A NATIONAL STUDY OF ATTITUDES TO AIRCRAFT NOISE, AND WILLINGNESS TO PAY

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1. BACKGROUND

Noise from aviation sources can be an important issue for many residents living near major airports. The Government has kept itself informed about airport noise issues by commissioning, from time to time, surveys of attitudes to noise from aviation sources in residential areas around major airports. Similar surveys have been carried out in many other countries around the world.

Over the past 40 years, several UK studies have sought to quantify the relationship between the amount of aviation (primarily aircraft) noise and the degree of community annoyance that it gives rise to. These enable government and planning authorities to be better informed in their decisions regarding the aircraft noise environment. This paper presents findings from research commissioned in 2001 by the Department for Transport to contribute to informed decision making in this area. Further details of the research are reported in '*Attitudes to Noise from Aviation Sources in England*' (ANASE).

Prior to this study, the last major survey of attitudes to aircraft noise in the UK was carried out in 1982 and reported in 1985. This was the United Kingdom Aircraft Noise Index Study (ANIS study**)** which assessed the then existing Government method for measuring aircraft noise around airports, using the Noise and Number Index (NNI). The NNI took into account both average sound levels and the numbers of aircraft noise events exceeding a sound level threshold of 80 PNdB (approximately equivalent to 65 dBA) in a defined 12-hour busy summer daytime period. It included a 'noise and number trade-off' factor of 15 which meant that each doubling or halving of the numbers of aircraft noise events was considered equivalent to a 4.5 dB increase or decrease in average sound levels. Based on previous research carried out in 1961 and 1967, values of 35, 45, and 55 NNI had been considered broadly equivalent to low, medium and high annoyance.

ANIS was based on research carried out at Heathrow, Gatwick, Luton, Manchester, and Aberdeen airports. It concluded that the NNI placed too much weight on the number variable and that a trade-off factor of 9 or 10 would provide a better fit to the data. A trade-off factor of 10 means that each doubling or halving of the numbers of aircraft noise events is considered to be equivalent to a 3 dB increase or decrease in average sound levels. Based on the results of the ANIS study, the government concluded that the NNI should be replaced by a different index – Leq. This index measures the total amount of “acoustical energy” received at a point, averaged over a specified period of time, and therefore also accounts for the duration of noise events. Furthermore, the ANIS study suggested that, on a 24-hour basis, “55 Leq could be used to represent the onset of community disturbance”. The study also noted that, although according to some of the measures tested, there was some evidence of a rapid increase in reported response around this value, the decision on the value of Leq for policy purposes needed to be judgemental since there was "a smooth, almost linear, variation of disturbance with Leq". Following consultation, the UK Government in 1990 adopted the current 16-hour (07:00-23:00) basis for Leq (DORA report 9023, 1990). It defined the 57 dBA Leq contour as being broadly equivalent to the onset of annoyance, superseding the 35 NNI contour which had previously been taken as an indicator of low annoyance.

Since 1982, however, the overall amount of air traffic has increased significantly whilst the sound levels generated by individual aircraft events have been significantly reduced as older, noisier aircraft types have been replaced by more modern aircraft types with quieter engines and much improved climb performance. In addition, it is possible that attitudes to aircraft noise may have changed due, for example, to the general growth in personal income, and that the aircraft noise indicator adopted after the 1982 ANIS study (Leq) may be less appropriate for present day conditions. It was therefore considered timely to see whether the current understanding of the links between reported annoyance and aircraft noise levels still held.

2. OBJECTIVES

The stated objectives for the ANASE research were as follows:

- re-assess attitudes to aircraft noise in England;
- re-assess their correlation with the Leq noise index; and
- examine (hypothetical) willingness to pay in respect of nuisance from such noise, in relation to other elements, on the basis of stated preference (SP) survey evidence.

3. METHODOLOGY

The research comprised two main phases. Phase 1 examined a number of issues relating to the study scope, in the form of a series of pilot studies. Phase 2 comprised a national survey to explore the attitudes and values of a representative sample of residents in close proximity to some of the major airports around England.

In addition to these two main phases, there was an interim task, known as the Comparative Performance Trial (CPT), which served as a “rehearsal” for the full set of survey and analysis procedures required in Phase 2. This minimised the risks for the Phase 2 fieldwork. Hence, not only were the general methods of presentation and analysis carefully developed and piloted throughout Phase 1 of the work, but what was effectively an extended pilot of the finalised survey was carried out prior to the commitment of the full fieldwork programme.

The Phase 2 survey methodology began by identifying aircraft noise exposed areas within England which were suitable for the study, both in terms of identifying the airports themselves and then defining the spatial envelope surrounding them, outside of which it can be assumed that aircraft noise is only faintly audible. Within these aircraft noise exposed areas, a means of stratifying the population according to the characteristics of the aircraft noise to which it is exposed was developed. Areas were selected to populate a ‘matrix’ dimensioned by average event sound level (L) and number of movements (N). The sampling methodology ensured that, within each stratum, all residents of every candidate area had the same probability of selection.

Interviews were undertaken at 2,733 households in 76 different sites. At the higher noise sites, a total of 2,132 interviews were undertaken (around 60 in each of 36 randomly selected sites). At the lower noise sites or sites close to airports with irregular aircraft traffic, 601 interviews were undertaken (around 15 interviews in each of 40 randomly selected sites). The maximum variation in LAeq within each site was limited to 3.5dB, so as to ensure that respondents within each site were responding to a narrow range of aircraft sound levels. (LAeq denotes an A-weighted value of Leq, and is the most common way of measuring aircraft sound levels. That is, it measures aircraft sound levels using an A weighting filter that reduces the sensitivity of the measuring instrument to low frequency and to very high frequency sound to approximately correspond to the frequency sensitivity of the average human listener).

The survey was undertaken during the period August 2005 to February 2006.

Prior to analysis the social survey data was weighted to correct for response bias (e.g. older residents being more or less likely to participate) and correction for household size.

A sound level measuring and modelling exercise was carried out in parallel with the social survey data collection, to derive aircraft sound level estimates for each respondent. The particular metrics required for the study were estimates of: LAmax, the maximum sound level received during a single aircraft noise event, LAeq, average numbers of aircraft events above an LAmax of 65dB (Nav), and average sound level (Lav and SEL) of aircraft events above an LAmax of 65dB (Lav). In reality, it was only possible to estimate LAeq values for the population-weighted centroid of each CNA. LAmax was adopted as a proxy for measuring aircraft sound levels in areas where aircraft events were so irregular as to make it impossible or meaningless to derive a value of LAeq with any degree of precision.

Key inputs to the noise modelling process were Air Traffic Control (ATC) data from each airport where the social survey was carried out; and monitoring data collected as part of the ANASE study to calibrate the modelled results. The model used to calculate sound levels at every site was the Integrated Noise Model (INM) v6.2.

