and at night have been analysed in order to obtain an average measured *lateral*, *flyover* and *approach* result for each aircraft type, using the methods described in ERCD Report 0205[2]. Collecting measurements during the day also enabled a much wider variety of aircraft types to be included than if relying only on the aircraft that operated at night. The use of different operating procedures by daytime and night-time operators (and any possible effect on measured noise levels) has not been investigated.

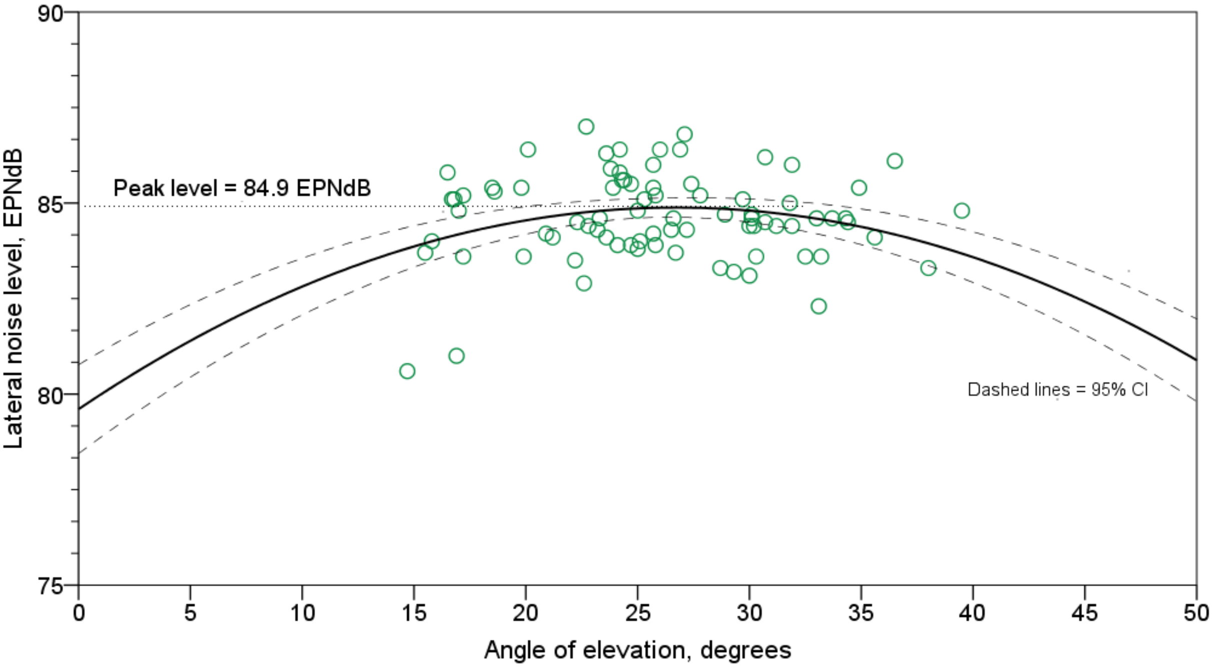
Measured flyover EPNLs were obtained from Heathrow's existing fixed noise monitors which are located close to the 6.5 km flyover reference point from the start of each runway. Measured approach EPNLs were obtained from fixed monitor B (for easterly arrivals landing on the northern runway) and mobile monitor 137 (for westerly arrivals on the southern runway), both of which are located close to the 2 km approach reference point.

Allowance was made for any differences between the actual monitor locations and the flyover and approach certification reference distances using industry-supplied 'Noise-Power-Distance' (NPD) relationships[12], which give EPNLs as a function of engine power at different distances from the aircraft.

It is generally recognised that lateral noise levels are more difficult to determine than flyover and approach levels because the longitudinal position of the 450 m lateral reference point is not fixed[13] and can vary markedly in terms of distance from start-of-roll, parallel to the runway, by aircraft type, take-off weight and airline departure procedure.

For this study, lateral noise levels for relatively fast-climbing aircraft types were measured using a single mobile monitor[14] positioned on a sideline 450 m to the south of the southern runway (27L), at approximately 3 km from start-of-roll (monitor 148 in Figure 2). The peak lateral noise level for each aircraft type was then estimated by plotting a polynomial best-fit curve through the measured datapoints. Figure 3 illustrates this process for one aircraft type, which plots the results expressed in terms of angle of elevation subtended as the aircraft passed by the monitor.

Figure 3 Estimating the peak lateral noise level at the 450 m sideline monitor 148 (A320-251N with LEAP-1A26/26E1 engines)



[12] www.aircraftnoisemodel.org

[13] On average, the peak lateral noise from jet-powered aircraft occurs when the aircraft is at a height of around 1000 feet. However, the distance of the aircraft from start-of-roll when it reaches 1000 feet varies depending on climb performance. Ideally, to measure the operational lateral level directly for all types of aircraft requires a row of monitors positioned along the sidelines, which is not practical in the built-up areas surrounding Heathrow.

[14] Additional 450 m sideline monitoring locations at Heathrow were not available.

For other slower-climbing aircraft types, peak lateral noise levels were not estimated from the sideline noise monitor because the true peak level would have occurred much further along the departure flight path. Instead, the lateral noise levels were estimated by adjusting measurements made directly beneath the flight path at monitor 137 (for easterly departures on the southern runway) with the aircraft still at take-off power. These estimates are referred to as pseudo-lateral noise levels and further details of the measurement procedure can be found in ERCD Report 0206[15].

[15] ERCD Report 0206, *A Practical Method for Estimating Operational Lateral Noise Levels*, Civil Aviation Authority, April 2003.

Chapter 4

Comparison of Operational and Certificated EPNLs

Arrivals

Operational arrival EPNLs were determined for 111 different aircraft types. Results are summarised in Table B1 of Appendix B. The measured results for individual aircraft types that did not achieve a 95% confidence interval of ±1.0 EPNdB or better have not been reported.

The arrival EPNLs are compared with the QC bands in Figure 4 (for QC/0.25 aircraft and quieter) and Figure 5 (for QC/0.5 to QC/2). In each figure, the certificated EPNL values (adjusted by -9 EPNdB) are indicated by red circles and are compared with the measured results. The average measured arrival EPNLs (also adjusted by -9 EPNdB) are shown in blue, with the extremities of the horizontal lines indicating the 95% confidence intervals for the mean result. Note that some aircraft types with the same engine model and certificated weight may be shown more than once due to having different recorded certificated noise levels (for example, as a result of other modifications).

The mean point is shown as a blue diamond if the value falls within the appropriate QC band, as an open blue circle if the mean value falls in a lower QC band than the certificated value, and as an open blue box if the mean value falls in a higher QC band than the certificated value. The 95% confidence interval has to be clear of the band limit for the result to be considered above or below the QC band. The relevant data labels for any results that fall above or below the QC bands are also marked with an asterix (*) for ease of reference.

Figures 4 and 5 show that for the vast majority of aircraft types monitored, including new aircraft designs such as the A320/321neo[16], A350, B737 MAX 8, CS100/300[17] and B787-8/-9 (many of which currently operate during the night quota period at one or more of the London airports), the operational arrival levels match, or in some cases better, their QC classifications. This finding is generally as expected, since aircraft rarely land at maximum certificated weight and often land with reduced landing flap selected. A reduced landing flap setting sets the flap angle to less than the maximum possible, resulting in lower drag and thereby requiring less engine power during the approach and resulting in less noise being emitted. Consequently, operational arrival noise measured at the approach reference point may be expected to be lower than in certification.

[16] Type designation A320-251N, A320-271N, A321-251N and A321-271N

[17] Previously designated the C Series, the CS100 and CS300 are now known as the A220-100 the A220-300 respectively.

However, the operational levels of 13 aircraft types (out of 111) lie entirely above their arrival QC bands, including some variants of the A380. As noted in Chapter 1, the A380 was previously identified as being noisier in operation than its arrival QC/0.5 classification.

The results for several older aircraft types, including variants of the B757-200, B757-300 and B767-300, are also shown to exceed their QC classification by a significant margin, a finding consistent with measurements published previously in ERCD Report 0205. It is also worth noting that, despite the two studies being conducted almost 20 years apart (and using different noise instrumentation), the average measured approach levels for some aircraft types monitored in both studies agree to within 0.5 EPNdB.

