

## SUPPLEMENTARY AIRCRAFT NOISE METRICS

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### Background

Over the past three decades the Australian Noise Exposure Forecast (ANEF) system has been used as the primary measure of aircraft noise exposure in the vicinity of airports. The ANEF has been used in four key ways. It has been used to delineate where and what type of development can take place around airports; to determine which buildings have been eligible for insulation around Sydney and Adelaide airports; for technical assessments of airport operating options in Environmental Impact Statement (EIS) processes; and as a tool for providing information to the public on noise exposure patterns around airports.

Experience has shown a range of problems with relying solely on the ANEF as a noise information tool as there are limitations in using the ANEF to describe aircraft noise exposure to laypeople.

While the populations with the highest aircraft noise exposure often live within the 20 ANEF contour, experience shows the majority of noise complaints that are received come from residents living outside the 20 ANEF contour. Traditionally the residents of these areas have been given little information on aircraft noise through the ANEF system other than that the area is considered 'acceptable' for housing. Some people living outside the 20 ANEF contour have been given an expectation of receiving little or indeed no aircraft noise and as a consequence find the levels of noise actually experienced to be unacceptable.

It is not recommended that the ANEF system be replaced as a planning tool. The ANEF system is a well-established and technically complete means of portraying aircraft noise exposure. However, land use planning could be improved through recognition that aircraft noise does not suddenly stop at the 20 ANEF contour.

It is likely that no single standard will be appropriate for all airports but the concepts that follow can readily be adapted to meet local conditions. In particular, there is a need to improve the information used for assessment of proposed noise-sensitive development where residents will be newly exposed to aircraft noise. There is also a need to recognise the particular sensitivities of night-time noise in circumstances where neighbouring residents are not protected by airport curfews. There is a range of research pointing to the negative health impacts of sleep disturbance and the ANEF gives only limited recognition to the impact of night-time aircraft noise.

## Why the ANEF?

In 1982, the National Acoustic Laboratories released a major study, *Aircraft Noise in Australia: A Survey of Community Reaction* (the NAL Study), regarding the impacts of aircraft noise on residential communities in Australia. The results were subsequently used in framing relevant Australian Standards and land use planning controls around Australia's airports.

The NAL study was a survey of 3,575 residents around the commercial airports in Sydney, Adelaide, Perth and Melbourne and the Richmond Air Force Base. From responses to a questionnaire, subjective reaction to aircraft noise was measured and correlated with existing and potential objective measures of aircraft noise.

Analysis of the survey showed that the best correlation between community reaction was achieved using a modified version of the existing Noise Exposure Forecast (NEF) which measures average daily sound pressure levels from aircraft. Attitudes towards the aviation industry, personal sensitivity to noise, and fear of aircraft crashing were found to be important in modifying the extent to which a person would be affected by aircraft noise.

The study recommended the methodology establishing the ANEF and suggested that an ANEF value of 20 could be regarded as an 'excessive' amount of aircraft noise. This value has subsequently been enshrined in planning systems and in the relevant *Australian Standard AS 2021-2015 Acoustics – Aircraft noise intrusion – Building siting and construction* as a boundary, beyond which it is acceptable to site noise sensitive land uses such as residential properties.

AS 2021 states that the actual location of the 20 ANEF contour is difficult to define accurately, because of variations in aircraft flight paths, pilot operating techniques and the effect of meteorological and terrain conditions on noise propagation. For that reason, the 20 ANEF contour is shown as a broken line on ANEF plans.

## How is the ANEF derived?

The ANEF system is a measure of the aircraft noise exposure levels around aerodromes. It is based on average daily sound pressure levels, which are measured in decibels. Noise exposure levels are calculated in ANEF units, which take into account the following factors of aircraft noise:

- the intensity, duration, tonal content and spectrum of audible frequencies of the noise of aircraft take offs, approaches to landing, and reverse thrust after landing (for practical reasons, noise generated on the aerodrome from aircraft taxiing and engine running during ground maintenance is not included);
- the forecast frequency of aircraft types and movements on the various flight paths, including flight paths used for circuit training; and
- the average daily distribution of aircraft arrivals and departures in both daytime and night-time (daytime defined as 0700 hours to 1900 hours, and night-time defined as 1900 hours to 0700 hours). Night time movements are represented with a 6 decibel adjustment in the ANEF calculation.

Decibels are a logarithmic unit. This is because the human ear is relatively insensitive to changes in sound pressure level and the decibel scale more helpfully reflects human reaction to sound. So, for example, a 70 decibel sound pressure level represents a ten-fold increase in sound energy compared to a 60 decibel event, but it will be perceived by the human ear to be only about twice as loud.

The following table<sup>1</sup> represents sound levels of a range of common events.

| Noise Level dB(A) | Description                                           |
|-------------------|-------------------------------------------------------|
| 120               | Threshold of pain                                     |
| 95                | Pneumatic drill (un-silenced at 7m distance)          |
| 83                | Heavy diesel lorry (40 km/h at 7m distance)           |
| 81                | Modern twin-engine jet (at take-off at 152m distance) |
| 70                | Passenger car (60 km/h at 7m distance)                |
| 60                | Office environment                                    |
| 50                | Ordinary conversation                                 |
| 40                | Library reading room                                  |
| 35                | Quiet bedroom                                         |
| 0                 | Threshold of hearing                                  |

The ANEF measures total noise dose energy so, for example, a 70 decibel aircraft noise event will make the same contribution on the ANEF as 10 sixty decibel events while an 80 decibel event will make the same contribution on the ANEF as 100 sixty decibel events.

