EUROPEAN CIVIL
AVIATION CONFERENCE

Tel : +33 1 46 41 85 44

CONFERENCE EUROPEENNE
DE L'AVIATION CIVILE

Fax : +33 1 46 24 18 18

SECRETARIAT
3 bis, Villa Emile Bergaret
9522 Neuilly-sur-Seine Cédex
FRANCE

ECAC.CEAC Doc 29

4th Edition

Report on Standard Method of Computing Noise Contours around Civil Airports

Volume 3, Part 1 - Reference Cases and Verification Framework

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FOREWORD

With the publication of the 4th Edition of the ECAC.CEAC Doc 29 European guidance on the standard method of computing noise contours around civil airports comes this new third volume. It follows: **Volume 1** which provides a general and largely non-technical introduction to the topic, as well as practical advice to model users; and **Volume 2** which recommends a specific methodology for calculating aircraft noise exposure around civil aerodromes. Those for whom the subject is new might usefully treat Volume 1 as a primer for Volume 2.

Volume 3 consists of two parts. This **Part 1** contains guidance for noise model developers to support their work in developing new noise models that produce results that are equivalent to those calculated by noise models that adhere to the methodologies defined in ECAC.CEAC Doc 29 Volume 2.

For noise model developers, a set of reference cases is presented. This includes 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 ECAC.CEAC Doc 29 Volume 2.

A subsequent **Volume 3 Part 2** is planned for a future edition of the guidance and will contain guidance for noise model operators on the validation of already ECAC.CEAC Doc 29 Volume 2 compliant noise models using noise measurements of actual aircraft events.

Since Volumes 1 and 2 were published, a number of noise models have been developed based on the methodology. The developers of such models have collaborated to undertake the detailed comparative analysis that underpins this volume.

Although this third Volume aims to facilitate harmonisation of noise models across ECAC Member States, it still remains the responsibility of the model user to assure the quality of modelling outputs. The methodology and the ANP data are as accurate as understanding and facilities presently allow but, throughout the guidance in Volume 1 and Volume 2, it is stressed that achieving reliable results requires meticulous collection and pre-processing of scenario data (describing airport and aircraft operations). Doing this in a measured and cost-effective way is perhaps the practitioner's greatest challenge.

This Volume will eventually involve comparing noise contour calculations with on-site measurements. Discrepancies can point to modelling deficiencies but it must always be remembered that obtaining appropriate, accurate measurements is at least as difficult as modelling itself. However, persistent disagreement might well be symptomatic of model or data deficiencies and this should be reported via the feedback mechanisms of the ANP website.

The recommended methodology can be used to model airport and aircraft operations in minute detail, if that is necessary. But often such detail is inappropriate, for example when the accuracy and reliability of the data, or the resources to do the job, are limited. In this case the scope of the modelling must be tailored accordingly, ensuring that attention is focused on the most noise-significant factors.

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EXPLANATION OF TERMS AND SYMBOLS

Some important *terms* are described here by the general meanings attributed to them in this document. The list is not exhaustive; only expressions and acronyms used frequently are included. Others are described where they first occur. More explanation can be found in **Volume 1** and **Volume 2**.

Very few mathematical *symbols* are used in the main text and appendices. Those that are used are defined where they first appear in the text.

The reader is reminded periodically of the interchangeability of the words *sound* and *noise* in this document (as in **Volume 1** and **Volume 2**). Although the word *noise* has subjective connotations - it is usually defined by acousticians as ‘unwanted sound’ - in the field of aircraft noise control it is commonly taken to mean just sound - airborne energy transmitted by acoustic wave motion. The symbol → denotes cross references to other terms included in the list.

Terms

Aircraft configuration	The positions of slats, flaps and landing gear.
Aircraft movement	An arrival, departure or other aircraft action that affects noise exposure around an aerodrome.
Aircraft noise and performance data	Data describing the acoustic and performance characteristics of different aeroplanes types that are required by the modelling process. They include → *NPD relationships* and information that allows engine thrust/power to be calculated as a function of → *flight configuration*. The data are usually supplied by the aircraft manufacturer, although when that is not possible it is sometimes obtained from other sources. When no data are available, it is usual to represent the aircraft concerned by adapting data for a suitably similar aircraft - this is referred to as *substitution*.
Altitude	Height above mean sea level.
ANP database	The international Aircraft Noise and Performance database www.aircraftnoisemodel.org
A-weighted sound level, L_A	Basic sound/noise level scale used for measuring environmental noise including that from aircraft and on which most noise contour metrics are based.
Cumulative sound/noise level	A decibel measure of the noise received over a specified period of time at a point near an airport, from aeroplane traffic using normal operating conditions and flight paths. It is calculated by accumulating in some way the event sound/noise levels occurring at that point.
Decibel sum or average	Sometimes referred to elsewhere as ‘energy’ or ‘logarithmic’ (as opposed to arithmetic) values. Used when it is appropriate to sum or average the underlying energy-

	like quantities; e.g. *decibel sum* $=10 \cdot \log \sum 10^{L_i/10}$
Equivalent (continuous) sound level, L_{eq}	A measure of long-term sound. The level of a hypothetical steady sound, which over a specified period of time, contains the same total energy as the actual variable sound.
Event sound/noise level	A decibel measure of the finite quantity of sound (or noise) received from a passing aeroplane → *sound exposure level.*
Flight configuration	= → *Aircraft configuration* + → *Flight parameters*
Flight parameters	Aircraft power setting, speed, bank angle and weight.
Flight path	The path of an aeroplane through the air, defined in three dimensions, usually with reference to an origin at the start of take-off roll or at the landing threshold.
Flight path segment	Part of an aircraft flight path represented for noise modelling purposes by a straight line of finite length.
Flight procedure	The sequence of operational steps followed by the aircraft crew or flight management system: expressed as changes of flight configuration as a function of distance along the ground track.
Flight profile	Variation of aeroplane height along the ground track (sometimes includes changes of → *flight configuration* too) - described by a set of → *profile points.*
Ground plane	(Or Nominal ground plane) Horizontal ground surface through the aerodrome reference point on which the contours are normally calculated.
Ground track	Vertical projection of the flight path onto the ground plane.
Height	Vertical distance between aircraft and → *ground plane*
Lateral attenuation	Excess attenuation of sound with distance attributable, directly or indirectly, to the presence of the ground surface. Significant at low angles of elevation (of the aircraft above the ground plane).
Maximum noise/sound level	The maximum sound level reached during an event.
Mean Sea Level, *MSL*	The standard earth surface elevation to which the → ISA is referred.
Net thrust	The propulsive force exerted by an engine on the airframe.
Noise	Noise is defined as unwanted sound. But metrics such as *A-weighted sound level* (L_A) and *effective perceived noise level* (EPNL) effectively convert sound levels into noise levels (see **Volume 1**). Despite a consequent lack of rigour, the terms sound and noise are sometimes used interchangeably in this document, as elsewhere - especially in conjunction with the word *level*.
Noise contour	A line of constant value of a cumulative aircraft noise level

