AIRPORT NOISE RESPONSE AND ITS IMPLICATION TO THE BUILT ENVIRONMENT

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1.0 INTRODUCTION

The intensity of a reaction to noise is significantly affected by a wide range of social, physical and environmental factors. Aircraft noise is particularly sensitive to such non-auditory cues and such inputs can skew the response of an exposed population. This can be manifested as a change in the onset threshold of an adverse effect in an individual. Planning is concerned with populations and not individuals and this can result in conflict. This paper examines this conflict against the background of control of the adverse effects of aircraft noise.

2.0 OMEGA

The Omega group was set up to work closely with those at the front line of the aviation community to explore solutions that are practical and deliverable. Together with Cambridge and Cranfield, Manchester Metropolitan University leads this group with Leeds, Loughborough, Oxford, Reading, Sheffield and Southampton Universities being the other partners. Noise forms a significant part of the work of Omega and a number of workshops and studies reported on this subject. Omega sponsored an Attitudes to Aircraft Noise Workshop and a subsequent technical meeting for European researchers. The conclusions of these meetings were contained in the report of Omega(1) in 2008. Reporting on these meetings the report concluded that there is no doubt that the understanding of attitudes to noise was not fully mature. The Omega Community Noise Study(2) considered that the absence of a common language of reporting, communication and negotiation in relation to aircraft noise was a key obstacle to more effective noise management. To address this deficiency the study undertook a preliminary systematic evaluation of public understanding of conventional and supplementary noise metrics.

Classification	Example metric
Single event max Sound Level	L_{Amax} (dB)
Single event energy dose	SEL (dB) sound exposure level
Cumulative Energy Average metrics	$L_{Aeq,T}$ (dB) Equivalent sound level
Cumulative Time metrics	TA (mins) Time above in a period

Table 1 Aircraft noise metrics

Descriptor/indicator	Comment
Flight Path movements	Show individual movement or numbers of movements over a given period
Respite charts	Number of hours with no jet movements, expressed as a

	%age of the total number of hours during the period of interest
N70 Contours	Combine single event noise level information with aircraft movement data. Maps show number of events louder than 70 dB(A)
Person-Events Index	Allows total noise load generated by an airport to be computed by summing, over the exposed population, the total number of instances where an individual is exposed to an aircraft noise event above a specified noise level over a given time period.

Table 2 Supplementary indicators

The figures 1 and 2 below compare the presentation of primary and supplementary indicators.

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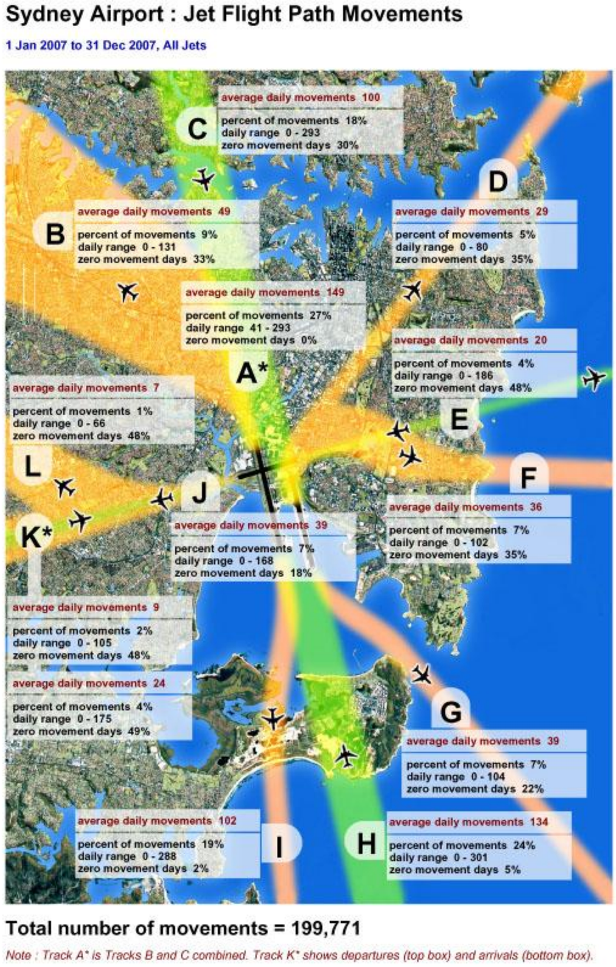

Figure 1 Sydney Airport 2004 & 2029 ANEF

Figure 2 Sydney Airport Total movements

The conventional metrics provide a legal and repeatable basis for Planning purposes but can obscure other important aspects in the assessment of airport noise effects. Supplementary indicators have made a positive contribution to the consultative process in planning the development of Australian airports.

