Use of the Aviation Environmental Design Tool (AEDT) in Australia and the Australian Noise Exposure Forecast (ANEF) technical endorsement process

Mark Latimore (1), Paul Zissermann (1) and Ian Yorke (1)

(1) Air Navigation Services, Airservices, Canberra, Australia

ABSTRACT

The Integrated Noise Model (INM) was developed by the United States Federal Aviation Administration (FAA) and has been used extensively in Australia for the environmental assessment of aircraft noise, development of Australian Noise Exposure Forecast/Index maps (ANEF/ANEIs), and the generation of number above (Nxx) noise contour maps. The INM software was supported by the FAA until September 2016 and has since been replaced by the Aviation Environmental Design Tool (AEDT). To keep abreast with technology changes, the aviation industry in Australia must migrate away from the use of INM to AEDT. The continual use of the outdated software will eventually affect the accuracy of noise modelling and prediction of noise impacts around airports in Australia. This paper aims to informatively discuss the proposed use of AEDT in Australia and to specifically address Airservices' technical endorsement process of ANEFs using the new model. The paper presents preliminary work undertaken to validate the use of AEDT in Australian conditions with data extracted from Airservices' Noise and Flight Path Monitoring System (NFPMS), and presents comparative results of noise contours. The paper also aims to review airport noise modelling best practice in Australia and provides insight into modelling with AEDT.

1 INTRODUCTION

In Australia, the ANEF system is used as a land use planning tool around airports. ANEFs have traditionally been generated using the INM software developed by the US FAA. The INM software was supported by the FAA, with updated information for new aircraft types and training material, until September 2016. It has since been replaced by the FAA's AEDT.

The use of the FAA's INM modelling software has been primarily driven by Airservices' requirements for technical endorsement of ANEFs. The technical endorsement process is delegated to Airservices by the Department of Infrastructure, Regional Development and Cities (DIRDC) through a Manner of Endorsement. The Manner of Endorsement was updated in April 2017 to remove any references to INM.

To keep abreast with technology changes and to move away from using an unsupported model, the aviation industry in Australia must migrate away from the use of INM to AEDT. The continual use of the outdated INM software will eventually affect the accuracy of noise modelling and prediction of noise impacts for communities living around airports in Australia.

2 KEY STAKEHOLDERS

The key stakeholders affected by the introduction of AEDT in Australia are Airservices, DIRDC, the Department of Defence, airports and their consultants, and Standards Australia. Other important stakeholders include local governments (councils) around airports, and State and Territory planning authorities, as they rely on the ANEFs in relation to land zoning, planning decisions and approval of developments around airports. It is also reasonable to assume that communities affected by aircraft noise will have an interest in the introduction of AEDT in Australia, as well as Federal and State Members of Parliament that represent these communities, and the Aviation Noise Ombudsman (ANO). More information on key stakeholders is presented below.

- As a Commonwealth agency, Airservices is required by the Environment Protection and Biodiversity Conservation Act 1999 (the EPBC Act) to assess the potential environmental significance of any actions it takes, including changes to airspace, flight paths and flight procedures. Under a Ministerial Direction (M37/99), Airservices is required to maintain and operate a Noise and Flight Path Monitoring System (NFPMS), to provide aircraft movement data to the industry and to technically endorse ANEFs and ANEIs.
- The DIRDC ('the department') advises the Australian Government on the policy and regulatory framework for Australian airports and the aviation industry, manages the administration of the Government's interests in privatised airports under the Airports Act 1996, and provides policy advice to the Minister responsible for transport on the efficient management of Australian airspace and on aircraft noise and emissions (DIRDC website, 2018). DIRDC are the developer of the Transparent Noise Information Package (TNIP) that is used to generate noise above (Nxx) contours in Australia. This software has direct interfaces with the obsolete INM and will be required to be updated for use with AEDT.
- The Department of Defence ('Defence') is another Commonwealth agency that has obligations relating to aircraft noise under the EPBC Act. Defence is also required to produce ANEF maps around military airports.
- Airports and consultants. All leased federal airports (except for Tennant Creek and Mount Isa) are subject to a planning framework in the Airports Act 1996 (the Airports Act). As part of the Master Planning process, an Australian Noise Exposure Forecast (ANEF) must be prepared for leased federal airports. This work is usually carried out for airports by specialised consultants. Under the Airports Act these ANEFs are required to be endorsed in a 'manner' approved by the Minister (DIRDC website, 2018).
- Standards Australia. Standards Australia is the nation's peak non-government, not-for-profit standards organisation. The Australian standard AS2021:2015 *Acoustics - Aircraft noise intrusion - Building siting and construction*, has direct references to INM and appendices that provide calculated noise levels of aircraft based on INM calculations. This will need to be updated once AEDT replaces INM in Australia.

