Federal Interagency Committee On Aviation Noise

The Use of Supplemental Noise Metrics in Aircraft Noise Analyses

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The Federal Interagency Committee on Aviation Noise (FICAN) has a long-standing interest in the use of supplemental metrics to describe the impacts of aviation noise. The Federal Interagency Committee on Noise (FICON) that called for the creation of FICAN recommended that FICAN address this issue. In February 2001, FICAN held a public forum on the use and application of noise metrics to supplement Day-Night Average Sound Level (DNL). At that symposium, a panel of representatives from airports, community groups, and industry presented their perspectives on the need for supplemental metrics, methods for evaluating their usefulness, and recommendations for the types of metrics that should be applied in different situations.

FICAN finds that supplemental metrics provide valuable information that is not easily captured by DNL.

INTRODUCTION

The Federal Interagency Committee on Aviation Noise (FICAN) has a long-standing interest in the use of supplemental metrics to describe the impacts of aviation noise. This interest extends at least to the Federal Interagency Committee on Noise (FICON) Report of 1992[1]:

> "The Schultz curve relating DNL to the percent of highly annoyed is generally accepted as a valid criterion for noise impact and has been re-validated by recent analyses (Fidell et al. 1989; Finegold et al. 1992). There are however, no other validated impact criteria related specifically to sleep or speech disturbance or criteria related to short-term impacts associated with supplementary metrics." (FICON, Section 3.7).

The FICON report included a recommendation that FICAN address this issue. Since FICAN was formed in 1994, a great deal of work has been done in the area of sleep disturbance, and FICAN has developed a position and recommended sleep disturbance curve (FICAN, 1997). However, FICAN has not developed criteria for evaluating other short-term noise impacts through the use of supplemental metrics (e.g., Sound Exposure Level, SEL, and Time Above, TA).

In February 2001, FICAN held a public forum on the use and application of noise metrics to supplement DNL. The members of the panel included: David Southgate of the Australian Department of Transport and Regional Services; Mr. Mark Myles of the Hanscom Field (Bedford, MA) Noise Workgroup; and Mr. Vincent Mestre of the Consulting Engineering Firm Mestre Greve Associates (Newport Beach, CA). Their presentations can be found on the FICAN web site (www.fican.org).

This paper presents a summary of the issues presented at the symposium, and FICAN's findings on the subject.

EFFORTS IN AUSTRALIA TO EXPLAIN AIRCRAFT EXPOSURE

David Southgate, Director Sydney Environment, Airports
Federal Department of Transport and Regional Services, Australia

In 1994 strident public claims were made that Australia's noise contouring system – the Australian Noise Exposure Forecast (ANEF) System – had failed in predicting the noise exposure patterns from a new runway at Sydney Airport. These claims were essentially endorsed by the findings of a Senate Select Committee in 1995.

The Department of Transport and Regional Services ("the Department") released its Discussion Paper *Expanding Ways to Describe and Assess Aircraft Noise* in March 2000 in an effort to encourage debate on finding better ways to describe aircraft noise exposure patterns to the public and decision makers. In essence, the Department is proposing that conventional equal energy noise contours only be retained for purposes where a 'line' based on community reaction needs to be drawn – for example, when defining eligibility areas in land use planning

[1] FICAN itself was formed on the basis of a recommendation from the FICON report.

and insulation schemes. Mr. Southgate believes that targeting individual, not community, reaction is the key to successful aircraft noise information. For example, before making a house purchase, buyers need to be given the type of information that lets them form their own judgements on whether the aircraft noise at a particular location is likely to be acceptable.

Mr. Southgate's discussion focused on the N70 – the number of events above 70 dBA – it's evolution over recent years in Australia and ways it may be used in the future to increase understanding of aircraft noise exposure patterns.

Underlying Principles

One of the fundamental principles of successful communication is 'listen and mimic'. Listen to the language your audience uses when its members discuss an issue amongst themselves and then try to talk with them in the same way. When members of the public talk to each other, or make a complaint to airports and aviation authorities about aircraft noise, they generally talk in terms of flight paths, the numbers and times of aircraft movements, how long it has been since they have had a break from the noise, and the loudness of particular individual events.

