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Peer Review of ANCON-3 Noise Model

An ECAC Doc 29 compliance review

CUSTOMER: UK Civil Aviation Authority



Royal NLR - Netherlands Aerospace Centre

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ANCON is the UK Government's civil aircraft noise contour model. The noise calculation engine of ANCON is required to be fully compliant with ECAC Doc 29 Volume 2, 4th edition. In strengthening evidence of compliancy, UK CAA decided to contract an independent third party to perform a peer review of the ANCON noise model to verify that ANCON-3 correctly implements the ECAC Doc 29 Volume 2 noise calculation method.

Description of work

NLR conducted a peer review of the ANCON-3 noise model, which consisted of three main components, or three checks:
Check 1 - A comparison of ANCON-3 results with ECAC Doc 29 reference case results, including the reference SEL results, reference segmental results and the reference grid results.
Check 2 - An inter-model comparison between ANCON-3, ANCON-2, and IMPACT for a Heathrow Airport scenario.
Check 3 - A comparison of Lden noise contours between ANCON-3 and NLR's Tuna model for a scenario based on the reference cases.

Results and conclusions

The results of the first check showed that ANCON-3 accurately reproduces the ECAC Doc 29 reference case results, with only some minor differences (0.03 dB or less) found in some of the reference SEL results. These differences were investigated further and were found to be small and not material.

The most important part of this first check is the comparison of the reference grid results. The results show that the difference is well within the ECAC Doc 29 recommended limit, proving ANCON's ability to generate noise level results that are equivalent to those generated by a Doc 29 Volume 2 compliant model. This successful reproduction of noise levels at thousands of grid points across the full set of reference cases provides strong, by-proxy evidence of compliance with Doc 29 Volume 2, as such systematic agreement would be very unlikely in a non-compliant implementation.

The second check performed by NLR was the review of an inter-model comparison prepared by the CAA. This comparison indeed confirms similarity in LAeq contour location and contour area between ANCON-3 and other Doc29-compliant models, such as ANCON-2 and IMPACT, for an average summer day at Heathrow Airport.

The comparison of Lden noise contours (Check 3) between ANCON-3 and Tuna for a scenario based on the reference cases showed that both models produce practically identical results, also at lower noise exposure levels, further away from the airport and beyond scope of the reference cases. The differences in contour lines are too small to be distinguished and relative differences in contour areas are at 0.0% for all contour levels considered.

Based on total results, it can be concluded that ANCON-3 correctly implements the ECAC Doc 29 Volume 2 method and is compliant with the standard. This means that ANCON-3 can be used with confidence to produce ECAC Doc 29 compliant noise levels results.

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Abbreviations and acronyms

Abbreviation / ACRONYM	DESCRIPTION
ANCON	Aircraft Noise Contour model
CAA	Civil Aviation Authority
dB(A)	Decibel (A-weighted)
DfT	Department for Transport
ECAC	European Civil Aviation Conference
ft	feet
LAeq	A-weighted Equivalent Sound Level
Lden	Day-Evening-Night Level
NLR	Royal NLR - Netherlands Aerospace Centre
NPD	Noise-Power-Distance
RMS	Root-Mean-Square
SEL	Sound Exposure Level
UK	United Kingdom

1 Introduction

1.1 Background

ANCON is the UK Government's civil aircraft noise contour model, owned and funded by the Department for Transport (DfT) and developed and maintained by the UK Civil Aviation Authority (CAA). The current version (ANCON-3) has been developed to comply with Volume 2 of the internationally accepted 4th edition of ECAC Doc 29 method [Ref. 1,2,3]. The model generates various outputs, including noise exposure contours around airports and exposure statistics (population, households). These outputs serve as a foundation for UK aviation noise policy and regulatory decisions.

The noise calculation engine of ANCON is required to be fully compliant with ECAC Doc 29 Volume 2, 4th edition. In strengthening evidence of compliancy, UK CAA decided to contract an independent third party to perform a peer review of the ANCON noise model to verify that ANCON-3 correctly implements the ECAC Doc 29 Volume 2 noise calculation method.

1.2 Scope of Work

NLR has been commissioned by the UK CAA to conduct this technical peer review of the ANCON-3 model. The main objective of this review is to verify that ANCON-3 correctly implements the ECAC Doc 29 Volume 2 method (4th edition). The review is based on data shared by CAA, including model inputs, model settings and model outputs in addition to comparison studies already performed by CAA.

1.3 Methodology

Before explaining the approach to the review, it is important to realize that ECAC Doc 29 currently consists of three parts:

- Volume 1 [Ref. 1] provides an introduction to noise calculation and the methodology used to calculate noise levels around airports.
- Volume 2 [Ref. 2] describes the specific methods and algorithms used to calculate noise levels, including flight path segmentation, noise calculation using NPD data and applying several corrections.
- Volume 3, Part 1 [Ref. 3] contains guidance for noise model developers to support the development of (new) noise models that produce results that are equivalent to those calculated by noise models that adhere to the methodology outlined in Volume 2.