3 AEDT TRANSITION PROCESS

Airservices has been directed by the DIRDC to lead the transition from INM to AEDT within Australia. To achieve this Airservices is required to:

- internally upskill in the use of AEDT to enable the technical endorsement process,
- establish an appropriate transition timeframe to enable airports and consultants to upskill and use the new software,
- perform validation work to ensure the software is appropriate for use in Australian conditions, and
- provide information to the aviation industry regarding the use of AEDT.

4 THE AEDT MODELLING TOOL

AEDT is a software system that models aircraft performance in space and time to estimate fuel consumption, emissions, noise, and air quality impacts. It is a comprehensive tool that provides information to FAA stakeholders on each of these specific environmental impacts (FAA, 2018).

The underlying calculation of noise exposure of AEDT remains similar to INM, where noise levels are calculated based on aircraft performance and noise databases. AEDT 2d uses the Base of Aircraft Data (BADA) database 3.13.1 and the Aircraft Noise and Performance (ANP) database 2.1 (FAA, 2018).

As next generation aircraft types are introduced into Australia, it is imperative that noise modelling software includes up to date aircraft performance and noise data. For example, the new Airbus A350 jet aircraft operated at Sydney Airport 661 times over the period January to July 2018 (sourced from Airservices NFPMS). Aircraft such as this are not part of INM. AEDT will be updated to include aircraft noise and performance data for the A350, whereas INM will not. Table 1 below shows next generation aircraft types that will operate in Australia in the near future.

Table 1: Next generation aircraft types that will operate in Australia (Sydney Airport, 2018).

Aircraft Type
Airbus A320neo
Airbus A321neo
Boeing 737Max

Although these aircraft types are planned for introduction in the near future, they do not have the relevant aircraft performance and noise data in the INM.

Unlike INM, AEDT also enables the calculation of emissions from aircraft operations. This capability will be used by Airservices to evaluate the environmental impact of aircraft emissions from airspace and flight path changes.

Other software solutions do exist to evaluate aircraft noise, including Soundplan and, CadnaA. For continuity, a joint decision between DIRDC and Airservices was reached in early 2017 to use AEDT as the preferred model to replace INM. Extensive review and verification activities have been performed by the FAA to ensure AEDT is fit for purpose, as evidenced by their uncertainty verification documentation. The uncertainty quantification consists of four major elements: expert review, verification and validation, capability demonstrations, and parametric uncertainty/sensitivity analysis (FAA, *Aviation Environmental Design Tool (AEDT) 2a, Uncertainty Qualification, Executive Summary*, *Updated August 2013*). AEDT has also been built to comply with the European Civil Aviation Conference (ECAC) *Document 29, Report on Standard Method of Computing Noise Contours around Civil Airports, December 2016.*

5 PROPOSED IMPLEMENTATION TIMEFRAMES

In June 2018, Airservices' noise and environment specialists underwent training in AEDT and from August 2018 begun using it to environmentally assess proposed flight procedure changes. The quarterly and annual Sydney Airport ANEI and N70 chart information for 2018 published by Airservices will also be generated using AEDT.