Finally, it should be remembered that the 3 EPNdB-wide bands mean that aircraft within the same QC band can have noticeably different certificated (and measured) noise levels. It is also possible for an aircraft's measured result to fall entirely above or below a QC band despite being only marginally noisier or quieter than its certificated level (i.e. if its certificated noise level lies at the very top or bottom of the QC band).

Figure 4 Operational Approach EPNLs: QC/0 to QC/0.25 (see main text for details)

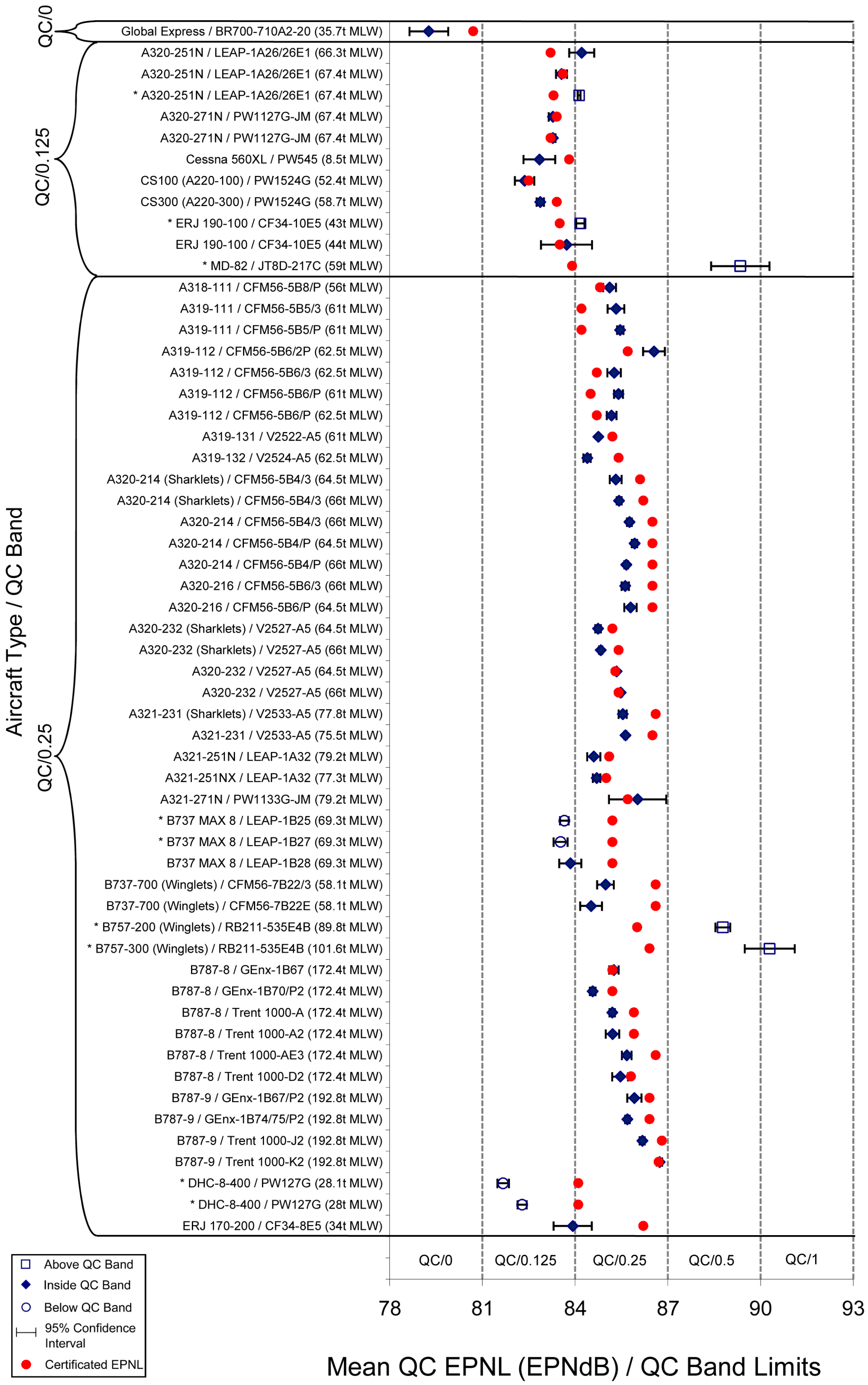
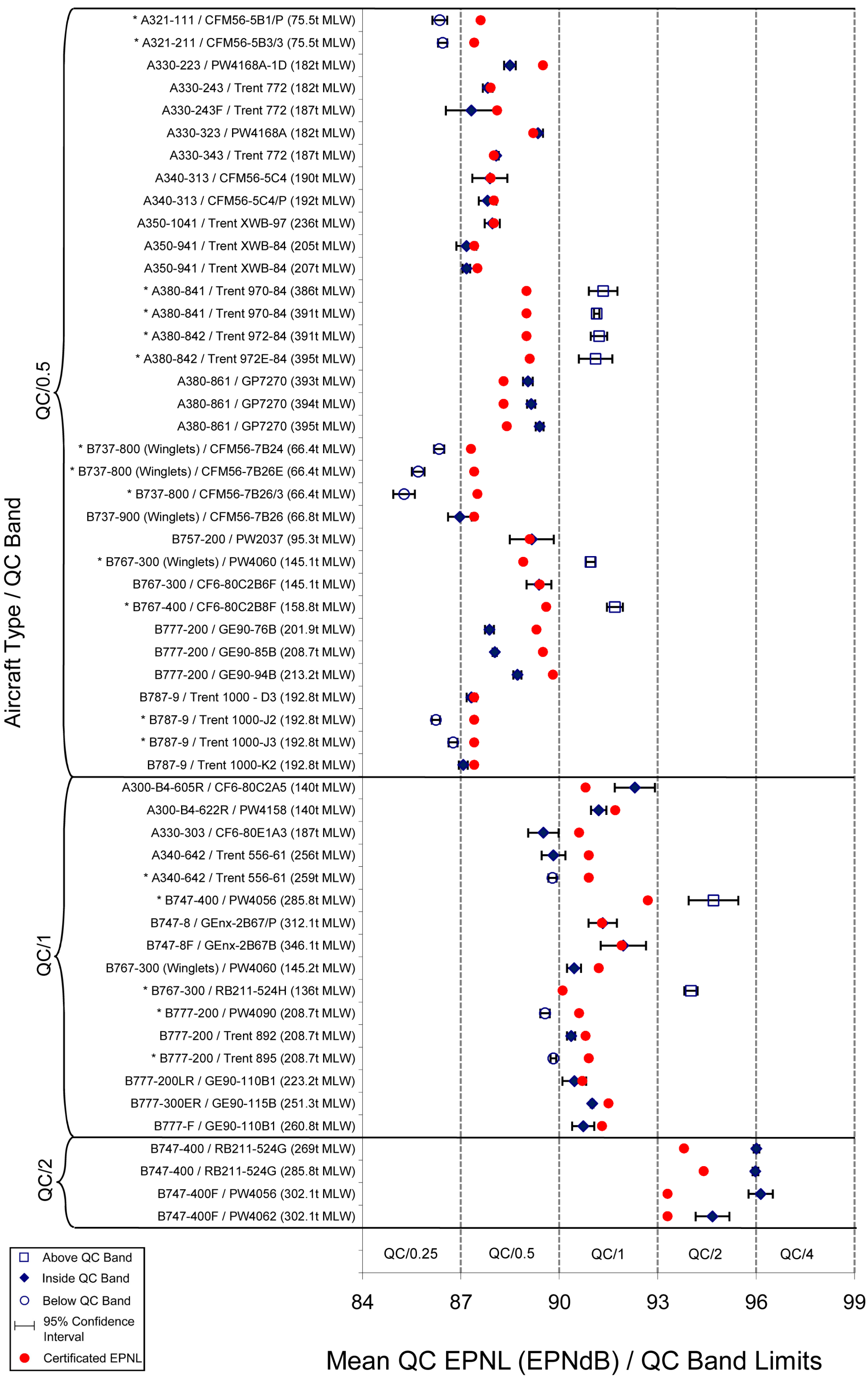


Figure 5 Operational Approach EPNLs: QC/0.5 to QC/2 (see main text for details)



Departures

Operational lateral and flyover EPNLs were determined for 131 different aircraft types. Results are summarised in Table B2 of Appendix B. The measured results for individual aircraft types that did not achieve a 95% confidence interval of ±1.0 EPNdB or better (at flyover *and* lateral) have not been reported.