	or index around an airport.
Noise index	A measure of long term, or cumulative sound which correlates with (i.e. is considered to be a predictor of) its effects on people. May take some account of factors in addition to the magnitude of sound (especially time of day). An example is day-evening-night level L_{den}.
Noise level	A decibel measure of sound on a scale which indicates its loudness or noisiness. For environmental noise from aircraft, two scales are generally used: A-weighted sound level and Perceived Noise Level. These scales apply different weights to sound of different frequencies - to mimic human perception.
Noise metric	An expression used to describe any measure of quantity of noise at a receiver position whether it be a single event or an accumulation of noise over extended time. There are two commonly used measures of single event noise: the *maximum level* reached during the event, or its *sound exposure level*, a measure of its total sound energy determined by time integration.
Noise significance	The contribution from a flight path segment is ‘noise significant’ if it affects the event noise level to an appreciable extent. Disregarding segments that are not noise-significant yields massive savings in computer processing.
SEL	→ *Sound Exposure Level*
Sound	Energy transmitted through air by (longitudinal) wave motion which is sensed by the ear.
Sound attenuation	The decrease in sound intensity with distance along a propagation path. For aircraft noise its causes include spherical wave spreading, atmospheric absorption and → *lateral attenuation.*
Sound exposure	A measure of total sound energy immission over a period of time.
Sound Exposure Level, L_{AE}	(Acronym *SEL*) A metric standardised in ISO 1996-1 [ref. 1] or ISO 3891 [ref. 2] = A-weighted single event sound exposure level referenced to 1 second.
Sound level	A measure of sound energy expressed in decibel units. Received sound is measured with or without ‘frequency weighting’; levels measured with a weighting are often termed → *noise levels.*

1 INTRODUCTION

1.1 AIM AND SCOPE OF DOCUMENT

Contour maps are used to indicate the extent and magnitude of aircraft noise impact around airports, that impact being indicated by values of a specified noise metric or index. A contour is a line along which the index value is constant. The index value aggregates in some way all the individual aircraft noise events that occur during some specified period of time, normally measured in days or months.

The noise at points on the ground from aircraft flying into and out of a nearby aerodrome depends on many factors. Principal among these are the types of aeroplane and their power plant; the power, flap and airspeed management procedures used on the aeroplanes themselves; the distances from the points concerned to the various flight paths; and local topography and weather. Airport operations generally include different types of aeroplanes, various flight procedures and a range of operational weights.

Volume 1 of this ECAC guidance on aircraft noise contour modelling, an Applications Guide, is aimed primarily at noise model users who do not necessarily need a comprehensive understanding of the modelling process, but who need a good understanding of the principles, the problems involved, and the requirements for getting results that adequately meet the objectives of particular noise impact assessments.

Volume 2, a Technical Guide, is written for modellers themselves, those who develop and maintain the computer models and their databases. It fully describes a specific noise contour modelling system which is considered by ECAC to represent current best practice. It does not prescribe a computer program but rather the equations and logic that need to be programmed to construct a physical ‘working model’. Any physical model that complies fully with the methodology described can be expected to generate contours of aircraft noise exposure around civil airports with reasonable accuracy. *The methodology applies only to long-term average noise exposure; it cannot be relied upon to predict with any accuracy the absolute level of noise from a single aircraft movement and should not be used for that purpose.*

Volume 3 of this guidance addresses noise model verification and validation. **Part 1** is aimed at noise model developers implementing the methodology of Doc 29 Volume 2. A **Part 2** is planned for a future Edition of the guidance and will be aimed at noise model operators validating an already ECAC.CEAC Doc 29 Volume 2 equivalent noise model using noise measurements of actual aircraft events. It is assumed that readers of **Volume 3** are familiar with the concepts presented in Volumes 1 and 2.

In this **Part 1**, a suite of reference cases is presented to assist in the development of models which comply with Doc 29 Volume 2. These include a comprehensive set of inputs which can be used to test a development model, and a corresponding set of reference results against which the outputs of a development model may be checked. The reference cases are based on three hypothetical aircraft types and four operation/route combinations which test the various elements of the implementation of the noise calculation methodology defined in ECAC.CEAC Doc 29 Volume 2.

Since Volumes 1 and 2 were published, a number of noise models have been developed based on the methodology. Volume 3 is based on the collaborative work of the developers of such models. Detailed comparative analyses were undertaken, the results of which underpin the technical contents of this volume, and indeed the updates to Volume 2 in this 4th Edition.

The organisations involved were the UK Civil Aviation Authority (using the ANCON model), EUROCONTROL (using the STAPES model), the Netherlands Aerospace Centre (using the

NLR model) and the Norwegian research organisation, SINTEF (using the NORTIM model). Developers from the US Federal Aviation Administration (FAA) also contributed with results from the Aviation Environmental Design Tool (AEDT), a model based on the methodology set out in ICAO Doc 9911 [ref. 3], which is largely based on ECAC.CEAC Doc 29 Volume 2.

1.2 OUTLINE OF THE DOCUMENT

This document is to be read with reference to **Doc 29 Volume 2**, as principles and parameters mentioned in **Volume 3, Part 1** are explained in detail in **Volume 2**.

Chapter 2 describes, in detail, who should use which parts of this document and under what circumstances.

Chapter 3 presents the reference cases and refers to **Appendix A**, which contains tables of the inputs for the reference cases.

Chapter 4 presents the reference case results. It refers to **Appendix B**, which contains tables of the reference results that have been calculated by models that fully reflect the methodologies and algorithms set out in Doc 29 Volume 2. In some cases, only the table headings are provided, as the full set of reference results contains many data points and has more appropriately been made available via the ECAC website: www.ecac-ceac.org.

Appendix C lists conversions between the SI and US units that are used frequently throughout.

To assist noise model developers, the tabulated data contained in the appendices are available in a Microsoft Excel workbook. This can be downloaded from the ECAC website: www.ecac-ceac.org

2 INTENDED USE OF VOLUME 3, PART 1

This chapter describes, in detail, who should use which parts of this document and under what circumstances.

This Volume is primarily to be used by noise model developers implementing Doc 29 Volume 2 in a new noise model. It should be used during the implementation of a model following the coding of the noise calculation for a single event, to check against the methodology detailed in **Doc 29 Volume 2 Chapter 4**. This will also serve to check the coding of the construction of flight path segments against the methodology in **Doc 29 Volume 2 Chapter 3**, which will need to have been implemented in order to calculate noise for a single event.

The **reference SEL results** are intended to enable a relatively quick and efficient check to be made of development model results against the reference results.

The **reference segmental results** present the results for the main parameters at each step in the calculation. Developers may use these results to diagnose any discrepancies between the results of a development model and the reference SEL results.

It would be expected that a developer would be able to achieve a model which faithfully reproduces the reference SEL and segmental results. These results consider only 18 receptors at key locations relative to single aircraft departure and arrival operations. In practice, noise models are used not only to calculate noise levels at receptors, but also to calculate noise footprints and contours.

For noise contour calculation, noise levels are calculated across a grid of receptors and then post-processed to produce a series of noise contours. **Doc 29 Volume 2 Chapters 5** and **6** present methodologies for calculating cumulative levels and for calculating noise contours from a results grid respectively.

The **reference grid results** are therefore 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.

All the above reference results may also be used by noise modelling practitioners to investigate the effect of varying certain model parameters. Practitioners using non-Doc 29 Volume 2 compliant models may also use this information to quantify the differences between such models and models that meet the Doc 29 Volume 2 standard.