3.0 THE PLANNING DILEMMA

This work, summarised in the Omega reports, neatly defines the dilemma that is presented to the aviation world. The bounds of this world being defined as all who are involved in or are effected by aircraft noise. The Planning element, as in land use planning, needs to have a defined area so that the discipline of Planning can function. It is not possible to have a plan led policy if a stable plan cannot be drawn. Lines on a map not only delineate areas of particular effect but also define areas of prescribed action. This is true of course not only of the consideration of aircraft noise but any other physical phenomenon. The need for a line also presupposes that the phenomenon has an element of stability and repeatability. No actions can be taken that are based upon a short term change. The question as to whether the noise is the same on, say, a Tuesday as on a Saturday has no relevance. A long term averaging process over say a year is required in order that short term fluctuations can be accommodated. This time can be broken down into Summer and Winter and can even include transition periods but essentially what is needed is a metric that repeats year upon year. It is only with such a defined line that communities can attempt to plan and implement a viable land use scheme. With such schemes once an area is subject to a particular allocation, say housing based upon a ‘suitable’ noise exposure value, then to all intents and purposes that area remains so defined for a considerable period. All noise affecting factors such as fleet noise levels, flight routing, operating procedures, curfew hours and so on are fixed. To do otherwise would prejudice Planning Policy. As a result that flexibility would be lost.

4.0 OPERATIONAL EFFECTS

On the other hand the aviation industry is addressing environmental factors and properties of noise and pollution are receiving a huge input in efforts to reduce the emissions of new aircraft. Such aircraft achieve much reduced noise levels over the previous generation of equipment. Attention is being directed towards operational effects and constant energy approach to airports, adherence to noise reducing procedures and suchlike all serve to potentially reduce noise exposure. These improvements are all measurable and event on event comparisons can be made. Whether these improvements have a real effect upon an exposed population that can be expressed in a measurable way will inevitably depend upon the method of measurement and the metric used.

As an illustration, the noise under the approach path can be reduced by 5-8 dB(A) for a single event by the adoption of the optimum approach procedure. In subjective terms this could be expected to be noticeable to an observer and a worthwhile reduction. If all aircraft arriving at an airport adopted these procedures then there is no doubt that an overall improvement in this phase of the airport operation would be registered. However arriving aircraft make up 50% of the airport movements and the other 50%, the departing aircraft, may not exhibit such an improvement in their particular operational phase. The max noise level improvement of the individual arriving aircraft would be present no matter what the other aircraft did. However, how this is reflected in the overall average equivalent energy metrics is not clear cut. Given that approach paths are subject to a large number of sometimes conflicting demands then it is not realistic to assume that there will be 100% usage of optimised approach procedures. Timing, weather, economics, safety, mixed generation fleets will all need to be optimised together with noise in order to operate the airport. Noise will receive its due consideration but it would be unrealistic to consider that the theoretical reductions attributable to a particular action will be achieved in practise.

5.0 THE NATURE OF COMMUNITY RESPONSE

There have been a number of large scale works that have examined the response of a population exposed to aircraft noise and related that subjective response to the physical noise exposure. These results can be drastically paraphrased into the statement that the percentage of an exposed population report being adversely affected increases as the level of the exposure increases. In essence a simple noise dose/response relationship. The results are of course related to the response of an exposed population and the noise exposure is related in most instances to an average energy exposure. Over time these relationships have been refined and have reached a stage where the correlations are probably as good as they can be.

However, it is undeniable that this situation does not allow the reaction of an individual to be predicted on any particular occasion. The variation of individual response is too wide and the variation of noise exposure day by day and hour by hour is again too wide. Examination on a global scale is not helpful in this context. A smaller scale approach is required.

