ONE CAN CONTROL AIRPORT NOISE - THE TRIED AND PROVEN AIRNOISE BOUNDARY CONCEPT

Philip J Dickinson

Massey University Wellington, New Zealand

Abstract

In many countries, the air transport industry is given privileges that other, just as important, industries are denied. Whereas the large majority of industries have to meet strict noise emission standards, it would seem that, except in a very few countries, the air transport industry does not - irrespective of any public health concerns by local territorial authorities. Admittedly, just as a piece of industrial machinery may have to meet certain sound emission levels at source, so commercial aircraft have to meet noise certification levels. However, once a specially prepared single example of the aircraft is tested at certain all-up weights, rarely if ever are the production aircraft checked for compliance - and the certification levels themselves bear little relationship to the noise produced around an airport when the aircraft is in airline service. Added to these problems, it is common for governments to hide the noise immission of residential areas in the airport environs by using sound descriptors that no-one can measure, and by making themselves the sole suppliers of information. Yet there are very effective and transparent ways of controlling airport noise as proven in New Zealand over the last ten years. There, the local residents have a say in how much noise the airport is going to be allowed to make in their area, and hold the airport to it. The situation around some airports is an order of magnitude better than 10 years ago – indeed at Wellington International Airport in the summer months of 2003/2004, complaints about aircraft noise were zero.

Introduction

New Zealand may well be a small country far away from the centres of science and technology, but it does hold one dubious distinction. The earliest authenticated complaint recorded against aircraft noise was lodged in March 1903. Richard Pearse faced no threatened court action - only the ignominy of being pelted with potatoes and other farm refuse if he did not cease from crashing into his neighbours' fields and making such an awful noise!

Some twenty years later, the noise emission from the motors of individual aeroplanes was bad enough for there to be serious research to make them quieter. The Aeroplane magazine in 1926 published a proposal for steam engines to be used in aeroplanes to reduce the noise [1].

Figure 1 Steam-powered aircraft.

But, even then, the clouds of war were on the horizon and the main effort was for increased power and performance. Larger and more powerful motors were developed, each increase in horse power bringing with it a corresponding increase in noise emission. With the introduction of the gas turbine engine, the goals of power and performance were amply met, but at a cost of excessive noise for all those living within some miles of the aerodrome. When one is at war, and life expectancy is low, anything that may achieve peace is gladly accepted and the noise emission of a (protecting) aeroplane is music to the ears.

At the end of World War 2, individual noise levels from aeroplanes were a thousand times as great as those in the 1920s, and, with the development of commercial airlines, many more aeroplanes were flying and many more people were experiencing excessive noise levels.

The commanders of our military airbases were quick to notice murmurings of discontent amongst those people living nearby, and it was not uncommon for them to resort to advertisements extolling the need for the aircraft in a protection role and calling the noise emission "The Sound of Safety" or something similar. The managers of our commercial airports could fall back on no such excuse, and public action against airport noise started to develop. In the early 1960s, several surveys of noise around the major airports were conducted [for example: 2, 3] and resulted in the development of special noise units to describe the sound exposure received by the nearby residents. But, almost without exception, the units were so obscure and so complicated that no one could measure the noise with a sound level meter, and hence take action about it. So the noise continued to grow: Commercial aircraft became even more noisy and their numbers increased as travel increased.

Noise Certification

Public outcry reached such a pitch in the early 1970s that government agencies concluded that manufacturers should be encouraged to produce quieter (commercial) aeroplanes and noise certification was introduced by the US Federal Aviation Administration (FAA) followed shortly afterwards by the International Civil Aviation Organisation (ICAO) who introduced Annex 16 to the Convention on International Civil Aviation. For noise certification a specially chosen aircraft of the model under test is flown in standard conditions and the noise emission measured at three specific locations (Figure 2), using a special metric (EPNL).

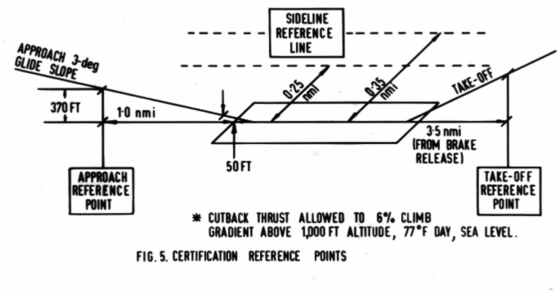

Figure 2 Noise certification positions.