There are three different types of aircraft noise contour charts produced using the ANEF system. All three types of charts are prepared using the same computational procedures. The differences arise from the types of data which have been input to produce the maps. The noise exposure contours for each type of map are expressed in increments of five from 15 through to 40 (the higher the ANEF value the greater the forecast noise exposure).

The three categories of ANEF that may be used in an airport master plan under the *Airports Act 1996* are:

**Standard ANEF (5-20 years)** - this is a forecast of expected aviation noise exposure levels during a specified period of 5-20 years. A standard ANEF includes a forecast of aircraft movement numbers and operating times, aircraft types, flight paths and anticipated use of runways at the aerodrome.

**Long Range ANEF (20+ years)** - This is a forecast of expected aviation noise exposure levels for a specified period greater than 20 years. Forecasts have regard to present and anticipated future trends and may take account of predicted future aircraft types, movement numbers, flight paths and any changes to runway configurations that are expected to occur within the projected period.

Inclusion of a long-range ANEF in a Master Plan is aimed at assisting the States and Territories with planning decisions around airports by identifying where future incompatible development might occur as a result of exposure to expected future levels of aircraft movements and flight paths.

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<sup>1</sup> Source: Noise Mapping Northern Ireland [http://www.noiseni.co.uk/index/glossary\\_of\\_noise\\_terms.htm](http://www.noiseni.co.uk/index/glossary_of_noise_terms.htm)

**Ultimate Practical Capacity ANEF** - This is a forecast of aviation noise exposure levels that are expected to exist when the airport is developed to its ultimate practical capacity. An estimated date of when the airport is expected to reach its ultimate practical capacity must be stated. Forecasts have regard to present and anticipated future trends and may take account of predicted future aircraft types, movement numbers, flight paths and runway configurations that are expected to occur at the point of the airports ultimate practical capacity.

## Limitations of the ANEF

The 1982 NAL study was a landmark study in terms of measuring community reaction to aircraft noise. But experience over the last 30 years has highlighted some limitations to the study's methodology and conclusions that are important to consider.

Firstly, although the study concluded that the ANEF system provided the 'closest fit' in terms of describing the propensity for residents to feel negatively impacted by aircraft noise, the correlation is relatively weak. Only 13 per cent of people's reaction to aircraft noise was related to the objective measure of aircraft noise. Most of the remaining variation in response was explained by factors such as negative attitudes toward the aviation industry or government, fears of aircraft crashes and overall sensitivity to noise.

The NAL Study found that a slightly improved correlation could be achieved by combining the ANEF value with an N70 value (explained on pages 8 and 9), however the computing technology of the day made this calculation unacceptably complex. Major improvements in computing power and reduced costs have made this limitation less relevant today than it was in the early 1980s.

Secondly, the 20 ANEF threshold for acceptability of residential housing was not a conclusion of the NAL study. Rather, the study's authors suggested that an ANEF value of 20 might be regarded as representing an 'excessive' amount of aircraft noise. The study's authors added that questions related to noise regulation and land use planning around airports in Australia can be answered only by translating the present scientific assessment into a socio-political context.

*Whether or not areas with this exposure are incompatible with residential zoning is another matter. As scientists, the authors are charged with describing community reaction to aircraft noise. The task of prescribing regulations and standards relating to land-use around airports properly belongs to legislative and planning authorities<sup>2</sup>.*

It is important to understand that the NAL study itself attached no particular significance to the 20 ANEF measure. At the 20 ANEF level, it is estimated that approximately 11 per cent of people will be seriously affected by aircraft noise and approximately 45 per cent of people moderately affected by aircraft noise. The figure on the page 5 also shows that at the 15 ANEF level, approximately 8 per cent of people will be seriously affected by aircraft noise and approximately 34 per cent of people moderately affected. The question of how many people should be subject to disturbing levels of aircraft noise through land use planning decisions clearly requires subjective judgements from land use planners as to what is an acceptable number of people expected to experience negative effects of aircraft noise, balanced against other relevant considerations.

AS 2021 makes this point and foreshadows use of additional noise tools for use in land use planning near airports:

*Figure 1 shows the dose/response relationship between aircraft noise and community reaction derived from the NAL Report. This figure indicates that significant community reaction may occur for exposures below 20 ANEF. Experience has shown that newly exposed communities may exhibit a higher reaction than that suggested by the curves in [Figure 1]. ANEF values average noise exposure*

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<sup>2</sup> NAL Report, p154

over a year and do not take account of variations in noise exposure patterns to which the community reacts on an hourly, daily, weekly or seasonal basis. To address this issue, other parameters such as maximum noise levels and frequency of noise events may be included in noise assessments of airports to supplement ANEF levels<sup>3</sup>.

