THE UNITED KINGDOM AIRCRAFT NOISE INDEX STUDY PART I - MAIN RESULTS

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INTRODUCTION

The Noise and Number Index (NNI) has been used over the past two decades in the UK for the assessment of noise nuisance arising from aircraft flights at major civil airports. The UK Department of Transport (Civil Aviation Policy Division) commissioned this study to either substantiate the NNI for continued use or, if necessary, devise a new index of noise disturbance. Because an aircraft noise exposure index could be crucial to development decisions for many years - probably the rest of this century - the study required careful design in regard to the statistical sampling involved.

This paper presents a synopsis of the criticisms of the NNI relevant to study design, and then details the planning, execution and main results of the study. The companion paper [1] examines the statistical modelling and analysis involved in matching disturbance to noise exposure. An extensive account of the study methodology and results is given in the main report [2].

THE NNI: HISTORY AND CRITICISMS

The aircraft noise index NNI has been used in the UK since 1963. NNI is defined by -

$$NNI = L + 15\log_{10}N - 80.$$

Here L is the logarithmic average peak noise level heard, expressed in PNdB, and N the number of aircraft heard: 'heard' is taken as $\geq$ 80 PNdB and all variables are measured during the day (0700-1900 BST) during three summer months each year. The NNI summarises the relationship between annoyance and physical variables as determined in a social survey in 1961 of a sample of 1731 in the vicinity of Heathrow airport [3]. Annoyance here has a precise meaning: it is the average reaction from a group of people exposed to a similar noise 'climate' - an individual's reaction being assessed from responses to a set of questions asking about annoyance, particularly in the context of interference with certain specified activities. From these responses an annoyance 'score' is calculated, ranging from zero to 6 in unit steps - the score on the Guttman Annoyance Scale (GAS - [4]). A contour of 55 NNI around an airport is taken to indicate the area of high annoyance: a contour of 35 NNI is taken to indicate the threshold of community annoyance.

Over the last two decades NNI has, on the whole, been accepted by Inspectors and Assessors at Public Inquiries into airport development as a well-based planning tool. A number of criticisms have been made by Inquiry participants and in the technical literature. The following points are those most relevant to the need for and design of this study (see [5] for more details).

The NNI is out of date: The continued use of the NNI has been criticised on the basis that annoyance responses and/or the nature of the aircraft noise environment have changed since 1961. People's reaction to aircraft noise, as measured by a scale such as GAS, could have changed because of general shifts in attitudes to disturbance or through changes in the importance of activities (eg watching television, listening to 'Hi-Fi') used in constructing annoyance scores. In addition there have been changes in the aircraft noise environment: at Heathrow in 1961 out of around 150,000 movements about a quarter were jets, currently with around 280,000 movements nearly 90% are by jets - a quarter of these by wide-bodied aircraft.

The NNI is 'out-of-line' with indices used elsewhere: A large number of indices have been used in other countries. Some were based, to some extent, on studies akin to the present one; some rely on psycho-acoustic experiments; some appear to have been developed from the equivalent continuous noise level measure, L_{eq}, from information on complaints, social surveys and 'expert opinion'. Increasingly the tendency is to use L_{eq}-like indices, ie with (approximately) a 10log N term rather than 15log N; to count all aircraft movements during the 24 hours; to 'weight' movements at certain times, eg the 10dB penalty on night movements in the USA Index L_{dn}.

The NNI does not weight the number of aircraft adequately: Residents affected by plans for airport development have consistently argued that the 15log N dependence is not 'strong' enough, ie a higher coefficient or a term linear in N would be more appropriate. Technically the argument has been that the 1961 study results have been excessively extrapolated.

The effects of background noise have not been taken into account: The argument is that road traffic noise affects the perception of aircraft noise. For example, in a rural environment the background noise would generally be lower than in 'suburbia' and would result in the 'peak signals' of aircraft noise events being more noticeable and more disturbing. This has been the subject of a complementary study [6] and there is also a European Community study (with UK participation) in progress. Quoting from the conclusions to [6]: 'There is no strong evidence to suggest that background noise plays a significant role in the annoyance responses to aircraft noise for all levels of aircraft noise.'

Other factors: There are a number of criticisms of the NNI relating to its functional form. These are listed briefly here (see [5] for a full account):

: The effects of runway use on disturbance.

: Duration of aircraft noise.

: Diurnal/Weekly/Seasonal patterns.

: The absence of airport dependent factors, ie resulting from people's reaction to a particular airport rather than measurable variables.

STUDY DESIGN

Three objectives were identified by the Department of Transport and the study team:

(a) An aircraft noise index should enable decisions to be made on as equitable a basis as possible.

(b) The use of the index should be substantiated by reference to measured data.

(c) The nature of disturbance around the 'London' airports - Heathrow, Gatwick and Stansted - should be reflected.

It must be borne in mind that the extent of disturbance at Heathrow is more than an order of magnitude greater than any other UK airport. For example, over a million people currently live within the Heathrow 35 NNI contour compared with less than 40,000 at Gatwick, while for 55 NNI the approximate figures are 40,000 and 1,000 respectively. Manchester and Gatwick airports are comparable in their environmental impact. Because of Heathrow's 'dominance' the major part of any UK-based study needs to take place in its environs.