The Department has therefore attempted to develop descriptors that present information in this form. Feedback on these 'new' metrics, termed 'relational' indicators, has strongly indicated that the layperson believes these give a much better 'picture' of an airport's noise exposure patterns than conventional equal energy noise contours. In order to effectively communicate it is also important that the recipients of information can easily verify for themselves the veracity of what they are being told. The 'new' descriptors have clear advantages over conventional metrics in this area.

Flight Path Movements

One of the key methods the Department uses is a flight path movements chart, which is superimposed over ANEF contours for the same period. These represent two different ways of presenting the same information. Feedback from a very varied audience has indicated that the flight path movements chart gives a much more realistic mental 'picture' of the Airport's noise exposure patterns than the ANEF contour. For many people an airport's noise exposure patterns are visualised as something like a hub (the airport) with radiating spokes (the flight paths). The noise contour does not easily fit with this image. An example of this kind of presentation of data is provided as Exhibit 1. Given the positive reaction to the flight path movements chart, the Department has produced a second product – the respite chart – using essentially the same flight path image to report on 'breaks' in aircraft noise. Details on respite charts can be obtained from the Department's *Expanding Ways* Discussion Paper.

The N70 Contour

Single event contours are the first step toward the N70. For many people, the flight path and aircraft movement data contained in the flight path movement and respite charts satisfy their aircraft noise information needs. Others are interested in supplementing this with sound pressure level data. However, they are virtually never interested in receiving logarithmically averaged noise data – they are looking for single event noise information.

Throughout the world, single event noise contours are commonly included in environmental assessment and information reports. These contours are conventionally placed on a plain background to allow the user to compare the noise footprints of different aircraft types. In drawing up a plan for re-arranging Sydney airspace in 1996, community representatives pressed for the contours to be overlaid on indicative flight paths so that the information could be given some geographical context. This led to the publication of single event flight path maps.

A key drawback of single event contours is that they give no indication of the number of events on each of the flight paths. During the process of consultation on the proposals for rearranging Sydney's airspace, a suite of five single event contour maps was prepared for one specific flight path in response to a request from an elected representative of an area to the north east of Sydney Airport. Each map separately showed single event 70, 80 & 90 dBA contours for the five particular aircraft types that would use that flight path. While this presentation proved very useful for one particular flight path, it would have clearly been impractical to produce such information for every flight path at the Airport. The search for a way to provide aggregated information of this type led directly to N70 maps being produced.

The N70 contour depicts the number of events louder than 70dBA on an average day. The trigger level of 70dBA is used because it equates to a noise event likely to disturb conversation and/or listening inside a house with open windows. The main positive about the N70 is that it reports noise in a way that a person thinks and talks about aircraft noise – by the number of events. It is also an arithmetic contour rather than a logarithmic contour – all other things being equal, the N70 will double if the number of movements on a particular flight path doubles. The downsides of the N70 are that, like other noise contours, it can give the impression that there is no noise beyond the outer contour. It also shares the 'average day' weakness with conventional contours and it does not provide as good a mental image of the noise exposure patterns as flight path based data. An example of N70 contours is provided in Exhibit 2.

The Number Above metric can equally be used to generated contours for noise levels other than 70 dBA. For example, preliminary work has indicated that for general aviation airports, where the noise climate is predominated by very high numbers of movements by relatively quiet aircraft, the N60 gives a good representation of noise exposure patterns.

The N70 is particularly useful for showing noise exposure levels for short time periods. Conventional metrics such as the DNL and the ANEF, which are essentially based on a 24 hour weighted day, do not lend themselves to an analysis based on partial days. Similarly, N70 contours produced for individual days give a very intelligible picture of the noise exposure patterns. Some examples of single day N70s are shown in the *Expanding Ways* Discussion Paper. Another example of the versatility of the N70 is shown in Chapter 5 of the Discussion Paper under the title the 'Person-Events Index'. This is a tool based on the N70 that allows a simple and transparent analysis of the noise exposure patterns around an airport.

The Department computes its N70 contours indirectly by using INM to produce a detailed Time Above (TA) 70 dBA grid and then summing the number of non zero events. Concern has been expressed that since N70 is not produced directly by INM the contours are not validated. These are understandable concerns and clearly until such time as rigorous validation studies are carried out N70 contours derived indirectly from TA information need to be treated with caution. Irrespective of this, there is a reasonable correlation between measured and modelled N70s at Sydney Airport. Given that the N70 is a 'yes or no' type metric it is inevitable that there will be specific sites where there are significant differences between measured and modelled data.

