Recommended Method for Computing Noise Contours Around Airports – Recent Updates to ICAO Doc 9911

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INTRODUCTION

In 2018, the second edition of ICAO Doc 9911 "Recommended Method for Computing Noise Contours around Airports" was published[1]. Doc 9911 provides guidance and methodologies for modelling noise that emanates from aircraft in the vicinity of airports, as well as providing guidance on the aircraft performance needed to appropriately model that noise. It provides guidance for full Doc 9911 harmonization and implementation in computer models used to undertake ICAO policy assessments and in models used in ICAO contracting States for environmental analyses.

This article presents background on the efforts leading up to the publication of the second edition of Doc 9911, the technical updates included in that document, and some potential upcoming updates to the guidance document.

GUIDANCE DOCUMENTS LEADING UP TO DOC 9911

The second edition of ICAO Doc 9911 "Recommended Method for Computing Noise Contours around Airports" was completed at the end of CAEP/10 and published in 2018. This marked the end of a multi-year effort to update the first edition of Doc 9911, published in 2008[2], which in turn was an update to ICAO Circular 205 ("Recommended Method for Computing Noise Contours Around Airports"), published in 1988[3].

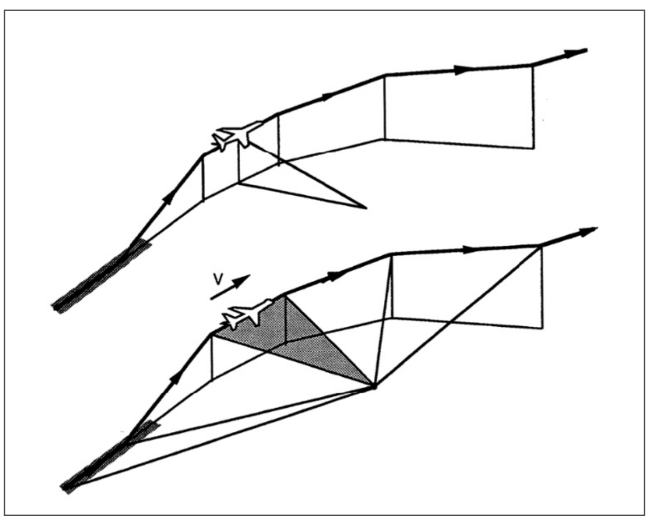
The international guidance that led up to the creation Doc 9911 can be traced back to the document, "Procedure for the Calculation of Airplane Noise in the Vicinity of Airports" (SAE-AIR-1845), which was first published by SAE International in 1986[4]. This represented the first internationally agreed text on a common method for the calculation of aircraft noise in the vicinity of civil airports.

Much has changed since that time. In the mid-1980s, most States where aircraft noise was a serious problem, had developed their own national noise calculation methods, usually linked to nationally developed noise indicators. There were no international standard calculation methods, and there was no common method for the provision of supporting data collected from aircraft manufacturers. Without high quality standardized reference data, harmonized calculation methods had obviously limited application.

The original foundation document SAE-AIR-1845 was, by modern standards, a simple method. It was known as a 'closest point of approach' method, and it solely related noise level at a single point on the ground to the state of the aircraft at the closest point of approach to that point. The first edition of Doc 9911 comprehensively enhanced this aspect so that the method took into account all flight path segments and thus fully reflected situations where the maximum noise level may be associated with a segment other than the segment nearest to the observer point on the ground (See Figure 1). This can occur, when the noise emission is higher for flight path segments that are more distant from the observer. In such cases, the higher noise emission offsets the additional attenuation associated with the flight path segment which is further from the observer than the closest segments.

A secondary advance in Doc 9911 over the SAE-AIR-1845 method is improved modelling of the lateral effects of sound. Lateral attenuation is the process by which sound is attenuated or reduced to the side of the aircraft relative to directly beneath it. Previously, lateral attenuation was calculated as a function of lateral distance and elevation angle only. This was derived empirically from a large pool of data based on 1980's vintage aircraft, predominantly with tail-mounted engines such the Boeing 727 and Douglas DC-9. This lateral attenuation model remains reliable for aircraft with tail-mounted engines in non-turning flight but the latest SAE-AIR-5662[5] method now recognizes that part of this 'attenuation' is in fact a lateral directionality associated with engine installation effects. This is described in an aircraft frame of reference so that aircraft banking during turns - previously irrelevant - now has to be taken into account. Although lateral directivity might be sensitive to various features of engine installation, at present only two lateral directivity functions are employed: for aircraft with tail-mounted and wing-mounted engines respectively.

FIGURE 1: Change from closest point of approach to a segmentation method



ICAO AIRCRAFT NOISE AND PERFORMANCE (ANP) DATABASE

The first edition of Doc 9911 was written around a common data specification which describes the fundamental aircraft performance and noise characteristics of an aircraft. Unlike ground-based transportation noise sources, aircraft noise is highly dependent on the performance of the aircraft since this, along with how an aircraft is operated, dictates the height and position of an aircraft, which are so strongly related to the noise level calculated (or measured) on the ground.

The data specification has led to the development of a harmonized data request form that is provided to aircraft manufacturers. In 2000, data for some of the most common aircraft types operating had not been provided to the international noise modelling community. By 2010, most of the major data gaps had been addressed. The ICAO endorsed ANP database is hosted by EUROCONTROL[6] and maintained in collaboration with the US DOT and European Union Aviation Safety Agency (EASA) providing independent access to the data.