The military faced no such noise limitation and indeed much of the flack has been taken away from them by the civil airports, the main public attack being only of intrusion into the super-adjacent space of the nearby residents.

Under Annex 16 aircraft noise certification was introduced in December 1972, became effective in April 1973, and, in August 1973, was applicable to all new jet aircraft accepted into service before 6 October 1977. The limits chosen were those considered to be achievable by 75% of the aircraft then in service. Aircraft meeting these conditions were said to conform with Chapter 2 of Annex 16. Aircraft Noise Certification of light propeller-driven aeroplanes and subsonic jet aeroplanes of 5 700 kg or less was adopted in April 1974 and was effective in February 1975 under Chapter 6 to Annex 16. Noise certification standards for future subsonic jet aeroplanes, propeller driven types (other than Short Take Off and Land aeroplanes), future supersonic aeroplanes, propeller-driven STOL aeroplanes and Auxiliary Power Units, were adopted in June 1976 and became applicable to all new aeroplanes in October 1977. These chapters were 3, 5, 4, 7 and 9 respectively.

In 1978, after much debate from airlines, a new parameter in Noise Certification was introduced. The limits were adjusted according to the number of engines on the aeroplane, and manufacturers could trade-off any exceedance of the noise limits at one of the certification positions, with any noise in hand at the other locations, provided the excesses were not 3 dB – i.e., double what they should be, as given in Table 1.

Table 1 Aircraft noise certification levels

	Chapter 3				
	Level EPNdB	Weight kg	dB/halving weight	Level EPNdB	Weight kg
Take-off					
Engines					
> 3	106	≥ 385,000	4	89	≤ 20,000
3	104	≥ 385,000	4	89	≤ 27,000
< 3	101	≥ 385,000	4	89	≤ 32,000
Approach					
	105	≥ 280,000	2.33	98	≤ 35,000
Sideline					
	103	≥ 400,000	2.56	94	≤ 35,000

Helicopter noise certification was included as Chapter 8 in May 1981, when the entire Annex was reissued to include also updated standards for future production of existing supersonic transports and updating of noise certification for APU and associated aircraft systems.

Advertisement has made it appear that Chapter 3 Noise Certification is the very latest and most stringent, producing the very quietest aircraft. This is far from true. It became applicable to all subsonic jet aeroplanes for the prototype accepted on or after 1977 October 6th. So it has been in force for nearly 30 years. Many people consider the requirements of Chapter 3 are long out of date and that much stricter noise requirements should be adopted together with the introduction of new noise certification that gives a true indication of the noise received on the ground from an aircraft, irrespective of its size or how many engines it has. The present system gives no such indication.

Realities

Only in recent times have the effects of noise exposure on the health and well-being of the community been realized by the general public, due to the insidious nature in which noise affects the human body and its functions. Just like a single drop of water falling upon a particular spot on a person's forehead, a single loud transient sound is most unlikely to cause any harm. But when continued many times, the result can be devastating. There is ample scientific evidence that noise can cause extreme fatigue, can alter social behaviour, can decrease a person's resistance to illness, can alter work performance, can make a person more prone to accident, can cause, or contribute to, a hearing loss, and can be a contributing factor to the development of a stress condition. Indeed, it is now known that noise adversely affects the lives and health of more people than any other pollutant.

One also tends to forget that the rules laid down in many countries for the protection of workers from noise assumes the remaining hours of the day and night are quiet enough to allow the worker's hearing mechanism to regenerate. Regrettably, in many cases these "restful" hours are subject also to excessive noise and sleep disturbance, hindering recovery and, it is feared, in some cases negating the chance of a return to normal. Transportation noise is a major factor in many areas, and that from aircraft the most prominent.