There are networks of noise monitoring terminals around all the major Australian airports. While community pressure has been a key driver in these networks being installed, it has proven very difficult to find ways to report the results of noise monitoring in a way that a layperson finds satisfactory. The amount of information gathered by a noise monitoring terminal (NMT) is extremely large and summarising this data in a simple way is a daunting task. Over the years many ways of presenting NMT data have been tested but generally these have not gained wide acceptance. Recently, community representatives have requested that reports be based on N70 information. Presenting measured N70 information allows a member of the public to cross compare between measured and modelled data and thus carry out at least some simple form of validation of published contours. This is not possible with ANEF contours.

Software to Evaluate N70

The Department is currently developing a software package – TNIP (Transparent Noise Information Package) – to assist airports and aviation agencies produce the 'new' descriptors put forward in the *Expanding Ways* Discussion Paper. TNIP facilitates the very rapid production of flight path movement and respite charts and measured N70 reports as high quality graphic pdf images. The package also includes a routine for producing N70 grids from INM detailed TA70 grids. A module to provide Person-Events Index (PEI) analyses is now being prepared. TNIP can be configured for any airport relatively easily. A flight path template, which shows the 'normal', spread of the airport's flight paths needs to be prepared using a standard graphics package. This template can be then used for ongoing reporting provided the flight path arrangements do not change. Data files with fields containing information on aircraft type, runways used, dates, times and origin and destination of movements need to be prepared on a routine basis for regular environmental reporting. TNIP also allows the user to query the database by date and time to produce charts for specific time periods. It is intended that the package will ultimately be configured for the Internet so that community members can interrogate an airport's movements database. TNIP is freeware and copies can be obtained by emailing the author at david.southgate@dotrs.gov.au.

In recent years, Australia has moved to an almost one hundred per cent high by-pass Chapter 3 fleet. This has been coupled with an environment of increasing numbers of aircraft movements at airports. As a result noise reporting has increasingly become a 'numbers game' and every indication is that this trend will continue. The concept of 'numbers and times' based descriptors appears to be well suited to this environment. Complaint patterns in recent years indicate that there will be increasing pressure to report noise events down to the N60 level even at major metropolitan airports. Preliminary work indicates that the N60 may well be a useful tool for portraying noise exposure patterns at GA airports.

Conclusions

The Department is anxious to see the International Civil Aviation Organization's (ICAO) Committee on Aviation Environmental Protection (CAEP) broaden its work program to encompass examination of ways to improve communicating noise exposure patterns to the public and decision makers. The concepts discussed in the *Expanding Ways* Paper are not intended to be the final product. Rather they are designed to stimulate ideas on better ways to present a 'real' picture of aircraft noise exposure patterns around airports. It is clear that aircraft noise issues will not be effectively managed while 'experts' and 'non-experts' fail to talk the same language.

COMMUNITY EFFORTS TO DESIGN SUPPLEMENTAL NOISE METRICS

Mark Myles
Hanscom Noise Working Group

Hanscom Field is a general aviation airport in Bedford, Massachusetts; its operations affect residents in the surrounding communities of Bedford, Concord, Lexington, and Lincoln MA, as well as the Minuteman National Historical Park. The Hanscom Noise Working Group (HNWG) was chartered by Massport to comply with Massachusetts Secretary of Environmental Affairs comments on an Environmental Impact Report. The HNWG included representatives of abutting towns, aviation-related business owners, citizen groups, US Air Force, the National Park; community members had impressive credentials for this project, including a number of PhDs, noise professionals, and pilots.

Overall Recommendations

One of the first tasks the HNWG undertook was an evaluation of existing metrics and a list of attributes for a desired "ideal" noise metric. The HNWG concluded that an ideal noise metric, or set of metrics, should: express the sound level above ambient noise level, take into account the duration of aircraft noise events, be affected by the number of aircraft noise events, express the number of people affected, and express the absolute sound level of events.

Furthermore, the HNWG believes metrics should: (1) assess current aviation operations and predict impacts of future changes (e.g., changed number of operations, changed fleet mix); (2) reflect the "peaky" nature of over-flight noise (i.e., does not average excessively over space or time); (3) readily express year-to-year and month-to-month changes; (4) correlate to subjective perceptions of the community affected; (5) provide sufficient detail for analysis in order to understand the root cause of noise and noise trends; (6) complement, not replace, the Day-Night Noise Level; (7) be modeled by the Integrated Noise Model (INM) program, allowing for rerunning of INM data from previous years; (8) be measurable by the currently available noise monitoring system; and (9) show variations of predicted noise levels expected from modeling assumptions and simplifications.