Volume 3, Part 1 contains a set of reference cases: a comprehensive set of inputs which can be modelled using a development model, and a corresponding set of reference results against which the development model outputs may be checked. The reference cases test the various elements of the implementation of the noise calculation methodology defined in Volume 2. While these reference cases were developed to aid developers, they can also be used to demonstrate the ability of models to generate noise level results at grid points that are equivalent to those generated by a Doc 29 Volume 2 compliant model. This also means that the successful reproduction of noise levels at

thousands of grid points across the full set of reference cases provides strong, by-proxy evidence of compliance with Doc 29 Volume 2, as such systematic agreement would be very unlikely in a non-compliant implementation.

Accordingly, the reference cases will play a central role in the peer review, but the review is more extensive and consist of three main components, or three checks:

1. A comparison of ANCON-3 ECAC Doc 29 reference case results against the published reference results.
2. A review of comparisons already performed by the CAA, regarding LAeq noise contours produced by ANCON-3, ANCON-2 and EUROCONTROL's IMPACT for an average summer day in 2023 at Heathrow.
3. A comparison of Lden noise contours between ANCON-3 and NLR's Tuna for a scenario based on the reference cases.

It is important to note that the main objective of this peer review, which is to verify that ANCON-3 correctly implements the ECAC Doc 29 Volume 2 method, can already be met with the first check. In that sense the second and third component can be seen as additional activities to confirm consistency between different Doc 29 implementations beyond the scope of the reference cases.

1.4 Scope Limitations

The scope of this peer review is limited to the technical verification of the ANCON-3 noise model against the ECAC Doc 29 Volume 2 method. The review is based on information (input data and results) provided by the CAA. NLR did not have access to the ANCON-3 software or its source code.

It is also essential to note that this review focuses on verification, not validation. Verification involves checking that the model implementation (software) is correct, whereas validation involves comparing model results with measurements. As stated in Section 1.1 of Volume 3, Part 1 of Doc 29 [Ref. 3], validation is a separate step that requires comparing model results with measurements to determine if the model produces realistic results.

1.5 Audience and Report Structure

This report on the technical peer review of the ANCON-3 noise model is a rather technical document, delving into specific details of noise calculation methodologies and model comparisons. This report is intended for aviation professionals and stakeholders involved in noise modelling and regulation.

This report is structured into several chapters, each focusing on a specific aspect of the peer review of the ANCON-3 noise model:

- Chapter 1 provides an introduction to the peer review, including the background, scope of work, approach, and scope limitations.
- Chapter 2 presents the results of Check 1, which compares ANCON-3 results with ECAC Doc 29 reference results, including 1) receptor-based integrated SEL results, 2) segmental results, and 3) grid-based noise outputs.

- Chapter 3 discusses Check 2, an inter-model comparison between ANCON-3, ANCON-2 and IMPACT, focusing on LAeq contours for a Heathrow scenario. The chapter presents a comparison of outputs, including contours and contour areas.
- Chapter 4 describes Check 3, which involves a reference case scenario comparing Lden noise contours between ANCON-3 and NLR's Tuna model for a traffic scenario based on the reference cases. This chapter defines the scenario created for this comparison and presents the results.
- Chapter 5 summarizes the conclusions drawn from the peer review, highlighting the main findings and implications for the compliance of ANCON-3 with ECAC Doc 29 Volume 2 method.

Finally, Appendix A provides more information on the authors of this report that performed the review.

2 Check 1 – ECAC Doc 29 reference results

2.1 Introduction

The first check consists of comparing the ANCON-3 results with the ECAC Doc29 reference cases. These reference cases consist of a comprehensive set of inputs which can be modelled using a development model, and a corresponding set of reference results against which the development model outputs may be checked. The reference cases test the various elements of the implementation of the noise calculation methodology defined in Volume 2.

While these reference cases were developed to aid developers, they can also be used to demonstrate the ability of models to generate noise level results at grid points that are equivalent to those generated by a Doc 29 Volume 2 compliant model. This also means that the successful reproduction of noise levels at thousands of grid points across the full set of reference cases provides strong, by-proxy evidence of compliance with Doc 29 Volume 2, as such systematic agreement would be very unlikely in a non-compliant implementation.

The reference results can be found in ECAC Doc29 Volume 3, Part 1 (4th edition) [Ref. 3], where the inputs and outputs for 12 reference cases are presented. These reference cases consist of a combination of three hypothetical aircraft and four routes on an east-west runway, as presented in Table 2-1.