At each stage of the Phase 1 and Phase 2 work, the findings were scrutinised by independent review bodies. Four distinct advisory project committees were established during the course of the study: *a Steering Group* (to oversee the development of the study); *an international Peer Review Group* (international experts from whom the DfT obtained advice); *an SP sub-group* (subset of SG members with SP expertise, and invited SP experts from the transport and environment fields); and *a Non-SP sub-group* (technical experts who reviewed the non-SP analytical and modelling results).

4. REPORTED ANNOYANCE

Respondents were asked two versions of the ISO standard noise annoyance questions, directly relating to their annoyance with aircraft noise:

"Thinking about the last 12 months or so, when you are at home, how much does noise from aircraft bother, disturb or annoy you: Not at all, Slightly, Moderately, Very, Extremely?"

"Thinking about the last 12 months or so, what number from zero to ten best shows how much you are bothered, disturbed, or annoyed by aircraft noise?"

Analysis of the responses between these two questions showed that there was a high correlation of 0.89 between these two sets of responses, and the subsequent analysis focused on the first question.

A principal objective of the study was to consider the relationship between annoyance and LAeq. As LAeq is only available at site level, the majority of the analysis was carried out at site level.

In order to obtain a single annoyance score for each site, it was necessary to combine the responses, and this was carried out in two ways:

- Calculating a mean annoyance score; and
- Calculating the percentage of respondents who were annoyed to a given degree.

The calculation of the mean annoyance was carried out in line with research undertaken by Miedema and Oudshoorn, who transformed all annoyance scales to run from 0 to 100. The distribution used in the ANASE survey, matched the definition used by Van Kempen and Kamp which scores the standardised 5-point noise annoyance scale as 10, 30, 50, 70 and 90 points on the Miedema and Oudshoorn scale:

- Not at all annoyed 10
- Slightly annoyed 30
- Moderately annoyed 50
- Very annoyed 70
- Extremely annoyed 90

Figure 1 shows the proportions of respondents that are at least slightly annoyed, at least moderately annoyed and at least very annoyed plotted against the mean site annoyance score. The scatter points show the expected shape (ie “at least slightly annoyed” rising quickly and then flattening, “at least moderately annoyed” rising steadily across the range of mean annoyance, and “at least very annoyed” rising slowly at first and then increasing steadily).

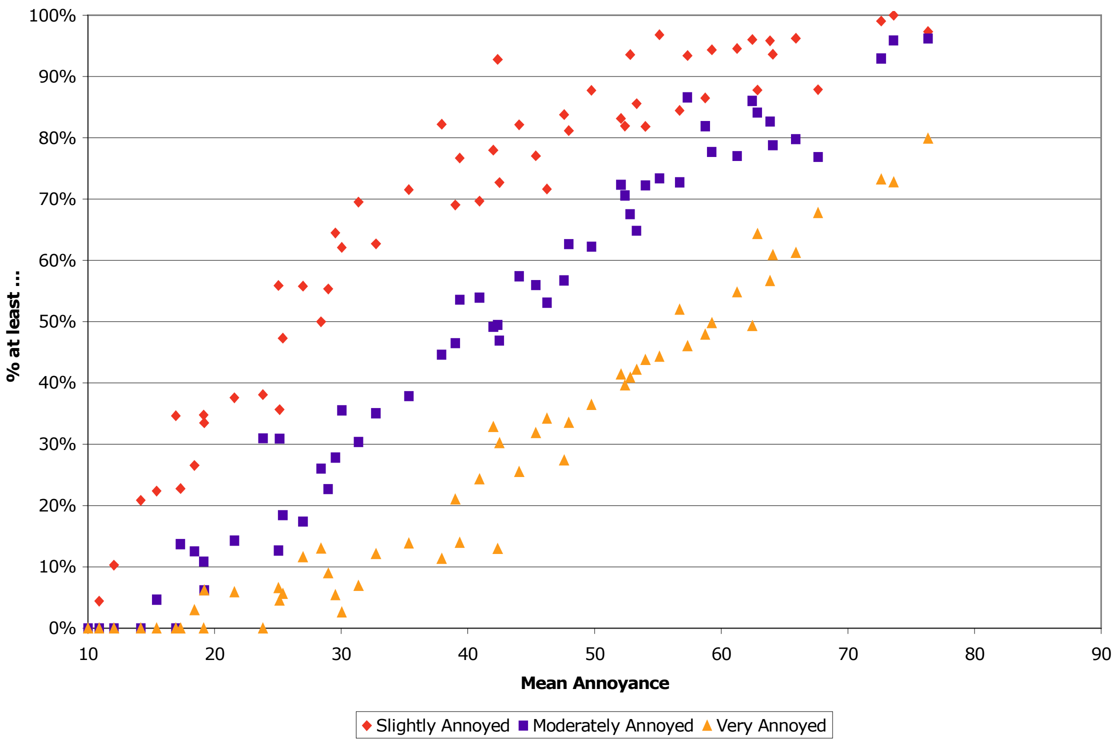


Figure 1 Comparison of Annoyance Metrics

Given the strong relationships between each of the annoyance categories and mean site annoyance, and the fact the mean score contains potentially more information, the main analysis was carried out using LAeq and mean site annoyance.

Figure 2 shows the mean annoyance against LAeq. 56 sites are included in this plot as it was not possible to obtain reliable LAeq data for the 20 sites close to the airports with irregular traffic. The figure shows that as the sound level increases, then the reported level of annoyance also increases.

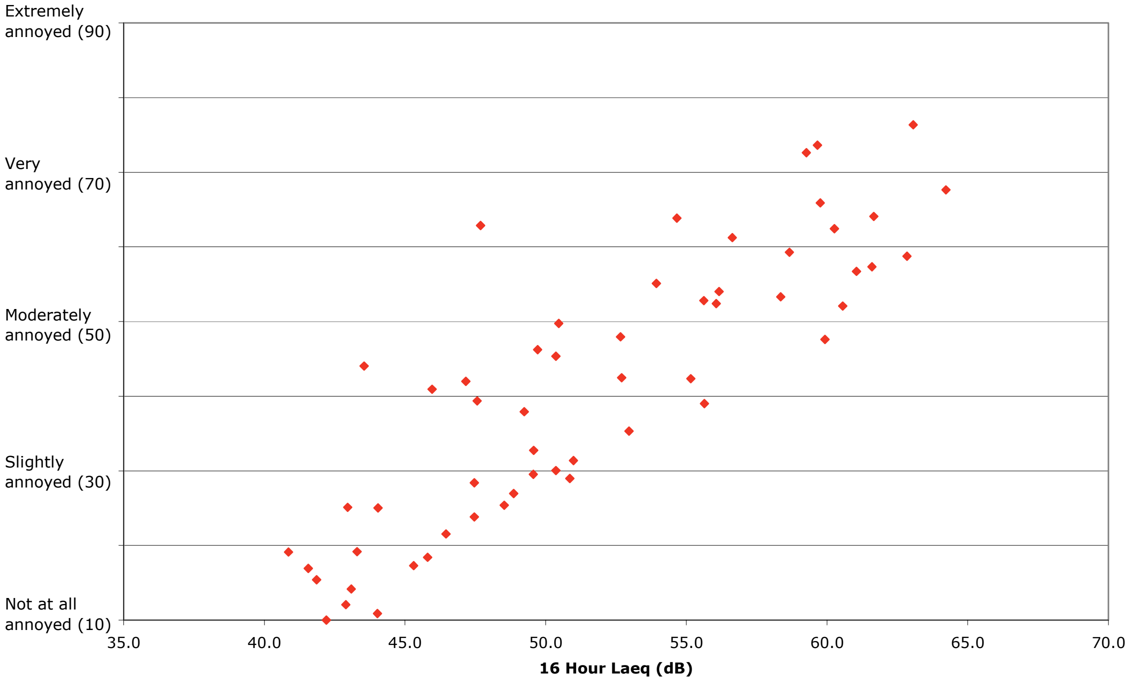


Figure 2 Mean Annoyance against LAeq

To understand this relationship in more detail, models were developed using regression analysis that attempted to relate the reported annoyance, defined by their mean annoyance score with the sound level metric LAeq.