IMPROVEMENTS IN DOC 9911 SECOND EDITION

This latest version of Doc 9911 represents the current state of the science for environmental analyses of aircraft noise in the vicinity of civil airports. Its methodologies and guidance have been leveraged by multiple entities for the development of aircraft noise and performance models. The second edition of Doc 9911 reflects a number of technical updates to the noise and performance modelling methodology developed since the release of the first edition in 2008, as well as editorial updates and additional clarification identified during code development efforts to implement Doc 9911 in computer software. The majority of the guidance found in Doc 9911 second edition is harmonized with similar guidance found in European Civil Aviation Conference (ECAC) Doc 29 "Report on Standard Method of Computing Noise Contours around Civil Airports" fourth edition.[7]

Several technical amendments went into the second edition of Doc 9911, in order to improve or expand its methodology. First, an aircraft substitution method and guidance based on similar guidance found in ECAC Doc 29 third edition Vol. 1[8] was added and expanded, which allows for a standardized method for modelling aircraft not directly represented in the ICAO Aircraft Noise and Performance (ANP) Database.

Second, a change in the aircraft source height in the methodology was made. Previously a source height of 0.0 m (0.0 ft.) was assumed in the guidance. While this may have been acceptable for modelling when the aircraft is in flight, it is somewhat unrealistic when the aircraft is on the ground during takeoff and landing. Therefore, a recommended minimum height for modelling an aircraft noise source is 1.0 m (3.3 ft.) above the aerodrome level or local topography was added to the guidance.

Third, in an effort to improve aircraft performance modelling guidance, updates were made to the aircraft flight segmentation methodology, including the method for sub-segmenting flight tracks with arcs, initial climb segments, final approach segments, and ground roll tracks. Additional supplemental guidance for determining power and velocity across a segment was also provided, along with supplemental guidance for determining equivalent flight path geometry for the lateral attenuation adjustment.

During the development of the second edition of Doc 9911, SAE published "Application of Pure-Tone Atmospheric Absorption Losses to One-Third Octave-Band Data" (SAE-ARP-5534)[9]. This guidance document was intended as a replacement for "Standard Values of Atmospheric Absorption as a Function of Temperature and Humidity" (SAE-ARP-866A)[10]. Since several guidance documents and regulations continue to reference SAE-ARP-866A, Doc 9911 was updated to include both SAE-ARP-866A and SAE-ARP-5534 methods for modelling the atmospheric absorption of sound for non-standard atmospheric conditions, as well as the corresponding example calculation in the document's appendices.

Several Doc 9911 compliant models utilize an acoustic impedance adjustment, to correct the reference-day noise data for off-reference, non-sea level conditions. The acoustic impedance adjustment takes into account temperature, atmospheric pressure, and altitude, indirectly through this adjustment to the noise levels. Therefore, Doc 9911 was supplemented with this acoustic impedance adjustment.

Also during the development of the second edition of Doc 9911, SAE published "Method to Calculate Behind Start of Takeoff Roll Noise Level Adjustments" (SAE-AIR-6297)[11], which includes two methods to calculate noise level adjustments at various angles behind an airplane (directivity) at the start of takeoff roll (SOTR); one for modern commercial jet aircraft and another for modern turboprop aircraft. These directivity curves were based on empirical data (collected in 2004), and replaced the method described in SAE-AIR-1845A, which used empirical data from a much older fleet (circa 1980). This adjustment was included in the second edition of Doc 9911 along with updates to the finite segment correction for ground roll and guidance on their implementation.

Two ANP data submittal forms were included in the Doc 9911 update: "ANP Database Submittal Form" and "ANP Database Submittal Form for Propeller-Driven, Fixed-Wing Aircraft". These forms promote and standardize the submission of new data for inclusion in the ICAO ANP database to be used as aircraft source inputs for by Doc 9911 compliant models.

Finally, several example studies were added to the second edition of Doc 9911. These case studies provide input and output results for verification of software implementation and confirmation of the Doc 9911 methods.

FUTURE DEVELOPMENTS

During the development of the second edition of Doc 9911, several potential updates to the guidance and methodology were identified in order to: expand the capabilities, improve accuracy, and provide clearer guidance for software implementation. From that list, the following potential updates are being considered for a third edition of Doc 9911 to be developed during the CAEP/12 cycle (through 2021). Those potential updates could include (and are not limited to):

- Adding a helicopter noise calculation methodology.
- Adding a line-of-sight blockage calculation methodology to account for terrain features shielding the propagation path between source and receiver.
- Guidance on modelling population growth for forecasting noise.
- Modelling the effects on noise level of variable aircraft configurations and speeds which may become increasingly important as airframe noise becomes a greater component of total aircraft noise.
- Developing a ranking/rating method for accounting for the effects of certain modelling aspects on the results.
- Reviewing and updating the Doc 9911 performance modelling methodology (Doc 9911 Second Edition, Appendix C), in order to improve and/or include: departure and approach aircraft performance modelling, reduced power takeoff modelling, calculation of bank-angle on flight path geometry, guidance for modelling airports that have intersecting runways, and guidance on the level of detail required to better define arrival and departure flight profiles.

Future updates beyond the third edition of Doc 9911could include expanded source noise models. These models could cover: low frequency noise, improved propeller driven aircraft source models, taxi and reverse thrust noise, and on-route aircraft noise sources. The third edition could also cover new aircraft types (i.e., supersonic, commercial space vehicles, and unmanned aerial vehicles), as well as additional environmental effects (i.e., variable ground impedance).

REFERENCES

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11. SAE-AIR-6297, “Method to Calculate Behind Start of Takeoff Roll Noise Level Adjustments”, 2017.