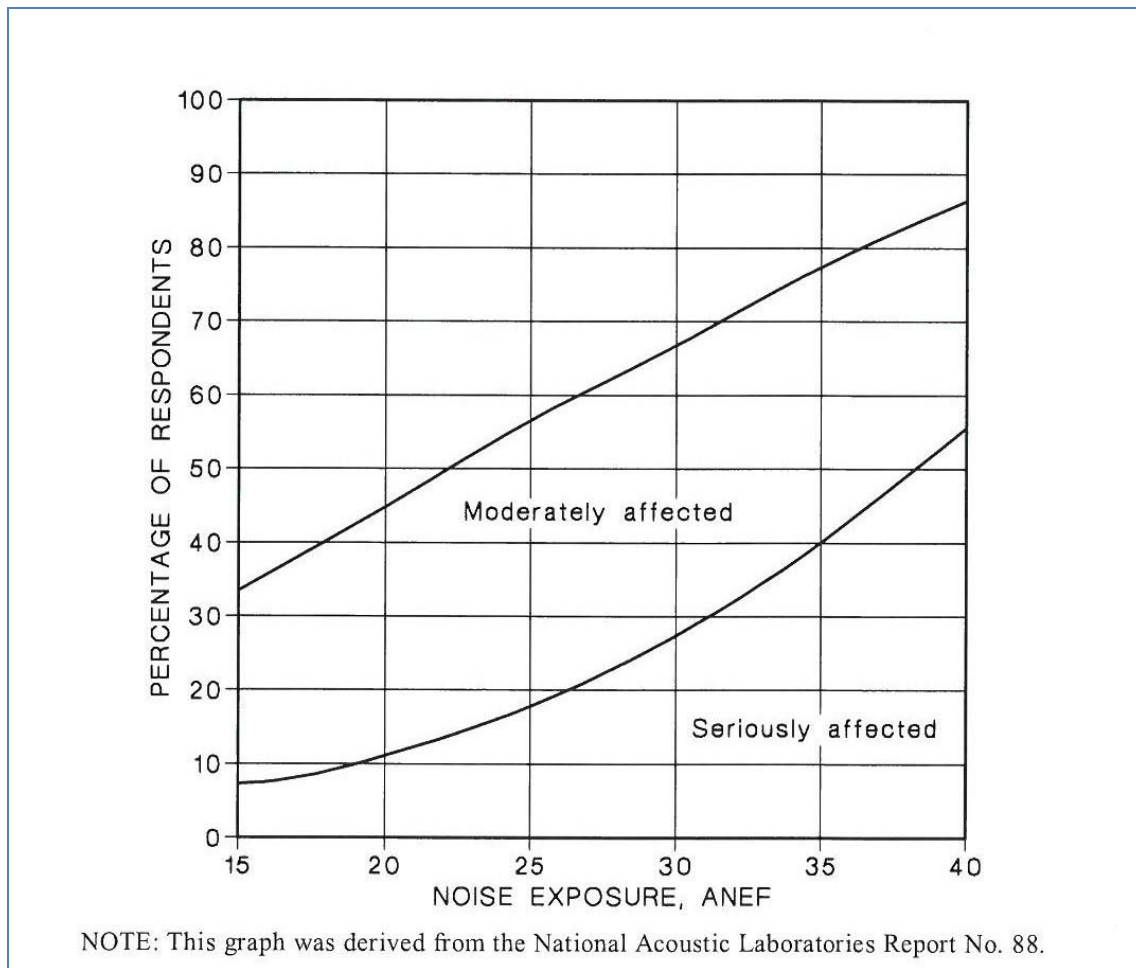


Figure 1: Reaction between noise exposure forecast level and community reaction in residential areas

There is evidence to suggest that an approach to measuring aircraft noise based on the number of aircraft movements may be appropriate as over time individual aircraft events have become quieter, but the frequency of movements has increased.

For example, a 2007 study into Attitudes to Noise from Aviation Sources in England<sup>4</sup> compared average energy measures with frequency based measures of aircraft noise in two surveys from 1982 and 2005 respectively. The study found that in 1982, there was little relationship between annoyance and aircraft numbers, while in 2005, there was a strong relationship. This coincides with significant changes to both aircraft numbers, which have increased, and individual noise levels, which have decreased.

In Australia also, the mix of aircraft in the airline fleet is considerably different today than it was in 1980 (when the NAL survey was conducted). Modern aircraft are considerably quieter than aircraft of 30 years ago. At the same time, frequency has increased significantly. For example, in Sydney

<sup>3</sup> AS2021-2015; Standards Australia, p 140

<sup>4</sup> ANASE (Attitudes to Noise from Aviation Sources in England) – MVA Consultancy for the Department for Transport in association with John Bates Services, Ian Flindell and RPS, October 2007

there were 138,000 aircraft movements in 1985-86, growing to over 290,000 in 2010-11. The number of aircraft movements also doubled at Brisbane, Canberra, Melbourne and Perth over the same period.

The following sections detail a range of additional aircraft noise metrics that have been developed over the past 15-20 years, many within Australia, to better describe aircraft noise. These measures were first developed in response to the *Senate Select Committee on Aircraft Noise: Falling on Deaf Ears*, which investigated these issues following the opening of the third runway at Sydney Airport in 1994.

The paper concludes with some suggested nominal levels of frequency based aircraft noise measures which could be used by land use planners to action the AS 2021 recommendation to more comprehensively assess the potential impact of aircraft noise on future noise sensitive development.

## Supplementary noise information measures

Following the opening of the third runway at Sydney Airport in December 1994, it was recognised that the ANEF, while a useful tool for land use planning, was deficient as a useful tool for describing information about aircraft noise to residents. **Figure 2** shows the poor correlation between the 20 ANEI<sup>5</sup> contour and the aircraft noise complaints in the Sydney area. In fact, 90 per cent of the complaints at the time were found to have originated outside the 20 ANEI contour.