Criteria for a satisfactory model include:

- the explanatory power of the model (indicated by a high R^2 value);
- the plausibility of the mechanisms suggested by the model (especially the signs of the relevant coefficients);
- the significance of each independent variable (indicated by high t-ratios);
- economy in terms of the numbers of variables used;
- (ideally) the inclusion of variables which are both relevant and predictable in the policy context; and
- random distribution of the residuals.

The simplest model form was the "Basic Linear Model":

Mean annoyance = a + b x LAeq

using the weighted mean annoyance score and the 16-hour LAeq value applying to the site.

The estimated model is:

Model 1 Mean Annoyance = -80.0 + 2.3 x LAeq

R^2	Adjusted R^2	N	Intercept	LAeq coefficient
0.739	0.734	56	-79.95 *(-8.09)*	2.34 *(12.35)*

In this and all later models, the bracketed figures are the t-ratios corresponding to the coefficients; values greater than about 2.0 (for a sample of this size) indicate coefficients that are significantly different from zero at the 5% confidence level, meaning that there is less than a 5% likelihood that such differences could have arisen by chance. T-ratios above about 2.6 indicate values with a 1% confidence level. Both the constant and the LAeq coefficient are significant at the 1% level in this model.

The R^2 value expresses the proportion of the overall variation in mean annoyance that is explained by the model; Model 1 suggests that just under three-quarters of the variation in average reported annoyance between sites can be explained by LAeq alone. The adjusted R^2 value takes account of the number of variables used; this allows models with different numbers of variables (degrees of freedom) to be compared on a like-for-like basis.

The coefficient on LAeq indicates the change in the mean annoyance score which results (on average) from a difference of 1 dB in the LAeq index.

Model 1 explains a high proportion of the variation, using just one behaviourally plausible and predictable independent variable of the expected sign (annoyance increasing with LAeq) at a high confidence level.

The data for mean annoyance are plotted in Figure 3, showing the relationship with LAeq in Model 1. Curves have also been plotted as a means of identifying sites that appear as outliers from the modelled relationship. (The curves identify the area within two standard errors of the modelled relationship at the mean values of LAeq, rising to three standard errors at the extremities.)

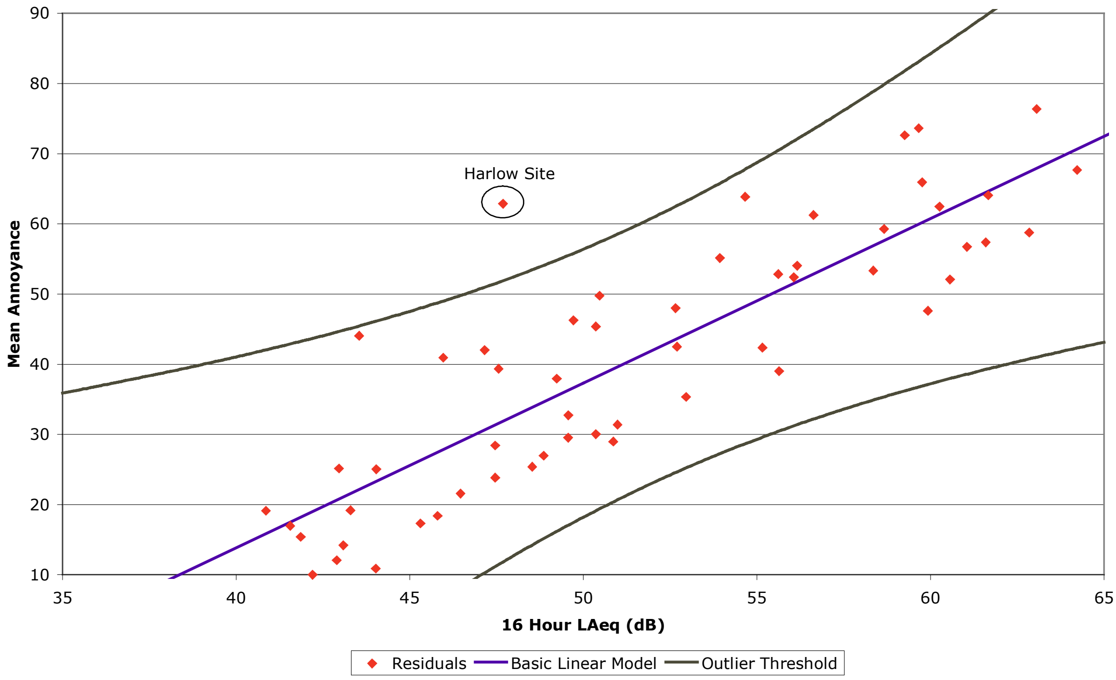


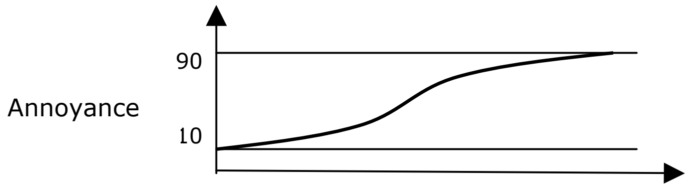
Figure 3 Basic Linear Model of Mean Annoyance against LAeq

Only one site has much higher annoyance levels than expected: a site in Harlow, about 19km from Stansted Airport. Of course, with 56 sites in the model, such a result is not unexpected (we would expect 5% of sites – ie about 3 – to lie outside the range of ± 2 standard errors).

It should be remembered that the mean annoyance scores are based on (typically) 60 respondents at the noisier sites, and 15 respondents at the quieter sites. As the quieter survey sites are based on less data, we can have less confidence in the mean annoyance scores. Regressions were carried out with the full survey sites being given greater weights than the restricted survey sites, but these models were very similar to the unweighted models, with a smaller R^2 value, indicating a poorer fit to the data (as would be expected from the smaller sample sizes).