Table 2-1: Reference case combinations

Aircraft	Operation	Route	Case ID
Jet fuselage-mounted engines	Arrival	Curved	JETFAC
Jet fuselage-mounted engines	Arrival	Straight	JETFAS
Jet fuselage-mounted engines	Departure	Curved	JETFDC
Jet fuselage-mounted engines	Departure	Straight	JETFDS
Jet wing-mounted engines	Arrival	Curved	JETWAC
Jet wing-mounted engines	Arrival	Straight	JETWAS
Jet wing-mounted engines	Departure	Curved	JETWDC
Jet wing-mounted engines	Departure	Straight	JETWDS
Propeller engines	Arrival	Curved	PROPAC
Propeller engines	Arrival	Straight	PROPAS
Propeller engines	Departure	Curved	PROPDC
Propeller engines	Departure	Straight	PROPDS

The reference results are provided on three different levels:

- The **reference SEL results** are intended to enable a relatively quick and efficient check of the development model results against the reference results.
- The **reference segmental results** present the results for the main parameters at each step in the calculation. The main purpose of these results is for developers to diagnose any discrepancies between the results of a development model and the reference SEL results.
- The **reference grid results** are intended to be used by noise model developers to test the ability of a development model to generate noise level results at grid points that are equivalent to those generated by a Doc 29 Volume 2 compliant model.

To confirm correct implementation of the ECAC Doc29 Volume 2 method, the reference grid results are most important, but all three result types have been compared for this review. As a preceding step, first a check is performed to confirm the consistency of the reference case inputs between ANCON-3 and the ECAC Doc29 Volume 3 reference cases.

2.2 Reference case inputs

An initial check was performed to ensure consistency in the reference case inputs. The aircraft flight profiles, routes and Noise-Power-Distance (NPD) tables were compared. Next to this, the implemented grid definition and receptor locations were compared. No differences were found between the ANCON-3 reference case inputs and the ECAC Doc29 reference case inputs. This ensures that potential differences in model outputs would be caused by differences in model implementation rather than (accidental) differences in the inputs.

2.3 Reference SEL results

Reference case results are provided for a series of 18 receptor points, which are defined along the arrival and departure routes. With 12 reference cases and 18 receptor points, one might expect 216 reference results, but not all receptors are relevant to all cases. In total, ECAC Doc29 Volume 3, Part 1 provides 99 reference SEL results, that all have been compared with the ANCON-3 model output.

The results show that out of the comparison of the 99 reference receptor results, 86 are identical[1]. A minor difference in SEL output was found in 13 receptor points, ranging from -0.01dB to 0.03dB. Most differences were found for the propeller engine aircraft cases. Overall these differences are considered to be small, and already shows that the implementation does not suffer from serious, material errors. The differences that have been found have been investigated further against the reference case segmental results.

2.4 Reference case segmental results

Next to the SEL results in the receptor points, Volume 3, Part 1 also provides segmental results for each reference case and relevant receptor point. These segmental results include information along the segmented flight path such as aircraft location and slant distance, and most importantly, the segmental SEL value. This segmental SEL value is the contribution of the segment to the overall SEL of the entire trajectory. For each reference case and relevant receptor, the difference between the segmental results of ANCON-3 and the reference segmental results from Volume 3 have been computed.

When comparing the reference results with the ANCON-3 results, it was found that small differences occur in the flight path geometry (x, y, z location relative to receptor) for all reference cases. These differences are smaller than 2.0 ft, except for a few points with a worst case difference of 18.4 ft in segment start x-location which was found for the PROPAC and PROPAS cases. As to be expected, with these small differences in geometry also some small

[1] The volume 3 reference SEL results have a precision of two decimal places, while the ANCON-3 results have more precision: identical means a difference of 0.005 or less dB.

differences in segmental SEL values were found. Here the maximum difference in the segmental SEL values is equal to 0.048dB, found for the JETFDC case.

The differences in geometry have been investigated further and explained here. The first reason for differences lies in the accuracy of the input geometries. The reference case trajectories seem to be based on an indirect unit conversion from meters to nautical miles to feet (divide by 1852, multiply by 6076), which is less exact than the conversion of meters directly to feet (divide by 0.3048) as used in ANCON. The ANCON conversion is more accurate, but this results in small differences between ANCON and the reference on the majority of the locations considered.

The difference of 18.4 feet only occurs for the PROPAC and PROPAS cases and occurs at a single location due to sub-segmentation. An existing trajectory segment is broken into smaller parts and ANCON-3 and the reference model subdivides at slightly different locations, where ANCON-3 subdivides earlier than the reference model. The subdivision seems to be in place to limit the speed decrease over a segment, but this could not be checked as the reference results do not include the reason for the speed sub-segmentation, nor do the segmental reference results include speed output. The result of the difference in sub-segmentation is practically none: while it results in a shorter first segment for ANCON-3 with a slightly lower segment noise contribution (0.006 dB on average), this is mostly compensated by a longer second segment with a slightly higher segment noise contribution (0.008 dB on average).

Sub-segmentation based on speed happens regularly, both within these two reference cases as well as in the remaining 10 reference cases, without such differences occurring. This and the fact that the differences are only 18.4 feet (which is 0.07% of the segment length) makes it unlikely that there is a mistake in the implementation. The exact reason for the difference remains unknown, but small inaccuracies in the speed data due to unit conversion or rounding might be the underlying reason. Without speed data in the reference results, a more definitive explanation could not be given.