It is proposed that Airservices will accept ANEF and ANEI studies from airports for technical endorsement generated by AEDT 2d from 1 January 2019. A transitional period of 12 months from 1 January to 31 December 2019 is proposed, where Airservices will accept studies generated in INM. After this transitional period, noise studies generated in INM will no longer be accepted. This proposed time frame should enable airports and consultants to upskill and transition to the use of AEDT, and for other stakeholders to be informed of the transition. A list of airports whose master plans have recently been completed, or will need to be updated in the near future, is provided below in Table 2, together with an indication of the applicable modelling software used or proposed based on the transition period above.

Table 2: Airport master plan timeframes and applicable noise models used to produce ANEFs (based on Airservices proposed transitional period of 1 January to 31 December 2019).

Airport	Master Plan (last approved)	Master Plan (next draft)*	Noise Modelling Software
Melbourne	23 Dec 2013	23 Dec 2018	INM (completed)
Adelaide	9 Jan 2015	9 Jan 2020	INM or AEDT
Perth	9 Jan 2015	9 Jan 2020	INM or AEDT
Sydney	18 Feb 2014	18 Feb 2019	INM (completed)
Brisbane	3 Feb 2015	3 Feb 2020	INM or AEDT
Essendon	11 Sep 2014	11 Sep 2019	INM or AEDT
Bankstown	5 Jan 2015	5 Jan 2020	INM (completed)
Canberra	11 Jan 2015	11 Jan 2020	INM or AEDT
Jandakot	17 Feb 2015	17 Feb 2020	INM or AEDT
Launceston	15 May 2015	15 May 2020	INM or AEDT
Alice Springs	1 Oct 2015	1 Oct 2020	AEDT
Camden	18 Dec 2015	18 Dec 2020	AEDT
Hobart	23 Dec 2015	23 Dec 2020	AEDT
Moorabbin	2 Aug 2016	2 Aug 2021	AEDT
Townsville	9 Aug 2016	9 Aug 2021	AEDT (Joint civil and military)
Gold Coast	15 Jul 2017	15 Jul 2022	AEDT
Archerfield	15 Jul 2017	15 Jul 2022	AEDT
Darwin	6 Sep 2017	6 Sep 2022	AEDT
Parafield	19 Jan 2018	19 Jan 2023	AEDT

* Next draft master plan dates are based on a five year planning cycle.

6 TECHNICAL ENDORSEMENT PROCESS

Under Ministerial Direction (Instrument Number M37/99), Airservices has an obligation to make available data for the development of aircraft noise exposure analyses and prediction, and to be responsible for technically endorsing Australian Noise Exposure Indices/Forecasts for all Australian airports. It is also a requirement that an ANEF is endorsed in a 'manner' approved by the Minister. The Manner of Endorsement was updated in April 2017 to reflect changes in noise modelling software (i.e. Any references to INM were removed).

Traditionally, Airservices has provided information on aircraft operations and sample radar flight tracks to airports and their consultants for integration into INM studies. As AEDT is adopted as the accepted noise model, this process will remain, however an increase in radar track data may be possible. To submit an ANEF study for technical endorsement, the AEDT administration database file and study reports will be required. These can be easily packaged in AEDT through the study maintenance options on the user interface. A technical report of all model inputs, similar to what has previously been provided for INM, will still be required to be produced by airports and their consultants, and submitted to Airservices to complete the technical endorsement of the ANEF.

The complex database structure of AEDT provides a challenge to Airservices' endorsement process, as the underlying database has been normalised to reduce data redundancy and improve data integrity. Traditionally using INM, database files such as the flight operational (ops_flt.dbf) and track (track.dbf) files could be directly evaluated for the endorsement process. These files are no longer available in AEDT, however similar data can be extracted using the Structured Query Language (SQL).

To technically endorse ANEF/ANEIs, Airservices has implemented a checklist approach that covers all the elements of the manner of endorsement, including aircraft type selection, runway coordinates, flight tracks, weather inputs, operational forecasts and State and Federal Government consultation. This checklist process will remain to evaluate the model inputs with additional elements relevant to AEDT. Elements that are specific to AEDT relate to the resolution of the receptor grid and annualisation parameters. Note that in AEDT receptors define locations where noise or emissions dispersion is calculated and can be single points or grids. Annualisation refers to the process of grouping operations over the time period that is being calculated.