A characteristic of the estimated model is that for values of LAeq less than 38, the mean annoyance will be less than 10, which is not possible as the 'not at all annoyed' score was given a value of 10. Similarly, for high values of LAeq (above 73), the model will predict that the mean annoyance is greater than 90 (extremely annoyed). This is a drawback of the basic linear model. Different types of models which are constrained to low and high levels of mean annoyance were therefore considered.

One such type of model is the logistic model, which can be adapted to cater for general upper and lower bounds, in this case between 10 and 90.



Non-linear least squares regression has been used to estimate the logistic model:

Model 2 **A = 10 + 80 / (1 + exp (7.32 – 0.13 x LAeq))**

R^2	Adjusted R^2	N	Constant	LAeq coefficient
0.729	0.733	56	7.32 *(10.34)*	-0.13 *(-10.01)*

The adjusted R^2 value for the logistic regression is only very slightly lower than the adjusted R^2 value of the basic linear model (a value of 0.733 compared to 0.734), indicating that the two models fit the annoyance data equally well. Both models are shown in Figure 4.

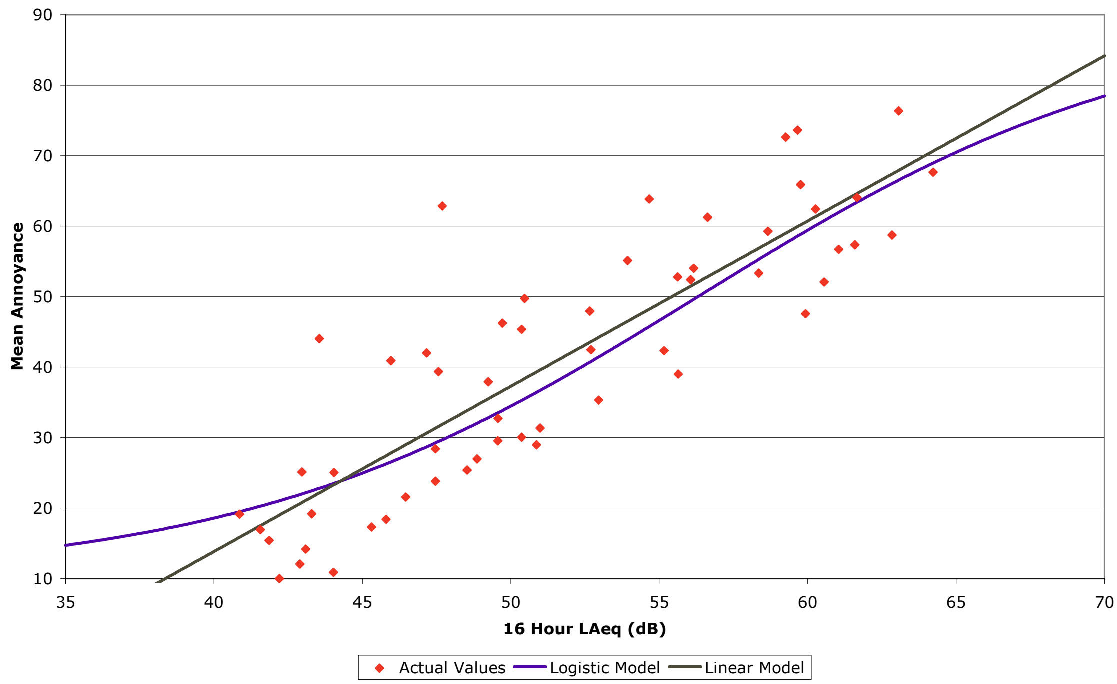


Figure 4 Models for Linear and Logistic Regressions on LAeq

Although the logistical model is preferred on the grounds that it respects the bounds of annoyance in the data, further analysis was carried out on the linear model for practical purposes.

A range of different socio-economic variables were added to the model to understand the factors that help explain the relationship between annoyance and sound level. The proportion of people working from home, mean household income and socio-economic group (SEG) were found to significantly affect the level of annoyance. The best fitting model was found to be with LAeq and mean income as the explanatory variables.

Models with a step function were also tested, to understand whether there was a step change in annoyance levels at any value of LAeq. This analysis showed that no threshold could be identified in the relationship between mean annoyance and LAeq.

5. ATTITUDES OVER TIME

Between 1982 and 2005, when the ANIS and ANASE studies were undertaken, there have been substantial changes in the aircraft fleet. Aircraft have become quieter, but there has been a significant increase in the number of aircraft events.

Figure 5 shows the values of mean annoyance calculated from ANIS and ANASE plotted against LAeq. The ANASE points are, of course, identical to those shown in Figure 2. For a given value of LAeq the ANIS points are generally below those from ANASE.

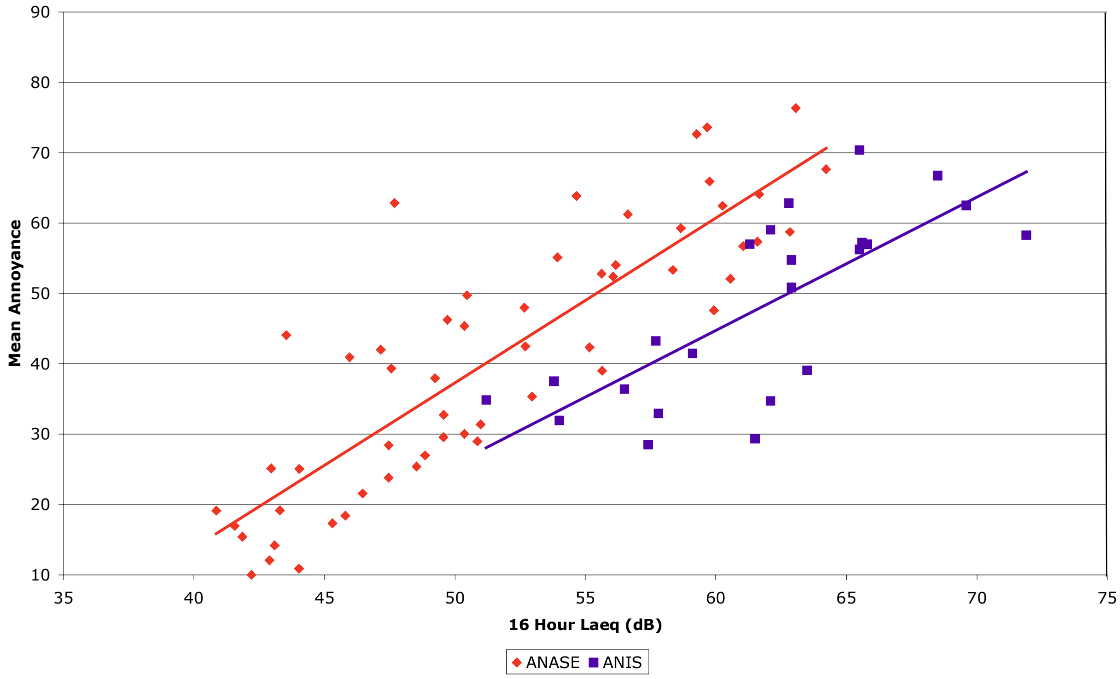


Figure 5 Mean Annoyance against LAeq for ANASE and ANIS

The difference in annoyance levels for a given value of LAeq may be due to a change in attitudes to aircraft noise, or it may be that despite its correlation, LAeq is not necessarily the most appropriate measure for representing people's attitudes to aircraft noise. The different measures to represent sound level were therefore investigated further.

