

Edinburgh Airport Noise Calculations and Comparisons with Measurements

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Background to this document

1. Edinburgh Airport began developing proposals to change its airspace design in 2016. The CAA's airspace change process requires sponsors of airspace change proposals to provide in certain circumstances noise data and analysis to the CAA for the purpose of informing the CAA's decision whether or not to approve the change. Edinburgh's proposal submitted to the CAA for decision, included such noise data and analysis, and was published on the CAA's website. A number of Edinburgh Airport's stakeholders including Edinburgh Airport Noise Advisory Board (EANAB), challenged publicly the validity of the noise modelling within Edinburgh's airspace change proposal.
2. As airspace change decision maker the CAA must reach a view on whether the quality of the noise data and analysis in the proposal is sufficient to enable the CAA to make a decision. As a step towards considering that issue, the CAA required Edinburgh to provide a response to the feedback received for the CAA, as airspace change decision maker to consider.
3. As is explained in more detail below, the CAA's Environmental Research and Consultancy Department (ERCD) carries out noise analysis under contract for a number of airports. ERCD sits in the CAA, but is distinctly separate from the CAA's Airspace Regulation Directorate. In this case Edinburgh commissioned ERCD to produce the noise analysis for the purpose of developing its airspace change proposal. Edinburgh accordingly instructed ERCD to produce a response to the feedback received about that analysis.
4. This document was produced by ERCD for Edinburgh for that purpose.
5. On 22 November 2018 the CAA decided to reject Edinburgh's airspace change proposal (for the reasons set out in the letter containing the CAA's minded to decision on 29 October 2018). [https://www.caa.co.uk/Commercial-industry/Airspace/Airspace-change/Decisions/FASI\(N\)/](https://www.caa.co.uk/Commercial-industry/Airspace/Airspace-change/Decisions/FASI(N)/). Had the CAA not made that decision this document would have been delivered by ERCD to Edinburgh who would have used it to meet the requirement of the airspace change process set out in paragraph 2 above.
6. Notwithstanding that the airspace change proposal for which this document was prepared is no longer active, the CAA considers it important that the response to the feedback received, set out in this document, is shared and published. The analysis methods referred to are likely to be used by Edinburgh or other airports in other airspace design issues, for noise monitoring or related purposes and are used by the wider industry. This document is therefore intended to respond both to EANAB's criticisms and inform wider stakeholders about noise analysis.

Executive Summary

7. A number of Edinburgh Airport's stakeholders including Edinburgh Airport Noise Advisory Board (EANAB), challenged the validity of the noise modelling the Environmental Research and Consultancy Department (ERCD) of the CAA had undertaken on behalf of Edinburgh Airport for its airspace change proposal. We welcome the time stakeholders have invested in this important issue.
8. This report sets out some background to noise modelling, ERCD's response to these challenges and its own assessment of EANAB's analysis. In summary, the CAA believes that ERCD's noise modelling, and the results of its analysis used in Edinburgh's recent airspace change proposal, is robust and that the alternative analysis presented by EANAB contains a number of inaccuracies. This report sets out why.
9. This report also addresses an issue (albeit not raised in external feedback) that ERCD identified with the calculation of one of its supplemental noise indicators – L_{Amax} .

Ways of Calculating aircraft noise

10. The purpose of aviation noise modelling is to represent the level of aviation noise experienced by populations near airports in a quantifiable way. There is international aviation noise modelling best practice guidance set by the global aviation regulator, the International Civil Aviation Organization (ICAO). The UK's Aircraft Noise Contour Model (ANCON) meets internationally recognised best practice guidance and has been benchmarked against other international models that accord with the international best practice guidance. The quality of its outputs, however, depend on the quality of its data inputs.
11. There are a number of ways of modelling aircraft noise. At a basic level, there is the Aircraft Noise and Performance (ANP) database, which is an ICAO sponsored global database of aircraft and their noise and performance characteristics. This data is vital to ERCD's modelling, but the standard assumptions, such as the power aircraft are using when taking off, can under- or over-estimate noise as they do not always match with how aircraft are flown in reality. Therefore, there is a need to adapt ICAO's ANP to reflect local conditions to provide the most accurate reflection of the actual noise experienced.
12. The CAA's advice is that the more local information received, the richer the noise modelling will be. One method of supplying this is through Noise and Track Keeping (NTK) systems. These systems match air traffic control radar data (i.e. aircraft flight paths and flight profiles) to related noise measurements at set ground positions. The UK's three noise designated airports (Heathrow, Gatwick

and Stansted) have made a significant investment in NTK systems and it is longstanding practice that the data sourced at these airports informs modelling at other airports which do not have this equipment or sufficient noise monitors in appropriate locations.

