Citywide noise mapping for ANEF Contours

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ABSTRACT

Australian Noise Exposure Forecast (ANEF) contour maps are typically developed for major airports only. It is uncommon for such maps to be developed for smaller metropolitan airports, regional airports and aerodromes. Furthermore, flight paths that are outside the vicinity of airports are not generally considered when developing the noise models used to generate ANEF contours.

It is suspected that the aircraft noise exposure levels around smaller metropolitan airports, regional airports and aerodromes, as well as metropolitan areas away from major airports, may be comparable to those documented in the published ANEF contours for the major airports, albeit the lower values with a smaller footprint.

To investigate this, data for aircraft movements was acquired across Australia and New Zealand during May and June 2019, as captured by a flight tracker provider. This data, sampled at 15 second intervals, captured the plane type, altitude, speed and other parameters, and was used to develop aircraft noise models for Australia and New Zealand using SoundPLAN, with all flights modelled as moving point sources.

Greater Melbourne was nominated for our study comparison.

1 OVERVIEW

Ambient Maps is constructing a national noise model, with corresponding noise maps, that will provide the road, rail and aircraft noise exposure levels at every façade of every floor of every building across Australia.

This national model, being developed using SoundPLAN, incorporates models for road, rail and aircraft, for which each have the following data requirements:

- Road traffic models consider day, evening and night traffic volumes, speeds and heavy vehicle percentages for every road; ranging from motorways to cul-de-sacs.
- Rail traffic models consider train and rolling stock types, volumes, lengths, speeds, track radius curvatures, etc. for every railway.
- Aircraft noise models consider all aircraft types and movements identified from a flight tracking provider.

The national noise model includes almost 16 million buildings and hundreds of kilometres of noise barriers, sourced from records of historical works provided by relevant State governments. Buildings and noise barriers have not been included in the aircraft noise models.

The primary purpose of the national noise map will be to service the real estate market via the provisioning of property reports and supporting information for property valuation forecasts, governments (both State and Local) by providing planning overlays and researchers, particular those in the fields of health and epidemiology.

2 STUDY OBJECTIVE

There are various planning requirements imposed by State and/or local governments when a sensitive building, such as a dwelling, is constructed. These planning requirements can include a consideration of external transport noise impacts, as well as the materials used for the building's elements, to help protect the inhabitants. Examples of planning requirements that consider noise include the Queensland Development Code, Mandatory Part 4.4 and the Victorian Better Apartments Design Standards.

For aircraft noise, guidance on the siting and construction of sensitive buildings in the vicinity of airports is provided in Australian Standard AS 2021:2015 "Acoustics - Aircraft noise intrusion - Building siting and construction". This standard outlines the methodology for estimating Australian Noise Exposure Forecast (ANEF) levels at a site, which are then used to classify the site as 'acceptable', 'conditionally acceptable' or 'unacceptable' for activities expected to be undertaken within buildings at that site. For activities undertaken outdoors, the standard provides no guidance on the acceptability (or otherwise) of the site.

Within Greater Melbourne, ANEF level contour maps are available for the Tullamarine and Avalon airports only, despite there being smaller commercial airports at Moorabbin, Essendon and Yarra Valley (Coldstream). Although these smaller airports do not support the larger aircraft that the major airports do, it is hypothesised that due to (1) the number of flights arriving and departing at these airport still being relatively high and (2) aircraft consistently fly in pre-determined training routes within the local area, that the noise impacts from these aircraft movements can reach sufficiently high levels to potentially warrant expansion of the ANEF contours for planning.

3 CALCULATION OF PUBLISHED ANEF NOISE CONTOURS

The ANEF level at any given location is a single number index representing the predicted cumulative exposure to aircraft noise over a given period (typically one year), based on the aircraft movements on an average day.

This is based on measured aircraft noise levels (as Effective Perceived Noise Decibels or EPNdB) and the number of aircraft movements during both day and night; with a 6 dB penalty applied for aircraft operating at night (7pm to 7am) due to the greater sensitivity of building occupants during this period. The EPNdB is, in turn, a formulation that incorporates not only the aircraft's noise level, but also frequency characteristics and variation over time.

The equation for calculating the *partial* ANEF level, for a given aircraft type on a given path, is given below:

$$ANEF_{ij} = EPNdB_{ij} + 10\ \mathrm{Log}_{10}\ (N_d + 4\ N_n) - 88 \qquad (1)$$

where

$ANEF_{ij}$ = noise exposure due to aircraft type i on flight path j
$EPNdB_{ij}$ = noise level of aircraft type i on flight path j
N_d and N_n = number of flights during the day and night respectively, of aircraft type i and flight path j

Note that the '88' constant is an arbitrary number chosen to ensure ANEF values will be within a range clearly distinct from other noise ratings.