2.5 Reference grid results

Lastly, the reference grid SEL results were evaluated. For each reference case, the SEL is calculated for the rectangular grid shown in Table 2-2. Volume 3, Part 1 reports all grid points where the SEL values are equal to, or higher than, 80dB.

Table 2-2: Reference grid

Parameter	x-axis (m)	y-axis (m)
Minimum value	-27000	-12000
Maximum value	20000	2000
Distance between grid points	100	100

A comparison between the ANCON-3 grid results (where SEL ≥ 80dB) and the reference grid results, showed very small differences for each of the reference cases. This was to be expected as small differences were already found in the segmental SEL results. The absolute differences do not exceed 0.01dB. Volume 3, Part 1 mentions that if differences are found in the grid points, that a root-mean-square (RMS) test can be carried out to summarize the results and test for ECAC Doc 29 equivalence. The RMS of the differences can be computed with the equation below, where the difference in SEL between the ANCON-3 results and the reference results are evaluated at each grid point *i*, over a total of *n* gridpoints. The aim is to have a δ_{RMS} in the order of 0.01dB or less.

$$\delta_{RMS} = \sqrt{\frac{\sum_1^n \left(SEL_{ANCON3_i} - SEL_{ref_i}\right)^2}{n}}$$

The δ_{RMS} was computed for each reference case. This showed that the δ_{RMS} did not exceed 0.004dB, falling well within the recommendation of 0.01dB or less. Overall, this shows that the ANCON-3 model outputs SEL results which are equivalent to those generated by a Doc29-compliant model. Strictly speaking, proving equivalence is not the same as proving compliance. However, the successful reproduction of noise levels at thousands of grid points across the full set of reference cases provides strong, by-proxy evidence of compliance with Doc 29 Volume 2, as such systematic agreement would be very unlikely in a non-compliant implementation.

3 Check 2 – Inter model comparison

3.1 Introduction

The next step is to review an inter-model comparison prepared by the CAA. The objective is to check the consistency between the ANCON-3 model and other Doc29-compliant models. The ANCON-3 model was therefore compared to ANCON-2 and IMPACT[2] for an average summer day for Heathrow Airport in 2023. The check focuses on consistency between input parameters and outputted LAeq. For this, several input and output files were provided by CAA for the ANCON-3, ANCON-2 and IMPACT models.

3.2 Comparison of input files

For the comparison of the input files it should be noted that the ANCON-2 and ANCON-3 model use the same input structure. Therefore, the comparison of the input files is only performed for the consistency between the ANCON input parameters and the IMPACT input parameters.

Firstly, the routes used were compared between the ANCON and IMPACT files. Both route sets consisted of 24 departure routes and 45 arrival routes. The IMPACT route coordinates were transformed to the local coordinate system used in the ANCON files and the routes were compared between the models. The comparison showed good agreement for the departure routes and arrival routes. The arrival routes of the IMPACT model were extended to a distance of around 40km along the track, whereas the ANCON routes were extended further to about 60km along the track. This difference mostly takes place far away from the airport and will therefore have a limited effect on the outputted contours. The median routes are considered consistent between the models.

Next to the median routes, the IMPACT model provides 6 sub-tracks to account for dispersion, with 3 sub-tracks on each side of the median track. A distribution of operations per sub-track is specified and each sub-track has a specific location from the median. ANCON provides the standard deviation of the spread, which together with the Doc29 sub-track distribution leads to the same set of sub-tracks as the IMPACT model.

Next, the distribution of the operations was evaluated. The number of operations were given per route and per aircraft type. For IMPACT, the number of operations per route consisted of the sum of the number of operations on the median track and its 6 sub-tracks, while for ANCON only the total amount of operations per route was provided. The number of operations was evaluated independently for the east arrivals, west arrivals, east departures and west departures. The comparisons showed a match in used operations per route per aircraft type between the ANCON and IMPACT models.

Additionally, grid definitions and atmospheric conditions were compared between the models. Here it was noted that the y-gridpoints for ANCON are defined from -24947 to 24927 with step size 101, and the y-gridpoints for IMPACT are defined as exactly -30000 to 30000 with step size 100. This could possibly lead to a different noise value interpolation between points.

[2] https://www.eurocontrol.int/platform/integrated-aircraft-noise-and-emissions-modelling-platform

3.3 Comparison of output files

In order to check the output of the different models the reported, LAeq (16h) contours were compared. The contours range from 54dB to 72dB, with a step size of 3dB. The reported contour areas of the three models are presented in Table 3-1. Here, also the percental difference of the ANCON-2 and IMPACT values with respect to the ANCON-3 values are reported. It can be seen that the contour areas of the ANCON-3 and ANCON-2 models are very similar, with only a minor difference for the 72dB contour. Although it is common that contour area can become more sensitive with decreasing contour size, it is unknown where this larger difference at the 72dB contour comes from, as the ANCON-2 contour shapes could not be compared with the ANCON-3 contour shapes. It can be noted that, based on the ANCON-3 contour shape and location, the 72dB contour mostly lies within the bounds of the airport perimeter. The differences between the ANCON-3 and IMPACT models are also considered small, but are generally slightly larger than the ANCON-2 differences. It is unclear what is the exact cause of these differences, as it could be due to differences in (unchecked) input variables or files, or due to a difference in contour generation algorithm.