The metrics recommendations by the HNWG fall into five major categories: (1) Greater use of the Time Above (TA) noise metric, (2) Statistical description of aviation noise events (more information than just the average), (3) Linear dimensionless metric to complement DNL, (4) Community Metrics easily understood by the general public, and (5) Assessment and discussion of modeling limitations. Each of these is discussed in some detail below.

Time Above (TA) noise metric

The HNWG believes that TA correlates better with the number of flight operations than does DNL. The group's specific recommendations for TA include plotting TA contours for 45, 55, and 65 dBA using INM, and presenting the area inside each contour (a single number expressing area affected). The Working group feels that the strengths of TA include the following: (1) Specific Time and area both readily understood by general public, (2) Calculated and plotted by INM, (3) Time Above the L90 appears to correlate approximately linearly with changes in number of aircraft operations.

Statistical description of aviation noise events

The HNWG's proposal for a statistical descriptor is the Single Event Level Distribution (SEL/D). This approach uses conventional statistical technique to generate a histogram distribution of noise events to describe the range of levels due to aviation events. One of the main advantages of this approach is that the data already are easy to obtain and, in fact, are already collected at the Airport on a regular basis. The data can form the basis for trending analysis and a "Loud Events Count" (Citizen metric).

Linear dimensionless metric to complement DNL

The main rationale for creating a linear dimensionless metric is that decibel measures are not easily comprehended by the general public, for two reasons: (1) large changes in noise seem to result in apparently small changes on the dB scale, and (2) most measures with which we are familiar (weight, length, etc) combine linearly. To address these concerns, the HNWG proposes an Aviation-to-Ambient Ratio, which expresses the relationship between p^2_{dn}Aviation (the day-night A-weighted sound pressure due to overflights) and p^2_{ref}Ambient (the representative L90 ambient pressure).

The HNWG believes that the benefits of the linear metric are the following: (1) it scales linearly with number of identical acoustical events, (2) it complements, but does not replace, DNL, (3) it is a linear equivalent to DNL, and (4) reference to ambient sound allows scaling from urban to suburban communities.

Community Metrics' easily understood by the general public

The objectives of community metrics are to facilitate communication with public and to improve credibility of the airport authority and noise experts. The HNWG believes that the ideal attributes of such metrics would: (1) have zero value for zero impact, (2) scale linearity, (3) be few in number, (4) relate to people’s experience, (5) have explanatory titles, (6) have reference values (e.g., 45 dB Sound Pressure Level (SPL) SPL is a whisper, 65 dB SPL leads to speech interference), and (7) be expressed in simple numbers.

The HNWG has proposed three community metrics: (1) the area experiencing 30 or more minutes per day of 55 dBA aircraft noise (i.e., TA55 of 30 min/day); (2) area impacted by noise per EPA (55 dB DNL contour area); and (3) monthly loud events count (events per month > 94 dB SEL).

Assessment and discussion of modeling limitations

The issue of noise modelling accuracy is based on two concerns: first, that all mathematical models rely on assumptions, and produce results with some degree of error; and second, actual measurements and modelled results can vary significantly. The HNWG believes there should be more standardized procedures for input disclosure and error band predictions. These procedures would enable assumptions to be scrutinized, understood, and approved by other scientists and the general public; they would allow predictions reproducible by any INM user; they would allow reviewers to devote special attention to locations with large error bars; and would ultimately enhance public trust in the modeling process.

The HNWG believes that, taken together, its recommended metrics would: enhance understanding of acoustic impact of aviation operations; increase credibility of noise reports, EIR's, etc; and increase trust and understanding of citizens.

THE APPLICATION OF SINGLE EVENT METRICS IN AIRPORT NOISE ANALYSES

Vince Mestre, P.E.
Mestre Greve and Associates

Mr. Mestre started his presentation with some background on FICAN’s involvement with supplemental noise metrics. He quoted the findings of the Federal Interagency Committee on Noise (FICON) Report, as follows:

> “After reviewing all noise exposure metrics, the FICON technical subgroup concluded that no other metrics are of sufficient scientific standing to replace DNL.“
>
> “Continue agency discretion in the use of supplemental noise analysis.”
>
> “Supplemental analyses are most often used to determine aircraft noise impacts at specific noise sensitive locations, particularly in analyses of speech interference and sleep disturbance.”
>
> (FICON, 1992)

Mr. Mestre believes that these findings and recommendations are the driving force behind FICAN’s current interest in the subject.