13. Installing NTK systems is a significant investment and the decision about whether to invest in these systems is a question of proportionality related to the size of the airport and the level of noise impact. Balancing this cost against the quality of the data it produces to inform decision and best practices affects all airports in the UK. As a consequence we will be providing guidance to airports about best practice noise measurement in due course.
14. For the Edinburgh airspace change proposal the ERCD used an adapted ANP database based on Gatwick vertical flight profiles for its modelling for Edinburgh Airport. The airlines and aircraft that contribute most to the overall noise exposure at Edinburgh Airport, also operate at Gatwick Airport.
15. Finally, it is worth noting that in noise modelling, the generally accepted margin of error is ± 1 dB. Furthermore, in terms of noise measurements, the error margin even on high specification noise measurement devices is of a similar level. Inappropriate use of the instrument can, however, increase the level of measurement uncertainty. Care should therefore be taken in interpreting small differences in dB measures between the results of different studies.

Criticisms and Response

16. Although raw noise measurement data wasn't used in the noise analysis prepared for Edinburgh's airspace change proposal, EANAB was supplied with the raw noise measurement data by Edinburgh Airport and used further information on the flight profiles from Flight Radar 24 to form the basis of its feedback. Through its analysis of this data, EANAB are of the view that the ERCD's use of Gatwick's vertical flight profiles as an assumption for Edinburgh Airport's noise modelling is inappropriate because Edinburgh Airport's actual vertical flight profiles are different. EANAB argued that this resulted in a difference between the calculated noise levels and the actual measured data.
17. The CAA welcomes robust engagement from all its stakeholders, especially on issues as important as noise. However, following further review, we consider ERCD's modelling is robust and we do not consider the EANAB's analysis as a valid comparison against ERCD's for the following reasons:
 - Inconsistent time periods - The Gatwick data used by ERCD was for a standard summer period. The data used in EANAB's analysis uses an earlier period in the year. Temperature affects aircraft performance and therefore its noise footprint.

- Inconsistent aircraft destinations – The aircraft used in the Gatwick data are heading to a variety of destinations, both domestic and international. EANAB's data sample is purely Edinburgh to Gatwick flights. Aircraft flying shorter distances such as this tend to carry less fuel and climb more rapidly after take-off, creating different height and noise profiles.
- Incomparable height data - The two datasets use different pressure settings to measure height. Gatwick data is presented on the basis of pressure settings measured at the height above airport runway, EANAB's data relied on standard pressure settings. With heights having considerable impacts on noise levels, it is not an adequate comparison.

18. In addition, the position of one of Edinburgh Airport's three noise monitors when the sound measurements were taken did not meet ISO standards for airport noise monitors as it was located on top of a hard surface (a school roof), meaning that its measurements may be strongly affected by surface reflections, impacting the accuracy of any readings. The CAA would also normally exclude the departure noise measurements taken from one of Edinburgh Airport's other monitors as it is to the side rather than underneath a flight path. Edinburgh Airport confirmed to the CAA that the Livingston school monitor (EDI 01) was relocated on the 19th September 2018 away from large reflecting surfaces. Edinburgh Airport are in the process of installing a monitor under the runway 06 departure flight paths, retaining monitor EDI 03 for monitoring runway 24 arrivals. The CAA understands that Edinburgh Airport has already changed the location of the Livingston microphone.

Edinburgh Airport Noise Measurement Data

19. It is important to stress that Edinburgh's airspace change proposal was not based on any noise measurement data collected by Edinburgh Airport's NTK system.
20. In the course of addressing criticisms from EANAB, ERCD identified an issue with noise measurements recorded prior to the introduction of Edinburgh Airport's new NTK system on the 6 April 2018. ERCD believes that Edinburgh Airport's noise data prior to April 2018 and supplied to EANAB may contain some inconsistencies. We believe the likely cause is a time inconsistency between the radar and noise data, an issue that the new NTK system that Edinburgh Airport has introduced has resolved. Looking at the data available from April 2018, our assessment is that it matches much more closely to the ANCON modelled values, and is certainly well within the margins of error for such calculations. We do not believe that the pre-April 2018 noise measurement data is sufficiently reliable to provide a basis for accurate comparison with noise today and any future airspace change proposals.

