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AIRCRAFT NOISE IMPACT ASSESSMENT VALIDATION AND SINGLE EVENT DESCRIPTORS

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ABSTRACT
We describe the prediction and assessment of the noise impact of aircraft movements associated with the Runway Extension project for the Adelaide International Airport. As a critical component of the Environmental Impact Statement (EIS), the work involved detailed modeling of aircraft movement and operational scenarios providing predicted noise levels. Two long term (over four months) noise monitoring programs were carried out at 15 sites in the vicinity of the airport. Over 20,000 recorded aircraft noise events were accurately (over 95% success rate) cross-correlated with flight time-stamp data and prevailing meteorological conditions. The statistically robust data-set provided accurate validation of the prediction of noise levels in nearby residential areas for different aircraft types and operational scenarios.

1 - INTRODUCTION
There were a number of phases of the Noise Assessment Program arranged to assess the effects of the extension of the main 05 runway at Adelaide International Airport (AIA). An EIS involved the prediction of the noise levels and likely impact on residents of aircraft operations (flight and ground-based) associated with the runway extension.

There has recently been a paradigm shift associated with using the standard ANEF system (equal energy contours) for the prediction of aircraft noise impact and community responses. As a result, in addition to the generation of time-averaged ANEF contours, simulation of individual aircraft events such as flights, take-offs/breakaway thrust and ground movements (e.g. taxiing) was undertaken. In particular, emphasis was placed upon single event noise descriptors (i.e. peak indices such as L_{Amax} as opposed to equivalent energy indices), which facilitated clear communication of the likely impact with community groups.

2 - NOISE MODEL PREDICTIONS
The runway extension project required a complete EIS (Environmental Impact Statement, [1]) study of the potential impacts, including noise, of the proposal. ANEF (Australian Noise Exposure Forecast) contours were predicted for a range of aircraft and runway scenarios. These equal-energy noise measures (weighted averages), which are similar to the US NEF contours, are meant to correlate well with community exposure or reaction.

The number of people affected was estimated for each ANEF contour band. In addition, maximum single event noise levels due to ground based events (e.g. taxiing, reverse thrust and take-offs) were predicted. The main conclusions from the EIS study were that there would be: 1) a slight increase (in noise levels and in the number of people affected) over time due to the natural increase in aircraft traffic and 2) an increase in levels due to take-off and taxiing events (by up to 5 dBA) for the nearby residential area due to the runway extension.

The validity and accuracy of the ANEF aircraft noise predictions has been questioned [1]. The public response highlighted the need for a more understandable measure of expected noise levels from aircraft. Accordingly, maximum noise levels from individual aircraft flight events (i.e. single event dBA levels) were also adopted for this study.

Maximum event noise levels due to aircraft flights for different scenarios were predicted and the results showed a potential increase of up to 4 dBA due to the runway extension, at residential sites in the vicinity of the runway extension.

3 - NOISE MONITORING PROGRAM

The long-term noise monitoring program was performed over two main phases: 1) before runway extension completion in March to June 1997 and 2) after runway extension opening in August to November 1998. The monitoring sites are in the vicinity of the runway extension (off the runway center line) and are located about 500m to 1km from the end of the runway.

Long-term continuous Noise Monitoring Terminals (NMTs) were placed out in the field at a total of 15 locations: 10 residential sites in Glenelg North (in the vicinity of the runway extension) and 5 reference sites within the airport boundary. The monitoring period for each site was at least 2 weeks to ensure that a representative sample of noise data was obtained over a range of aircraft operations and weather conditions.

Each NMT was set up to automatically record noise events above a certain noise level threshold. This threshold was set at 70 dBA after consideration was given to the level of most aircraft noise events at the residential locations and to help eliminate unwanted general community noise that can contaminate the data, such as nearby road traffic, dogs etc.

For each aircraft flight event (landing or take-off), the NMT would record the noise levels for the duration of the event, which is defined as the period of time over which the noise level remains above the threshold level (70 dBA). The NMT recorded the L_{Amax} level reached during the event, the L_{Aeq} (average equivalent) level over the event and the duration of event.

These event noise levels were recorded for all types of jet aircraft (using the western end of the airport near runway extension), turbo-prop aircraft and general aviation aircraft. Taxiing (and reverse thrust, take-off) events were difficult to detect above the general background and were measured manually for a wide range of ground-based events at a nearby reference point.