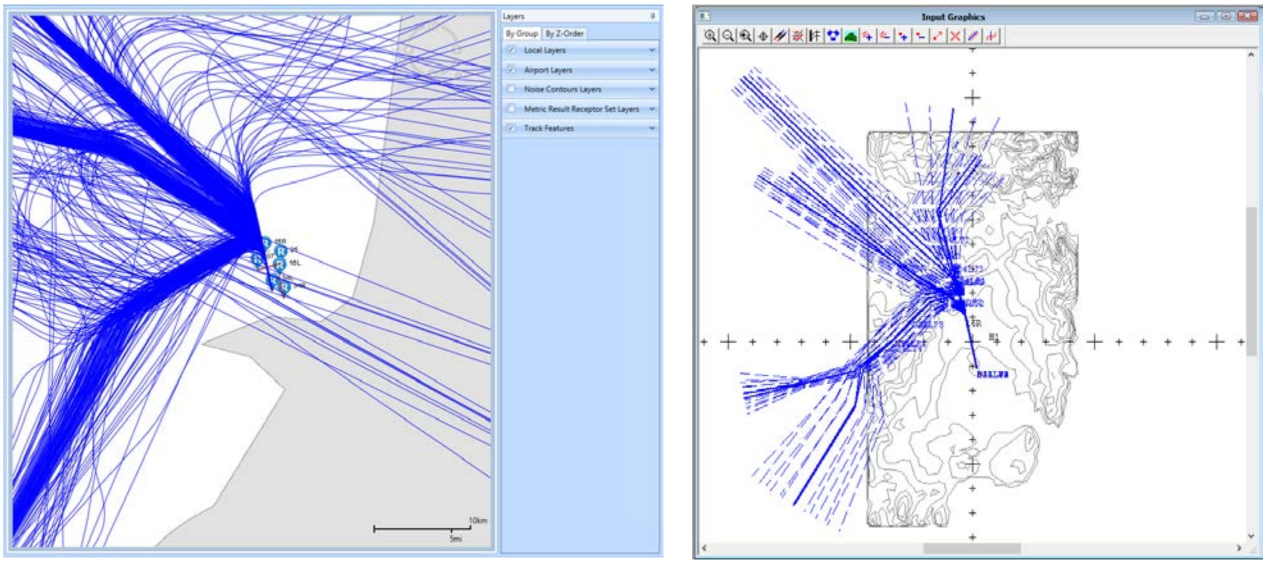
During the technical endorsement process, Airservices will also have the ability to review AEDT log files and re-run the model with course receptor grids. Information regarding which software package was used should be included on the resulting ANEF chart.

7 AEDT VALIDATION WORK

To test the use of AEDT against INM, Airservices produced the Sydney Airport ANEI map for quarter four 2017 (October to December) using both models and evaluated the resulting noise contours.

The main differences of note between the ANEI maps produced by the two models in their development were as follows:

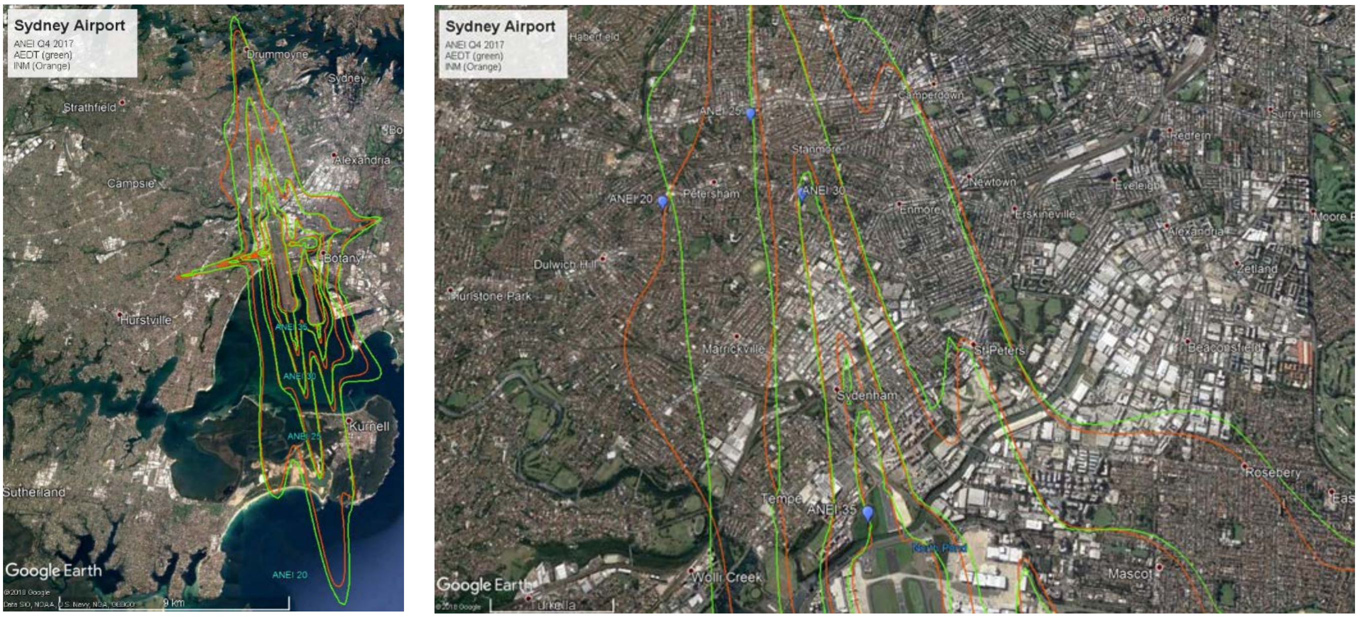
- The INM study used the traditional method of implementing aircraft flight tracks via a backbone and sub-tracks with a normal distribution of aircraft operations applied to each track. The assignment of aircraft operations to INM modelled tracks was performed based on Airservices NFPMS data for the quarter.
- The AEDT study used radar flight track data directly imported from Airservices NFPMS. The AEDT model incorporated around 84,300 fixed wing flight tracks and 2,500 helicopter tracks. An example of the flight track structure used in both models can be seen below in Figure 1.
- In the INM study, the number of arrivals and departures was artificially balanced to be equal per day, as is normal practice for generating ANEF/ANEI contours using INM. The AEDT model was based on actual radar track data, therefore this balancing was not performed.
- Helicopter flight tracks for the AEDT model included circuit profiles for aircraft that arrived and departed at the airport, whereas the INM model split aircraft performing circuits into arrivals and departures.
- The AEDT study used the in-built generic airport weather inputs for Sydney Airport, whereas the INM weather parameters were entered manually based on the Australian Bureau of Meteorology (BoM) data for the quarter.
- The same terrain files (3CD/3TX files) were used for both models.
- The INM study incorporated 43 different aircraft types, whereas AEDT incorporated 81.
- The INM study incorporated a recursive grid with settings of tolerance 0.1 and refinement of 10, whereas the AEDT study utilised a 0.1 nautical mile x 0.1 nautical mile receptor grid to calculate and plot the ANEI.
- Both N70 studies were generated with the same calculation grid size of 0.5km by 0.5km. Note that for this paper, the ANEI and N70 studies used different grid sizes. The N70 grid size for AEDT was chosen to replicate existing work already completed in INM to enable a direct comparison of results. Historically, larger grid sizes have been used for N70 calculations due excessive file sizes and computation time.



Source (Airservices, 2018)

Figure 1: Example of radar flight tracks modelled in AEDT (left) and representative flight tracks modelled in INM (right) for departures at Sydney Airport from Runway 34L.

The figure below present results of the ANEI comparison using INM and AEDT.