The general approach adopted in the study was to investigate disturbance from aircraft noise within a number of geographically small communities, in each of which the exposure to external noise levels from aircraft is approximately the same - common noise areas so-called. This obviates the need for extensive noise measurement/interpolation or reliance on a noise contouring program predictions. With regard to the latter, direct measurements of the noise environment do add to public confidence in the results: a noise contouring estimate is generally quite adequate, but its predictions are sometimes in error when cautious assumptions (ie leading to over-estimates of noise exposure) have been made in modelling.

The aim was to choose samples of sufficient size in a spread of common noise areas so as to provide an adequate statistical substantiation for the index characteristics. As is probably evident from the earlier discussion here on criticisms of the NNI, the crucial task was to distinguish between the relative merits of NNI and L_{eq}. The major difference between the two is the trade-off between L and N, as discussed earlier.

A general linear index of disturbance, of the form L + klogN, can be identified in a statistically efficient manner if sampling from as large a range of L and N as possible is achieved, and if the sample design decorrelates L and N as much as possible. (Note that the 1961 study was concerned, in part, with 'painting the environmental picture' around Heathrow - a different objective from the identification of a noise index.)

A matrix of L-N combinations formed the base for the design; L ranging from about 80 PNdB to 104 PNdB, N from around 24 to 400. Areas with L and N increasing together were eliminated, whilst areas with high L-low N and vice versa were in some cases double-sampled (which was also more economical in noise measurement). As noted earlier the concentration was on Heathrow areas, but a selection of non-Heathrow locations was added. The final design included:

Heathrow	-	20 areas
Gatwick	-	2 areas
Luton	-	2 areas
Manchester	-	1 area
Aberdeen	-	1 area

(Here double-sampled areas are counted as two areas.)

A total of 2097 people were interviewed, some during 1980, the majority during 1982, ie about 80 in each area. The questionnaire used was based on the 1961 version, but included improvements from a second survey in 1967 (which had not yielded conclusive results regarding the use of the NNI) and from research studies carried out by Ollerhead et al during the 1970s (see [5] for discussion and references). Disturbance measures constructed from questionnaire responses are discussed in part II [1].

Noise measurement was mainly by automatic monitoring equipment: attending monitoring with sound level meters/tape recorders was necessary at some 'low' L sites, so as to identify individual aircraft events. All measurements were made at single sites located centrally within the common noise areas. At least 22 days of measurement were made at each site. With the help of Air Traffic Control Runway logs, noise metrics of peak noise level, number of aircraft and L_{eq} were calculated for different 'thresholds' (cf $\geq$ 80PNdB) and for different periods (one week - three months before the survey) and for different time periods (day, evening and night). Fuller details are given in [2].

STUDY CONCLUSIONS

The results of social survey and noise measurement are given in [2] which also examines the match between disturbance and noise exposure - summarised in II [1]. Brief conclusions are as follows - the main report [2] section 9 should be consulted for fuller details:

(a) The study has been successful in disentangling the effects of aircraft noise level and number.

(b) GAS is a good measure of disturbance, which agrees well with other scales, eg the proportion of people 'very much annoyed' in the community.

(c) The 'trade-off' of 15 is not confirmed by the study results: a value of 9 or 10 is estimated - this is unlikely (ie statistically significant at the 5% levels) to be merely a result of sampling fluctuations from a true value of 15. A stronger dependence on N than the logarithm form is not indicated.

(d) Noise events below 80PNdB should be included in an index calculation.

(e) Aircraft movements in the evening and night should be incorporated in an index, but there is no marked evidence of the need for any weighting of movements at these times (cf L_{dn}).

(f) A good fit to disturbance response is given by 24 hour L_{eq} averaged over the week before the social survey. This averaging period was in preference to an average over a longer time (eg the three months for NNI) or to the exposure when the airport runway operations were at their worst for each location. (This does not of course specify over what period of time an airport's annual noise exposure contours should be specified - [2] section 9 discusses further.)

(g) No marked airport dependence was detected.

(h) Several 'confounding factors', ie socio-demographic variables, affected the response, in particular the proportion of respondents who work at or who have business at the airport.

(i) There is some indication of a 'step' in response at around 57 L_{eq}.

STUDY IMPLICATIONS

It was not the purpose of the Study to make policy recommendations - that is the responsibility of the sponsor, the Department of Transport. Technically, on the study results, L_{eq}, measured over the 24 hours, is a better descriptor of the disturbance responses than NNI. However, there is a close match between L_{eq} and NNI and it can therefore be argued that the use of NNI will not have led in the past to any major mis-statement of the environmental problems around airports.

In the future major problems could occur because of the 80PNdB cut-off used in the NNI. Larger numbers of less noisy aircraft would result in the NNI under-estimating the disturbance which the use of L_{eq} would predict.

Approximate equivalents are:

35 NNI - 56 L_{eq},
55 NNI - 70 L_{eq},

a linear interpolation generally being adequate between these values for most current airport noise environments.

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