3 REFERENCE CASES

The reference cases provide a comprehensive and established set of inputs for use in testing noise model calculations. To date, reference cases have been based on actual aircraft, the parameters of which are subject to changes in the ANP database. The reference cases presented here are based on hypothetical aircraft parameters which do not rely on the ANP database, so serve as a fixed reference.

The reference cases comprise combinations of three hypothetical reference aircraft, on curved and straight notional routes, for arrival and departure operations. A total of 12 combinations therefore make up the reference cases.

A coding convention is used to identify the aircraft types and routes. The codes are introduced in the following sections and summarised in **Table 3-1**.

3.1 REFERENCE AIRCRAFT

The three hypothetical reference aircraft types comprise the following:

- a turbofan (jet) aircraft with engines mounted on the rear fuselage (code/NPD ID: JETF);
- a turbofan (jet) aircraft with engines mounted under the wings (code/NPD ID: JETW); and
- a propeller aircraft (code/NPD ID: PROP).

The aircraft are defined in modelling terms using parameters that are introduced and described in **Doc 29 Volume 2**. The full set of parameters and their values for the three hypothetical aircraft are presented in **Appendix A**, **Tables A-1** to **A-8**, which cover the following data set out in the format of the relevant tables in **Volume 2 Appendix G**:

- Table A-1: general aircraft characteristics, e.g. number of engines, installation, take-off and landing weights, etc.
- Table A-2: jet coefficients (for JETF and JETW)
- Table A-3: propeller coefficients (for PROP)
- Table A-4: aerodynamic coefficients, i.e. flap settings
- Table A-5: default weights
- Table A-6: fixed-point profiles
- Table A-7: NPD (Noise-Power-Distance) curves
- Table A-8: spectral class

3.2 METEOROLOGICAL CONDITIONS, RUNWAY AND ROUTES

The reference cases also define a hypothetical aerodrome from which to model the reference aircraft. This is defined in terms of prevailing meteorological conditions, presented in **Appendix A**, **Table A-9**, and runway end coordinates given in terms of x and y coordinates on a flat-earth grid (see **Table A-10)**.

There are four reference routes, all operating in an easterly direction, which are defined in terms of x and y coordinates on a flat-earth grid. There is a curved route and a straight route (represented by codes ‘C’ and ‘S’ respectively) for both arrival and departure operations (represented by codes ‘A’ and ‘D’ respectively). The four routes are therefore identified by the following route identifiers (route IDs): ‘AC’ and ‘AS’ for curved and straight arrival routes respectively, and ‘DC’ and ‘DS’ for curved and straight departure routes respectively.

The routes and coordinates are presented in **Appendix A**, **Table A-11** and illustrated in **Figure 3-1** below.

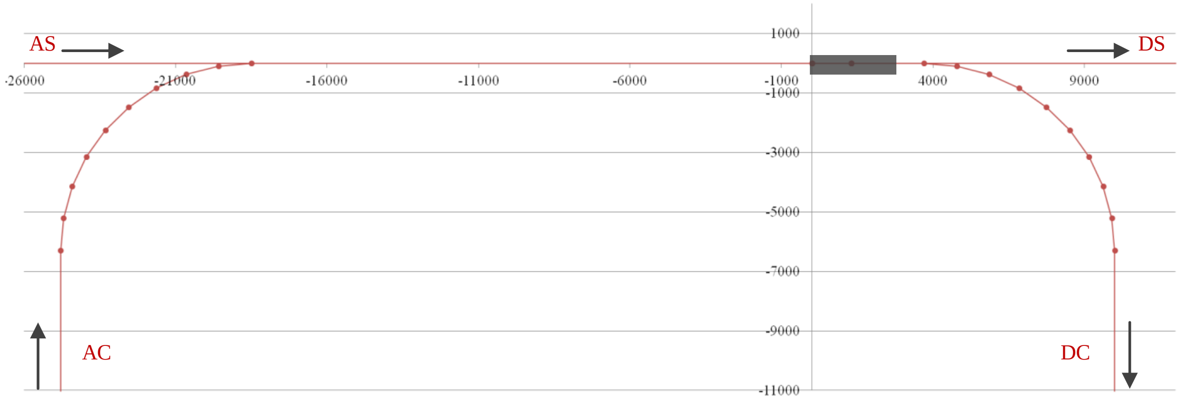

Figure 3-1: Reference case routes

3.3 REFERENCE CASES – TWELVE COMBINATIONS

The full list of 12 reference cases is given in **Table 3-1** below. Each case has a unique case ID based on the aircraft and route codes given in the preceding sections. These are given in the 'Case ID' column.

Table 3-1: 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

3.4 RECEPTORS

Reference results are provided for each of the cases presented in **Section 3.3**. A series of 18 receptors is defined in terms of x and y coordinates on a flat-earth grid at which the reference results are given. These receptors are identified by a unique receptor ID, from R01 to R18. They are presented in **Appendix A**, **Table A-12** and illustrated in blue in **Figure 3-2**.

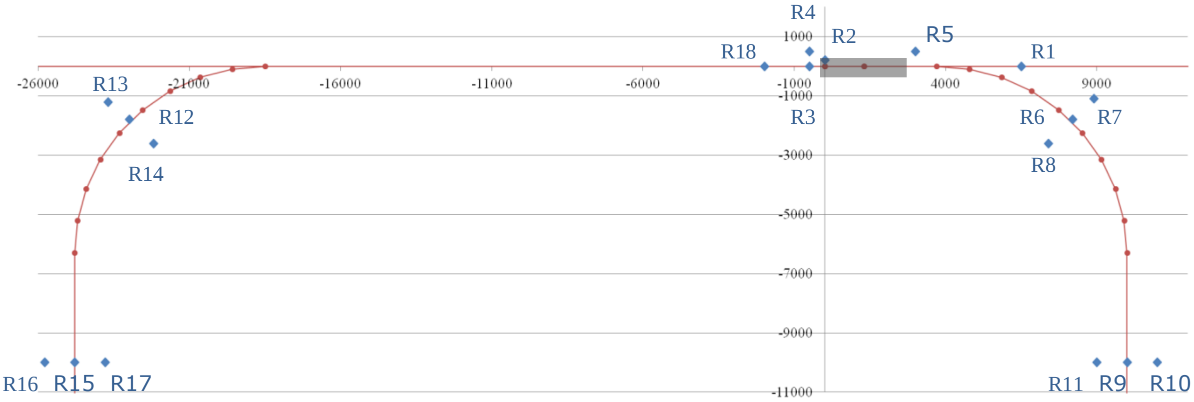

Figure 3-2: Receptors

Not all receptors are relevant to all cases, and reference results for a given case are only provided at relevant receptors. For example, noise levels calculated at receptor R16 for cases involving straight departures (route ID: DS) would be below what would contribute to valid noise contour levels, given the distance between the receptor and the ground track. Results at this receptor for this case are therefore not considered relevant.

Table 3-2 below gives the mapping of the receptors that are relevant to each of the four route IDs, namely arrivals (A) and departures (D) on curved (C) and straight (S) routes.

Table 3-2: **Relevant receptors for reference case routes**

Route ID	**Receptor ID**																	
	R01	**R02**	**R03**	**R04**	**R05**	**R06**	**R07**	**R08**	**R09**	**R10**	**R11**	**R12**	**R13**	**R14**	**R15**	**R16**	**R17**	**R18**
AC		✓	✓	✓	✓							✓	✓	✓	✓	✓	✓	✓
AS		✓	✓	✓	✓								✓					✓
DC	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓							
DS	✓	✓	✓	✓	✓													

4 REFERENCE CASE RESULTS

There are three categories of reference case results: SEL results, segmental results and grid results. These are described in the following sections.