In addition to LAeq, the average sound level, Lav, and average number, Nav, of aircraft at a site have been calculated for values of LAmax over 65 dB in ANASE and over 67 dB in ANIS. Figure 6 shows the site values of Lav and Log Nav for ANIS and ANASE.

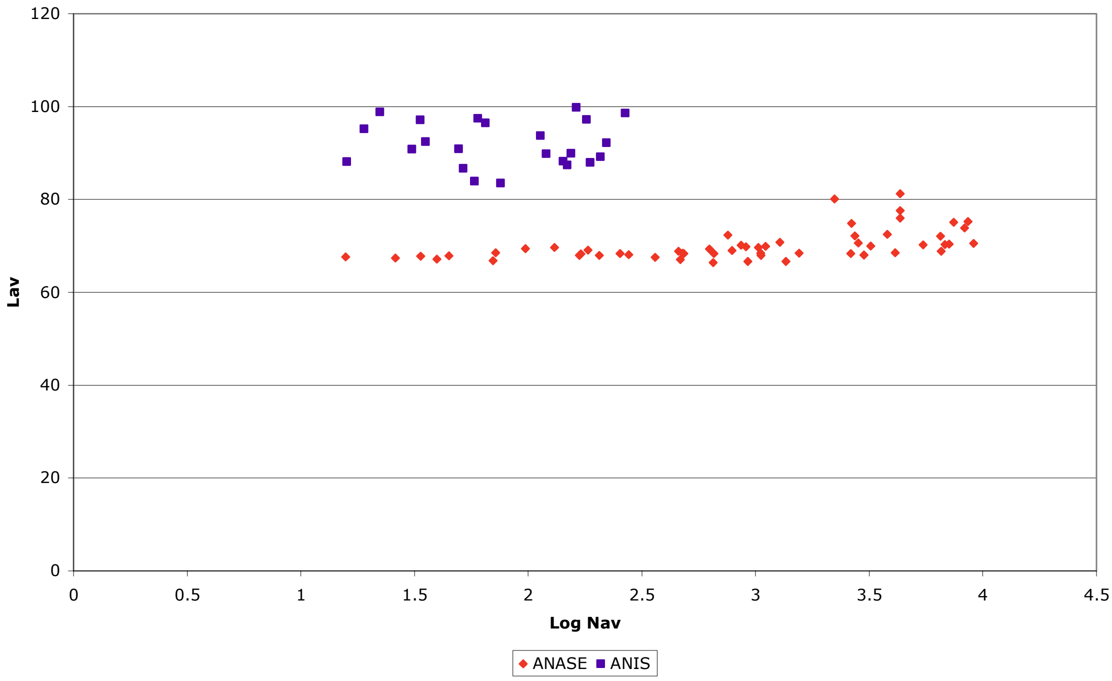


Figure 6 Lav against Log Nav for ANIS and ANASE

It can be seen that there is no overlap whatsoever between the data points from the two surveys. For the ANIS study, undertaken in the early 1980s, there were generally fewer aircraft, but the average sound levels were higher. In the more recent ANASE study, there is a greater number of aircraft, but average sound levels were lower. It should be noted that this is not a fault of the sample design. Because of changes that have taken place between 1982 and 2005, it would not have been possible to test the original ANIS findings under exactly similar aircraft noise exposure conditions.

The difference in the mean annoyance against LAeq between the studies could therefore be related to the differences in the patterns of aircraft sound levels that are currently experienced.

Figure 7 shows the relationship between mean annoyance and Lav for both the ANIS and ANASE survey.

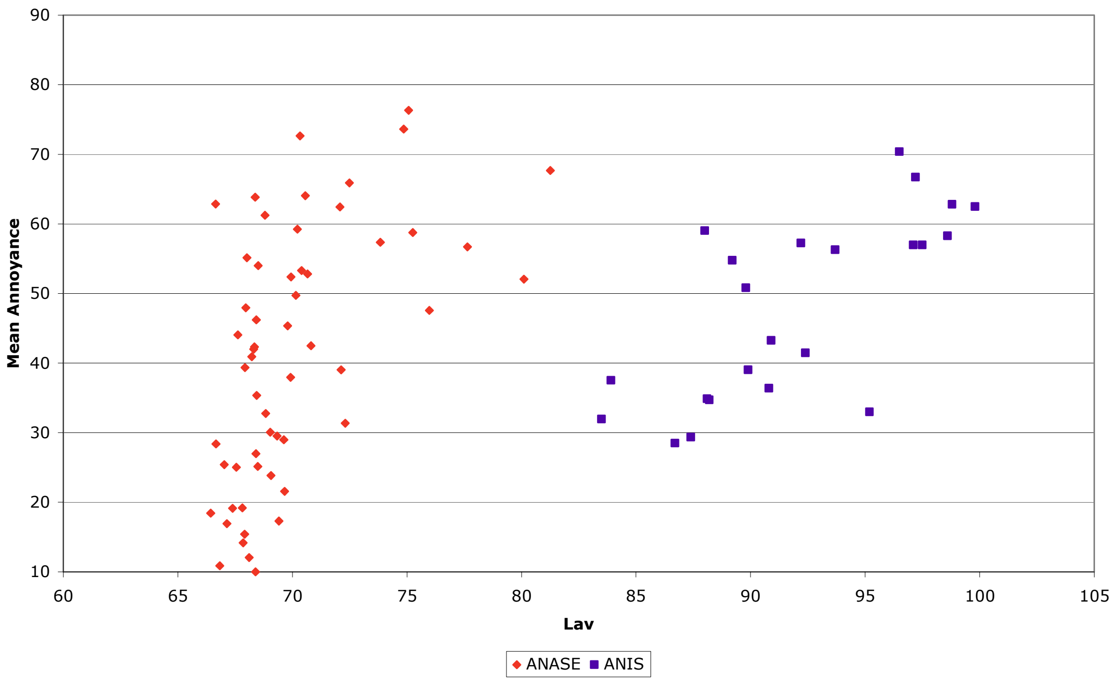


Figure 7 Mean Annoyance against Lav for ANIS and ANASE

While, for ANIS, there is a fairly clear relationship of increasing annoyance as Lav increases, for ANASE the relationship is less well defined: a large number of sites with lower values of Lav display a wide range of mean annoyance.

Figure 8 shows a similar plot of mean annoyance against log Nav.