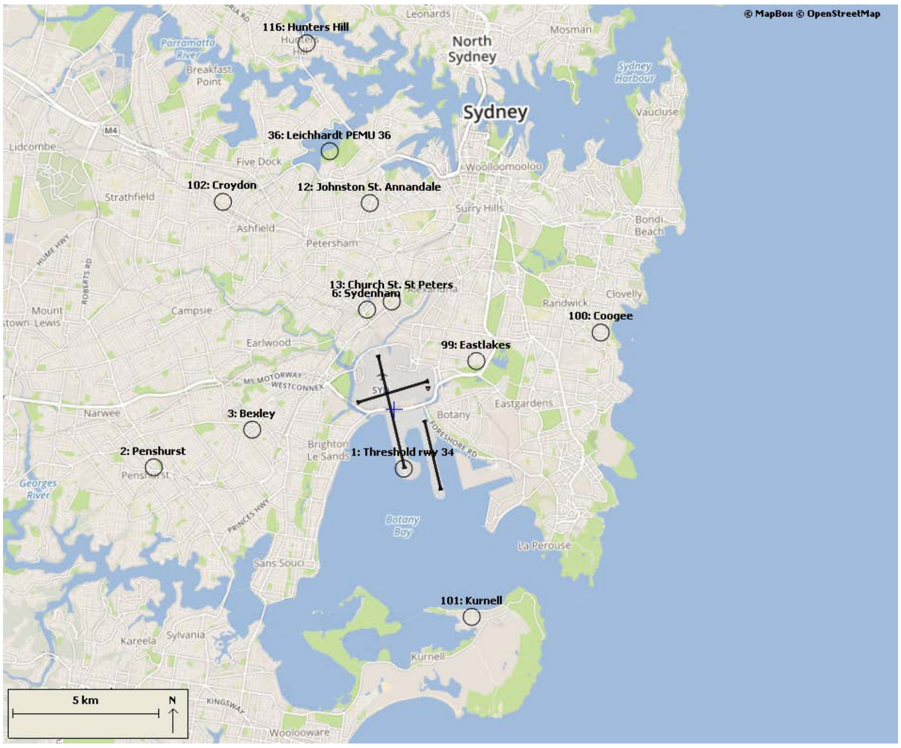
Source (Airservices, 2018)

Figure 2: Sydney Airport quarter four 2017 ANEI generated by AEDT (green) and INM (orange).

The ANEI contour results above in Figure 2 indicate similarity between the INM and AEDT models, with the AEDT model showing slightly more noise exposure (by area). Some areas of difference exist, typically to the north-west of the airport. The noise contours in this area differ by up to around 500m and are driven by departure aircraft from Runway 34L. The AEDT model should represent a more accurate contour in this location due to the use of actual radar flight track information, rather then a representative backbone track and a spread of subtracks.

The calculation of N70 values provide the ability to directly compare modelled noise events with actual measured noise events from Airservices NFPMS. A comparison has been performed below to help validate the use of AEDT. For this comparison, the number of measured noise events above 70 dB(A) per day, at each of Airservices 12 noise monitors around Sydney Airport has been calculated over the same quarter above (October to December 2017), and compared to the modelled data from both INM and AEDT. The results are shown below in Table 3.

The modelled N70 values are taken from a calculation grid of 0.5km x 0.5km resolution. The nearest calculation point to the actual noise monitors was used where appropriate. At some noise monitor locations, an average of four N70 grid values was used and considered more appropriate, where the noise monitor location was toward the middle of a 0.5km x 0.5km grid cell. The exact geographical location of each noise monitor was not modelled, therefore the results are considered to be indicative only. This approach was taken due to time constraints in developing the paper and to hinge off existing work previously completed using INM. The same grid points are used between the two models to enable direct comparison of results. Noise monitoring locations are shown below in Figure 3.



Source (Airservices, NFPMS 2018)
Figure 3: Airservices aircraft noise monitoring locations around Sydney Airport.

Table 3: Sydney Airport – Number of noise events above 70 dB(A) per day in Quarter Four (October to December) 2017.