21. For all the reasons set out above, our view is that ANCON remains a robust and valid model for the calculation of noise, and that using Gatwick vertical profiles is an acceptable substitution for actual vertical flight profiles. It would, however, be entirely acceptable if Edinburgh Airport measured actual flight profiles and used them in its noise modelling.

L_{Amax} validation issue

22. Since Sound Exposure Level (SEL) is required to calculate L_{Aeq} noise contours, ERCD has always validated SEL calculations against measurement. However, this was not for the maximum sound level measured during the event (L_{Amax}) indicator. ERCD has discovered that previously provided estimates of the L_{Amax} were underestimated across all airports where it provides modelling for some critical aircraft types. Earlier this year when comparing L_{Amax} calculations with measurements for the first time ERCD discovered that calculations over-estimated L_{Amax} for some aircraft types, and under-estimated L_{Amax} by 2-3dB for other aircraft types, particularly the Airbus A320 series¹. The ERCD understands the cause of the issues and has now addressed it by undertaking the same level of validation as for SEL, i.e. comparing calculated L_{Amax} levels against L_{Amax} measurements on an aircraft type by type basis for departures and arrivals..

Recommendations

23. While the CAA remains confident in the UK's ANCON model, it has a number of actions and recommendations as follows:
- The CAA would like to arrange a seminar with EANAB and other interested stakeholders to discuss the conclusions presented in this report.
 - Edinburgh Airport should consider and address as appropriate the noise measurements issues identified in this report such as the location and number of microphones and confirming the time synchronisation issues in the pre-April 2018 data.
 - Having addressed these issues, Edinburgh Airport should consider carefully and consciously decide upon the appropriate methodology for the production of noise contours that will inform its stakeholders and any airspace change process.

¹ Some of these L_{Amax} estimates were used in the consultation from January to May 2017 that formed part of Edinburgh's airspace change proposal. L_{Amax} is not a core measure of noise required under the CAA's airspace change process and is a supplementary measure used by a number of stakeholders. No L_{Amax} information was submitted within Edinburgh Airport's formal Airspace Change Proposal to the CAA which in any event has now concluded.

- Any airport, where noise is an issue or which is contemplating making an airspace change where noise will be a consideration, should satisfy themselves, using a qualified external party if required, about the validity and reliability of their noise data and input data for noise modelling and create a reliable baseline before starting any process and should note that such considerations and validations will form part of the CAA's airspace change decision making analysis.
- CAA will publish a more general form of guidance about how noise can be modelled and measured to inform all airports, particularly important for those considering making airspace change proposals, of:
 - issues to consider, such as avoiding the time synchronisation issue
 - best practice regarding audit and maintenance of noise monitors
 - how airports should publish information about their noise methodology.

24. In conclusion, and save for the now corrected L_{Amax} calculation issue, the CAA is confident in our noise modelling including that used in Edinburgh's recent airspace change proposal. We have set out in this document a number of inaccuracies in EANAB's own noise analysis. However, we strongly welcome the engagement on this issue from all of our stakeholders and we look forward to continuing our engagement with them going forward.

Purpose of this document

25. During Edinburgh Airport's preparation and consultation of its proposed airspace change in 2017 and 2018, the Edinburgh Airport Noise Advisory Board and a number of other interested parties challenged the validity of the noise analysis that the CAA had prepared under contract to Edinburgh Airport and presented their own alternative analysis based on data provided by Edinburgh Airport. This report sets out some context about undertaking noise analysis more broadly, and addresses the specific challenges raised by Edinburgh Airport's stakeholders and assesses the validity of EANAB's own noise analysis. The CAA welcomes the challenge from these stakeholders together with the opportunity to address these directly and publicly.
26. Given that a number of these questions came directly and publicly to the CAA, and the CAA's wider role in aviation regulation, this report is being published on the CAA's website. In due course, the CAA will provide additional guidance to airports about options and best practice for undertaking noise analysis.

Introduction

27. The purpose of estimating aircraft noise levels in the vicinity of an airport is to provide a quantitative assessment of the noise experienced by those living near an airport. A reliable assessment forms part of an important evidence base that informs how aircraft noise is understood and managed. Noise calculations are used to provide historic and forecast trends of noise exposure, as part of the formal planning processes related to airport developments and in the CAA's Airspace Change Process.
28. This note addresses four points in the context of the noise analysis undertaken as part of the Edinburgh Airport Airspace Change Proposal:
 - Different ways of calculating aircraft noise
 - Calculation approach used for Edinburgh Airport
 - Criticisms of the approach taken
 - Response to the criticisms