4.1 REFERENCE SEL RESULTS

The reference SEL results are sound exposure levels calculated for each of the reference cases listed in **Table 3-1**, at the relevant receptors given in **Table 3-2**. These results are presented in **Appendix B Table B-1** and listed in the accompanying workbook in worksheet *B-1_SEL_Results*.

Computing overall SEL results is a relatively quick and simple modelling task. These results therefore provide a benchmark against which noise model developers can check the performance of a new model. Making such a comparison will highlight where differences exist between the overall outputs of a development model and the reference results.

Results at different locations are sensitive to different elements of the noise calculation. For instance, receptors R06-R11 are affected by aircraft in flight, so outputs may match the reference SEL results even if there are errors in the ground-roll adjustment algorithms. Receptors R02-R05, however, are near to the runway and therefore require the ground-roll adjustments to be correctly implemented for the outputs to match the reference SEL results.

Comparing the SEL results at different receptors will therefore help developers identify areas where a development model deviates from the Volume 2 methodology. Once these areas are known, focused diagnosis can be undertaken using the reference segment results, as described in the next section.

4.2 REFERENCE SEGMENTAL RESULTS

The reference segmental results comprise the results for the main calculation parameters for each segment of the trajectories of the twelve reference cases. These parameters cover:

- profile geometry;
- the distance and thrust for interpolating NPD curves;
- the baseline SEL;
- distances and angles for calculating the noise adjustments;
- the noise adjustments; and
- the segment SEL.

The full list of parameters is presented in **Appendix B Table B-2**. It is recommended that noise models are implemented with a means for exporting calculation data in precisely this format. This will facilitate the comparison of a development model's outputs with the reference results, and therefore the development of the model.

Due to the quantity of segmental results data, these are provided only in the accompanying workbook. Worksheet *B-2_Segment_Results* contains results for all parameters for each segment of each of the reference case trajectories at the relevant receptors. They are presented using the same naming convention as in **Table B-2**, which, for clarity, incorporates the units.

After the reference SEL results have been used to identify areas where development model outputs deviate from the reference results (see **Section 4.1** above), detailed comparisons using the reference segment results can be used to pinpoint which specific part(s) of the calculation are giving rise to the discrepancies. The relevant parts of Volume 2 can then be consulted to check the accuracy of the implementation of those algorithms.

If noise model developers iterate their model so as to achieve these results to the degree of accuracy to which they are presented, the developer can be confident that the development model is aligned with the methodology of Volume 2, at least at the discrete receptor locations.

4.3 REFERENCE GRID RESULTS

The reference grid results are sound exposure levels across a grid of receptors covering an area that is representative of a large airport noise contour. To reduce the data-handling requirements and to simplify the analysis, the reference grid results are considered only at grid points which have significant influence on calculated noise contours, and at locations which are meaningful in terms of assessing noise impact at real airports. Grid results are therefore:

- included for grid points where the reference grid result is greater than or equal to 80 dB SEL; and
- *not* included for grid points located on the runway.

Appendix B refers to the worksheet *B-3_Grid_Results* in the accompanying workbook, which contains the reference grid results according to the above criteria. There is a set for each of the 12 reference cases, identified by the Case ID, and presented according to grid point coordinates. Because the different reference cases give rise to different noise calculation results, the list of reference grid points also varies between the different cases. Owing to the quantity of data, the reference grid results are provided only in the accompanying workbook.

Calculation grids are usually specified in a noise model as a rectangular grid. **Table 4-1** defines a rectangular grid that is large enough to include all reference grid points for all 12 reference cases. Calculating SEL noise levels for this rectangular grid is a simple method which noise model developers can use to generate grid outputs from a development model.

Table 4-1: **Rectangular grid containing reference grid points**

Parameter	**x-axis (m)**	**y-axis (m)**
Minimum value	-27000	-12000
Maximum value	20000	2000
Distance between grid points	100	100
Number of grid points	471	141
Distance between maximum and minimum value points	47000	14000

This grid also includes many grid points that do not form part of the reference set, i.e. grid points where resulting reference SELs are below 80 dB SEL, or that are on the runway. This will therefore require more computer processing than is strictly necessary to run each case. A more efficient way to generate grid outputs would be to calculate noise levels for only the grid points listed in the *B-3_Grid_Results* worksheet, for the respective cases.

Grid outputs from a development model are to be compared with the reference grid results. Whereas the reference segment results enable the elements of the calculation to be scrutinised in detail, the grid results provide the means to check that a development model is predicting the correct values at every relevant grid point, as is needed for contour generation.

If there are differences at one or more grid points, a convenient way of quantitatively summarising the difference is to calculate the root-mean-square of the differences δ_{RMS} between the development model output $L_{E_{dev-mod}}$ and the reference result $L_{E_{ref}}$ at each grid point *i*, where there is a total of *n* grid points, according to **equation 4-1** below:

$$\delta_{RMS} = \sqrt{\frac{\sum_1^n \left(L_{E_{dev-mod_i}} - L_{E_{ref_i}}\right)^2}{n}} \qquad (4\text{-}1)$$

While refining the model as described in the sections above, δ_{RMS} may be calculated periodically to monitor progress towards calculating results that equal the reference grid results. The aim is to reduce δ_{RMS} to the order of 0.01 dB or less.

REFERENCES

[1] International Organization for Standardization: *Acoustics – Description, measurement and assessment of environmental noise – Part 1: Basic quantities and assessment procedures.* ISO 1996-1 (2001).

[2] International Organization for Standardization*: Acoustics – Procedure for describing aircraft noise heard on the ground.* ISO 3891 (1978).

[3] ICAO DOC 9911 *Recommended Method for Computing Noise Contours Around Airports*, First Edition.

APPENDIX A: REFERENCE CASE INPUTS

The full set of parameters and values for the three reference aircraft are presented in **Tables A-1** to **A-8**. Prevailing meteorological conditions at the virtual aerodrome are presented in **Table A-9**, runway end and route coordinates in **Tables A-10** and **A-11** respectively, and the receptors in **Table A-12**.

All coordinates are given in terms of x and y coordinates with units of metres on a flat-earth grid.

Each table is replicated in the workbook on the ECAC website (www.ecac-ceac.org). Each table is presented in a separate worksheet, named with reference to the table numbering and titles in this appendix.