The average departure EPNLs ([lateral EPNL + flyover EPNL] / 2) are compared with the QC bands and certificated EPNL values in Figure 6 (for QC/0.5 aircraft and quieter) and Figure 7 (for QC/1 to QC/4). In each figure, the certificated EPNL values are indicated by red circles and are compared with the measured results. The average measured departure EPNLs are shown in blue, with the extremities of the horizontal lines indicating the 95% confidence intervals for the mean result.

Again, the 95% confidence interval has to be clear of the band limit for the result to be considered above or below the QC band. The relevant data labels are also marked with an asterix (*) for ease of reference.

As in the case for arrivals, Figures 6 and 7 show that for the vast majority of aircraft types monitored, including new aircraft designs such as the A321neo, A350, B737 MAX 8 and B787-8/-9, the operational departure levels match, or in some cases better, their QC classifications. However, the operational levels of 21 aircraft types (out of 131) lie entirely above their QC bands, including all four measured variants of the A320neo (classified QC/0.125) and one variant of the B737 MAX 8 (classified QC/0.25). Whilst there are no scheduled departures during the night quota period at Heathrow, the A320neo and B737 MAX 8 are expected to operate regularly during the night quota period at Gatwick and Stansted in the coming years.

In the case of the A320neo, the measured results also show that the -271N variant (with PW1127G engines) is more than 1 EPNdB noisier, on average, than the -251N variants (LEAP engines). This is despite both engine variants having similar certificated departure levels and flying similar stage lengths. It should be emphasised however that the measured A320neo variants are between 2 to 6 EPNdB quieter in normal operation than the original A320 variants shown in Figure 6.

Further analysis of the B737 MAX 8 data revealed that the noisier variant was flying a significantly longer average stage length than the two quieter variants (>2000 NM vs. 800 NM). Aircraft that are flying further will generally be heavier because they are carrying more fuel and will therefore be lower, on average, over the ground (all other things being equal). Alternatively, to achieve the same height over the ground the heavier aircraft would require a higher engine power setting on take-off. In either case, the heavier aircraft would be noisier on the ground directly beneath the flight path.

In Figure 7, it can also be seen that the operational departure levels for some larger wide-body aircraft types, including the A340-300 and B747-400, also exceed their QC classifications (QC/2 and QC/4 respectively).

Operational differences between normal airline service and certification mean that noise is distributed differently along and about the flight path. Generally, measured in-service lateral levels are expected to be lower than in certification (because aircraft rarely fly at maximum weight and typically use a reduced engine power setting on take-off to save fuel and minimise engine wear). However, flyover levels can be significantly higher in normal operation, due to a much lower height over the monitor at 6.5 km.

For noise certification, the aircraft takes off and climbs as quickly as possible up to a point just before reaching the flyover noise monitor. At this point the engine power is reduced significantly to a minimum safe level so as to minimise the flyover noise level. In normal operation however, engine power is typically reduced to a climb thrust setting as soon as possible after take-off (at or above 800 feet above runway level) to minimise engine wear. This generally means that the operational flyover noise level is higher than in certification.

The design difference between twin-engine aircraft and four-engine aircraft leads to higher rates of climb for twins resulting in relatively low flyover EPNLs under the certification process. As a result, the trade-off between the lateral and flyover noise levels may not be achieved, which may explain, at least partly, why the operational levels are higher than the certificated levels for some aircraft types.

Finally, it should again be noted that the 3 EPNdB-wide bands mean that aircraft within the same QC band can have noticeably different certificated (and measured) noise levels. It is also possible for an aircraft’s measured result to fall entirely above or below a QC band despite being only marginally noisier or quieter than its certificated level.

Figure 6 Operational Departure EPNLs: QC/0.125 to QC/0.5 (see main text for details)

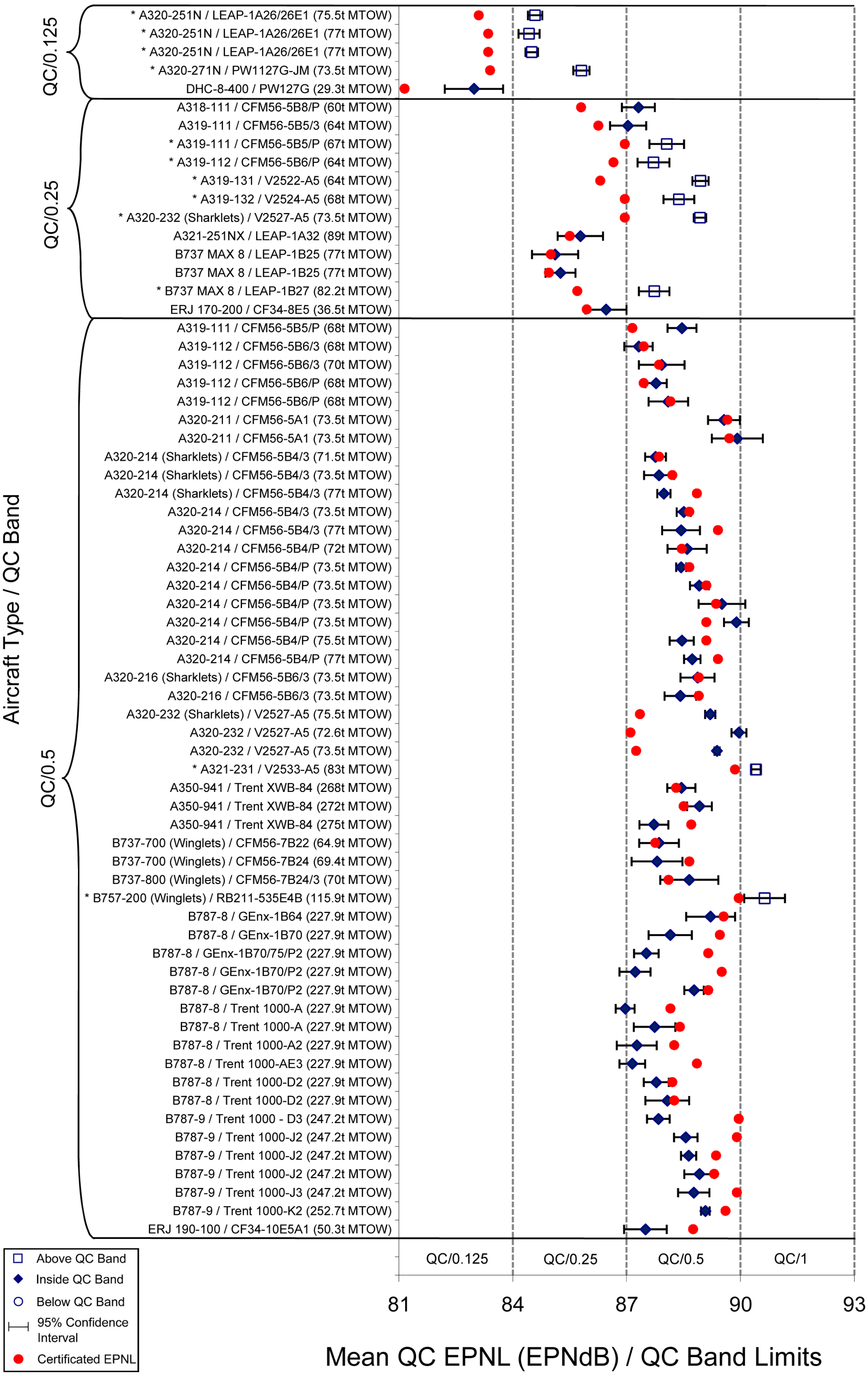
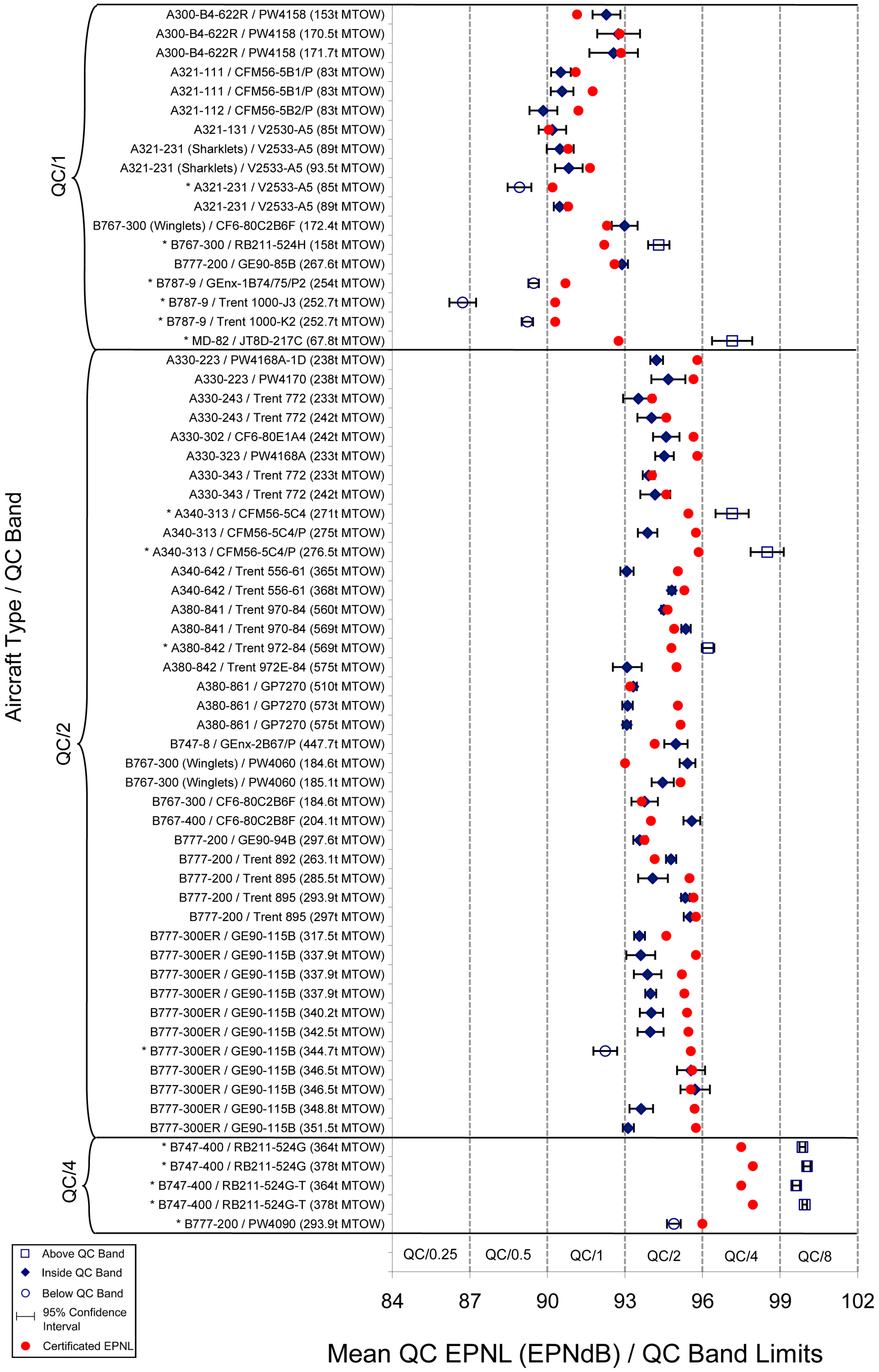