Table 3-1: Contour areas per model, including difference with respect to ANCON-3 areas

Contour (dB LAeq16h)	ANCON-3 (km²)	ANCON-2 (km²)	IMPACT (km²)	ANCON-3 vs. ANCON-2	ANCON-3 vs. IMPACT
>54	129.62	129.61	129.41	0.01%	0.16%
>57	74.44	74.44	74.66	0.00%	-0.29%
>60	41.96	41.95	42.26	0.04%	-0.71%
>63	24.92	24.91	24.88	0.03%	0.18%
>66	12.64	12.64	12.67	0.03%	-0.23%
>69	6.22	6.22	6.25	-0.02%	-0.54%
>72	3.41	3.37	3.42	1.25%	-0.17%

The output files of ANCON-3 and IMPACT also includes the LAeq contours as shapefiles. These contours are plotted in Figure 3-1, where the blue contours represent the ANCON-3 output and the red contours represent the IMPACT output. Some differences can be seen, especially in the extremities of the lower LAeq contours. Although not directly evident here, it was also concluded from the shape of these contours that ANCON-3 and IMPACT use a different algorithm for interpolating grid results to generate contour shapes. Another possible reason for the differences is the difference in grid definition, which could lead to a different interpolated value between grid points. It should be noted that the IMPACT study was derived from a study which was originally set up for ANCON. The focus of this IMPACT study was to give assurance to the ANCON implementation, rather than to focus on creating an exact duplicate of the airport study in IMPACT.

Overall, the results show that the ANCON-2 and ANCON-3 results are very similar. The differences with the IMPACT results are larger, but this is not unexpected:

- The ANCON scenario, including all routes and profiles had to be converted to IMPACT input formats,
- Both models use different coordinate systems and there are slight differences in grid,
- Both models seem to use different contour algorithms.

Although differences are therefore to be expected, results are still considered to be similar, especially since the input for both noise models is also not exactly equal. This means that differences are caused by a combination of differences in input and (possibly) in modelling. Therefore, the next chapter will present an intermodal comparison

where all inputs used by both models are exactly identical. The results of that comparison show results which are practically identical.

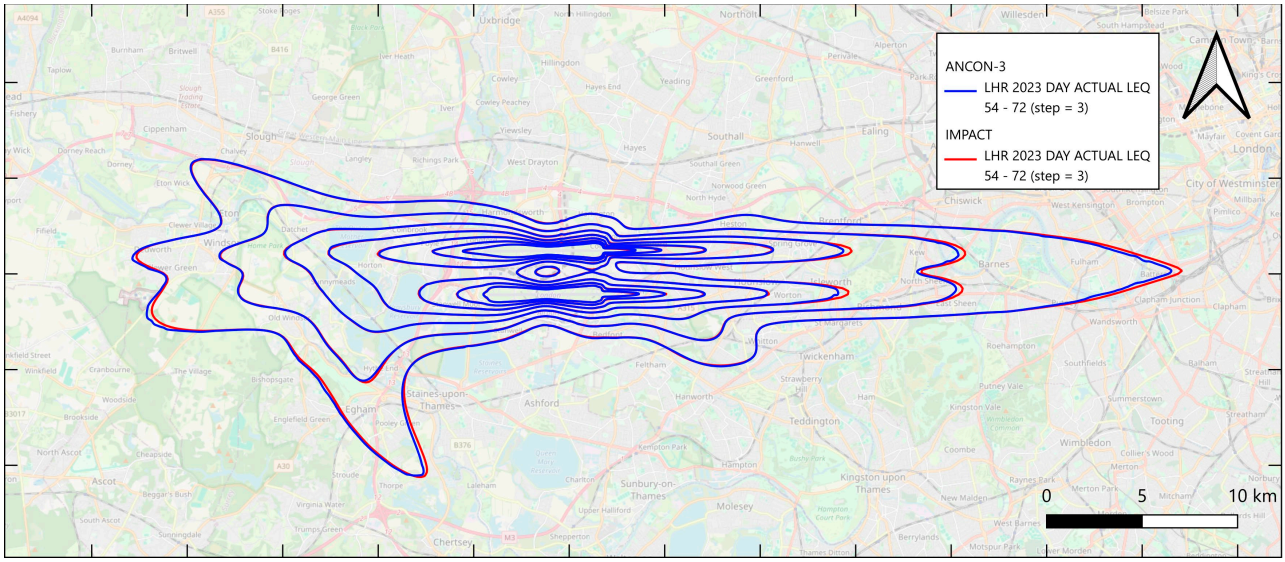

Figure 3-1: ANCON-3 and IMPACT noise contours of a 2023 average day (LAeq 16h)

4 Check 3 – Reference case scenario

4.1 Introduction

The ECAC Doc 29 reference cases are a means to demonstrate compliance with ECAC Doc 29 Volume 2. More specifically, the reference cases can be used to demonstrate the ability of the model to generate the correct SEL of a single event. However, ECAC Doc 29 models are typically used to create noise contours based on the cumulative noise exposure levels, like Lden and LAeq. Calculating these exposure levels involves operations like the summation of single event contributions, applying penalties and averaging. These operations are not covered by the reference cases and this additional test will address that.