Ways of calculating aircraft noise

Some history

29. Historically, aircraft noise calculations were undertaken using nationally developed calculation models. The earliest models were wholly empirical and relied on measurements obtained around airports. Beginning in the 1980s, the US developed a performance-based calculation model that estimated aircraft performance during landing and take-off and from this estimated the associated noise levels. Being performance-based, the model recognised that aircraft noise levels experienced on the ground are directly linked to aircraft performance and to assumptions regarding the way in which aircraft are flown.
30. The US performance-based calculation model was gradually adopted as the global recommended method for aircraft noise calculation. The method was adopted into guidance published by the International Civil Aviation Organization (ICAO)² and the European Civil Aviation Conference (ECAC)³. The recommended method, when supported with suitable data, can estimate single event noise levels for a variety of different metrics, including maximum noise level (L_{Amax}) and Sound Exposure Level (SEL) of individual aircraft overflights. The primary metric of interest is the calculation of long-term average day or night noise exposure, using the L_{Aeq} indicator, which takes account of event noise level, duration and how many events occur in a given time period. L_{Aeq} is based on an aggregation of the SEL measurements or calculations, of individual aircraft overflights occurring within a given time period. For example, the average summer day indicator, L_{Aeq16h} , is calculated from the SELs occurring within an average summer day period from 0700 to 2300. Day-Night Level (DNL), Day-Evening-Night Level (L_{den}) and Night Level (L_{night}) are all variants of L_{Aeq} with either weightings applied to different times of day and/or different time periods. Using the recommended method, L_{Amax} plays no role in the calculation of L_{Aeq} type metrics.

The ANCON model and ANP database

31. The UK's Aircraft Noise Contour model, ANCON version 2, developed and maintained by the CAA on behalf of the Department for Transport (DfT) and introduced in 1997, was the first version of ANCON to implement the ECAC

² [ICAO Doc. 9911, Recommended Method for Computing Noise Contours Around Airports, 2nd Edition, International Civil Aviation Organization, 2018.](#)

³ [ECAC Doc. 29, Report on Standard Method of Computing Noise Contours around Civil Airports, 4th Edition, European Civil Aviation Conference, December 2016.](#)

performance-based calculation guidance. In 2005 a supporting global Aircraft Noise and Performance (ANP) database was created by European Civil Aviation Conference (ECAC) and subsequently endorsed by ICAO, based on information provided by the aircraft manufacturers that is necessary to fully utilise the method.

32. The ANP database provides aerodynamic and engine performance characteristic data for over 150 distinct aircraft types and variants of those types. This data describes the physical characteristics of the aircraft and engines, e.g. how much lift and drag are generated and how much thrust is available for take-off and climb. In addition, the data includes nominal information on how take-off weight varies with distance flown, the greater the distance flown requiring greater fuel to be carried, therefore increasing take-off weight. Default take-off weights provided assume the payload (passengers, baggage and cargo) is 65% of the maximum payload. This should not be confused with the more commonly referred to passenger load factor, which in practice can be as high as 90%, since this does not include any cargo allowance. Nevertheless, the 65% may or may not be representative of a particular airline's operations at any given airport. Take-off weight information, from which passenger load factor may be inferred, is considered commercially sensitive and even average information is rarely made available to the global aircraft noise modelling community.
33. The ANP database also includes standardised assumptions on other aspects of the aircraft performance that affect noise modelling. It assumes aircraft take-off at full power (thrust), which only holds for airports with short runways. Where the runway is longer than necessary and subject to meeting surrounding obstacle clearance requirements, aircraft are routinely operated at less than full take-off thrust to prolong engine life and also to reduce NO_x emissions whilst the aircraft is on the runway and during initial climb. Left unadjusted, the ANP database take-off performance assumptions place the aircraft at greater height than observed by radar data, but with higher noise emission close to the airport.
34. Take-off thrust cannot be maintained indefinitely following take-off (even when at a reduced level). Thus in practice all departures will reduce engine thrust to a lower climb thrust setting, when at least 800 ft above the airport level. An incorrect assumption regarding take-off thrust could result in calculations showing that an aircraft is higher than it would actually be, but at the same climb thrust setting. The net result is that the default ANP data and underlying assumptions tend to over-estimate noise directly beneath the flight path close to the airport (below 800 ft and less than 5 km from start of take-off roll), but underestimate noise further away. Figure 1 illustrates the difference between the default ANP profile for an Airbus A319 departure to airports up to 500 nm away (a common aircraft type on a short-haul flight), compared with the ANCON average profile calculated from radar data at Gatwick Airport in 2015.