Figure 7 Operational Departure EPNLs: QC/1 to QC/4 (see main text for details)



Additional factors for consideration

When considering possible reasons for any measured differences (positive or negative) between operational and certificated EPNLs, it should be noted that there are many reasons why the operational levels may not match certification. These include the following:

- The operational EPNLs measured at an airport are naturally more variable than certificated EPNLs, which are measured under much more tightly constrained operational conditions (including adjustment of the EPNLs to standard atmospheric conditions).
- The operational EPNLs are sample averages and therefore estimates of the ‘true’ averages. Many random variable factors including weather, aircraft weights and operating procedures contribute to the scatter of individual EPNLs and it is the effects of these which are 'averaged out' by gathering large data samples.
- It is possible that there may be some bias in the operational measurements due to, for example, errors in radar-measured flight paths or limitations of the noise measurement and analysis methodology.

Chapter 5
Conclusions

Operational noise measurements from suitably positioned airport monitors were extracted and analysed from the Heathrow Noise and Track Keeping (NTK) system for the period June 2018 to March 2019 in order to obtain average measured lateral, flyover and approach EPNLs for a large number of aircraft types.

Operational EPNLs are naturally more variable than certificated EPNLs, which are measured under much more tightly constrained operational conditions. Many random variable factors including weather, aircraft weights and operating procedures contribute to the scatter of individual EPNLs and it is the effects of these which are 'averaged out' by gathering large data samples.

The 95% confidence intervals associated with the mean operational EPNLs for this study are, by design, no greater than ±1 EPNdB, although in most cases the 95% confidence intervals are much less than this. The measured results are therefore considered to be reliable.

For the majority of aircraft types monitored, including new aircraft designs such as the Airbus A350 and Boeing 787, the operational arrival and departure noise levels correlated well with the QC classifications. However, large differences between the operational noise levels and the QC classifications were observed for some aircraft types, including some relatively new aircraft designs.

Arriving aircraft rarely land at maximum weight and often land with reduced landing flap selected. Consequently, arrivals noise measured at the approach reference point may be expected to be lower than in certification. However, the operational approach levels of 13 aircraft types (out of 111) lie entirely above their QC bands. These include variants of the B757-200, B757-300 and B767-300, a finding consistent with measurements published previously in ERCD Report 0205. These differences cannot be explained in operational terms.

On departure, the operational levels of 21 aircraft types (out of 131) lie entirely above their QC bands, including variants of the A320neo and B737 MAX 8. Operational differences between normal airline service and certification mean that departure noise is distributed differently along and about the flight path.

Generally, measured in-service lateral levels are expected to be lower than in certification. This is because aircraft rarely fly at maximum weight and typically use a reduced engine power setting on take-off to save fuel and minimise engine wear.

However, flyover levels can be significantly higher in normal operation, due to the aircraft being at a much lower height over the monitor at 6.5 km, particularly for some smaller twin-engine aircraft. As a result, the trade-off between the lateral and flyover noise levels may not be achieved for some aircraft types, which may explain, at least partly, why the operational levels are higher than the certificated levels for some aircraft types.

Despite any differences that may exist between operational and certification noise, it should be noted that ANCON, the UK civil aircraft noise model, is validated using noise measurements at the London airports. Operational noise levels are therefore reflected in any noise management controls linked to any published ANCON contours.

APPENDIX A

Glossary of terms

Glossary of terms	
Certificated noise levels	The ICAO aircraft noise certification procedure for subsonic jet aeroplanes and propeller-driven aeroplanes over 8,618 kg requires three separate noise measurements to be made at approach, lateral and flyover locations. The three certificated noise levels (measured in EPNdB) are determined within tight tolerances and normalised to standard atmospheric conditions.
EPNdB	Effective Perceived Noise decibels. The measurement unit for EPNL.
EPNL	Effective Perceived Noise Level (measured in EPNdB). Its measurement involves analysis of the frequency spectra of noise events as well as the duration of the sound.
ICAO	International Civil Aviation Organization.
NTK	Noise and Track Keeping monitoring system. The NTK system associates air traffic control radar data with related data from both fixed (permanent) and mobile noise monitors at prescribed positions on the ground.
Operational noise levels	Defined in this report as the average EPNLs derived from measurements near the airport that are comparable to the certificated noise levels.
QC	Quota Count. The basis of the London airports' night flying restrictions regime.
SOR	Start-of-roll: The position on a runway where aircraft commence their take-off runs.
Threshold	The beginning of that portion of the runway usable for landing.