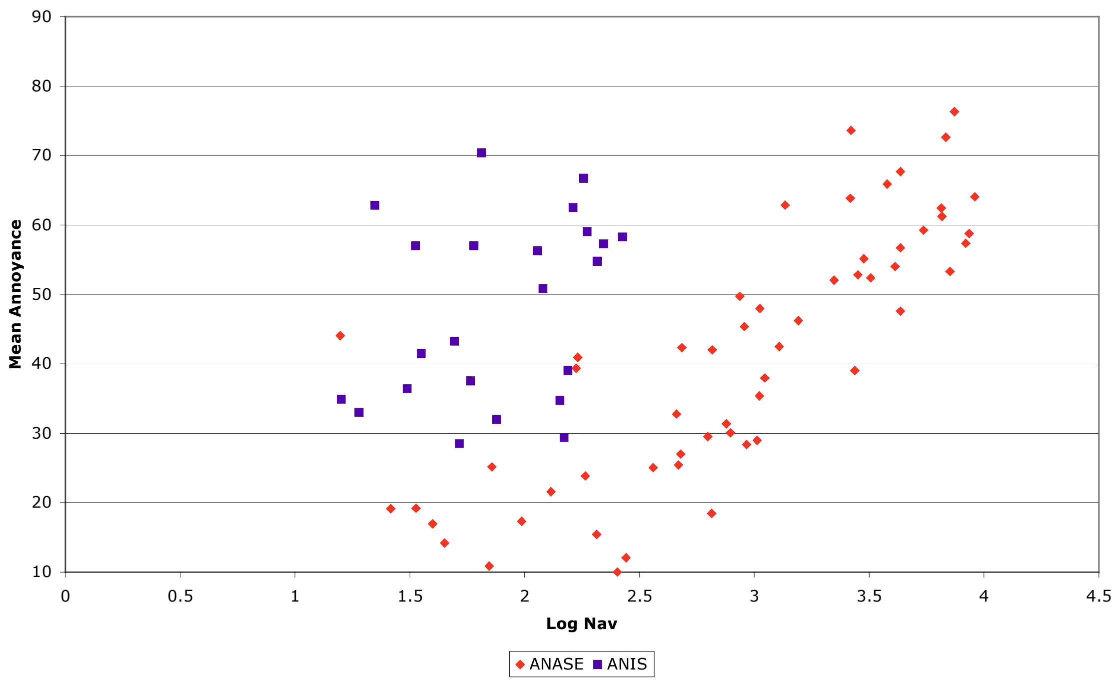


Figure 8 Mean Annoyance against Log Nav for ANIS and ANASE

Here the opposite can be seen. For this comparison, while ANASE shows a clear relationship of increasing annoyance as the number of aircraft (expressed as log Nav) increases, for ANIS this relationship is not apparent; instead a wide range of annoyance is reported for the range of log Nav recorded.

Therefore, between the ANIS and ANASE surveys, it appears that there has been a shift in the relative importance of the two components of annoyance: the sound level of the aircraft and the number of aircraft.

To explore the relationships further, regression analysis was undertaken of the form

Mean Annoyance = a + b x Lav + c x log Nav

For this regression on the ANASE data (Model 3), a ratio, c/b, of 21 produced the best match with the mean annoyance. A similar analysis on the ANIS data (Model 4) gives a very similar quality of fit to the data overall but with a much smaller ratio, c/b, of 6. This confirms the increase in importance of the number of aircraft (relative to average sound level) on the reported annoyance between the two surveys.

Model 3 (ANASE) Mean Annoyance = -71.6 + 0.86 x Lav + 17.9 x log Nav

R^2	Adjusted R^2	N	Intercept	Lav coefficient	Log Nav coefficient
0.656	0.643	56	-71.58	0.86	17.87
			(-2.06)	*(1.58)*	*(7.40)*

Model 4 (ANIS) Mean Annoyance = -158.3 + 1.99xLav + 12.5 x log Nav

R^2	Adjusted R^2	N	Intercept	Lav coefficient	Log Nav coefficient
0.646	0.611	23	-158.25	1.99	12.45
			(-4.57)	*(5.50)*	*(2.63)*

To provide an alternative metric for comparing ANIS and ANASE (ie with the same relative weighting for sound level and number), a weight of 15 for log Nav, in between the optimum values for ANIS and ANASE was used. A value of 15 also corresponds with the Noise and Number Index, that was in place before ANIS.

Model 5 shows the coefficients produced for the ANASE data, and Model 6 shows the coefficients produced for the ANIS data using the Lav + 15 log Nav metric.

Model 5 (ANASE) Mean Annoyance = -87.9 + 1.1 (Lav + 15 log Nav)

R^2	Adjusted R^2	N	Intercept	Lav + 15 log Nav coefficient
0.655	0.648	56	-87.93 *(-6.85)*	1.13 *(10.12)*

Model 6 (ANIS) Mean Annoyance = -112.1 + 1.3 (Lav + 15 log Nav)

R^2	Adjusted R^2	N	Intercept	Lav + 15 log Nav coefficient
0.541	0.519	23	-112.06 *(-3.48)*	1.33 *(4.97)*

The coefficients for ANIS and ANASE are similar, with the mean annoyance increasing by 1.1 for ANASE and 1.3 for ANIS for a unit increase of Lav + 15 log Nav.

Figure 9 plots mean annoyance against Lav + 15 log Nav for ANIS and ANASE and shows that the relationship for ANIS and ANASE is very similar. The overlap between the 1982 ANIS and the 2005 ANASE data suggests that an NNI type metric could provide a better fit than LAeq to the combined data set, and, hence, a better proxy for community annoyance over time than LAeq.

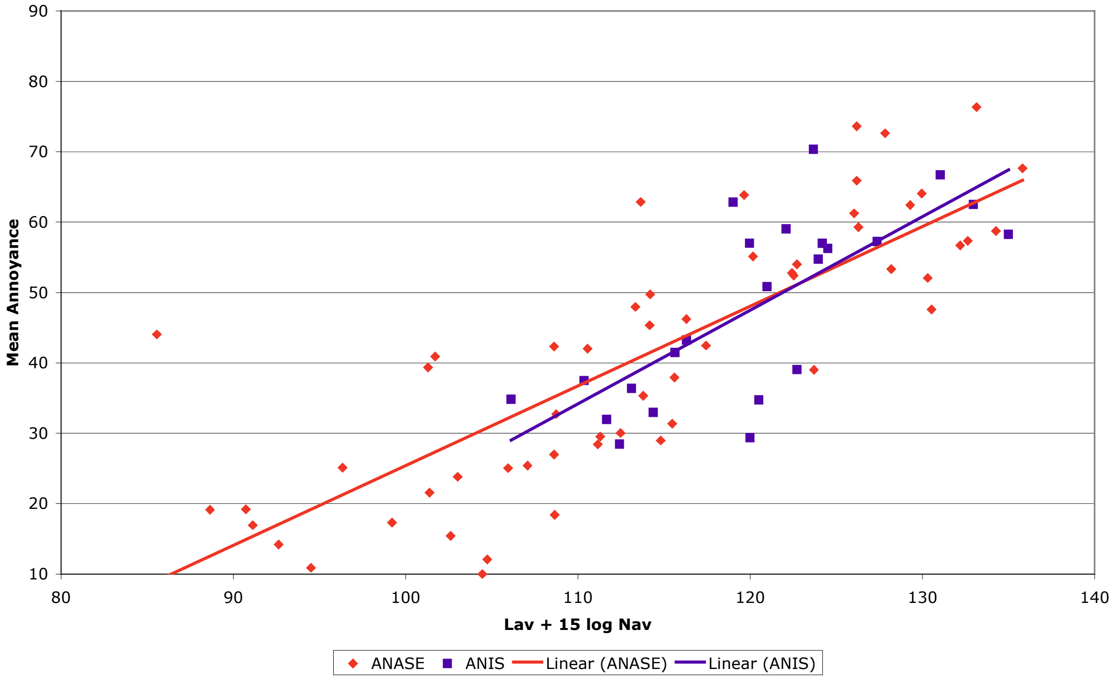


Figure 9 Mean Annoyance against Lav + 15 log Nav

6. WILLINGNESS TO PAY

The SP questions were of the form:

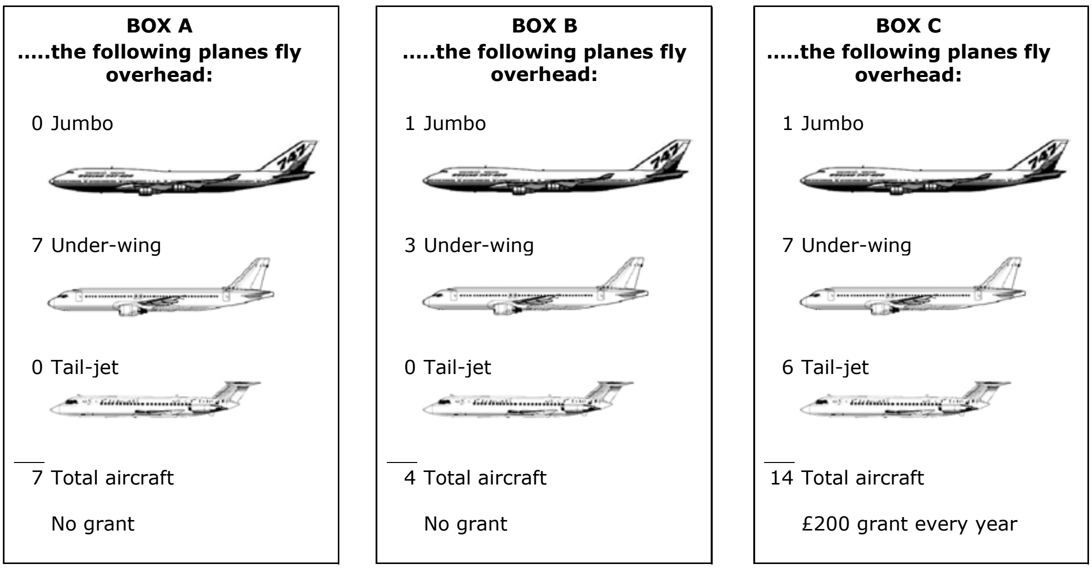
"Please think about what it would be like for you and the other member(s) of your household if there were different numbers of certain aircraft flying over YOUR HOME. I also want you to imagine that households near the airport qualify for an annual grant. <u>This household grant can be spent on anything your household wants.</u> So, you could spend it on improvements in insulation or double-glazing, or put it towards something like a new car or a holiday.

The Next questions are about the time of day between …… and …….

On a typical day there was this number of each type of aircraft flying over your area [on their way to land at/taking off from] the airport between …… and …….

I now want you to think about three different situations. ***[PRESENT COLOURCARD]*** *Have a look at the situations described in each of the three boxes A, B and C, and tell me which you think would be the best situation for you and your household.*

Please assume that there are no other differences in the numbers of the other types of aircraft, and no changes in the numbers of aircraft outside the hours …… and ……. We want you to only think about the effect of the differences shown on this card. Everything else remains the same.



Which do you think would be the best situation for you and your household?.

And which would be worst for you and your household?"

Different discriminable aircraft types were included in the SP exercise depending upon which types were the most common aircraft to fly over each site.

The ‘Basic’ SP models produced a relative coefficient ($ß_{ij}$) for each aircraft type in each time period, and a relative coefficient for money ($ß_m$) for each of the 36 sites. Each Basic SP Model, therefore, derived 13 or 19 relative coefficients, depending upon whether the site-specific SP exercise comprised 2 or 3 aircrafts with varying levels. With only 60 respondents contributing to the estimation of each Basic SP model, the fact that the vast majority of derived coefficients were statistically significant was a reassuring finding.

Aggregating by time period and (separately) aircraft type resulted in considerable loss of explanatory power at site level. This finding indicated that both the time of day and type of aircraft contributed significantly to respondents’ relative valuations. The final SP model was a pooled National SP Model covering all 36 sites, with a single set of time period coefficients, and a single money coefficient. The model provided the basis for deriving a relative weight (utility) for a unit reduction of aircraft by aircraft type at each site. Inspection of the within-site aircraft valuations within the National Model showed the vast majority to be consistent with relative sound energy level (SEL) values - i.e. aircraft with a higher SEL has a higher relative value than aircraft at the same site with a lower SEL. On average, a single jumbo had the same disutility as approximately 3 underwings or turboprops, or 4 tailjets.

Implications for LAeq

Transforming the sound levels of each SP option into an implied sound energy form enabled us to investigate the suitability of LAeq as a means of gauging changes in annoyance in response to changes in aircraft sound levels (namely the number of movements and the Sound Exposure Level (SEL)).

The result suggested a non-linear variation in valuation per dB (of a particular aircraft event) with the shape shown in Figure 10.