Noise monitor number and location	Number of noise events above 70dB(A) Measured	Number of noise events above 70dB(A) calculated AEDT	Number of noise events above 70dB(A) calculated INM
1: Threshold RWY34L	359	376	386
100: Coogee	7	4	3
6: Sydenham	196	190	194
116: Hunters Hill	83	70	70

13: St Peters	111	112	93
2: Penshurst	7	5	5
102: Croydon	16	13	14
99: Eastlakes	61	69	60
101: Kurnell	85	68	70
36: Leichardt	118	101	103
3: Bexley	8	7	8
12: Annandale	79	58	47

The table above shows that both noise models generally under-predict the measured number of noise events above 70 dB(A). There is usually a large variation in measured noise levels due to various meteorological conditions and aircraft performance, therefore a perfect match with modelled levels is not expected. Additionally, a large variation in aircraft departure profiles is evident in aircraft radar tracks. This usually causes discrepancies between modelled and actual measured noise levels. At this stage, no attempt has been made to further increase the accuracy of the noise models by adjusting departure or arrival aircraft vertical profiles. The implications of an under predictive model include:

- Understating potential noise impacts on the community when presenting noise contours associated with documentation such as Airport Master Development Plans and Major Development Projects.
- The potential influence on land use planning around airports where some areas could be incorrectly zoned to allow noise sensitive residential receivers.

8 BEST PRACTICE MODELLING CONCEPTS AND KNOWN ISSUES

When using AEDT, the most accurate way to generate a historic noise exposure model around airports is to use available radar data. The current modelling validation work has uncovered various issues that may help future users of AEDT when developing a model based on historic radar data. These include the following:

- Both noise models can be generally under-predictive. The accuracy of both models can be greatly increased by evaluating aircraft departure or arrival vertical profiles and adjusting the models accordingly. However, AEDT has no particular inherent capability to analyse departure/arrival profiles for specific trajectories.
- Some data extracted from Airservices NFPMS, such as the International Civil Aviation Organisation (ICAO) aircraft type designators may be incomplete or missing and therefore not directly translatable into AEDT studies. Careful checking of the input data for quality is required to ensure the correct aircraft types are modelled by AEDT.
- Radar data available from Airservices sometimes contains radar points that are located on or very near the runway. When using radar data directly in AEDT as flight tracks, careful filtering of the data is required to eliminate excessive points that are located on, or very near the runway. This is especially important for arrival aircraft, otherwise the resulting noise contour will not extend appropriately.
- The AEDT study generated as part of this paper used 92 days of radar flight track data. This was annualised into a single day for the purposes of generating ANEI and N70 noise metrics. An internal issue was found in AEDT where the annualisation process did not work as expected and the data had to be annualised manually. This was achieved by manually factoring each operation by 0.01087 (or 1/92 days). The FAA have been made aware of this issue and an update to the software is expected. Other users of AEDT have encountered the same problem.
- AEDT generates noise metric contour results based on a receptor grid. The resolution of this grid determines the 'smoothness' of the resulting contour. For the study used for this paper, multiple calculation runs were performed until a grid size of 0.1NM x 0.1NM was selected. In future ANEF technical endorsement work, Airservices will have to pay close attention to the receptor grid size used in each study.
- AEDT will calculate noise above metrics, such as N70 or N60 etc, on a grid (point by point) basis. However, the base program will currently not generate contours for these noise above metrics. As such, other

contouring methods are required to produce noise above contours, such as using Python on receptor grid results. The Python programming language has contouring algorithms that can be used on AEDT receptor grid results to produce contours. This approach has been used experimentally by Airservices previously, however the preferred method for generating N70 contour maps is using DIRDC's TNIP software package as described below.

9 FUTURE WORK CONCEPTS

In Australia today, there is an increasing demand by government agencies and communities to accurately predict aircraft noise levels at large distances from airports (>30km away). Usually these areas are well outside the typical ANEF and N70 contours produced as part of the airport master planning process. In some rural residential areas with low ambient noise levels during the day and night, noise levels from aircraft overflights at high altitude (i.e. 20,000ft or above) can be audible and may cause negative impacts to communities. Accurately modelling aircraft noise levels on the ground at such distances is difficult and requires accurate representation of aircraft tracks, both laterally and vertically. It is likely that aircraft user profiles will be required in AEDT when predicting noise levels at thresholds lower then 60 dB(A) in Australia. This should be the subject of further noise model verification work.