APPENDIX B

Tables of results

Table B1 Mean Operational Approach EPNLs

Aircraft Type (MLW, tonnes)	QC Classification	Certificated Approach EPNL (EPNdB)	Mean Operational EPNL (EPNdB)			Approach EPNL-9 (EPNdB)	
			Approach	95% CI	Count	Certificated	Operational
B747-400F / PW4062 (302.1t)	2	102.3	103.7	0.5	26	93.3	94.7
B747-400F / PW4056 (302.1t)	2	102.3	105.1	0.4	32	93.3	96.1
B747-400 / RB211-524G (285.8t)	2	103.4	105.0	0.1	1,451	94.4	96.0
B747-400 / RB211-524G (269t)	2	102.8	105.0	0.1	1,344	93.8	96.0
B777-F / GE90-110B1 (260.8t)	1	100.3	99.7	0.3	34	91.3	90.7
B777-300ER / GE90-115B (251.3t)	1	100.5	100.0	0.0	2,916	91.5	91.0
B777-200LR / GE90-110B1 (223.2t)	1	99.7	99.5	0.4	30	90.7	90.5
B777-200 / Trent 895 (208.7t)	1	99.9	98.8	0.1	1,037	90.9	89.8
B777-200 / Trent 892 (208.7t)	1	99.8	99.4	0.1	466	90.8	90.4
B777-200 / PW4090 (208.7t)	1	99.6	98.6	0.1	217	90.6	89.6
B767-300 / RB211-524H (136t)	1	99.1	103.0	0.2	291	90.1	94.0
B767-300 (Winglets) / PW4060 (145.2t)	1	100.2	99.5	0.2	151	91.2	90.5
B747-8F / GEnx-2B67B (346.1t)	1	100.9	101.0	0.7	8	91.9	92.0
B747-8 / GEnx-2B67/P (312.1t)	1	100.3	100.3	0.4	23	91.3	91.3
B747-400 / PW4056 (285.8t)	1	101.7	103.7	0.8	10	92.7	94.7
A340-642 / Trent 556-61 (259t)	1	99.9	98.8	0.1	363	90.9	89.8
A340-642 / Trent 556-61 (256t)	1	99.9	98.8	0.4	42	90.9	89.8
A330-303 / CF6-80E1A3 (187t)	1	99.6	98.5	0.5	30	90.6	89.5
A300-B4-622R / PW4158 (140t)	1	100.7	100.2	0.2	153	91.7	91.2
A300-B4-605R / CF6-80C2A5 (140t)	1	99.8	101.3	0.6	11	90.8	92.3
B787-9 / Trent 1000-K2 (192.8t)	0.5	96.4	96.1	0.1	165	87.4	87.1
B787-9 / Trent 1000-J3 (192.8t)	0.5	96.4	95.8	0.1	204	87.4	86.8
B787-9 / Trent 1000-J2 (192.8t)	0.5	96.4	95.2	0.1	221	87.4	86.2
B787-9 / Trent 1000 - D3 (192.8t)	0.5	96.4	96.3	0.2	139	87.4	87.3
B777-200 / GE90-94B (213.2t)	0.5	98.8	97.7	0.1	288	89.8	88.7
B777-200 / GE90-85B (208.7t)	0.5	98.5	97.0	0.1	1,199	89.5	88.0
B777-200 / GE90-76B (201.9t)	0.5	98.3	96.9	0.1	227	89.3	87.9
B767-400 / CF6-80C2B8F (158.8t)	0.5	98.6	100.7	0.2	335	89.6	91.7
B767-300 / CF6-80C2B6F (145.1t)	0.5	98.4	98.4	0.4	54	89.4	89.4
B767-300 (Winglets) / PW4060 (145.1t)	0.5	97.9	100.0	0.1	325	88.9	91.0
B757-200 / PW2037 (95.3t)	0.5	98.1	98.2	0.7	21	89.1	89.2
B737-900 (Winglets) / CFM56-7B26 (66.8t)	0.5	96.4	96.0	0.4	40	87.4	87.0
B737-800 / CFM56-7B26/3 (66.4t)	0.5	96.5	94.3	0.3	48	87.5	85.3
B737-800 (Winglets) / CFM56-7B26E (66.4t)	0.5	96.4	94.7	0.2	142	87.4	85.7
B737-800 (Winglets) / CFM56-7B24 (66.4t)	0.5	96.3	95.3	0.2	193	87.3	86.3
A380-861 / GP7270 (395t)	0.5	97.4	98.4	0.1	275	88.4	89.4
A380-861 / GP7270 (394t)	0.5	97.3	98.1	0.1	313	88.3	89.1
A380-861 / GP7270 (393t)	0.5	97.3	98.0	0.1	220	88.3	89.0
A380-842 / Trent 972E-84 (395t)	0.5	98.1	100.1	0.5	32	89.1	91.1
A380-842 / Trent 972-84 (391t)	0.5	98.0	100.2	0.3	81	89.0	91.2
A380-841 / Trent 970-84 (391t)	0.5	98.0	100.1	0.1	847	89.0	91.1
A380-841 / Trent 970-84 (386t)	0.5	98.0	100.3	0.4	41	89.0	91.3
A350-941 / Trent XWB-84 (207t)	0.5	96.5	96.2	0.1	364	87.5	87.2
A350-941 / Trent XWB-84 (205t)	0.5	96.4	96.2	0.3	69	87.4	87.2
A350-1041 / Trent XWB-97 (236t)	0.5	97.0	97.0	0.2	92	88.0	88.0
A340-313 / CFM56-5C4/P (192t)	0.5	97.0	96.8	0.3	88	88.0	87.8
A340-313 / CFM56-5C4 (190t)	0.5	96.9	96.9	0.5	34	87.9	87.9
A330-343 / Trent 772 (187t)	0.5	97.0	97.1	0.1	682	88.0	88.1
A330-323 / PW4168A (182t)	0.5	98.2	98.4	0.2	316	89.2	89.4
A330-243F / Trent 772 (187t)	0.5	97.1	96.3	0.8	10	88.1	87.3
A330-243 / Trent 772 (182t)	0.5	96.9	96.8	0.1	187	87.9	87.8
A330-223 / PW4168A-1D (182t)	0.5	98.5	97.5	0.2	302	89.5	88.5
A321-211 / CFM56-5B3/3 (75.5t)	0.5	96.4	95.4	0.1	181	87.4	86.4
A321-111 / CFM56-5B1/P (75.5t)	0.5	96.6	95.4	0.2	130	87.6	86.4