TABLE A-1 AIRCRAFT (GENERAL CHARACTERISTICS)

Aircraft Identifier	Description	Engine Type	Number of Engines	Weight Class	Maximum Gross Takeoff Weight (lb)	Maximum Gross Landing Weight (lb)	Maximum Landing Distance (ft)	Maximum Sea Level Static Thrust (lb)	NPD Identifier	Power Parameter	Approach Spectral Class Identifier	Departure Spectral Class Identifier	Lateral Directivity Identifier
JETF	Reference aircraft with two fuselage-mounted turbofan engines	Jet	2	Large	165347	143300	4921	25000	JETF	Corrected Net Thrust (lb)	204	133	Fuselage
JETW	Reference aircraft with wing-mounted turbofan engines	Jet	2	Large	165347	143300	4921	25000	JETW	Corrected Net Thrust (lb)	205	103	Wing
PROP	Reference aircraft with wing-mounted turboprop engines	Turbo-prop	2	Large	165347	143300	4921	16500	PROP	Shaft Horse-power (%)	234	112	Prop

TABLE A-2 JET COEFFICIENTS

Aircraft Identifier	Thrust Rating	E (lb)	F (lb/kt)	Ga (lb/ft)	Gb (lb/ft^2)	H (lb/degC)	K1 (lb/EPR)	K2 (lb/EPR^2)	K3 (lb/(N1/sqrt(theta)))	K4 (lb/(N1/sqrt(theta))^2)
JETF	MaxClimb	16000.0	-4.00000	0.40000	-0.00001	0.000	n/a	n/a	n/a	n/a
JETF	IdleApproach	1100.0	-6.50000	0.18000	0.00000	0.000	n/a	n/a	n/a	n/a
JETF	MaxTakeOff	25000.0	-25.00000	0.30000	0.00001	0.000	n/a	n/a	n/a	n/a
JETW	MaxClimb	16000.0	-4.00000	0.40000	-0.00001	0.000	n/a	n/a	n/a	n/a
JETW	IdleApproach	1100.0	-6.50000	0.17000	-0.00001	0.000	n/a	n/a	n/a	n/a
JETW	MaxTakeOff	25000.0	-25.00000	0.30000	0.00001	0.000	n/a	n/a	n/a	n/a

TABLE A-3 PROPELLER COEFFICIENTS

Aircraft Identifier	Thrust Rating	Propeller Efficiency	Installed Net Propulsive Power (hp)
PROP	MaxClimb	0.85	7800.0
PROP	MaxTakeOff	0.85	9500.0

TABLE A-4 AERODYNAMIC COEFFICIENTS

Aircraft Identifier	Operation Type	Flap Identifier	B	C/D (kt/sqrt(lb))	R
JETF	D	1	-	-	0.060000
JETF	A	15	-	-	0.075000
JETF	A	25	-	0.375000	0.100000
JETF	A	30	-	0.350000	0.120000
JETF	D	5	0.007500	0.400000	0.070000
JETF	D	ZERO	-	-	0.055000
JETW	D	1	-	-	0.060000
JETW	A	15	-	-	0.075000
JETW	A	25	-	0.375000	0.100000
JETW	A	30	-	0.350000	0.120000
JETW	D	5	0.007500	0.400000	0.070000
JETW	D	ZERO	-	-	0.055000
PROP	D	17	0.009100	0.365000	0.110000
PROP	A	D-35	-	0.360000	0.109000
PROP	A	U-INTR	-	-	0.094500
PROP	D	ZERO	-	-	0.080000

TABLE A-5 DEFAULT WEIGHTS

Aircraft Identifier	Operation	Stage Length	Weight (lb)
JETF	A	1	143300
JETF	D	1	165347
JETW	A	1	143300
JETW	D	1	165347
PROP	A	1	143300
PROP	D	1	165347

TABLE A-6 FIXED-POINT PROFILES

Aircraft Identifier	Operation Mode	Profile Identifier	Stage Length	Point Number	Distance (m)	Altitude (m)	True Airspeed (m/s)	Corrected Net Thrust (lb or % per engine)
JETF	A	FPP	1	1	-45644.2	1828.8	143.19	533.14
JETF	A	FPP	1	2	-26947.9	914.4	136.81	476.71
JETF	A	FPP	1	3	-26643.1	914.4	135.72	450.59
JETF	A	FPP	1	4	-18664.4	914.4	103.42	450.59
JETF	A	FPP	1	5	-18359.6	914.4	101.97	417.90
JETF	A	FPP	1	6	-17447.8	914.4	97.53	417.90
JETF	A	FPP	1	7	-17143.0	898.4	96.92	235.08
JETF	A	FPP	1	8	-14196.7	744.0	90.86	230.29
JETF	A	FPP	1	9	-13891.9	728.0	89.42	306.54
JETF	A	FPP	1	10	-11238.6	589.0	75.64	300.87
JETF	A	FPP	1	11	-10933.8	573.0	75.14	765.00
JETF	A	FPP	1	12	-9286.6	486.7	72.39	755.66
JETF	A	FPP	1	13	-8981.8	470.7	72.33	5011.09
JETF	A	FPP	1	14	-290.2	15.2	70.69	4737.00
JETF	A	FPP	1	15	0.0	0.0	69.33	4724.14
JETF	A	FPP	1	16	92.7	0.0	67.81	10000.00
JETF	A	FPP	1	17	1292.7	0.0	14.14	2500.00
JETF	D	FPP	1	1	0.0	0.0	0.01	25000.00
JETF	D	FPP	1	2	1708.5	0.0	85.11	20933.71
JETF	D	FPP	1	3	3439.5	304.8	86.39	21243.71
JETF	D	FPP	1	4	3744.3	320.2	88.50	15739.39
JETF	D	FPP	1	5	7811.4	526.0	113.06	15818.11
JETF	D	FPP	1	6	9152.0	580.0	122.08	15817.80
JETF	D	FPP	1	7	12119.6	914.4	124.11	16202.80
JETF	D	FPP	1	8	14218.7	986.6	137.89	16185.53
JETF	D	FPP	1	9	20671.6	1676.4	142.72	16846.58
JETF	D	FPP	1	10	26809.8	2286.0	147.19	17307.95
JETF	D	FPP	1	11	35175.9	3048.0	153.08	17884.66
JETW	A	FPP	1	1	-45644.2	1828.8	143.19	533.14
JETW	A	FPP	1	2	-26947.9	914.4	136.81	476.71
JETW	A	FPP	1	3	-26643.1	914.4	135.72	450.59
JETW	A	FPP	1	4	-18664.4	914.4	103.42	450.59
JETW	A	FPP	1	5	-18359.6	914.4	101.97	417.90