6.0 CONSIDERATIONS APPLIED TO THE BUILT ENVIRONMENT

The built environment encompasses dwellings, places of recreation, teaching institutions, retail areas and indeed anywhere where the local conditions are affected by the enclosing building. Added to this should be the areas that are adjacent to the buildings and ancillary to their use. In the domestic context this would include gardens and amenity areas and in the urban context areas of public open space in proximity to the main use. The built environment will affect both the reaction of exposure to the noise and could mitigate the adverse effect of the noise.

In all cases these will be localised effects and it is probable that defining noise response in terms of energy equivalent noise levels is not appropriate. There are many ways in which the nature of the built environment can affect the noise exposure from aircraft:

Mechanism	**Built characteristic**
Reflection	Plane surfaces
Focussing	Combination of surfaces
Shielding	Intervening surfaces
Masking	Generation of sounds
Modification	Surface absorption

Table 3 Control of aircraft noise

In areas close to the airport the noise management aim can only be to prevent the noise from entering the living or working space. Sealed buildings with noise reducing facades become the norm. Double and triple glazing and mechanical ventilation become the basic and essential design standard. Outdoor areas do not become attractive places for recreation, at least not for a recreational purpose that needs a degree of quiet. There are of course dwellings in such areas of high event noise and high frequency of occurrence but it is the common Planning position that dwellings are not built in such areas. The commonplace LAeq,T indices serve to define areas of high exposure and as they are also commonly also areas exposed to a high frequency of occurrence , this method is sufficiently robust.

As with all actions that are determined by relationship to a particular iso-line the question is raised as to what is the consequence of being just inside or outside the line. The inference in

Planning terms is that if the area in question is outside the line then a different action is taken to being inside the line. In terms of the likely reaction of an individual, or indeed a population, this cannot be so clear cut and a graded response is more likely. This philosophy is included in land use planning policies, typified by PPG 24[3] in the UK.

NEC	Qualifying Noise Level	Planning Action
A	Day <57 Night <48	Noise need not be considered as a determining factor in granting planning permission, although the noise level at the high end of the category should not be regarded as a desirable level.
B	Day 57-66 Night 48-57	Noise should be taken into account when determining planning applications and, where appropriate, conditions imposed to ensure an adequate level of protection against noise.
C	Day 66-72 Night 57-66	Planning permission should not normally be granted. Where it is considered that permission should be given, for example because there are no quieter sites available, conditions should be imposed to ensure a commensurate level of protection against noise.

Table 4 Noise Exposure Categories related to Planning actions.

It is very relevant to bear in mind that the requirements of this table are directed at new residential development. They are not directed at new noise sources affecting existing residents or to changes in existing noise sources affecting existing residents.

The guidance note does not set out what are desirable levels but it does suggest that levels of aircraft noise at 55-57 by day and 46-48 by night are not desirable.

The guidance note does not offer advice on the adequate level of noise protection in NEC B, nor does it offer advice on the commensurate level of noise protection on zone C. Presumably more protection is required in zone C than zone B but are the target levels that are sought to be met the same in either zone. Can it be assumed that the target level in either or any case is the same level of exposure that would be considered desirable in zone A.

The widely quoted threshold for the onset of annoyance from aircraft noise is 57dB $L_{Aeq,16hr}$ by day based upon a number of studies and social surveys and 48 dB $L_{Aeq, 8hr}$ based upon the1994 WHO guidelines and expediency.

It is worthwhile to look outside those areas that are exposed to lower values of LAeq,T but where adverse noise effects, as demonstrated by the response of residents, at certain times may be significant. Taking Heathrow as an example and the area beneath the stacks as a case in point. The airport becomes fully open to traffic at 0700 and to a limited range of aircraft at 0600. Long haul aircraft seek to arrive at the airport as early in the day as possible and this puts pressure on the system before the 0600 and 0700 times. In order to exert a measure of control and to prevent bunching on the approach an aircraft stacking system is employed. These accept aircraft at the top and they circle becoming gradually lower before being directed from the bottom of the stack by NATS to join the queue to complete their landing at Heathrow. A consequence of the procedure is that aircraft congregate at some distance from the airport where they are concentrated into a relatively small area. They are losing height in a turn for some time and cannot adopt a low drag constant power procedure as frequent changes of power are required to maintain the appropriate turn, rate of descent and departure from the stack. The low ambient levels that are present before 6am and the changes in engine noise serve to exacerbate the impact of the aircraft noise. After about 9am and until 9pm ambient levels rise and the noise effects of the stacks are reduced. Nevertheless the stacking procedures that are presently utilised , bearing in mind that they are most noticeable at times of the day of great sensitivity to noise, result in adverse reactions greater than would be expected by the consideration of the average energy metric.