Table B1 Mean Operational Approach EPNLs, continued

Aircraft Type (MLW, tonnes)	QC Classification	Certificated Approach EPNL (EPNdB)	Mean Operational EPNL (EPNdB) Approach	95% CI	Count	Approach EPNL-9 (EPNdB) Certificated	Operational
ERJ 170-200 / CF34-8E5 (34t)	0.25	95.2	92.9	0.6	24	86.2	83.9
DHC-8-400 / PW127G (28t)	0.25	93.1	91.3	0.2	423	84.1	82.3
DHC-8-400 / PW127G (28.1t)	0.25	93.1	90.7	0.2	197	84.1	81.7
B787-9 / Trent 1000-K2 (192.8t)	0.25	95.7	95.7	0.1	518	86.7	86.7
B787-9 / Trent 1000-J2 (192.8t)	0.25	95.8	95.2	0.1	451	86.8	86.2
B787-9 / GEnx-1B74/75/P2 (192.8t)	0.25	95.4	94.7	0.1	474	86.4	85.7
B787-9 / GEnx-1B67/P2 (192.8t)	0.25	95.4	94.9	0.2	55	86.4	85.9
B787-8 / Trent 1000-D2 (172.4t)	0.25	94.8	94.5	0.3	58	85.8	85.5
B787-8 / Trent 1000-AE3 (172.4t)	0.25	95.6	94.7	0.2	166	86.6	85.7
B787-8 / Trent 1000-A2 (172.4t)	0.25	94.9	94.2	0.2	64	85.9	85.2
B787-8 / Trent 1000-A (172.4t)	0.25	94.9	94.2	0.1	375	85.9	85.2
B787-8 / GEnx-1B70/P2 (172.4t)	0.25	94.2	93.6	0.1	302	85.2	84.6
B787-8 / GEnx-1B67 (172.4t)	0.25	94.2	94.3	0.2	136	85.2	85.3
B757-300 (Winglets) / RB211-535E4B (101.6t)	0.25	95.4	99.3	0.8	13	86.4	90.3
B757-200 (Winglets) / RB211-535E4B (89.8t)	0.25	95.0	97.8	0.2	143	86.0	88.8
B737-700 (Winglets) / CFM56-7B22E (58.1t)	0.25	95.6	93.5	0.4	36	86.6	84.5
B737-700 (Winglets) / CFM56-7B22/3 (58.1t)	0.25	95.6	94.0	0.3	86	86.6	85.0
B737 MAX 8 / LEAP-1B28 (69.3t)	0.25	94.2	92.8	0.4	20	85.2	83.8
B737 MAX 8 / LEAP-1B27 (69.3t)	0.25	94.2	92.5	0.2	90	85.2	83.5
B737 MAX 8 / LEAP-1B25 (69.3t)	0.25	94.2	92.7	0.1	197	85.2	83.7
A321-271N / PW1133G-JM (79.2t)	0.25	94.7	95.0	0.9	12	85.7	86.0
A321-251NX / LEAP-1A32 (77.3t)	0.25	94.0	93.7	0.1	203	85.0	84.7
A321-251N / LEAP-1A32 (79.2t)	0.25	94.1	93.6	0.2	86	85.1	84.6
A321-231 / V2533-A5 (75.5t)	0.25	95.5	94.6	0.0	3,032	86.5	85.6
A321-231 (Sharklets) / V2533-A5 (77.8t)	0.25	95.6	94.5	0.1	222	86.6	85.5
A320-232 / V2527-A5 (66t)	0.25	94.4	94.5	0.1	1,296	85.4	85.5
A320-232 / V2527-A5 (64.5t)	0.25	94.3	94.3	0.0	7,287	85.3	85.3
A320-232 (Sharklets) / V2527-A5 (66t)	0.25	94.4	93.8	0.1	1,587	85.4	84.8
A320-232 (Sharklets) / V2527-A5 (64.5t)	0.25	94.2	93.7	0.1	479	85.2	84.7
A320-216 / CFM56-5B6/P (64.5t)	0.25	95.5	94.8	0.2	86	86.5	85.8
A320-216 / CFM56-5B6/3 (66t)	0.25	95.5	94.6	0.1	384	86.5	85.6
A320-214 / CFM56-5B4/P (66t)	0.25	95.5	94.7	0.1	1,168	86.5	85.7
A320-214 / CFM56-5B4/P (64.5t)	0.25	95.5	94.9	0.1	654	86.5	85.9
A320-214 / CFM56-5B4/3 (66t)	0.25	95.5	94.8	0.1	728	86.5	85.8
A320-214 (Sharklets) / CFM56-5B4/3 (66t)	0.25	95.2	94.4	0.1	605	86.2	85.4
A320-214 (Sharklets) / CFM56-5B4/3 (64.5t)	0.25	95.1	94.3	0.2	129	86.1	85.3
A319-132 / V2524-A5 (62.5t)	0.25	94.4	93.4	0.1	324	85.4	84.4
A319-131 / V2522-A5 (61t)	0.25	94.2	93.8	0.0	7,877	85.2	84.8
A319-112 / CFM56-5B6/P (62.5t)	0.25	93.7	94.2	0.2	153	84.7	85.2
A319-112 / CFM56-5B6/P (61t)	0.25	93.5	94.4	0.1	268	84.5	85.4
A319-112 / CFM56-5B6/3 (62.5t)	0.25	93.7	94.3	0.2	103	84.7	85.3
A319-112 / CFM56-5B6/2P (62.5t)	0.25	94.7	95.6	0.4	63	85.7	86.6
A319-111 / CFM56-5B5/P (61t)	0.25	93.2	94.5	0.1	412	84.2	85.5
A319-111 / CFM56-5B5/3 (61t)	0.25	93.2	94.3	0.3	96	84.2	85.3
A318-111 / CFM56-5B8/P (56t)	0.25	93.8	94.1	0.2	110	84.8	85.1
MD-82 / JT8D-217C (59t)	0.125	92.9	98.3	0.9	8	83.9	89.3
ERJ 190-100 / CF34-10E5 (44t)	0.125	92.5	92.7	0.8	9	83.5	83.7
ERJ 190-100 / CF34-10E5 (43t)	0.125	92.5	93.2	0.1	266	83.5	84.2
CS300 (A220-300) / PW1524G (58.7t)	0.125	92.4	91.9	0.1	475	83.4	82.9
CS100 (A220-100) / PW1524G (52.4t)	0.125	91.5	91.4	0.3	44	82.5	82.4
Cessna 560XL / PW545 (8.5t)	0.125	92.8	91.8	0.5	6	83.8	82.8
A320-271N / PW1127G-JM (67.4t)	0.125	92.2	92.3	0.1	543	83.2	83.3
A320-271N / PW1127G-JM (67.4t)	0.125	92.4	92.3	0.1	266	83.4	83.3
A320-251N / LEAP-1A26/26E1 (67.4t)	0.125	92.3	93.1	0.0	2,317	83.3	84.1
A320-251N / LEAP-1A26/26E1 (67.4t)	0.125	92.6	92.6	0.2	191	83.6	83.6
A320-251N / LEAP-1A26/26E1 (66.3t)	0.125	92.2	93.2	0.4	30	83.2	84.2
Global Express / BR700-710A2-20 (35.7t)	0	89.7	88.3	0.6	9	80.7	79.3

Table B2 Mean Operational Departure EPNLs

	QC	Certificated EPNL (EPNdB)		Mean Operational EPNL (EPNdB)						Departure EPNL (EPNdB)	
Aircraft Type (MTOW, tonnes)	Classification	Lateral	Flyover	Lateral	95% CI	Count	Flyover	95% CI	Count	Certificated	Operational
B777-200 / PW4090 (293.9t)	4	98.1	93.9	94.6	0.4	33	95.2	0.2	354	96.0	94.9
B747-400 / RB211-524G-T (378t)	4	98.1	97.8	98.9	0.1	265	101.0	0.1	1,324	98.0	100.0
B747-400 / RB211-524G-T (364t)	4	98.2	96.8	98.9	0.2	102	100.3	0.1	994	97.5	99.6
B747-400 / RB211-524G (378t)	4	98.1	97.8	98.9	0.2	105	101.2	0.1	597	98.0	100.0
B747-400 / RB211-524G (364t)	4	98.2	96.8	99.0	0.1	153	100.7	0.1	1,209	97.5	99.9
B777-300ER / GE90-115B (351.5t)	2	98.7	92.8	92.9	0.4	118	93.4	0.1	3,388	95.8	93.1
B777-300ER / GE90-115B (348.8t)	2	98.8	92.6	94.1	0.7	46	93.2	0.2	95	95.7	93.6
B777-300ER / GE90-115B (346.5t)	2	99.0	92.1	96.1	0.9	6	95.3	0.2	75	95.6	95.7
B777-300ER / GE90-115B (346.5t)	2	98.8	92.4	95.6	0.9	6	95.5	0.2	104	95.6	95.6
B777-300ER / GE90-115B (344.7t)	2	98.8	92.3	92.0	0.4	11	92.5	0.5	36	95.6	92.2
B777-300ER / GE90-115B (342.5t)	2	98.8	92.1	94.2	0.8	9	93.7	0.3	117	95.5	94.0
B777-300ER / GE90-115B (340.2t)	2	98.9	91.9	94.2	0.8	19	93.9	0.1	883	95.4	94.0
B777-300ER / GE90-115B (337.9t)	2	98.9	91.7	93.7	0.3	56	94.3	0.1	594	95.3	94.0
B777-300ER / GE90-115B (337.9t)	2	99.1	91.3	93.7	0.8	8	94.0	0.3	58	95.2	93.9
B777-300ER / GE90-115B (337.9t)	2	98.7	92.8	93.2	0.7	15	94.0	0.4	50	95.8	93.6
B777-300ER / GE90-115B (317.5t)	2	99.2	90.0	93.7	0.3	43	93.5	0.1	906	94.6	93.6
B777-200 / Trent 895 (297t)	2	98.2	93.3	95.1	0.4	37	96.0	0.1	700	95.8	95.5
B777-200 / Trent 895 (293.9t)	2	98.3	93.0	94.6	0.2	59	96.0	0.1	974	95.7	95.3
B777-200 / Trent 895 (285.5t)	2	98.8	92.2	94.4	0.9	8	93.8	0.2	93	95.5	94.1
B777-200 / Trent 892 (263.1t)	2	98.0	90.3	95.2	0.3	42	94.4	0.1	793	94.2	94.8
B777-200 / GE90-94B (297.6t)	2	96.4	91.1	93.0	0.4	16	94.2	0.1	289	93.8	93.6
B767-400 / CF6-80C2B8F (204.1t)	2	96.8	91.2	96.4	0.5	12	94.8	0.1	657	94.0	95.6
B767-300 / CF6-80C2B6F (184.6t)	2	96.2	91.1	93.7	0.8	31	93.8	0.2	109	93.7	93.8
B767-300 (Winglets) / PW4060 (185.1t)	2	97.0	93.3	93.9	0.7	95	95.0	0.2	203	95.2	94.5
B767-300 (Winglets) / PW4060 (184.6t)	2	96.0	90.0	95.5	0.5	17	95.4	0.1	550	93.0	95.4
B747-8 / GEnx-2B67/P (447.7t)	2	93.9	94.4	93.9	0.4	6	96.0	0.5	43	94.2	95.0
A380-861 / GP7270 (575t)	2	94.4	95.9	91.7	0.2	118	94.5	0.1	502	95.2	93.1
A380-861 / GP7270 (573t)	2	94.4	95.7	91.3	0.3	54	94.9	0.1	311	95.1	93.1
A380-861 / GP7270 (510t)	2	94.8	91.6	91.9	0.2	152	94.7	0.1	751	93.2	93.3
A380-842 / Trent 972E-84 (575t)	2	94.5	95.5	91.7	0.7	9	94.5	0.5	42	95.0	93.1
A380-842 / Trent 972-84 (569t)	2	94.5	95.1	94.5	0.3	38	97.9	0.2	139	94.8	96.2
A380-841 / Trent 970-84 (569t)	2	94.2	95.6	93.6	0.2	69	97.1	0.2	316	94.9	95.4
A380-841 / Trent 970-84 (560t)	2	94.3	95.0	92.5	0.1	284	96.5	0.1	957	94.7	94.5
A340-642 / Trent 556-61 (368t)	2	95.9	94.7	93.1	0.2	140	96.5	0.1	804	95.3	94.8
A340-642 / Trent 556-61 (365t)	2	95.9	94.2	92.7	0.3	29	93.5	0.2	125	95.1	93.1
A340-313 / CFM56-5C4/P (276.5t)	2	96.1	95.6	96.6	0.7	8	100.4	0.6	26	95.9	98.5
A340-313 / CFM56-5C4/P (275t)	2	96.1	95.4	92.6	0.3	22	95.2	0.4	134	95.8	93.9
A340-313 / CFM56-5C4 (271t)	2	96.1	94.8	95.8	0.9	11	98.5	0.4	41	95.5	97.1
A330-343 / Trent 772 (242t)	2	97.3	91.9	93.7	1.0	79	94.7	0.2	239	94.6	94.2
A330-343 / Trent 772 (233t)	2	97.4	90.7	93.4	0.4	333	94.4	0.1	1,576	94.1	93.9
A330-323 / PW4168A (233t)	2	98.8	92.8	93.8	0.6	153	95.3	0.1	582	95.8	94.5
A330-302 / CF6-80E1A4 (242t)	2	98.2	93.1	95.1	0.7	28	94.0	0.3	75	95.7	94.6
A330-243 / Trent 772 (242t)	2	97.3	91.9	94.9	0.8	24	93.2	0.3	55	94.6	94.0
A330-243 / Trent 772 (233t)	2	97.4	90.7	94.2	1.0	46	92.9	0.2	180	94.1	93.5
A330-223 / PW4170 (238t)	2	98.6	92.7	94.4	0.9	27	95.0	0.4	29	95.7	94.7
A330-223 / PW4168A-1D (238t)	2	98.2	93.4	94.3	0.4	158	94.2	0.1	761	95.8	94.2