Mr. Mestre provided some background on DNL and CNEL and their usefulness in predicting human response – DNL is the only noise metric that is well correlated to human response (see Schultz curve).

However, there are other noise metrics that can be useful for analyzing other noise effects, particularly as related to short-term activity interference. These metrics include: the Single Event Noise Exposure Level/Sound Exposure Level (SENEL/SEL), the Maximum Noise Level (Lmax, dBA), and Time Above (TA, minutes).

The biggest drawback to using single event metrics, according to Mestre, is that they reflect the noise associated with “one and only one event”. At any given location there may be hundreds of thousands of noise events in a year, or hundreds per day. Which noise event should be reported as the "single event noise"? Mestre believes that the best answer is all of them.

When addressing noise from single events, the best sources of data are measured data (even better if they are from a permanent monitoring system). Another good source of data are INM estimates of the Energy Average SENEL/SEL. By plotting these values, an estimate of the most probable SENEL/SEL is the mode. He cautioned that if using the INM, the analyst must have sufficient detail in fleet mix and flight track conversion in order to simulate a measurement histogram.

Why should we be interested in Single Event Metrics? They are useful for a number of reasons: (1) to compare aircraft source noise from one aircraft type to another, (2) to evaluate the effectiveness of operational mitigation measures, (3) to inform public about event noise, (4) to evaluate sleep disturbance, and (5) to evaluate speech interference. Each of these is discussed briefly below.

Single Event Noise Contours

Single event noise contours are useful for comparing two or more different aircraft types – for example, a hushkit and non-hushkit aircraft. These are generally expressed in terms of Single Event Noise Exposure Level (SENEL) or Sound Exposure Level (SEL). The INM produces an 'energy average' SENEL/SEL contour. However, Mr. Mestre agrees with Mr. Southgate that the actual use of such contours can be misleading – he recommends presenting the data in a chart or other format that does not use underlying maps, such as the one presented in Exhibit 3.

Single event contours are also useful for evaluating operational changes. CNEL/DNL may be insensitive to some operational changes, such as noise abatement departure procedures. They are also useful for comparing sources of aircraft noise. One example of this is single event contours developed to address noise levels in the Bay Area – SENEL contours for departures from San Francisco can be compared against SENEL contours for departures from Oakland.

Applications for Other Single Event Metrics

Single event data, expressed as SENEL or SEL, are particularly useful for addressing sleep interference issues. In fact, the FICAN sleep disturbance curve (FICAN, 1997) uses SEL as the metric for estimating levels of sleep interference. Speech interference is best analyzed through the use of single event data, either expressed as Lmax, or Time Above.

Time Above

Time Above measures the number of minutes (or seconds) above a specified noise level. For example, computations of TA 85 dBA outdoors would be analogous to TA 65 dBA indoors, assuming 20 dB building noise reduction with windows closed. Similarly, computations of TA 77 dBA outdoors reflects TA 65 dBA indoors, assuming 12 dB building noise reduction windows open. The advantage of TA for addressing speech interference is that it describes the total exposure – it is not a 'single event' metric. TA data are most commonly presented in tabular format; although the INM is capable of computing TA contours, Mr. Mestre feels that geographic mapping of time is confusing for people to interpret. In his experience, people become used to noise contours, and have trouble understanding time contours.

Spectral Data

Spectral data are also useful in some special cases, such as addressing low frequency noise. The INM now allows the analyst to compute frequency-based noise levels, using the spectral classes that have been developed for the INM.

Summary

The major uses for supplemental metrics are: (1) comparison of aircraft noise levels, (2) disclosure; (3) investigation of noise source contributions; (4) evaluation of mitigation strategies in detail, i.e., where CNEL/DNL may not be sensitive. Single event data have limited application for land use planning, with the exceptions of Time Above for school site evaluation in addition to CNEL/DNL metric and evaluation of potential sleep disturbance.

FINDINGS

FICAN finds that Supplemental metrics provide valuable information that is not easily captured by DNL. Supplemental metrics are particularly useful for assessing the effects of aircraft noise on interference with activities such as sleep and speech. In these cases, the use of metrics such as single event exposure metrics can provide a more meaningful estimate of interference than a single DNL estimate.