This third and final test will also review noise model results at lower noise exposure levels, further away from the airport. The ECAC Doc 29 reference cases focus on results at or above a (single event) sound exposure level of 80 dB(A), up to distance of approximately 15-20 kilometres from the runway. Depending the traffic volume and fleet composition, noise exposure contours for airports can be considerably larger, especially if relatively low noise contour levels are considered. For this test, noise contours will be reviewed down to 45 dB(A) Lden.

4.2 Methodology

As the ECAC Doc 29 reference results do not include the data for a comparison at distances further away from the airport, an alternative source of reference results is required. For this approach, the NLR ECAC Doc 29 model implementation (Tuna) has been used to generate the reference material. The reference results are still based on the ECAC Doc 29 reference cases, but the cases have been combined into a multi-event traffic scenario. This traffic scenario was used to compute Lden noise exposure in a much wider area compared to the area of the reference cases.

Because both models are capable of reproducing the single-event reference case results accurately, it is expected that both models are also able to generate similar results for the scenario, unless there is an error in one of the models in the functionality beyond what is tested with the reference cases.

4.3 Traffic scenario

The ECAC Doc.29 reference cases are based on three hypothetical aircraft types and four operation/route combinations, resulting in 12 distinct trajectories (flights). All flights are to/from the same east/west hypothetical runway. The traffic for the reference case scenario is based on these 12 flights, where each flight is used multiple times to obtain Lden noise contours of a particular size.

The distribution of the flights over the day, evening and the night is based on the 2024 annual average day at Heathrow [Ref. 4] as shown in Table 4-1.

Table 4-1: Day, evening, night distribution for the reference case scenario

	Day (12h)	Evening (4h)	Night (8h)
Heathrow 2024 operations (average day)	947.9	271.4	82.0
Distribution	72.8%	20.9%	6.3%

The distribution over the three hypothetical aircraft types is not derived from Heathrow traffic data, as todays fleet almost exclusively consist of jet aircraft with underwing engines, like the JETW hypothetical aircraft type. Since using the actual distribution would not make good use of the available reference cases, a fictitious distribution is used instead. This distribution is shown in Table 4-2.

Table 4-2: Aircraft type distribution for the reference case scenario

Reference case (hypothetical) aircraft type	Distribution
JETF	30%
JETW	50%
PROP	20%

The distribution over the operation/route combinations has been chosen in such a way that there is a balanced but not identical distribution over the available routes. The result is shown in Table 4-3.

Table 4-3: Route distribution for the reference case scenario

Route description	Route ID	Distribution
Arrival – Straight	AS	40% of arrivals
Arrival – Curved	AC	60% of arrivals
Departure – Straight	DS	45% of departures
Departure – Curved	DC	55% of departures

The distributions over the day period, the aircraft types and routes have been used to generate the traffic for the reference case scenario, assuming that the number of arrivals is the same as the number of departures. The traffic is shown in Table 4-4.

Table 4-4: Traffic for the reference case scenario. The reference case ID is the combination of the aircraft type and the route ID

Reference Case ID	Day	Evening	Night	Total 24h
JETFAC	20.8	5.8	2.6	29.2
JETFAS	13.9	3.8	1.8	19.5
JETFDC	20.0	5.9	1.0	26.9
JETFDS	16.3	4.8	0.8	21.9
JETWAC	34.8	9.6	4.4	48.8
JETWAS	23.2	6.4	2.9	32.5
JETWDC	33.3	9.7	1.6	44.6
JETWDS	27.2	8.0	1.4	36.6
PROPAC	13.9	3.8	1.8	19.5
PROPAS	9.3	2.6	1.1	13
PROPDC	13.3	4.0	0.7	18
PROPDS	10.8	3.2	0.5	14.5
Total	236.8	67.6	20.6	325.0

The total number of operations was adjusted on the basis of the size of Heathrow's annual 2024 Lden noise contours [Ref. 4]. In this way the largest 55 Lden contour of the reference case scenario extends to about 22 kilometres from the runway threshold, similar as the extent of the 55 Lden contour on the East side of Heathrow in 2024.

4.4 Grid definition

The ECAC Doc.29 reference cases come with the definition of a rectangular grid that is large enough to include all reference grid points for each of the 12 reference cases. For the reference case scenario, where Lden contours are compared based on 325 daily movements, this default grid is not large enough to generate the entire 45 Lden contours. Therefore, a new, larger grid has been defined, as specified in Table 4-5.