Government compensation for occupational noise induced hearing loss is a major expense and the costs have been rising. This year it is expected that such claims, for noise induced hearing loss alone, will be counted in tens of millions of dollars. The yearly cost of excessive noise, to the over-all health of the communities in the form of related medical and prescription costs, hospital admissions, Social Welfare and sickness benefits, absenteeism from work, loss in production and changed social behaviour is incalculable but likely to be in excess of a hundred million dollars in New Zealand, or \$40 per head of population. This relates to about \$5000 Million in the United States and about twice that amount in Europe. It is for these reasons that a noise exposure policy was developed for the protection of community health with a small margin of safety. Local authorities, who in New Zealand have the responsibility to control noise in their districts, are advised to aim towards a 24 hour A-weighted sound exposure in any residential area of no more than 10 pasques (pascal-squared-seconds) - equivalent to a day/night level of about 55 dB. And this applies to any transportation noise source including both civil and military aircraft. In some areas, particularly around airports, this may not immediately be possible, and strategic air and land use planning must be brought into play.

One major problem has been the elevated importance given to the air transport industry. Whereas the large majority of industries have to meet strict noise emission standards, it would seem that, except in a very few countries, the air transport industry does not - irrespective of any public health concerns by local territorial authorities. Many aviation administrations expect local authorities to try to match predicted noise exposures with compatible land use planning (or sometimes no planning at all). Inevitably the predictions are low, often by an order of magnitude, and the local population has to put up with a most unsatisfactory situation not of their own choosing nor of their own making. In such a scenario, the airport keeps expanding and the noise exposure keeps increasing. But however glamorous such travel may be, one has to consider that the transportation industry is just that - an industry - and one that should be subject to the same rules as any other industry. Once the administrators have this clear in their minds, the way is open to introduce an effective and practicable environmental noise management system that will guarantee the welfare of the local community.

Effective Management

A main ingredient in the management process is modern noise logging instrumentation for:

- The essence of environmental noise management is to decide by the public process how much noise the operation is to be allowed and where, and then to hold the noise emitted to within those confines.

If the work is done properly with a balanced land use planning regime there is no reason why current trends - an increase in noise exposure even though individual noise levels are lower - cannot be reversed.

It may seem strange that a South Pacific country, with some of the quietest background noise levels in the world, could take a lead in environmental noise management. But perhaps New Zealand has benefited by being a long way from the main industrial countries and so can stand back and take a balanced look at what is going on and plan accordingly to avoid the hazards.

It is well known that, being a small nation and so far away from anywhere, New Zealand has been chosen by many manufacturers as the "guinea pig" on which to try out their products before placing them on more sensitive markets. It has also been ripe for big companies to dump on the market products unacceptable elsewhere. For example New Zealand also has the dubious honour of operating, it is believed, the last Stage 2 aircraft produced - aircraft that no-one else would buy. Such aircraft dominated the airport environment at a number of New Zealand's major airports for a time, but no longer: A series of noise management standards has been produced, and the first NZS 6805:1992 "Airport Noise Management and Land Use Planning" is having widespread effect.

The New Zealand Standard on Airport Noise NZS 6805 has been produced to help those authorities who have no noise control bylaw for their airports, or have existing bylaws that do not provide the protection necessary.

In essence; If an airport cannot arrange its operations so that no area outside the airport boundary receives and day/night sound exposure of 100 pascal-squared-seconds (pasques) - an Ldn of about 65 - then it must apply to the local territorial authority for permission to have a larger area in which to contain that amount of sound exposure. Sound exposure contours are predicted for a ten year period and presented for consideration. This is held in the public domain and the local territorial authority may allow the sound exposure in some areas but not in others. Eventually a line is drawn on the map - the "Airnoise Boundary" - enclosing the area in which the airport is to contain all sound exposure above 100 pasques. If agreement cannot be found, the case is put to the Environment Court for a decision. The final arrangement is put into law as a regulation which is based on the actual measured (not predicted) daily sound exposure averaged over an agreed period of time - a three month period is suggested (although no averaging is preferred). In some cases this may mean restricting the numbers of flights to achieve the desired sound exposure at the Airnoise Boundary, and a decision on how to allocate the number of units of sound exposure between the aircraft operators using the airport. The airlines then must plan their flight numbers and aircraft used so that their noise allocation is not exceeded at or outside the airnoise boundary. In a sense they are allocated a noise bucket that must not be allowed to spill over.

A series of noise monitoring stations at, or outside the boundary, maintain a watch on the noise exposure to ensure that the aircraft do not produce more than the permitted amount. Such a control does not protect from startle and sleep disturbance at night, and local authorities must consider whether some control at night is necessary – e.g., curfews, limiting individual noise events, limiting flights to certain types of aircraft etc.