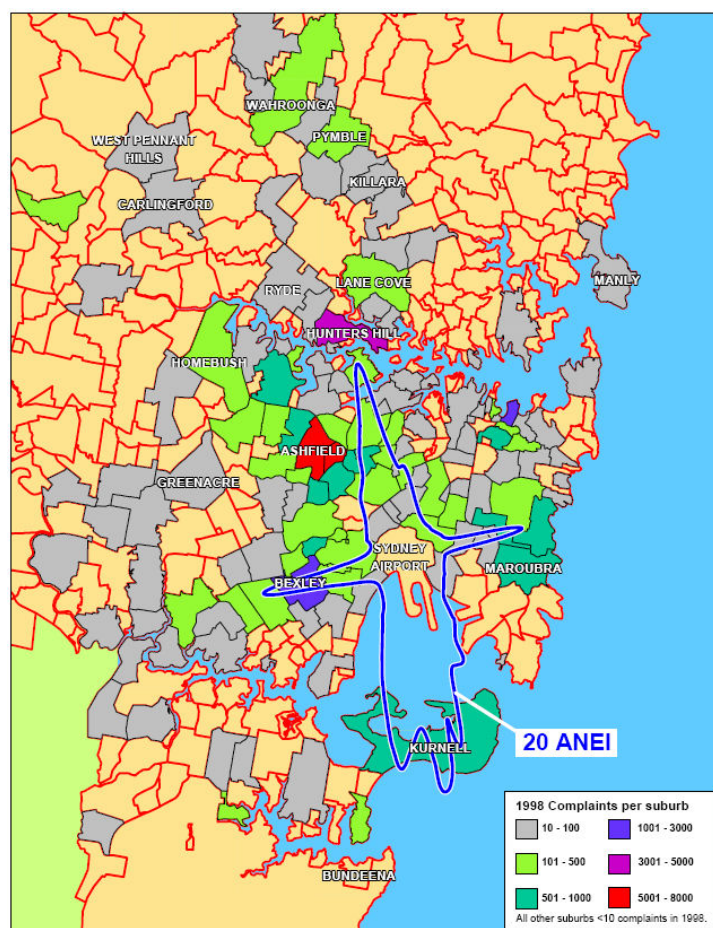


Figure 2: 1998 aircraft noise complaints vs 1998 20 ANEI contour

<sup>5</sup> The ANEI measures actual historic daily average noise dose whereas the ANEF measures forecast daily average noise dose

One important piece of information frequently sought by members of the public when looking to purchase a house is often the location of the flight paths. The Australian Government Department of Infrastructure and Regional Development, Airservices Australia and many airports have developed the use of flight path information over the last 15 years to provide a more meaningful summary of aircraft flight movements. **Figure 3** illustrates this type of information for Sydney. However, this information is of limited use in land use planning decisions.