The introduction of AEDT in Australia will allow users to model aircraft noise and emission impacts by region, including multiple airports, rather than on an individual basis. For example, an ANEF study may be generated including both Melbourne and Essendon Airports to more accurately represent noise and emissions impacts due to operations from both airports. This was not previously possible using INM.

It is understood that DIRDC are currently working on updating their TNIP package to integrate it with AEDT. As part of this work, the generation of noise above contours (N70, N60 etc.) may be addressed. This would eliminate the need for future AEDT users in Australia to generate bespoke software or programming code to produce number above contours.

Further analysis should be undertaken to fully understand the cause of the under prediction established in this preliminary validation work. Further work should include detailed analysis of other airport sites and evaluation of aircraft vertical profiles. A joint user approach between Airservices, DIRDC, Defence and the industry could be established with future workshops.

10 CONCLUSION

Airservices is proposing to transition from using the INM to the AEDT noise model in Australia, with a proposed transitional period of 12 months (from 1 January to 31 December 2019) for Airservices technical endorsement of ANEFs. The key stakeholders have been identified as Airservices, DIRDC, Defence, airports and their consultants, and Standards Australia.

Validation work performed by Airservices has shown that AEDT is capable of producing comparable noise exposure contours to INM, using the generation of Sydney Airport ANEI contours for quarter four 2017 as an example. The number of measured noise events above 70 dB(A) from Airservices NFPMS was compared with calculated N70 results from both INM and AEDT models. Both models were generally under-predictive, however produced comparable results.

Some initial technical issues have been identified by Airservices when using the AEDT model, including the use of Airservices radar data and receptor grid resolutions. Future concepts to improve the accuracy of aircraft noise modelling in Australia include the importance of providing accurate noise modelling capabilities at large distances from airports.

REFERENCES

Air Services Act 1995 - *Direction pursuant to section 16 concerning the responsibilities of Airservices Australia in respect of the environmental effects of aircraft.,* viewed 23 August 2018, <https://www.legislation.gov.au/Details/F2009B00155>

Australian Government, Department of the Environment and Energy, *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act),* viewed 23 August 2018, <https://www.environment.gov.au/epbc>

Australian Government, Department of Infrastructure, Regional Development and Cities, *Aviation*, viewed 23 August 2018, <https://infrastructure.gov.au/aviation/>

Australian Government, Department of Infrastructure, Regional Development and Cities, *Airport Planning and Regulation*, viewed 2018 <https://infrastructure.gov.au/aviation/airport/planning/index.aspx>

European Civil Aviation Conference ECAC.CEAC Doc 29 4th Edition, *Report on Standard Method of Computing Noise Contours around Civil Airports Volume 1: Applications Guide, 7 December 2016,* viewed 23 August 2018, <https://www.ecac-ceac.org/documents/10189/51566/01.+Doc29+4th+Edition+Volume+1.pdf/bfde6e09-b46b-44e1-b73f-388fc3527aaf>

Federal Aviation Administration, *Aviation Environmental Design Tool*, viewed 23 August 2018, <https://aedt.faa.gov/>

Federal Aviation Administration, *AEDT_FAQ_and_knowledge_base.pdf, April 2018,* viewed 23 August 2018, <https://aedt.faa.gov/Documents/AEDT_FAQ_and_knowledge_base.pdf>

Federal Aviation Administration, *AEDT_2A_UQ_Executive_Summary 20v2, August 2013,* viewed 23 August 2018, <https://aedt.faa.gov/Documents/AEDT_2A_UQ_Executive_Summary%20v2.pdf>

<https://www.datakustik.com/en/products/cadnaa/>, viewed 23 August 2018.

<https://soundplan.com.au/>, viewed 23 August 2018.

SAI Global Limited 2015, AS2021:*2015 – Aircraft Noise Intrusion – Building Siting and Construction (AS2021),* viewed 23 August 2018, <https://www.saiglobal.com/online/autologin.asp>.

Sydney Airport, *Sydney Airport Masterplan 2039,* viewed 31 August 2018, < https://www.masterplan2039.com.au/masterplan2039>