Table B2 Mean Operational Departure EPNLs, continued

Aircraft Type (MTOW, tonnes)	QC Classification	Certificated EPNL (EPNdB)		Mean Operational EPNL (EPNdB)						Departure EPNL (EPNdB)	
		Lateral	Flyover	Lateral	95% CI	Count	Flyover	95% CI	Count	Certificated	Operational
MD-82 / JT8D-217C (67.8t)	1	96.2	89.3	98.5	1.0	15	95.8	0.6	13	92.8	97.1
B787-9 / Trent 1000-K2 (252.7t)	1	91.9	88.7	88.4	0.3	58	90.1	0.1	324	90.3	89.2
B787-9 / Trent 1000-J3 (252.7t)	1	91.9	88.7	87.1	0.8	8	86.3	0.3	86	90.3	86.7
B787-9 / GEnx-1B74/75/P2 (254t)	1	92.3	89.1	88.8	0.3	93	90.2	0.1	737	90.7	89.5
B777-200 / GE90-85B (267.6t)	1	95.2	90.0	91.4	0.4	570	94.4	0.1	2,072	92.6	92.9
B767-300 / RB211-524H (158t)	1	95.2	89.2	94.2	0.7	249	94.4	0.1	457	92.2	94.3
B767-300 (Winglets) / CF6-80C2B6F (172.4t)	1	96.5	88.1	92.7	0.7	43	93.3	0.3	87	92.3	93.0
A321-231 / V2533-A5 (89t)	1	95.0	86.6	91.5	0.4	409	89.4	0.1	1,113	90.8	90.5
A321-231 / V2533-A5 (85t)	1	95.2	85.2	90.1	0.6	32	87.8	0.3	85	90.2	88.9
A321-231 (Sharklets) / V2533-A5 (93.5t)	1	95.0	88.3	91.7	0.6	17	89.9	0.5	36	91.7	90.8
A321-231 (Sharklets) / V2533-A5 (89t)	1	95.0	86.6	91.6	0.9	158	89.4	0.1	464	90.8	90.5
A321-131 / V2530-A5 (85t)	1	94.3	85.8	91.7	0.5	22	88.7	0.6	28	90.1	90.2
A321-112 / CFM56-5B2/P (83t)	1	96.4	86.0	90.9	0.9	28	88.8	0.2	127	91.2	89.8
A321-111 / CFM56-5B1/P (83t)	1	96.5	87.0	91.4	0.6	31	89.8	0.3	98	91.8	90.6
A321-111 / CFM56-5B1/P (83t)	1	95.9	86.3	90.9	0.6	119	90.2	0.2	287	91.1	90.5
A300-B4-622R / PW4158 (171.7t)	1	96.3	89.4	94.5	0.9	12	90.6	1.0	29	92.9	92.6
A300-B4-622R / PW4158 (170.5t)	1	96.3	89.3	94.1	1.0	13	91.4	0.7	37	92.8	92.8
A300-B4-622R / PW4158 (153t)	1	96.7	85.6	94.1	0.7	63	90.5	0.4	195	91.2	92.3
ERJ 190-100 / CF34-10E5A1 (50.3t)	0.5	92.9	84.6	89.5	0.6	14	85.5	0.5	38	88.8	87.5
B787-9 / Trent 1000-K2 (252.7t)	0.5	91.3	87.9	88.3	0.2	197	89.8	0.1	1,127	89.6	89.1
B787-9 / Trent 1000-J3 (247.2t)	0.5	91.9	87.9	88.4	0.6	26	89.2	0.2	206	89.9	88.8
B787-9 / Trent 1000-J2 (247.2t)	0.5	91.4	87.2	88.6	0.6	25	89.2	0.2	215	89.3	88.9
B787-9 / Trent 1000-J2 (247.2t)	0.5	91.4	87.3	88.2	0.3	106	89.0	0.1	779	89.4	88.6
B787-9 / Trent 1000-J2 (247.2t)	0.5	91.9	87.9	88.1	0.4	46	89.0	0.2	360	89.9	88.6
B787-9 / Trent 1000 - D3 (247.2t)	0.5	90.9	89.0	87.3	0.3	21	88.3	0.3	174	90.0	87.8
B787-8 / Trent 1000-D2 (227.9t)	0.5	90.7	85.8	87.2	0.9	12	89.0	0.3	85	88.3	88.1
B787-8 / Trent 1000-D2 (227.9t)	0.5	90.7	85.7	86.8	0.4	15	88.8	0.3	106	88.2	87.8
B787-8 / Trent 1000-AE3 (227.9t)	0.5	89.7	88.0	86.9	0.5	21	87.4	0.2	286	88.9	87.2
B787-8 / Trent 1000-A2 (227.9t)	0.5	89.1	87.4	86.6	0.8	7	87.9	0.3	117	88.3	87.3
B787-8 / Trent 1000-A (227.9t)	0.5	88.9	87.9	87.6	0.7	8	87.9	0.4	45	88.4	87.7
B787-8 / Trent 1000-A (227.9t)	0.5	88.9	87.4	86.4	0.4	43	87.5	0.1	541	88.2	87.0
B787-8 / GEnx-1B70/P2 (227.9t)	0.5	91.6	86.7	87.8	0.4	27	89.7	0.2	266	89.2	88.8
B787-8 / GEnx-1B70/P2 (227.9t)	0.5	91.6	87.4	86.3	0.7	158	88.1	0.1	438	89.5	87.2
B787-8 / GEnx-1B70/75/P2 (227.9t)	0.5	91.6	86.7	88.0	0.5	14	87.0	0.2	263	89.2	87.5
B787-8 / GEnx-1B70 (227.9t)	0.5	91.5	87.4	87.5	0.9	64	88.8	0.2	134	89.5	88.1
B787-8 / GEnx-1B64 (227.9t)	0.5	90.1	89.0	89.0	1.0	8	89.5	0.3	111	89.6	89.2
B757-200 (Winglets) / RB211-535E4B (115.9t)	0.5	93.8	86.1	90.1	0.9	62	91.2	0.2	229	90.0	90.6
B737-800 (Winglets) / CFM56-7B24/3 (70t)	0.5	92.3	83.9	87.3	1.0	25	89.9	0.5	40	88.1	88.6
B737-700 (Winglets) / CFM56-7B24 (69.4t)	0.5	93.0	84.3	87.2	0.9	14	88.4	0.4	28	88.7	87.8
B737-700 (Winglets) / CFM56-7B22 (64.9t)	0.5	92.2	83.3	87.6	0.7	26	88.2	0.3	57	87.8	87.9
A350-941 / Trent XWB-84 (275t)	0.5	91.5	85.9	87.6	0.6	103	87.9	0.2	357	88.7	87.7
A350-941 / Trent XWB-84 (272t)	0.5	91.5	85.5	88.3	0.5	75	89.5	0.2	335	88.5	88.9
A350-941 / Trent XWB-84 (268t)	0.5	91.6	85.0	88.4	0.5	68	88.5	0.2	130	88.3	88.4