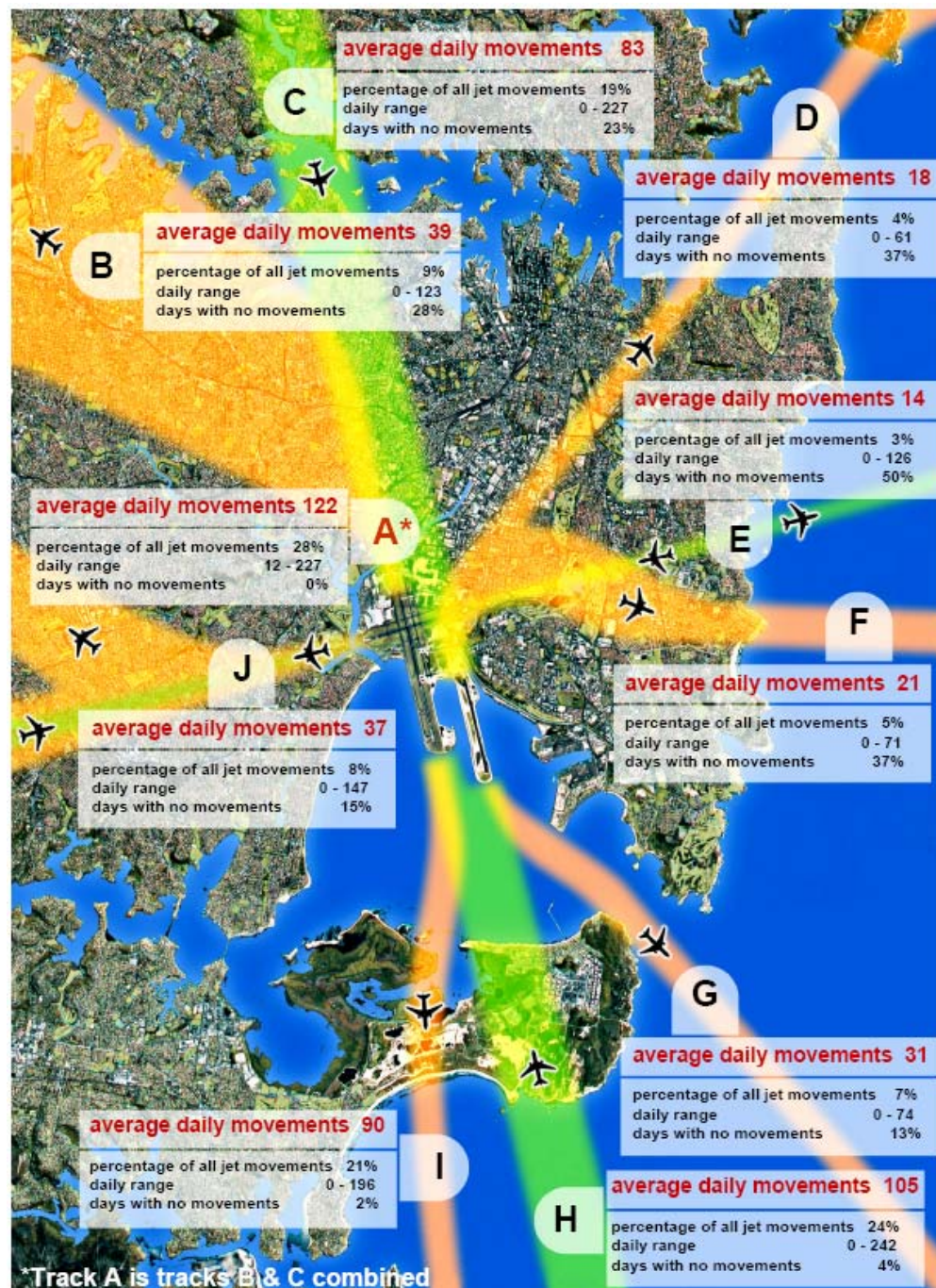
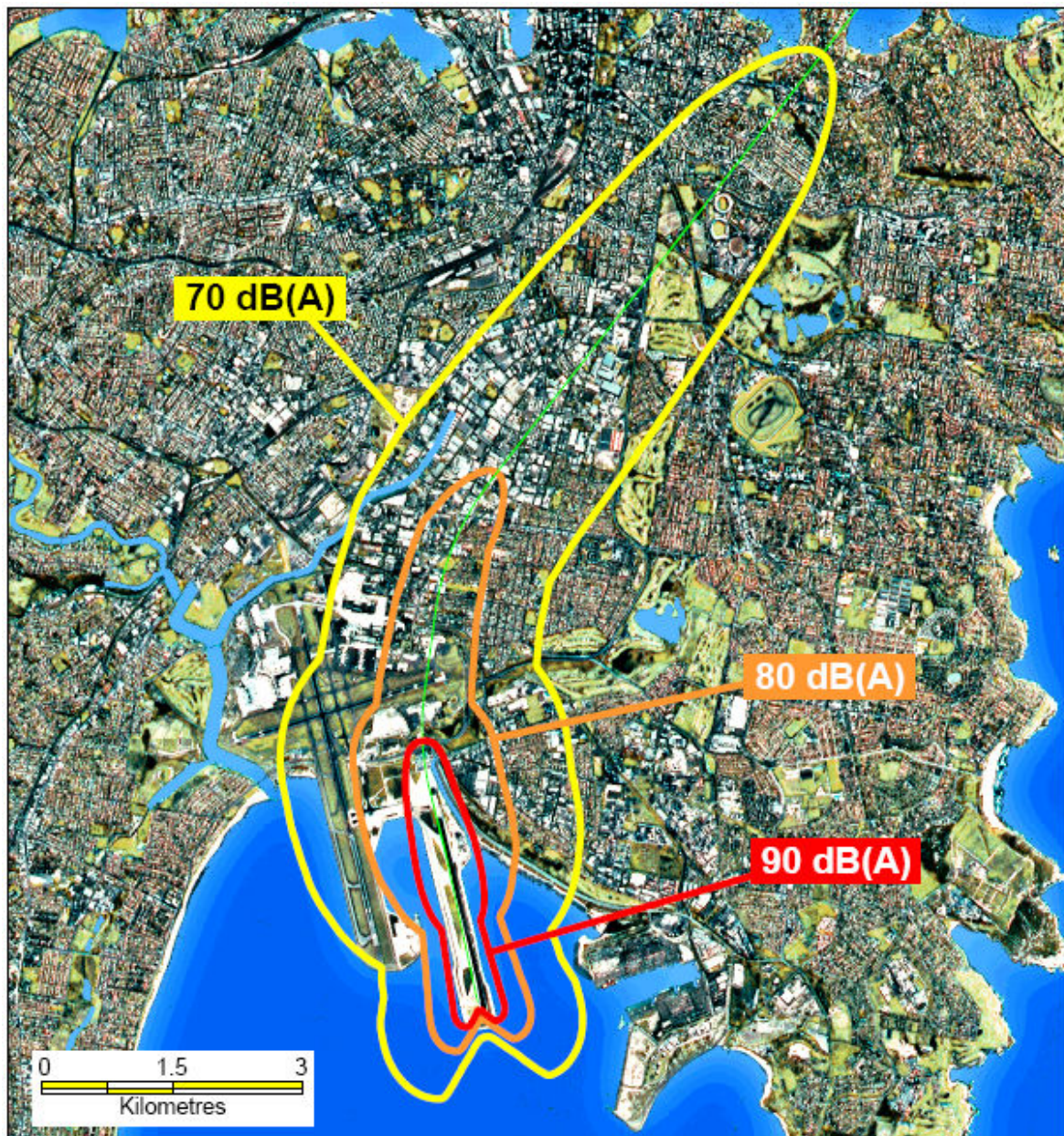