The *total* ANEF is the logarithmic sum of all individual noise exposures produced by each aircraft type operating on each flight path for an average day, as follows:

$$ANEF = 10\ \mathrm{Log}_{10} \sum_{i-1}^{i=I} \sum_{j-1}^{j=J} anti\ \ \mathrm{Log}10 \left(\frac{ANEF_{ij}}{10}\right) \qquad (2)$$

where

$ANEF$ = noise exposure forecast
I = total number of aircraft types
J = total number of flight tracks

The production of ANEF contour level maps around airports is typically facilitated with software packages such as the United States Federal Aviation Administration's (FAA) Integrated Noise Model (INM) or it's successor, the Aviation Environmental Design Tool (AEDT).

4 CALCULATION OF AIRCRAFT NOISE LEVELS USING SOUNDPLAN

Flight data for all aircraft movements over Australia was captured by FlightAware, a US-based aviation data provider, between Monday to Friday 13 - 17 May and Monday to Friday 3 - 7 June 2019. This flight information was captured by sampling radar flight tracking data every 15 seconds and included the following data points, amongst others:

- Timestamp
- Flight ID

- Aircraft type
- Origin airport
- Destination airport
- Latitude
- Longitude
- Waypoints
- Altitude
- Ground speed

The flight data for the two weeks was supplied to us in comma-separated values (CSV) file and included all flights to and from each of the 222 airports within Australia during this period. New Zealand was captured concurrently.

Firstly, the CSV file was imported into ArcGIS and converted to a Shapefile. All data points with the same Flight ID were then connected in sequence to construct a 3D polyline for each flight. Following this, the polylines were segmented into 1 km sections to allocate a status where applicable (e.g. arriving / departing) and an average speed.

The next step was to acquire EPNdB noise levels for every aircraft type within the dataset from the Aircraft Noise and Performance (ANP) database operated by Eurocontrol. Due to differences between the aircraft descriptors and ICAO codes used to identify plane types within the FlightAware data and those in the ANP database, the data needed to undergo a process of rationalisation before data matching could be undertaken.

A pilot currently working for a major international airline, who has first-hand knowledge of these plane types, was consulted to assist with this process. Some assumptions were made. As an example, there were many general aviation, light, single-engine piston engine aircraft for which data was unavailable and so, at the suggestion of the pilot we consulted, these were assigned the noise data for a Cessna CNA172; the plane judged the most representative of that class of aircraft.

Once the process of data rationalisation was completed, each flight was assigned three EPNdB noise levels (corresponding to engine power during ascent, cruising and descent).

All polylines throughout Greater Melbourne were then assigned a specific EPNdB noise level based on the following rules;

- Aircraft within 30 km of any of the five key airports where the flight origin matched said airport were assigned the noise level for ascent
- Aircraft within 30 km of any of the five key airports where the flight departure matched said airport were assigned the noise level for departure
- Aircraft with none of these airports as their origin or destination were assigned the noise level for cruising

The EPNdB levels assigned to each polyline were measured at a reference distance of 1000 feet (304.8 m). Although EPNdB levels and sound pressure levels are related, they should not be misconstrued as being the same thing; EPNdB is an *annoyance*-based metric, whereas sound pressure is a *loudness*-based metric.

Nevertheless, it is expected that the EPNdB level attenuates with distance in the same manner as sound pressure. Consequently, the EPNdB value at various distances should be predictable if the equivalent of an EPNdB "power" level is established. To this end, the EPNdB "power" level, which we'll denote $EPNdB_w$, was calculated for each EPNdB based on a simple distance calculation with spherical free-field propagation:

$$EPNdB_w = EPNdB + 20\,Log_{10}\,(304.8) + 11 \qquad (3)$$

Using the equation (3) above, the $EPNdB_w$ level was calculated for every EPNdB level in the dataset and assigned to the corresponding polyline.

Two environmental noise models for Greater Melbourne were setup in SoundPLAN; one for daytime flights and another for night-time flights. All polylines corresponding to daytime flights were imported into the daytime model and assigned to moving point sources as follows:

- The EPNdBw level associated with each polyline was adopted as the sound power level of the source
- The speed of the moving point source was equal to the capture ground speed of the aircraft
- The polyline itself was adopted as the trajectory of the source.

The process was then repeated with all polylines corresponding to night-time flights imported into the night-time model. However, for the night-time model an additional 6 dB was added to each $EPNdB_w$ value to match the 6 dB penalty applied to flights at night when calculating partial ANEF levels.

The noise levels at a height of 1.5m above ground level were then calculated across Greater Melbourne using SoundPLAN in conjunction with ISO 9613-3, one of the outdoor sound attenuation standards implemented by SoundPLAN. As the moving points sources were based on $EPNdB_w$ values instead of sound power levels, the noise levels calculated at ground level were not sound pressure levels, but rather the logarithmic summation of the EPNdB values for all flights, adjusted for distance attenuation, and with night-time penalties applied (where applicable).

As the flights represented 10 days of movements, a -10 dB correction was applied to the calculated noise levels to provide a noise level indicative of a single day. As a final step, 88 dBA is subtracted from all calculated noise levels, as per the ANEF equation detailed earlier.

The calculated noise levels are now, effectively, simplistic ANEF levels which can be presented as contour maps.