Table B2 Mean Operational Departure EPNLs, continued

	QC	Certificated EPNL (EPNdB)		Mean Operational EPNL (EPNdB)						Departure EPNL (EPNdB)	
Aircraft Type (MTOW, tonnes)	**Classification**	**Lateral**	**Flyover**	**Lateral**	**95% CI**	**Count**	**Flyover**	**95% CI**	**Count**	**Certificated**	**Operational**
A321-231 / V2533-A5 (83t)	0.5	95.2	84.5	91.9	0.2	1,304	88.9	0.0	3,954	89.9	90.4
A320-232 / V2527-A5 (73.5t)	0.5	91.4	83.1	90.7	0.1	3,043	88.1	0.0	9,514	87.3	89.4
A320-232 / V2527-A5 (72.6t)	0.5	91.5	82.7	91.4	0.3	500	88.5	0.1	1,550	87.1	90.0
A320-232 (Sharklets) / V2527-A5 (75.5t)	0.5	91.4	83.3	90.5	0.2	790	87.9	0.1	2,184	87.4	89.2
A320-216 / CFM56-5B6/3 (73.5t)	0.5	92.0	85.8	90.0	0.7	134	86.8	0.1	686	88.9	88.4
A320-216 (Sharklets) / CFM56-5B6/3 (73.5t)	0.5	92.0	85.8	88.8	0.7	22	88.9	0.2	100	88.9	88.9
A320-214 / CFM56-5B4/P (77t)	0.5	93.5	85.3	89.7	0.3	186	87.7	0.1	735	89.4	88.7
A320-214 / CFM56-5B4/P (75.5t)	0.5	93.5	84.7	89.4	0.5	97	87.5	0.1	410	89.1	88.5
A320-214 / CFM56-5B4/P (73.5t)	0.5	94.0	84.2	90.3	0.4	25	89.5	0.3	81	89.1	89.9
A320-214 / CFM56-5B4/P (73.5t)	0.5	94.5	84.2	90.5	0.8	10	88.5	0.4	49	89.4	89.5
A320-214 / CFM56-5B4/P (73.5t)	0.5	93.9	84.3	89.8	0.3	78	88.0	0.2	250	89.1	88.9
A320-214 / CFM56-5B4/P (73.5t)	0.5	93.6	83.7	89.4	0.2	717	87.5	0.1	2,857	88.7	88.4
A320-214 / CFM56-5B4/P (72t)	0.5	93.7	83.2	90.0	0.6	16	87.2	0.4	80	88.5	88.6
A320-214 / CFM56-5B4/3 (77t)	0.5	93.5	85.3	89.3	0.8	89	87.5	0.2	310	89.4	88.4
A320-214 / CFM56-5B4/3 (73.5t)	0.5	93.6	83.7	89.9	0.3	420	87.1	0.1	1,537	88.7	88.5
A320-214 (Sharklets) / CFM56-5B4/3 (77t)	0.5	92.9	84.8	89.3	0.2	140	86.6	0.1	446	88.9	88.0
A320-214 (Sharklets) / CFM56-5B4/3 (73.5t)	0.5	93.1	83.3	89.0	0.5	46	86.7	0.3	151	88.2	87.9
A320-214 (Sharklets) / CFM56-5B4/3 (71.5t)	0.5	93.3	82.4	89.5	0.4	178	86.0	0.1	604	87.9	87.8
A320-211 / CFM56-5A1 (73.5t)	0.5	93.8	85.6	92.0	1.0	11	87.8	0.3	79	89.7	89.9
A320-211 / CFM56-5A1 (73.5t)	0.5	93.7	85.6	91.4	0.6	65	87.8	0.2	233	89.7	89.6
A319-112 / CFM56-5B6/P (68t)	0.5	92.6	83.7	89.4	0.7	48	86.8	0.3	78	88.2	88.1
A319-112 / CFM56-5B6/P (68t)	0.5	91.8	83.1	88.6	0.4	161	87.0	0.2	444	87.5	87.8
A319-112 / CFM56-5B6/3 (70t)	0.5	91.7	84.0	89.6	0.8	19	86.3	0.4	50	87.9	87.9
A319-112 / CFM56-5B6/3 (68t)	0.5	91.8	83.1	89.0	0.5	62	85.7	0.2	188	87.5	87.3
A319-111 / CFM56-5B5/P (68t)	0.5	90.8	83.5	88.1	0.5	35	88.8	0.3	151	87.2	88.5
ERJ 170-200 / CF34-8E5 (36.5t)	0.25	90.7	81.2	87.9	0.6	11	85.0	0.5	39	86.0	86.5
B737 MAX 8 / LEAP-1B27 (82.2t)	0.25	88.0	83.4	87.4	0.6	11	88.0	0.3	213	85.7	87.7
B737 MAX 8 / LEAP-1B25 (77t)	0.25	87.5	82.4	85.2	0.4	57	85.3	0.4	69	85.0	85.3
B737 MAX 8 / LEAP-1B25 (77t)	0.25	87.5	82.5	85.4	0.9	62	84.8	0.3	112	85.0	85.1
A321-251NX / LEAP-1A32 (89t)	0.25	88.9	82.1	85.9	1.0	7	85.7	0.2	213	85.5	85.8
A320-232 (Sharklets) / V2527-A5 (73.5t)	0.25	91.4	82.5	90.2	0.2	214	87.7	0.1	703	87.0	88.9
A319-132 / V2524-A5 (68t)	0.25	91.9	82.0	89.7	0.6	119	87.0	0.2	343	87.0	88.4
A319-131 / V2522-A5 (64t)	0.25	91.5	81.1	89.9	0.4	3,770	88.0	0.0	10,662	86.3	88.9
A319-112 / CFM56-5B6/P (64t)	0.25	92.0	81.3	88.7	0.6	42	86.7	0.2	144	86.7	87.7
A319-111 / CFM56-5B5/P (67t)	0.25	90.9	83.0	89.0	0.8	173	87.1	0.1	784	87.0	88.1
A319-111 / CFM56-5B5/3 (64t)	0.25	91.0	81.5	86.6	0.7	61	87.5	0.3	232	86.3	87.0
A318-111 / CFM56-5B8/P (60t)	0.25	90.9	80.7	88.2	0.5	28	86.4	0.4	79	85.8	87.3
DHC-8-400 / PW127G (29.3t)	0.125	84.0	78.3	81.7	0.5	65	84.3	1.0	18	81.2	83.0
A320-271N / PW1127G-JM (73.5t)	0.125	86.9	79.9	86.2	0.3	303	85.4	0.1	693	83.4	85.8
A320-251N / LEAP-1A26/26E1 (77t)	0.125	86.2	80.5	84.9	0.2	329	84.1	0.1	615	83.4	84.5
A320-251N / LEAP-1A26/26E1 (77t)	0.125	85.8	80.9	84.9	0.3	81	84.0	0.3	110	83.4	84.4
A320-251N / LEAP-1A26/26E1 (75.5t)	0.125	86.2	80.0	85.2	0.3	420	84.0	0.1	1,767	83.1	84.6