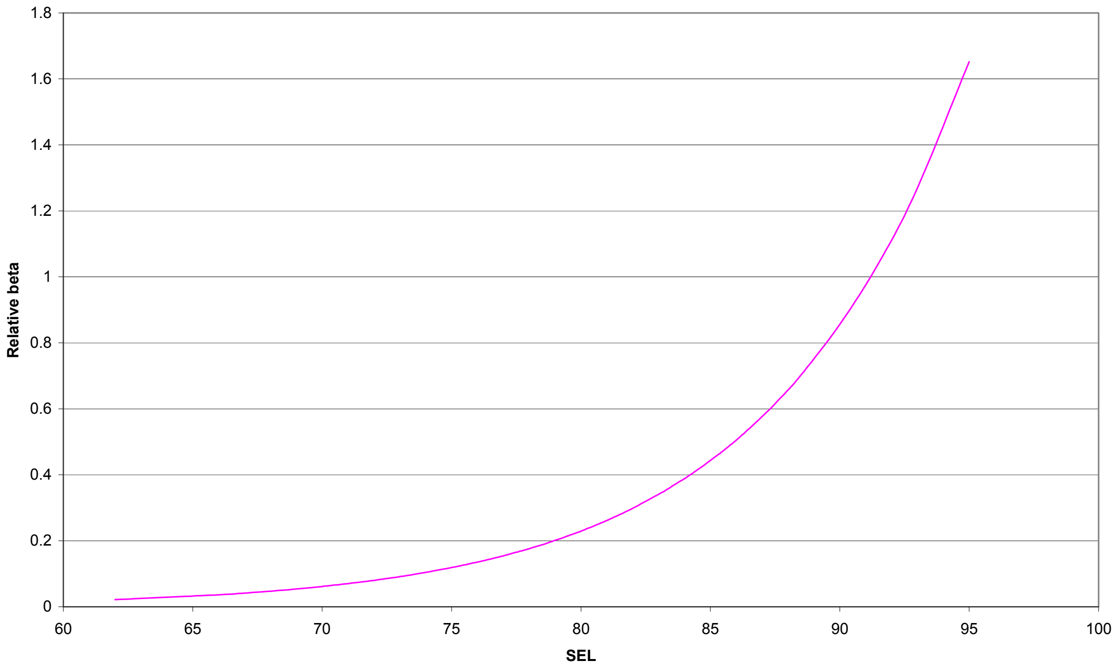


Figure 10 Relationship Between SP Coefficients and SEL

The graph is shown over the range of SEL presented in the SP survey. The implied valuation rises by about 14% for each additional dB, so that for an additional 10 dB the valuation is 3.7 times as much. However, although this looks steep, it is in fact only about half the rate per dB which would be implied by the LAeq formula, where the implied valuation increases by 10 times for an additional 10 dB. LAeq implies that, for example, 100 events with SEL 80 is equivalent to 10 events with SEL 90, over the same defined period. The results here imply that the equivalence is nearer to 32 events with SEL 90, in other words that the role of number should be upgraded relative to SEL. Approximately, the implied relationship can be considered to be:

$$LAeqx = SEL + 20 \log10 N – 10 \log10 T$$

Therefore, for predicting changes in community disutility in response to changes in aircraft sound levels, a ('k') weighting of 20 on the number variable would be better than the weighting of 10 that currently exists in the LAeq formula. This supports the finding reported from the non-SP analysis that NNI, which has a weighting of 15, may be a better proxy than LAeq for predicting changes in community annoyance over time.

Time of Day Sensitivities

The results of the National SP model indicates that, relative to the **daytime**, and with some rounding, the sensitivity to the same aircraft noise at other periods are:

- 2300-0300: 80% more annoying;
- 0300-0700: 35% more annoying;
- 1900-2300: 15% more annoying; and
- 1500-1900: 10% more annoying.

The above relativities reflect society's sensitivity overall, and implicit in these weightings are the proportion of people at home exposed to the noise. However, further investigation revealed that people are differentially annoyed at different times of day regardless of whether they are at home or not. This may be because they know aircraft noise annoys others in the home at this time, or because the respondent, though not at home, is exposed to aircraft noise elsewhere, or some other external factor that is correlated with presence in the home and annoyance with aircraft noise.

Willingness to Pay

The willingness to pay per month per household for one less aircraft per day for different sound levels during the middle of the day (1100-1500), implied by the National Model, is indicated below. The implied willingness to pay values are given by aircraft type, and across LAeq bands, in high noise areas (LAeq >60dB).

- Jumbo: £5 - £9 per aircraft (min SEL = 84dB, max SEL = 95dB)
- Underwing: £2 - £6 per aircraft (min SEL = 82dB, max SEL = 89dB)
- Turboprop: £2 - £3 per aircraft (min SEL = 77dB, max SEL = 84dB)
- Tailjet: £2 - £5 per aircraft (min SEL = 67dB, max SEL = 84dB)

At low aircraft sound levels (below 50 LAeq), the typical SEL of aircraft is around 10dB lower and the ANASE results suggested willingness to pay values of around £2 lower.

In comparison with the limited contemporary research available, these willingness to pay values seem high. The ANASE SP values are very high when one considers the number of aircraft – even Jumbos – that would need to stop flying overhead in order to reduce the overall LAeq by 1dB at the site.

We have not been able to explain the cause of this considerable disparity between the ANASE SP-based valuation and other research valuations based on hedonic pricing and contingent valuation. In the authors' view, there is no reason to think that SP will inherently produce vastly over-estimated monetary valuations of goods and services. The SP technique has been used for more than twenty years and has been validated (through the use of observed data) on many occasions.

We are also of the view that the SP design, data collection and analysis accurately captures the views and preferences of respondents. This is based on anecdotal information gained throughout the study (i.e. cognitive assessment of respondents' decision processes when considering the SP trade-offs), and we are confident that respondents considered the SP options that they were presented with to be realistic, and that they stated their 'true' preference from each choice-set.

We believe the area of greatest uncertainty is the link between respondents' willingness to pay for a reduction in aircraft (e.g. around £5 a month for one less jumbo every day during a certain 4-hour period) and their assumed improvement in their quality of life (through reduced annoyance by aircraft noise). The ANASE study has revealed that a change in the number of aircraft is perceived to have the greatest effect on reducing aircraft noise annoyance. However, more research is needed to explore how accurately people associate a reduction in aircraft numbers with a change in their overall experience of aircraft noise. It may be that respondents perceive that a reduction of a few jumbos during a particular period of the day would have considerable impact on their overall experience yet in reality might not even notice the reduction in practice.

7. CONCLUSIONS

Re-assessing Attitudes to Aircraft Noise in England

Through this research we have demonstrated that:

- most (circa 75%) of measured variation in annoyance can be accounted for by LAeq. Household income and SEG are also important influences on community annoyance;

- there is no evidence of a step-change at which annoyance levels suddenly increase; and

- for the same amount of aircraft noise, measured in LAeq, people are more annoyed in 2005 than they were in 1982. One possible explanation is a combination of changes in income/standard of living and changes in attitudes within society. This view is supported by social trend data.

Therefore, LAeq could continue to be adopted as a workable proxy for community annoyance, (though care must be taken when comparing over time) and there is no evidence to support the idea of a threshold at which there is an 'onset' of annoyance.

Re-assessing their Correlation with LAeq

However, in this research we have also demonstrated that there is a better proxy for community annoyance. Indeed, because of its instability over time, use of the LAeq measure to predict future levels of annoyance may be misleading.

Unfortunately, any alternative linear or logistic function could not be guaranteed to be stable over time. But the ANASE result is relatively insensitive to a weight greater than 20, so an NNI type measure provides a better tool for predicting annoyance from aircraft noise

Time of Day and Willingness to Pay to Reduce Aircraft Noise

The SP results have shown people to be more sensitive to aircraft noise at night (particularly around midnight and the early hours thereafter). In contrast, people are least sensitive to aircraft noise in the morning and early afternoon. These time-of-day sensitivities seem intuitively plausible and are also comparable with other research.

Unfortunately, despite the internal consistency, the implied valuations from the SP are much higher then may be considered plausible, when translated into a "per dB" value – or when compared with valuations derived from more traditional means.

Overall, therefore, we do not think that the valuations from the SP questions are safe, and it will probably be necessary to rely on sources based on Hedonic Pricing. Nonetheless, the relative valuations – particularly those relating to time of day variation – can be used.

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