Figure 3: 1998 jet flight path movements – Sydney

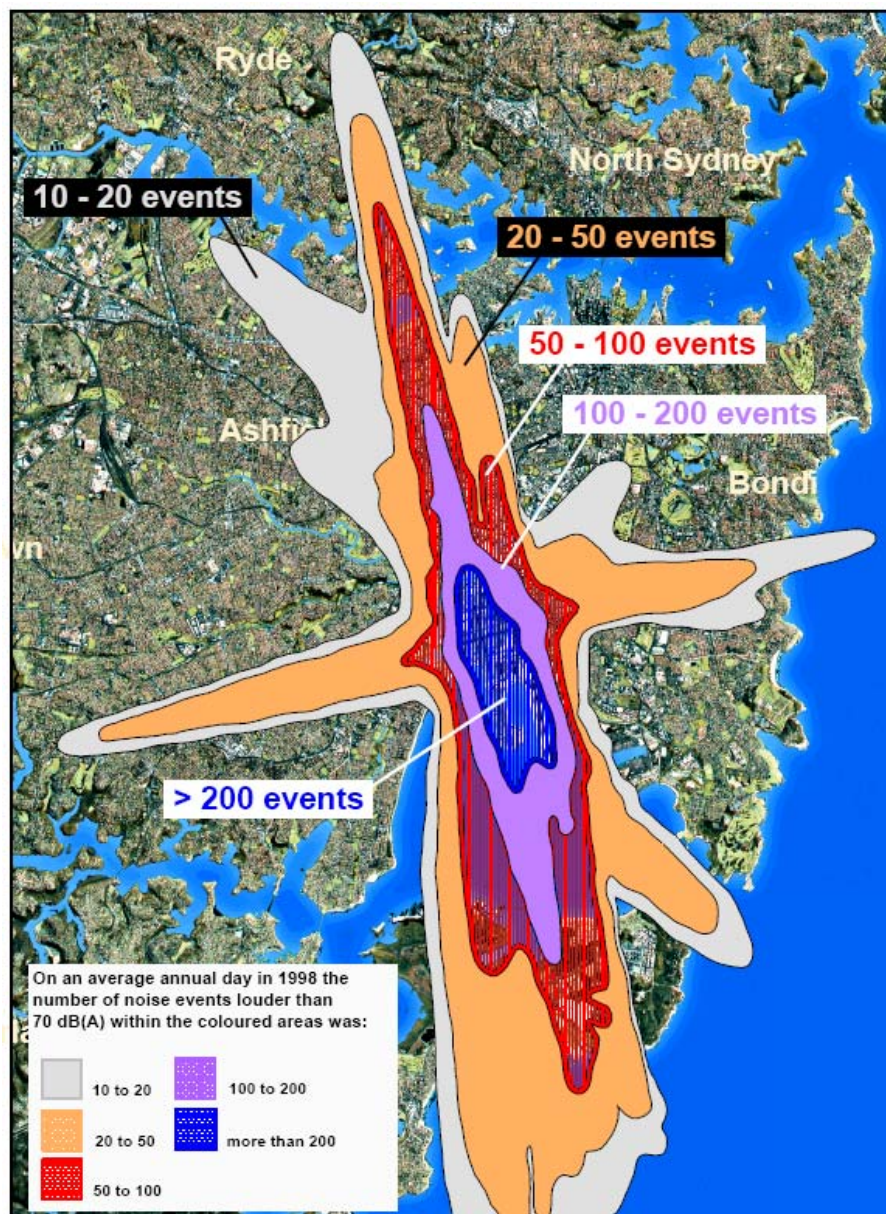
While aircraft flight paths are a useful way of presenting information on aircraft activity, they do not include information on the actual noise level of flights. Another useful way of presenting the impact of aircraft noise is to show the noise level of individual flight movements through the use of single event noise contours. **Figure 4** shows an example of a single event contour for a Boeing 767–300 departing from Sydney Airport’s Runway 34R on a particular track. It is possible to give an indication of how many of these flights will occur in a typical day. However, it is also difficult to use the single event contour in a land use planning context as separate diagrams are needed for each aircraft type and each track.



*Figure 4: Single event contour*

An approach that combines the information in a single event noise contour with the ability to consolidate this information into a description of high noise ‘zones’ is available. Information on the number of noise events is termed the ‘Number Above’ noise metric. In Australia, this is commonly called the N70 (or N65 or N60) where N70 is the number of aircraft noise events louder than 70 dB(A). Thus, residents can be informed in a way that is more intuitive, how many “noisy” events will be experienced within the illustrated zone. 70 dB(A) events have often been used to categorise an event as ‘noisy’ as these correspond to a 60 dB(A) noise level indoors, which can disturb conversation or other indoor activities such as watching television.

**Figure 5** shows a typical day N70 contour for Sydney Airport in 1998.



*Figure 5: 1998 N70 – average day – Sydney*

## Case Study of the Applicability of this Concept at Brisbane

The ultimate capacity model from the 2009 Brisbane Airport Master has been used to model the effects of aircraft noise around the Brisbane Airport<sup>6</sup>. The model provides an illustration which complements the ANEF modelling. **Figures 6, 7, and 8** show respectively, the 20 event N70 contour, the 50 event N65 contour and the 100 event N60 contour for the average day when the airport reaches its ultimate operating capacity. These measures recognise the variability in individuals' sensitivity to noise events. In particular, residents who value an outdoor lifestyle or those sensitive to sleep disturbing night-time noise events, may find the N60 measure more relevant to their concerns. The blue baseline area in each map represents the 20 ANEF contour outside of which there are currently no land use planning controls.