REFERENCES

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Federal Interagency Committee on Aviation Noise (FICAN), *Effects of Aviation Noise on Awakenings from Sleep*, June, 1997.

Federal Interagency Committee on Noise, *Federal Agency Review of Selected Airport Noise Analysis Issues*, August 1992.

Hanscom Field Noise Workgroup, *Report of the Hanscom Field Noise Workgroup*, 22 September 1999.

[Note: All references are available through the FICAN web site: www.fican.org.].

Exhibit 1. Flight Path Movements

Sydney Airport

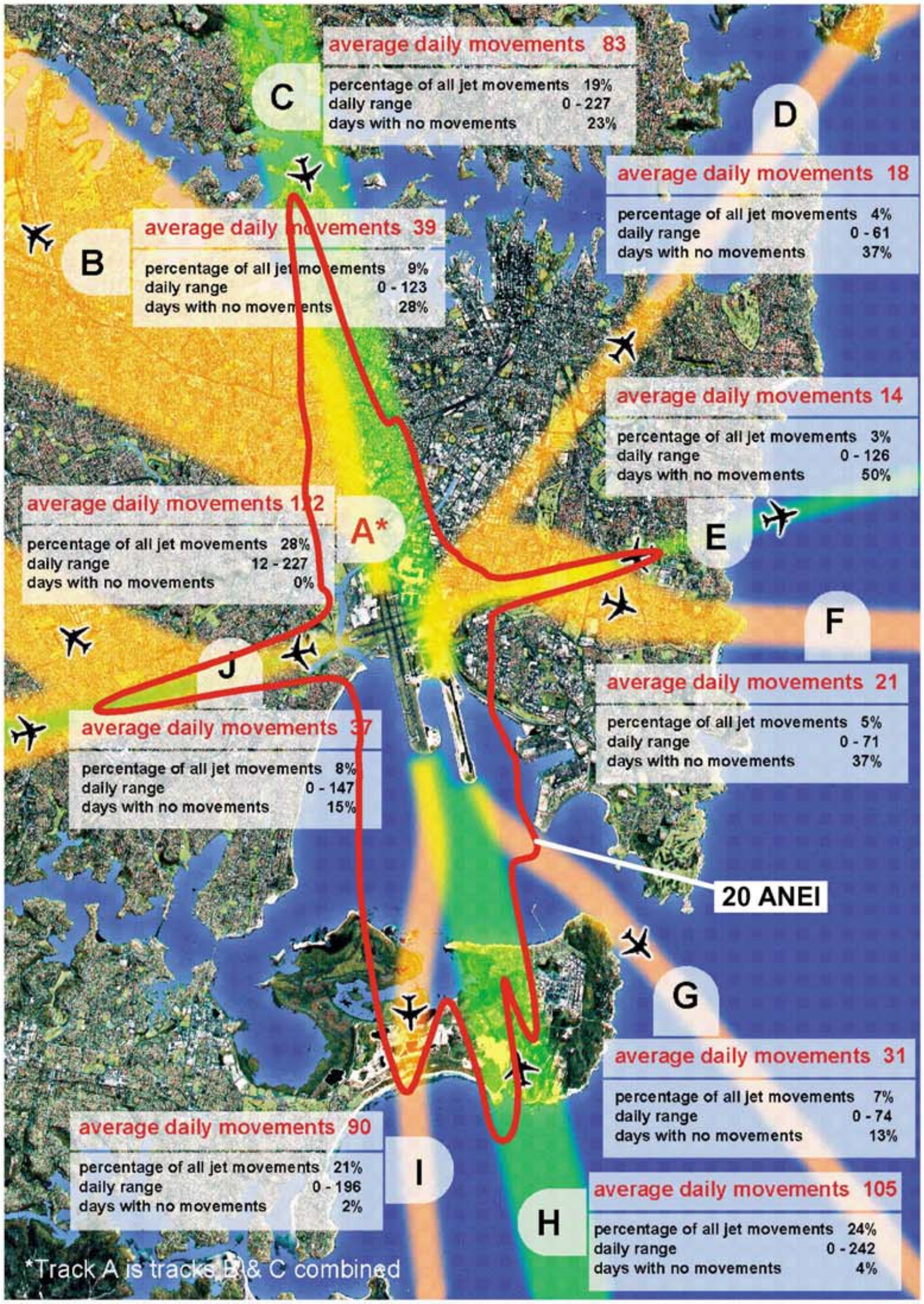

Figure 2.7 Comparison of 1998 Flight Path Movements and 1998 ANEI 20 Contour

Exhibit 2. N70 Contours

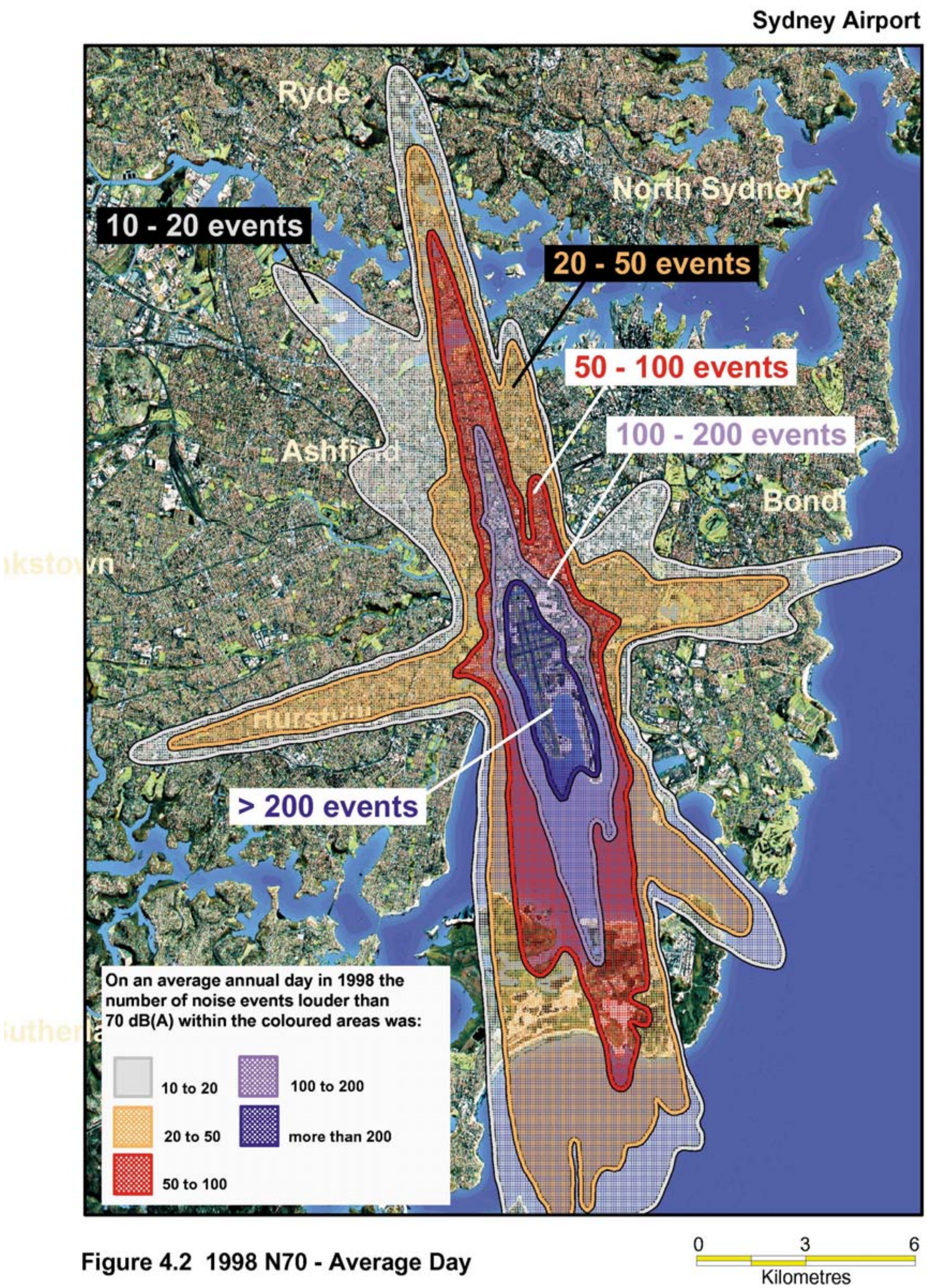

Figure 4.2 1998 N70 - Average Day

Exhibit 3. Aircraft Single Event Noise