Aircraft Identifier	Operation Mode	Profile Identifier	Stage Length	Point Number	Distance (m)	Altitude (m)	True Airspeed (m/s)	Corrected Net Thrust (lb or % per engine)
JETW	A	FPP	1	6	-17447.8	914.4	97.53	417.90
JETW	A	FPP	1	7	-17143.0	898.4	96.92	235.08
JETW	A	FPP	1	8	-14196.7	744.0	90.86	230.29
JETW	A	FPP	1	9	-13891.9	728.0	89.42	306.54
JETW	A	FPP	1	10	-11238.6	589.0	75.64	300.87
JETW	A	FPP	1	11	-10933.8	573.0	75.14	765.00
JETW	A	FPP	1	12	-9286.6	486.7	72.39	755.66
JETW	A	FPP	1	13	-8981.8	470.7	72.33	5011.09
JETW	A	FPP	1	14	-290.2	15.2	70.69	4737.00
JETW	A	FPP	1	15	0.0	0.0	69.33	4724.14
JETW	A	FPP	1	16	92.7	0.0	67.81	10000.00
JETW	A	FPP	1	17	1292.7	0.0	14.14	2500.00
JETW	D	FPP	1	1	0.0	0.0	0.01	25000.00
JETW	D	FPP	1	2	1708.5	0.0	85.11	20933.71
JETW	D	FPP	1	3	3439.5	304.8	86.39	21243.71
JETW	D	FPP	1	4	3744.3	320.2	88.50	15739.39
JETW	D	FPP	1	5	7811.4	526.0	113.06	15818.11
JETW	D	FPP	1	6	9152.0	580.0	122.08	15817.80
JETW	D	FPP	1	7	12119.6	914.4	124.11	16202.80
JETW	D	FPP	1	8	14218.7	986.6	137.89	16185.53
JETW	D	FPP	1	9	20671.6	1676.4	142.72	16846.58
JETW	D	FPP	1	10	26809.8	2286.0	147.19	17307.95
JETW	D	FPP	1	11	35175.9	3048.0	153.08	17884.66
PROP	A	FPP	1	1	-34895.6	1828.8	114.44	14.65
PROP	A	FPP	1	2	-17447.8	914.4	91.61	12.89
PROP	A	FPP	1	3	-8723.9	457.2	78.00	18.68
PROP	A	FPP	1	4	-5815.9	304.8	71.69	24.76
PROP	A	FPP	1	5	0.0	0.0	71.31	23.89
PROP	A	FPP	1	6	92.7	0.0	67.81	40.00
PROP	A	FPP	1	7	1292.7	0.0	15.56	10.00
PROP	D	FPP	1	1	0.0	0.0	0.01	105.63
PROP	D	FPP	1	2	2514.6	0.0	77.67	105.63
PROP	D	FPP	1	3	5712.7	304.8	78.83	107.93
PROP	D	FPP	1	4	6386.1	355.4	80.50	106.32

Aircraft Identifier	Operation Mode	Profile Identifier	Stage Length	Point Number	Distance (m)	Altitude (m)	True Airspeed (m/s)	Corrected Net Thrust (lb or % per engine)
PROP	D	FPP	1	5	6690.9	374.0	81.25	87.30
PROP	D	FPP	1	6	9135.1	522.5	86.94	82.45
PROP	D	FPP	1	7	14703.1	914.4	88.64	84.78
PROP	D	FPP	1	8	26268.2	1330.2	111.61	70.83
PROP	D	FPP	1	9	35321.8	1676.4	113.56	72.64
PROP	D	FPP	1	10	52502.3	2286.0	117.14	75.96
PROP	D	FPP	1	11	76628.0	3048.0	121.81	80.41

TABLE A-7 NPD CURVES

NPD Identifier	Noise Descriptor	Operation Mode	Power Setting (lb)	L_200 (ft)	L_400 (ft)	L_630 (ft)	L_1000 (ft)	L_2000 (ft)	L_4000 (ft)	L_6300 (ft)	L_10000 (ft)	L_16000 (ft)	L_25000 (ft)
JETF	LAmax	A	2000	97.4	90.1	85.2	80.1	72.1	63.6	57.4	50.4	42.6	34.6
JETF	LAmax	A	2500	97.6	90.3	85.4	80.3	72.3	63.8	57.6	50.6	42.8	34.8
JETF	LAmax	A	7500	99.9	92.6	87.7	82.6	74.6	66.1	59.9	52.9	45.1	37.1
JETF	LAmax	D	10000	100.2	92.9	88.0	82.9	74.9	66.4	60.2	53.2	45.4	37.4
JETF	LAmax	D	15000	102.4	95.1	90.2	85.1	77.1	68.6	62.4	55.4	47.6	39.6
JETF	LAmax	D	20000	106.9	99.6	94.7	89.6	81.6	73.1	66.9	59.9	52.1	44.1
JETF	LAmax	D	22500	109.1	101.8	96.9	91.8	83.8	75.3	69.1	62.1	54.3	46.3
JETF	SEL	A	2000	101.2	97.2	94.3	91.0	85.5	79.5	75.2	70.5	65.4	60.2
JETF	SEL	A	2500	101.4	97.4	94.5	91.2	85.7	79.7	75.4	70.7	65.6	60.4
JETF	SEL	A	7500	103.0	99.0	96.1	92.8	87.3	81.3	77.0	72.3	67.2	62.0
JETF	SEL	D	10000	100.6	96.6	93.7	90.4	84.9	78.9	74.6	69.9	64.8	59.6
JETF	SEL	D	15000	103.9	99.9	97.0	93.7	88.2	82.2	77.9	73.2	68.1	62.9
JETF	SEL	D	20000	108.1	104.1	101.2	97.9	92.4	86.4	82.1	77.4	72.3	67.1
JETF	SEL	D	22500	109.8	105.8	102.9	99.6	94.1	88.1	83.8	79.1	74.0	68.8
JETW	LAmax	A	2000	96.9	89.6	84.7	79.6	71.6	63.1	56.9	49.9	42.1	34.1
JETW	LAmax	A	2500	97.1	89.8	84.9	79.8	71.8	63.3	57.1	50.1	42.3	34.3
JETW	LAmax	A	7500	99.4	92.1	87.2	82.1	74.1	65.6	59.4	52.4	44.6	36.6
JETW	LAmax	D	10000	100.1	92.8	87.9	82.8	74.8	66.3	60.1	53.1	45.3	37.3
JETW	LAmax	D	15000	102.3	95.0	90.1	85.0	77.0	68.5	62.3	55.3	47.5	39.5
JETW	LAmax	D	20000	106.8	99.5	94.6	89.5	81.5	73.0	66.8	59.8	52.0	44.0
JETW	LAmax	D	22500	109.0	101.7	96.8	91.7	83.7	75.2	69.0	62.0	54.2	46.2

NPD Identifier	**Noise Descriptor**	**Operation Mode**	**Power Setting (lb)**	**L_200 (ft)**	**L_400 (ft)**	**L_630 (ft)**	**L_1000 (ft)**	**L_2000 (ft)**	**L_4000 (ft)**	**L_6300 (ft)**	**L_10000 (ft)**	**L_16000 (ft)**	**L_25000 (ft)**
JETW	SEL	A	2000	100.7	96.7	93.8	90.5	85.0	79.0	74.7	70.0	64.9	59.7
JETW	SEL	A	2500	100.9	96.9	94.0	90.7	85.2	79.2	74.9	70.2	65.1	59.9
JETW	SEL	A	7500	102.5	98.5	95.6	92.3	86.8	80.8	76.5	71.8	66.7	61.5
JETW	SEL	D	10000	100.5	96.5	93.6	90.3	84.8	78.8	74.5	69.8	64.7	59.5
JETW	SEL	D	15000	103.8	99.8	96.9	93.6	88.1	82.1	77.8	73.1	68.0	62.8
JETW	SEL	D	20000	108.0	104.0	101.1	97.8	92.3	86.3	82.0	77.3	72.2	67.0
JETW	SEL	D	22500	109.7	105.7	102.8	99.5	94.0	88.0	83.7	79.0	73.9	68.7
PROP	LAmax	A	28	99.0	93.0	88.7	84.0	76.2	67.6	61.6	55.1	48.0	40.8
PROP	LAmax	D	28	92.1	86.1	81.8	77.1	69.3	60.7	54.7	48.2	41.1	33.9
PROP	LAmax	A	100	108.0	102.0	97.7	93.0	85.2	76.6	70.6	64.1	57.0	49.8
PROP	LAmax	D	100	101.1	95.1	90.8	86.1	78.3	69.7	63.7	57.2	50.1	42.9
PROP	SEL	A	28	102.0	98.0	95.1	91.8	86.3	80.1	75.5	70.4	64.8	59.0
PROP	SEL	D	28	95.1	91.1	88.2	84.9	79.4	73.2	68.6	63.5	57.9	52.1
PROP	SEL	A	100	110.0	106.0	103.1	99.8	94.3	88.1	83.5	78.4	72.8	67.0
PROP	SEL	D	100	103.1	99.1	96.2	92.9	87.4	81.2	76.6	71.5	65.9	60.1