Table 4-5: Grid definition or the reference case scenario

Parameter	x-axis (m)	y-axis (m)
Minimum value	-45000	-34000
Maximum value	38000	4000
Distance between grid points	100	100

4.5 Results – contours

NLR provided UK-CAA with the traffic scenario and the grid definition and received the corresponding ANCON-3 grid in return. In parallel, NLR also generated the corresponding results with the NLR model Tuna and generated contour lines for both models. The results are shown in Figure 4-1.

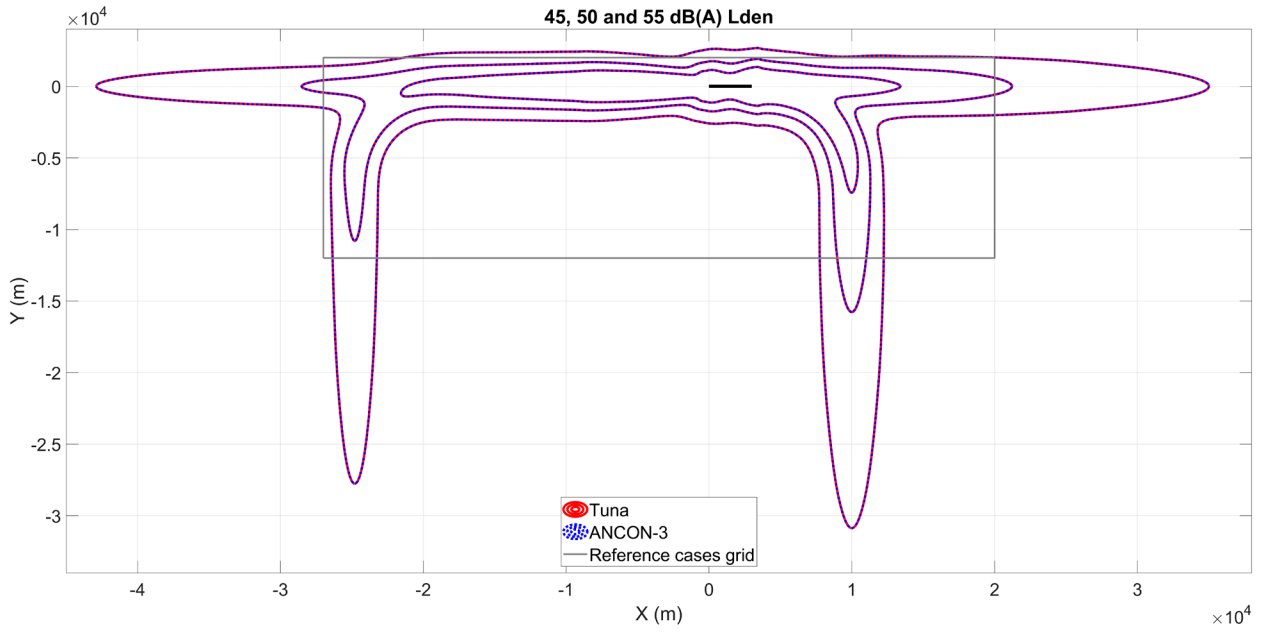

Figure 4-1: Lden noise contours for both model for the scenario based on the reference cases

The figure shows the Tuna contour lines using a solid red line and the ANCON-3 contour lines on top using a dashed blue line. From this graphical comparison it is immediately clear that the contour lines from both models coincide: differences in the grid results between both model are too small to cause visible differences. The extent of the ECAC Doc 29 reference cases grid has also been added to the figure, to visualise that this model comparison covers a much wider area than the reference cases.

4.6 Results – contour areas

Apart from the graphical comparison of the contour lines, a second way of comparing contour results is by comparing the contour area. For both models, the areas of the 45, 50 and 55 dB(A) Lden contours have been determined by NLR, using the ANCON-3 grid provided by UK-CAA, which means that all contours are computed using the same contour generation algorithm. The areas are listed in Table 4-6.

Table 4-6: Contour areas for both models

	45 dB(A) Lden	50 dB(A) Lden	55 dB(A) Lden
ANCON-3 (km^2)	468.91	181.21	70.47
Tuna (km^2)	468.96	181.23	70.48
Relative difference %	0.0%	0.0%	0.0%

The comparison of the contour areas confirms the earlier conclusion that the results are practically identical, with relative differences of 0.0% for all three contour levels.

5 Conclusions and recommendations

5.1 Conclusions

A peer review of the ANCON-3 noise model has been concluded. The review consisted of three main components:

- Check 1 - A comparison of ANCON-3 results with ECAC Doc 29 reference case results, involving the reference SEL results, reference segmental results and the reference grid results.
- Check 2 – the review of an inter-model comparison between ANCON-3, ANCON-2 and IMPACT for a Heathrow Airport scenario.
- Check 3 - A comparison of Lden noise contours between ANCON-3 and NLR's Tuna model for a scenario based on the reference cases.

The results of Check 1 showed that ANCON-3 accurately reproduces the ECAC Doc 29 reference case results, with only some minor differences (0.03 dB or less) found in some of the reference SEL results. These differences were investigated further using the segmental results and were found to be small and not material.