Other types of auxiliary data needed to be collected in addition to the noise data:

- Aircraft movement data for all individual aircraft flights for each day over the period, which included the times (of arrival/departure, to the minute), the runway used, type of aircraft. This ensured a match between the noise data and actual aircraft movement records.
- Meteorological data was also obtained for the whole monitoring period to observe the effects on noise levels due to a range of weather conditions.

4 - DATA CORRELATION

The L_{Amax} of an individual aircraft noise event is the maximum noise level that occurred during the event and, for all recorded events for a particular aircraft type, these maximum levels are averaged to give the average L_{Amax} for that type of aircraft over the whole monitoring period (for a particular site).

A software program was generated to sort and combine the noise and aircraft movement data sets, chronologically and by aircraft type and movement. The program identifies the aircraft event and matches it with the noise data collected at that time. The result is one combined data set with actual noise data related to each aircraft event that occurred over the monitoring period (along with meteorological data). Over 95% of the events were successfully cross-correlated with the noise data.

For the two monitoring phases, over 20,000 noise events were identified and tagged to a particular aircraft type and movement type. Any known extraneous events (due to lawn mowers, cars etc.) were detected and removed from the sample.

5 - RESULTS ANALYSIS AND VALIDATION

For each site and a particular aircraft type, differences (of up to 8 dBA) in the L_{Amax} levels showed that noise levels vary over the monitoring period due to a combination of effects such as weather conditions, different aircraft loads/thrust, take-off profiles etc.

The duration of B747 events (above 70 dBA) were slightly longer (by up to several seconds) than for the other jet aircraft at a particular site. The B747s were typically between 3 to 8 dBA louder than B737s/A320s or B767s.

The average L_{Amax} noise levels of the B747s reach about 95 dBA at the sites closest to the runway center line. The highest L_{Amax} recorded (after runway opening) was 101 dBA for B747s and 105 dBA for B727s before opening (which have since been phased out).

Analysis of noise levels in different weather conditions showed that a 3 to 5 dBA variation can occur due to the complete range of wind conditions. However, for most data, conditions did not cause the average noise levels to vary by more than 1 to 2 dBA from day to day.

Some noise events at the sites showed an increase of up to a few dBA during days of high humidity/low cloud. This effect, however, is usually more pronounced for sites at greater distances from the noise source (such sites would experience generally lower noise levels).
For a given site, the measured noise levels resulting from arrivals can be from 1 to 14 dBA lower than the levels associated with departures. However, at a site close to the runway center line, the noise levels due to arrivals can be 1 to 3 dBA higher. No significant change in flight tracks (from radar data) was observed due to the runway extension.
The average noise level difference between the two sets of monitoring (before and after runway extension) for particular sites was small. For the bulk of the aircraft movements (i.e. B737/A320s), about half of the sites showed either no change or a decrease (by 1 to 3 dBA) in noise levels and the other half of the sites showed an increase of between 1 to 3 dBA. Changes of less than 3 dBA are not typically discernible to the average human ear.
The duration of events (above 70 dBA) before and after runway extension showed either a slight increase or remained similar for most sites and seemed to correlate with the noise level changes. The duration here is equivalent to the TA70 (Time Above 70 dBA) descriptor.
A small increase in noise level (up to 3 dBA) occurred for take-offs from the full runway extension end compared to the old end (further away from the residences). Other ground based events such as taxiing and reverse thrust showed similar differences at times. This compares very well to the predicted increase of up to 4 dBA from the EIS modeling.
The statistically robust data-set provided accurate validation of the prediction of L_{Amax}noise levels in nearby residential areas for different aircraft types and operational scenarios. Using this validated data-set, further research will be carried out on other important single-event descriptors such TA70 and NA70.

6 - CONCLUSION

Over 20,000 recorded aircraft noise events were accurately (over 95% success rate) cross-correlated with flight time-stamp data and prevailing meteorological conditions. The statistically robust data-set provided accurate validation of the predicted noise levels (from modeling) in nearby residential areas for different aircraft types and operational scenarios.
Single event descriptors could provide a more reasonable measure of potential aircraft noise impact than equal-energy indices such as ANEF contours. In addition to L_{Amax}, other single event descriptors such TA70 and NA70 could provide a more robust metric for aircraft noise and community impact, and requires further research.

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REFERENCES

1. **Adelaide International Airport Runway Extension**, *Environmental Impact Statement*, SA Department of Transport, 1996