TABLE A-8 SPECTRAL CLASS

Spectral Class Identifier	Operation Mode	Description	L_50Hz	L_63Hz	L_80Hz	L_100Hz	L_125Hz	L_160Hz	L_200Hz	L_250Hz	L_315Hz	L_400Hz	L_500Hz	L_630Hz	L_800Hz	L_1000Hz	L_1250Hz	L_1600Hz	L_2000Hz	L_2500Hz	L_3150Hz	L_4000Hz	L_5000Hz	L_6300Hz	L_8000Hz	L_10000Hz
133	Departure	2-Engine.Tail.Low/MidBy.Tfan	57.3	56.3	61.5	67.7	71.4	73.7	67.0	72.1	73.8	74.1	71.3	70.4	70.9	70.0	68.2	67.3	63.4	60.9	56.6	53.2	47.8	40.5	31.7	27.9
103	Departure	2-Engine.HighByPass.Tfan	56.7	66.1	70.1	72.8	76.6	73.0	74.5	77.0	75.3	72.2	72.2	71.2	70.2	70.0	69.6	71.1	70.6	67.1	63.4	63.5	58.2	51.5	42.3	37.7
112	Departure	2/4-Engine.Tprop	74.0	95.0	92.0	75.0	96.0	90.0	74.9	78.0	75.0	75.0	74.1	74.0	72.0	70.0	71.0	72.0	71.0	70.0	66.0	64.0	60.0	54.0	46.0	39.9
204	Approach	2-Engine.Low/MidByPass.Tfan	58.8	57.1	59.4	68.0	72.8	73.7	69.1	72.3	74.8	75.6	73.6	72.1	72.1	70.0	66.3	63.6	59.9	57.5	54.8	51.8	48.8	45.8	42.8	39.8
205	Approach	2-Engine.HighByPass.Tfan	68.3	60.7	64.6	67.4	78.4	74.8	71.4	72.4	72.0	72.4	71.6	72.0	71.0	70.0	68.9	67.2	65.8	64.4	63.0	62.0	60.6	54.4	48.5	39.0
234	Approach	Military	56.3	77.3	80.3	74.2	74.3	70.2	72.2	69.3	69.1	71.2	69.1	72.1	69.1	70.0	69.9	67.7	67.4	65.1	63.7	61.4	55.3	49.1	42.9	33.5

TABLE A-9 AERODROME METEOROLOGICAL CONDITIONS

Metric units				**US units**					
Temperature (°C)	**Pressure (mmHg)**	**Headwind (m/s)**	**Elevation (m)**	**Temperature (°F)**	**Pressure (inHg)**	**Headwind (kt)**	**Elevation (ft)**	**Do Humidity**	**Humidity (%)**
15	759.97	0	0	59	29.92	0	0	No	70

TABLE A-10 RUNWAY ENDS

Runway Identifier	**Metric units**				**US units**			
	SOR X-coordinate (m)	**SOR Y-coordinate (m)**	**End X-coordinate (m)**	**End Y-coordinate (m)**	**SOR X-coordinate (nmi)**	**SOR Y-coordinate (nmi)**	**End X-coordinate (nmi)**	**End Y-coordinate (nmi)**
09	0	0	3000	0	0.0000	0.0000	1.6199	0.0000

TABLE A-11 ROUTES

Track Identifier	Track Points	Track Description	Metric units		US units	
			X-coordinate (m)	Y-coordinate (m)	X-coordinate (nmi)	Y-coordinate (nmi)
AC	1	Arrival, curved	-24800	-100000	-13.3909	-53.9957
AC	2	Arrival, curved	-24800	-6300	-13.3909	-3.4017
AC	3	Arrival, curved	-24704	-5206	-13.3391	-2.8110
AC	4	Arrival, curved	-24420	-4145	-13.1857	-2.2381
AC	5	Arrival, curved	-23956	-3150	-12.9352	-1.7009
AC	6	Arrival, curved	-23326	-2250	-12.5950	-1.2149
AC	7	Arrival, curved	-22550	-1474	-12.1760	-0.7959
AC	8	Arrival, curved	-21650	-844	-11.6901	-0.4557
AC	9	Arrival, curved	-20655	-380	-11.1528	-0.2052
AC	10	Arrival, curved	-19594	-96	-10.5799	-0.0518
AC	11	Arrival, curved	-18500	0	-9.9892	0.0000
AC	12	Arrival, curved	1300	0	0.7019	0.0000
AS	1	Arrival, straight	-100000	0	-53.9957	0.0000
AS	2	Arrival, straight	1300	0	0.7019	0.0000
DC	1	Departure, curved	0	0	0.0000	0.0000
DC	2	Departure, curved	3700	0	1.9978	0.0000
DC	3	Departure, curved	4794	-96	2.5886	-0.0518
DC	4	Departure, curved	5855	-380	3.1614	-0.2052
DC	5	Departure, curved	6850	-844	3.6987	-0.4557
DC	6	Departure, curved	7750	-1474	4.1847	-0.7959
DC	7	Departure, curved	8526	-2250	4.6037	-1.2149
DC	8	Departure, curved	9156	-3150	4.9438	-1.7009

Track Identifier	**Track Points**	**Track Description**	**Metric units**		**US units**	
			X-coordinate (m)	**Y-coordinate (m)**	**X-coordinate (nmi)**	**Y-coordinate (nmi)**
DC	9	Departure, curved	9620	-4145	5.1944	-2.2381
DC	10	Departure, curved	9904	-5206	5.3477	-2.8110
DC	11	Departure, curved	10000	-6300	5.3996	-3.4017
DC	12	Departure, curved	10000	-100000	5.3996	-53.9957
DS	1	Departure, straight	0	0	0.0000	0.0000
DS	2	Departure, straight	100000	0	53.9957	0.0000

TABLE A-12 RECEPTORS

Receptor Identifier	**Receptor Description**	**Relevant to Route Identifiers**	**Metric units**			**US units**		
			X-coordinate (m)	**Y-coordinate (m)**	**Height (m)**	**X-coordinate (nmi)**	**Y-coordinate (nmi)**	**Height (ft)**
R01	Takeoff, 6.5 km from SOR	DC, DS	6500	0	0	3.5097	0.0000	0
R02	SOR, to the side	AC, AS, DC, DS	0	200	0	0.0000	0.1080	0
R03	SOR, behind	AC, AS, DC, DS	-500	0	0	-0.2700	0.0000	0
R04	SOR, behind and to the side	AC, AS, DC, DS	-500	500	0	-0.2700	0.2700	0
R05	Sideline, at runway end	AC, AS, DC, DS	3000	500	0	1.6199	0.2700	0
R06	Departure curve, beneath	DC	8200	-1800	0	4.4276	-0.9719	0
R07	Departure curve, outside	DC	9600	-400	0	5.1836	-0.2160	0
R08	Departure curve, inside	DC	6700	-3300	0	3.6177	-1.7819	0
R09	Departure curve end, beneath	DC	10000	-10000	0	5.3996	-5.3996	0
R10	Departure curve end, outside	DC	12000	-10000	0	6.4795	-5.3996	0
R11	Departure curve end, inside	DC	8000	-10000	0	4.3197	-5.3996	0
R12	Arrival curve, beneath	AC	-23000	-1800	0	-12.4190	-0.9719	0
R13	Arrival curve, outside	AC, AS	-24400	-500	0	-13.1749	-0.2700	0