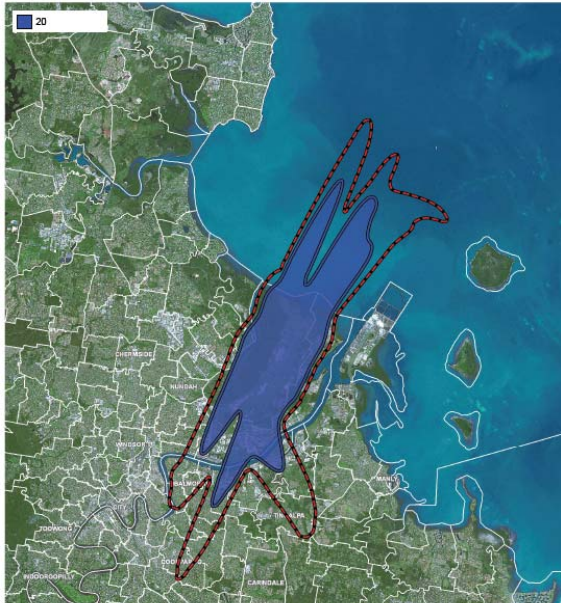


Figure 6: 20 event N70 – ultimate capacity - Brisbane

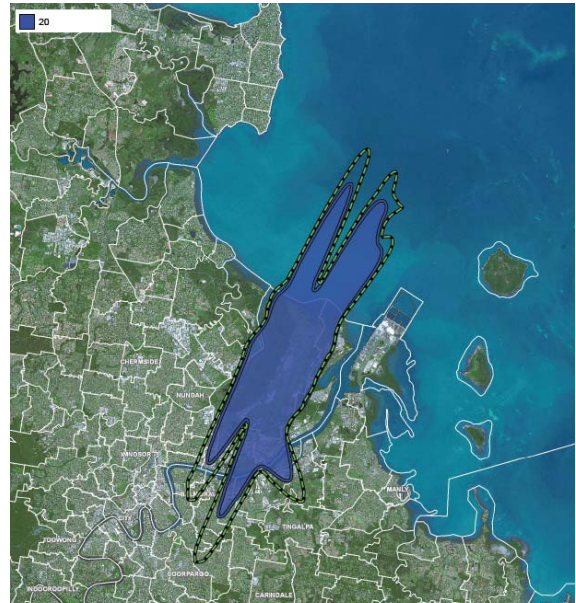


Figure 7: 50 event N65 – ultimate capacity - Brisbane



Figure 8: 100 event N60 – ultimate capacity - Brisbane

<sup>6</sup> Modelling carried out by the then Australian Government Department of Infrastructure and Transport

## Night Time Noise

The ANEF provides for weighting of night time noise events to take account of residents' increased sensitivity during evening and sleeping hours. Specifically, sound pressure levels are weighted by 6 dB(A) in the ANEF model for events between 7pm and 7am, effectively treating them as having four times the impact of daytime events. However, this can still under-represent the impact that a relatively small number of moderately noisy events can have during sleeping hours, as the ANEF describes cumulative noise dose rather than disturbance.

The night time (10pm to 6am) noise exposure patterns at Brisbane have been illustrated using N60 contours, at the 3, 6 and 12 event levels, as illustrated in **Figure 9**.