In terms of PPG 24 metrics the noise exposure of these areas are not a consideration. However, these trigger levels are based upon a WHO guidance that has now been significantly changed. Taking nighttime as an example the 1994 guidance was that the exposure should not exceed 35 dB LAeq within bedrooms in order that the restorative proves of sleep be preserved. The current guidelines considering the scientific evidence on the thresholds of night noise exposure indicated by Lnight, outside as defined in the Environmental Noise Directive (2002/49/EC), an Lnight, outside of 40 dB should be the target of the night noise guideline (NNG) to protect the public, including the most vulnerable groups such as children, the chronically ill and the elderly These are external noise levels and should be compared with the approximately 50 dB outside guidance level at the time of the PPG formulation. Clearly the NNG levels represent a considerable raising of the WHO guidance standard. A reduction of around10 dB for the new target level. If these new levels were to be incorporated into a revised PPG then for new dwellings the boundary of the NEC A zone would be at 47 dB by day and 38 dB LAeq at night.

Two important points must be made

> The standards that are applied to the judgement of aircraft noise should be significantly revised.
>
> The reaction of the population outside the lowest NEC zone should be seriously considered.

In terms of the built environment this imposes a raised performance level. This performance can only be achieved by employing the entire armoury of construction and design techniques. In some cases there will be conflicting demands. For example the attenuation performance of the building envelope may be degraded by the need for natural ventilation. Sustainability and energy conservation may conflict with the need for building mass. Land use pressures will inevitably be seriously exacerbated. Similar pressures will be imposed upon the aviation community. Source noise levels have to be reduced. Noise and operational sustainability procedures will need to be implemented.

7.0 TOWARDS ACCEPTABLE CONDITIONS

The increasing demand for acceptable noise conditions, a demand that will intensify globally as living standards generally improve, require that all available measures are used to address the problem.

For new development the first action, albeit one which may be coarse in its effect, is the land use planning aspect related to the energy noise exposure of the area. After the categorisation of the area comes a finer grained approach to examine the nature and properties of the potential effects.

These studies would lead into the design of the particular development. Questions as to the need for building attenuation performance, the means and degree of assisted ventilation should all bear on the basic specification of the dwellings. This basis specification would be further modified by the nature of the exposure. Is the area primarily exposed to approach noise, or is it departure noise, or indeed is it mixed. Is the area directly under a flight path or is it off to one side. The mode of exposure would give indicators as to the possible mix of frequency spectra. This would lead back to the specification of the building fabric. It would also inform decisions on the orientation of the individual buildings and the position of air handling vents.

As matters of site layout are addressed, the interaction of buildings in respect of reflection and shielding become important. Ancillary site facilities such as public open space, retail, educational and leisure are all important factors and influence the overall expectation and experience of noise in the area. Introducing masking and enhancing noise can influence the response of the occupants of the area.

All aspects of noise as it affects and influences overall satisfaction with the area should be considered holistically. A similar approach should take place when consideration is being given to the development of the airport and its facilities. Noise is an inevitable consequence of such development and without proper procedures to effectively take it into account there will equally inevitably be a constraint imposed upon the provision of air services.

REFERENCES

1. I H Flindell Attitudes to Aircraft Noise, Omega MMU 2008
2. P D Hooper et al, Cummunity NoiseStudy, Omega MMU 2009
3. PPG 24 Planning and Noise, Department of the Environment September 1994, HMSO

ABSTRACT

The intensity of a reaction to noise is significantly affected by a wide range of social, physical and environmental factors. Aircraft noise is particularly sensitive to such non-auditory cues and such inputs can skew the response of an exposed population. This can be manifested as a change in the onset threshold of an adverse effect in an individual. Planning is concerned with populations and not individuals and this can result in conflict. The conflict can generate difficulties in the derivation of land use planning procedures and influence the manner and measures taken to control noise in the built environment. This paper examines this conflict against the background of control of the adverse effects of aircraft noise.

The paper sets out the views of the Author which may not be shared by Manchester Metropolitan University.