Receptor Identifier	**Receptor Description**	**Relevant to Route Identifiers**	**Metric units**			**US units**		
			X-coordinate (m)	**Y-coordinate (m)**	**Height (m)**	**X-coordinate (nmi)**	**Y-coordinate (nmi)**	**Height (ft)**
R14	Arrival curve, inside	AC	-21500	-3300	0	-11.6091	-1.7819	0
R15	Arrival curve end, beneath	AC	-24800	-10000	0	-13.3909	-5.3996	0
R16	Arrival curve end, outside	AC	-26800	-10000	0	-14.4708	-5.3996	0
R17	Arrival curve end, inside	AC	-22800	-10000	0	-12.3110	-5.3996	0
R18	Approach, 2.0km from threshold	AC, AS	-2000	0	0	-1.0799	0.0000	0

APPENDIX B: REFERENCE CASE RESULTS

SEL RESULTS

Overall SEL reference results are presented in **Table B-1** for each case and relevant receptor. To facilitate data analysis, these results are presented as a list in worksheet *B-1_SEL_Results* of the accompanying workbook.

TABLE B-1 SEL RESULTS

Receptor Identifier	JETFAC	JETFAS	JETFDC	JETFDS	JETWAC	JETWAS	JETWDC	JETWDS	PROPAC	PROPAS	PROPDC	PROPDS
R01	-	-	84.35	90.13	-	-	85.61	90.03	-	-	86.10	91.88
R02	89.91	89.91	101.41	101.41	91.09	91.09	102.82	102.82	92.35	92.35	98.42	98.42
R03	105.09	105.09	74.76	74.73	104.59	104.59	76.17	76.13	104.22	104.22	75.53	75.53
R04	80.90	80.90	81.79	81.79	82.11	82.11	83.20	83.20	83.32	83.32	78.63	78.63
R05	63.21	63.22	91.07	91.09	64.22	64.22	92.65	92.68	65.99	65.99	85.31	85.32
R06	-	-	87.91	-	-	-	87.88	-	-	-	87.04	-
R07	-	-	71.16	-	-	-	72.82	-	-	-	70.48	-
R08	-	-	72.79	-	-	-	74.56	-	-	-	72.83	-
R09	-	-	80.55	-	-	-	80.46	-	-	-	80.34	-
R10	-	-	72.83	-	-	-	74.23	-	-	-	71.58	-
R11	-	-	72.84	-	-	-	74.26	-	-	-	71.58	-
R12	79.54	-	-	-	79.16	-	-	-	77.47	-	-	-
R13	69.25	78.07	-	-	70.14	78.22	-	-	69.57	76.35	-	-
R14	68.47	-	-	-	69.72	-	-	-	71.45	-	-	-
R15	76.98	-	-	-	76.50	-	-	-	74.01	-	-	-
R16	68.42	-	-	-	69.45	-	-	-	69.06	-	-	-
R17	68.23	-	-	-	69.31	-	-	-	69.08	-	-	-
R18	98.95	98.95	-	-	98.45	98.45	-	-	98.27	98.27	-	-

SEGMENTAL RESULTS

Segmental parameters are listed in **Table B-2**, along with their associated mathematical symbol and the section reference in Volume 2 where the parameter is introduced or defined.

Reference segmental results are provided in the accompanying workbook. Worksheet *B-2_Segment_Results* contains results for all parameters for each segment of each of the reference case trajectories at the relevant receptors. They are presented using the same naming convention as in **Table B-2**, which incorporates the units, for clarity.

TABLE B-2 REFERENCE SEGMENTAL RESULTS PARAMETERS

Parameter Name	**Mathematical Symbol**	**Doc 29 Volume 2 Reference**
case_ID	n/a	n/a
receptor_ID	n/a	n/a
segment_ID	n/a	n/a
segment_start_x(ft)	x_1	3.6 Construction of flight path segments
segment_start_y(ft)	y_1	3.6 Construction of flight path segments
segment_start_z(ft)	z_1	3.6 Construction of flight path segments
segment_end_x(ft)	x_2	3.6 Construction of flight path segments
segment_end_y(ft)	y_2	3.6 Construction of flight path segments
segment_end_z(ft)	z_2	3.6 Construction of flight path segments
segment_length(ft)	λ	4.4.1 Geometric parameters
slant_distance(ft)	d_p	4.4.1 Geometric parameters
distance_d1(ft)	d_1	4.4.1 Geometric parameters
distance_d2(ft)	d_2	4.4.1 Geometric parameters
distance_q(ft)	q	4.4.1 Geometric parameters
lateral_displacement(ft)	ℓ	4.5.2 Sound propagation geometry
NPD_interpolation_distance(ft)	d	4.2 Determination of event levels from NPD data
NPD_interpolation_thrust(lb/e)	P	4.2 Determination of event levels from NPD data
angle_beta(°)	β	4.5.2 Sound propagation geometry
angle_gamma(°)	γ	3.3.3 The aircraft coordinate system
angle_phi(°)	φ	4.5.2 Sound propagation geometry
bank_angle(°)	ε	3.3.3 The aircraft coordinate system
engine_Install_correction(dB)	Δ_I	4.5.3 Engine installation correction
lateral_attenuation(dB)	Λ	4.5.4 Lateral attenuation
baseline_SEL(dB)	$L_{E\infty}$	4.2 Determination of event levels from NPD data
speed_corr(dB)	Δ_V	4.5.1 The duration correction
Lmax_noise_fraction	Δ_F	E3 Consistency of maximum and time-integrated metrics – the scaled difference
noise_fraction	Δ_F	4.5.6 The finite segment correction
start_of_roll_correction(dB)	Δ_{SOR}	4.5.7 The start-of-roll directivity function
acoustic_impedance_adjustment(dB)	$\Delta_{Impedance}$	4.2.1 Impedance adjustment of standard NPD data
segment_SEL(dB)	$L_{E,seg}$	4.3 General expressions

GRID RESULTS

Reference grid results are provided in the accompanying workbook. Worksheet *B-3_Grid_Results* contains results for each relevant grid point for each of the 12 reference cases.

APPENDIX C: CONVERSIONS BETWEEN SI AND US UNITS

In general the units used in this document adhere to the *International System of Units* (SI), using metres and kilograms. The SI system was adopted by the 11th General Conference on Weights and Measures (1960) and it is described in the International Standard ISO 31 *'Quantities and Units'* (1992). However, flight parameters are mostly defined in units of feet, knots and pounds. The conversion factors are:

Symbol	**Name**	**Conversion**
ft	Foot, feet	1 ft = 0.3048000 m
nm	Nautical mile	1 nm = 1.852000 km
kt	Knot (= nm/h)	1 kt = 1.852 km/h = 0.5144 m/s
lb	Pound	1 lb = 0.4535924 kg
°F	Degrees Fahrenheit	°F = °C*9/5 + 32

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