The Airnoise Boundary Concept

1 The industry plans for the amount of noise it would like to emit for, say, the next 10 year period.

2 If the industry cannot keep all the noise above a certain level within its own property boundary, a request is put to the territorial authority, who discuss it in the public domain and decide the area in which the industry must contain the noise.
If necessary this will be by a Court ruling.

3 The industry is then obliged to keep its noise within the area allocated.

4 Strict land use controls are put on the affected area.

Very strict land use in this area compensates for the extra noise - the larger the airnoise boundary the more airport operations are possible but the more costly are the land use control measures within that boundary. The determination of where to put the boundary thus requires a considerable amount of thought. Local authorities have to balance the benefits given to the district, and the nation, by the airport operations against the costs to be incurred by the community to protect health and amenity. This may not be easy, but once the airnoise boundary is in place, noise management follows a fairly straightforward path.

Of special concern had been the possibility that pilots might be "encouraged" to undertake special noise abatement flight manoeuvres, so as to get more flights into their allocation, to the detriment of flight safety. The Standard therefore mandates that all flight operations shall follow standard operating procedures, that there shall be no deviation from these procedures and that there shall be no special procedures for noise abatement purposes to meet any unusual local situation. The Standard also mandates that if a control is in place to restrict noise at night, this control shall not apply to any flight that would normally have met the conditions but has been unavoidably delayed, nor shall it apply to any emergency nor to any rescue mission.

While a control at 100 pasques may well provide sufficient protection from a public health point of view, it can be argued that it does not provide sufficient protection of welfare or amenity for the area immediately outside the airnoise boundary. Hence a further control was deemed necessary: That of compatible land use zoning in the area where the noise exposure is likely to exceed 10 pasques - an Ldn of about 55. In essence this means setting a second (outer) control boundary where the noise exposure is not to exceed 10 pasques. As the location of this outer boundary is entirely dependent on the controls placed at the airnoise boundary, its actual position, unlike that of the airnoise boundary, may be based on prediction by a computer model, and no further noise exposure monitoring is needed. Tables 2 and 3 give the land use compatibility in the two control areas.[4]

Table 2 Criteria inside the airnoise boundary.

RECOMMENDED NOISE CONTROL CRITERIA FOR LAND USE PLANNING INSIDE THE AIRNOISE BOUNDARY

Sound exposure Pa^2s (1)	**Recommended control measures**	**Day/night level** Ldn (2)
>100	New residential, schools, hospitals or other noise sensitive uses are prohibited. Steps shall be taken to provide existing residential properties with appropriate acoustic insulation to ensure a satisfactory internal noise environment. Alterations or additions to existing residences or other noise sensitive uses shall be permitted only if fitted with appropriate acoustic insulation.	>65
>350	Consideration should be given to purchasing existing homes, or relocating residents, and rezoning the area to non-residential use only.	>70
>1000	There is a high possibility of adverse health effects. Land shall not be used for residential or other noise sensitive uses.	>75

NOTE –

(1) Night-weighted sound exposure in pascal-squared-seconds or "pasques".

(2) Day/night level (Ldn) values given are approximate for comparison purposes only and do not form the base for the table.

Table 3 Criteria outside the airnoise boundary.

RECOMMENDED NOISE CONTROL CRITERIA FOR LAND USE PLANNING INSIDE THE OUTER CONTROL BOUNDARY BUT OUTSIDE THE AIR NOISE BOUNDARY

Sound exposure Pa^2s (1)	**Recommended control measures**	**Day/night level** Ldn (2)
>10	New residential, schools, hospitals or other noise sensitive uses should be prohibited unless a district plan permits such uses, subject to a requirement to incorporate appropriate acoustic insulation to ensure a satisfactory internal noise environment. Alterations or additions to existing residences or other noise sensitive uses should be fitted with appropriate acoustic insulation and encouragement should be given to ensure a satisfactory internal environment throughout the rest of the building.	>55

NOTE –

(1) Night-weighted sound exposure in pascal-squared-seconds or "pasques".

(2) Day/night level (Ldn) values given are approximate for comparison purposes only and do not form the base for the table.