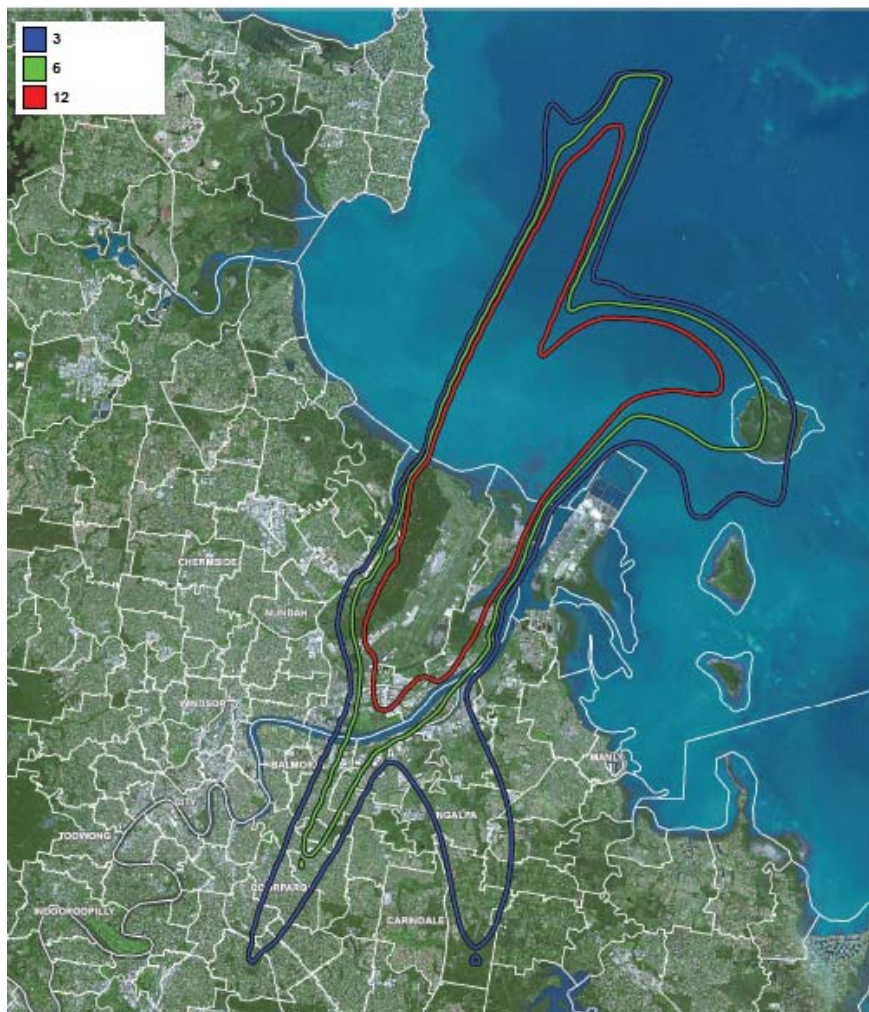


Figure 9: 3, 6 and 12 event N60s, 10pm – 6am – ultimate capacity – Brisbane

## Why 20 x N70, 50 x N65, 100 x N60?

The National Airports Safeguarding Advisory Group (NASAG), comprising Commonwealth, State and Territory transport and planning officials, has overseen a process to quantify a range of frequency-based aircraft noise events that may be useful in future land use planning considerations. It has done this recognising that the ANEF has certain limitations and that the existing guidance under AS 2021 highlights the increased sensitivity for residents newly exposed to aircraft noise

Just as aircraft noise does not suddenly stop at the 20 ANEF level, there is no hard and fast line where aircraft noise suddenly changes from being acceptable to being unacceptable at the 20 x N70, 50 x N60 or 100 x N60 levels. Aircraft noise impacts follow a continuum and clearly, noise impacts close to, but outside an identified threshold will be almost indistinguishable to the impacts on the 'the other side of the line'.

Therefore, there is a need for land use planners to take a balanced view of land use planning decisions that recognises aircraft noise does not suddenly stop at a line on a map, no matter how that line has been derived.

That said, frequency based measures of aircraft noise offer an additional information tool for illustrating potential aircraft noise impacts. Different airports exhibit different patterns of activity, so three related parameters are suggested for consideration. Used together, these measures should allow a more comprehensive assessment of noise impacts at most airports.

The 70 decibel (N70) measure has been the most commonly used frequency based aircraft noise measure to date because a 70 decibel outside noise will generally be experienced as a 60 decibel event inside a residence with the windows open. Sixty decibels is the sound level that will disturb a normal conversation or activities such as watching television.

There is also a strong case to consider the impact of 60 decibel aircraft events as worthy of consideration as an additional measure. Firstly, AS 2021 identifies 50 decibels as the level above which noise can be considered intrusive when defining building insulation requirements under AS2021. This inside intrusion would generally be experienced by a 60 decibel outside noise. Secondly, around training airports where there is a high number of moderately noise events, the experience of many residents, evidenced through complaint data and community consultation, shows that there can be significant noise impacts from a high frequency of overflights in the 60 decibel range.

Thirdly, 60 decibels is likely to be more disturbing during sleeping hours. AS 2021 sets an acceptable standard of noise for sleeping areas of 50 decibels. This level of intrusion is likely to result from a 60 decibel outside event.

The 65 decibel threshold is used to present a more comprehensive picture of likely aircraft noise impacts. This recognises the subjectivity of individual responses to aircraft noise and the difficulty in predicting whether individuals will be more sensitive to a moderate frequency of relatively loud events (the N70 measure) or a high frequency of less noisy events (the N60 measure). The N65 is a compromise measure lying between these two levels.

NASAG recognises the valuable role the ANEF plays in assisting land use planners to form an assessment of aircraft noise impacts. But it has long been recognised, including in AS 2021 itself, that the system fails to deal with certain scenarios, particularly the increased sensitivities that residents are likely to experience when newly exposed to aircraft noise.

Use of the 70, 65 and 60 decibel contours allows a balanced and comprehensive view of the impacts residents are likely to experience from aircraft noise. These measures better reflect high-frequency flight paths and known areas of sensitivity at existing airports, and are more easily understood by potential residents and land use planners who are not noise experts.

NASAG also recognises it is not possible, nor desirable to unnecessarily restrict land uses close to airports. The quantum of events nominated for the N70, N65 and N60 event contours respectively, aligns broadly to known areas of sensitivity around existing airports and gives some basis for guidance for areas close to, but outside, existing 20 ANEF contours.

The guidance material also provides assistance for the assessment of impacts from night time aircraft noise events, where a relatively small number of moderately noisy events can cause significant sleep disturbance for residents.

Like the 20 ANEF, there is no 'magical line' at the 20xN70, 50xN65 or 100xN60 contours at which we suddenly see aircraft noise change from being unacceptable to acceptable. These contours represent areas within which land use planners should consider aircraft noise impacts, particularly for new noise-sensitive developments.