The most important part of Check 1 is the comparison of the reference grid results, where ANCON-3 results have been compared to the reference results for thousands of locations within a rectangular grid and where the root-mean-square difference is computed. The results show that the root-mean-square difference is well within the ECAC Doc 29 recommended limit, proving ANCON's ability to generate noise level results that are equivalent to those generated by a Doc 29 Volume 2 compliant model. This successful reproduction of noise levels at thousands of grid points across the full set of reference cases provides strong, by-proxy evidence of compliance with Doc 29 Volume 2, as such systematic agreement would be very unlikely in a non-compliant implementation.

The review of an inter-model comparison prepared by the CAA (Check 2) indeed confirms similarity in LAeq contour location and contour area between ANCON-3 and other Doc29-compliant models, such as ANCON-2 and IMPACT, for an average summer day at Heathrow Airport.

The comparison of Lden noise contours between ANCON-3 and Tuna for a scenario based on the reference cases (Check 3) showed that both models produce practically identical results, also at lower noise exposure levels, further away from the airport and beyond scope of the reference cases. The differences in contour lines are too small to be distinguished visually and relative differences in contour areas are equal to 0.0% for all contour levels considered.

Summarizing, it can be stated that:

- The reference results comparison proves that that ANCON-3 is capable of generating noise level results that are equivalent to those generated by a Doc 29 Volume 2 compliant model.
- The other two checks demonstrate that ANCON-3 can be used to produce noise exposure contours on a typical airport scale that are consistent with other Doc29-based models.

Based on these findings it can be concluded that ANCON-3 correctly implements the ECAC Doc 29 Volume 2 method and is compliant with the standard. This means that ANCON-3 can be used with confidence to produce ECAC Doc 29 compliant noise level results.

5.2 Recommendations

This peer review did not yield recommendations regarding the ANCON-3 noise model, but three recommendations have been formulated for AIRMOD, the Working Group of the European Civil Aviation Conference that maintains and develops the European standard method of computing noise contours around civil airports. All recommendations relate to the updating of the reference cases when a new edition is published:

- To review the current results and to resolve unit conversion inaccuracies.
- To add the speed parameter to the segmental results to aid developers in diagnosing differences that may be caused by underlying differences in speed. Additionally, providing the reason for the sub-segmentation of each segment would be helpful for the developers.
- To extent the reference cases with cases based on multiple events and providing the Lden reference results in a wider area than the current grid for the reference cases.

6 References

1. European Civil Aviation Conference, Report on Standard Method of Computing Noise Contours around Civil Airports, ECAC.CEAC Doc 29, 4th edition, Volume 1: Applications Guide, December 2016.

2. European Civil Aviation Conference, Report on Standard Method of Computing Noise Contours around Civil Airports, ECAC.CEAC Doc 29, 4th edition, Volume 2: Technical Guide, December 2016.

3. European Civil Aviation Conference, Report on Standard Method of Computing Noise Contours around Civil Airports, ECAC.CEAC Doc 29, 4th edition, Volume 3, Part 1: Reference Cases and Verification Framework, December 2016.

4. UK Civil Aviation Authority, Heathrow Airport 2024 Summer and Noise Action Plan Contours, ERCD report 2501, August 2025.

Appendix A About the reviewers

This technical peer review has been performed by Sander Heblij and Stijn Nolet:

Sander Heblij holds a Master's degree from Delft University of Technology, faculty of Aerospace Engineering and a PhD, also from Delft University of Technology. He joined the Sustainability and Environment department of NLR in 2010 as R&D Engineer specialized in aircraft noise.

Since that time, he has been involved in many aircraft noise-related projects, including noise mapping studies, noise model development and noise model validation and verification. This includes both civil and military projects. Furthermore, he has been involved in several noise mitigation efforts, including flight path optimisation, the introduction of a new departure procedure at Amsterdam Airport and runway use optimisation. Finally, he also has experience with noise measurements of aircraft and helicopters, as well as with the subsequent processing and analysis of the measurement data.

Since 2021 Sander holds the position of Sr. Scientist at his original department. In this position he participates in AIRMOD, the Working Group of the European Civil Aviation conference that maintains and develops the European Standard method of computing noise contours around civil airports (ECAC Doc29).

Stijn Nolet holds a Master's degree from Delft University of Technology, the faculty of Aerospace Engineering, where he studied between 2016 and 2022. After his studies, he started working at NLR as an R&D Engineer at the department of sustainability and environment.

During his time at NLR he contributed in various projects concerning the environmental impact of aviation, mostly related to noise around airports, including noise mapping studies, noise exposure and annoyance studies and noise model development. He contributed both as a team member and a project leader. Next to this, he also has experience with noise measurements of aircraft, including the subsequent processing and analysis of the measurement data.

Finally, Stijn supports NLR's contribution in AIRMOD, the Working Group of the European Civil Aviation conference that maintains and develops the European Standard method of computing noise contours around civil airports (ECAC Doc29), contributing to the work on the ECAC Doc29 verification framework.

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