The metric

Accepting what at first glance appears to be a new metric - sound exposure in pasques - may be the hardest part of the noise management procedure, for old habits die hard. This is not a new metric, however, but the basic measure on which all other acoustical descriptors are based. Almost all sound logging meters, meeting Class 1 of IEC 61672 *Sound Level Meters*, capture the sound as small increments of sound exposure in pascal-squared-seconds (pasques) and from that data compute the descriptor of choice - in decibels or whatever. Remember:

- Sound Exposure Level is 10 times the logarithm of the sound exposure in pasques + 94 dB.

One pasque is 94 dB for 1 second and is A-frequency-weighted in environmental noise management. For the man in the street, one pasque is about the "volume" of noise one would get at kerbside from a noisy truck. Two noisy trucks would give two pasques, and so on.

For effective and transparent noise management, one needs a metric for sound exposure that can readily be summed, and not confused by the public with the metric for sound level. Retaining the decibel for sound level, but utilizing the basic measure in pascal-squared-seconds or "pasques" for sound exposure, considerably simplifies the noise management technique. Of course, before any noise management takes place, one has to be certain of the criteria to use and be able to justify its use in the public forum and in the High Court.

Justification

The justification of the noise exposure criteria used is of course extremely difficult. There has been a large number of studies on the effects of noise on community health and welfare. All seem to agree that below a noise exposure of about 10 pasques or 55 Ldn there is only a very small chance, if any, of an adverse health effect from the noise exposure alone. Most seem to be in agreement also that where daily noise exposures exceed about 1000 pasques or 75 Ldn, there may be serious adverse health effects and such an area is quite incompatible with the requirements for residential living.

There is a wide variation in thought, however, about where, in between these two exposures, adverse health effects become noticeable. This makes it difficult to place an upper limit on the aircraft noise exposure for the protection of community health without leaving oneself open to criticism. On the other hand, this author has found no substantiated research showing any adverse effect on community health for any daily exposure less than about 100 pasques (65 Ldn), although complaints and an adverse amenity value may be found for exposures down to about 10 pasques (55 Ldn).

These levels have therefore been chosen as the base criteria for environmental noise management in New Zealand. At night, sleep must be protected as well, so if an industry wishes to work at night, a maximum noise level at any residential boundary must also be set to avoid disturbance to sleep. The limit suggested for New Zealand is 70 dB, assuming a 10 dB attenuation by an open window, and 25 dB when closed, in the typical New Zealand house.

These criteria are used in present noise management in New Zealand for the want of better ones - although the die hard acoustical consultants for the airports successfully persuaded the Court that as elsewhere in the world aircraft noise was measured in decibels, it should be the same in New Zealand. So the criteria are given as day/night level rather than day/night sound exposure. If research in the future shows some other criteria to be more suitable, then at that time the management techniques can be changed to include this.

The standards produced in New Zealand are minimum performance standards. These may act as regulatory instruments under New Zealand's Resource Management Act 1991, which places an obligation on any occupier of land to ensure the emission of noise does not exceed a reasonable level, and this includes boats, trains and aircraft. The Act also places an obligation on the local authority (district or city council) to control any environmental noise and to mitigate any adverse effect. This applies also to the military who are bound by Act of Parliament to conform. Although they cannot be prosecuted for non-compliance, the Royal New Zealand Air Force is very active on noise management committees and has not been known to cause any infringement of the regulations.

If the local authority wishes to impose stricter noise limits than the Standards suggest, then it may do so, and this often is the case. If, in the other hand the local authority imposes less strict limits, or none at all, it has to answer with very good reasons to the Environment Court

Conclusion

It is believed that the airnoise boundary concept for airport noise management is feasible and practicable, and applicable to any aerodrome or airport irrespective of size. Use of the concept may greatly ease the related health problems around many busy airports, and yet still allow for necessary growth.

It is now one hundred and one years since the first complaint about aircraft noise. These last few months in Wellington complaints about aircraft noise have been minimal. There is no reason for airport communities to suffer from excessive aircraft noise. What is possible in New Zealand is possible anywhere else in the world.

References

[1] Picture kindly provided by the then editor of the Aeroplane Magazine August 1926
[2] The report on "Noise" by the Wilson Committee HMSO 1963.
[3] "The Second London (Heathrow) Survey." HMSO 1969
[4] New Zealand Standard NZS 6805:1992 "Airport noise management and land use planning."