Proceedings of The Institute of Acoustics

ANNOYANCE DUE TO COMBINATIONS OF NOISES

C.G. Rice and K. Izumi*

ISVR, The University, Southampton.

The use of a single valued quantity, such as the equivalent continuous A-weighted sound pressure level or its derivatives, as the noise exposure term in community noise annoyance prediction criteria has been forcefully advocated (1)(2)(3). However, there is a growing body of evidence (4)(5)(6) to support the assertion that such a simple *energy summation model* is insufficient to justify the faith that is being placed upon it. Factors against its promulgation are:

(i) no account is taken of possible differences in the annoying inducing potential of different sources

(ii) no separate account is taken of the absolute levels of the sources which contribute to the total sound level.

PREDICTIVE MODELS

Several models for use in the prediction of annoyance (A) due to combinations of noises have been reviewed by Taylor (4). All include noise measures of the form L_i (the L_{Aeq} of the i^{th} source) or L_T (the total noise level calculated as the sum of the L_{Aeq}'s of the separate sources) or both.

Energy Summation: Total annoyance is proportional to the total L_{Aeq} from all sources

$$A = f(L_T)$$

Independent Effects: Total annoyance is the contribution of the separate sources which are independent and additive

$$A = f_1(L_1) + f_2(L_2) + \ldots\ldots\ldots f_n(L_n)$$

Energy Difference: Total annoyance is a function of L_T and a correction factor which takes account of absolute level differences between separate sources

$$A = f_1(L_T) - f_2(|L_1-L_2|)$$

Response Summation: Total annoyance is a function of L_T and a correction factor (D_i) which takes account of the different annoying inducing potential of the separate sources. D_i is an increment which adjusts public sensitivity to that particular source

$$A = f(L_T + \sum_{i=1}^{n} D_i . 10^{(L_i-L_T)/10})$$

Summation and Inhibition: Total annoyance is a function of L_T and a correction factor (E) which takes account of both summation and inhibition effects which arise from the interactions of the separate sources

$$A = f(L_T + E)$$

Subjectively Corrected: Total annoyance is a function of the level of the subjectively dominant source L_D and a correction factor (C_i) which takes account of the relative subjective differences between L_D and the separate sources (7)

$$A = f(10 \log \sum_{i=1}^{n} 10^{(L_D+C_i)/10})$$

* Muroran Institute of Technology, Japan

RECENT STUDIES

A recent comparison (4) of the above models against social survey data obtained for a range of combinations of aircraft and traffic noise exposures around Toronto International Airport reveals two very important conclusions:

(i) the simple *energy summation* model was the weakest predictor of mean overall annoyance, and hence confirms the doubts expressed about its applicability for mixed source situations

(ii) the potential utility of alternative models was demonstrated, and whilst no single model could be recommended it was hoped that future studies would lead to a more definitive solution.

The joint CEC annoyance studies on combinations of impulse and traffic noise (6) drew similarly important conclusions:

(i) total annoyance is not uniquely predicted by a simple *energy summation* model

(ii) source specific annoyance to impulse noise decreases as background noise increases

(iii) responses to combinations of noise sources are confounded by the way in which the annoyance questions are asked.

ANNOYANCE RESPONSES

Models for the prediction of annoyance due to combinations of noise ought to make allowance for both source specific and total annoyance reactions. However the problem is confounded by the way in which the information is obtained and by the interpretation subjects place on the questions asked. For example it has been observed that in some circumstances source specific annoyance (e.g. aircraft noise) exceeds total annoyance, particularly when aircraft noise dominates the situation. This suggests that respondents do not spontaneously consider all noises to be part of their everyday environment, and need to be specifically reminded before they give their annoyance reactions. Hence as the background noise level increases it will increasingly drive total annoyance reaction.

Another explanation of this finding may be the order in which questions are asked. For example it is common practice to obtain the total noise annoyance responses quite early on in the questionnaire, and then proceed to elicit source specific information in later questions. It may be argued that an early total annoyance question does not alert respondents sufficiently, and that an additional composite question placed near the end might be more appropriate. The form of such a question might be:

Just to make sure that I have everything correct, could you please tell me how bothered or annoyed you are by

(a) the noise from aircraft
(b) the noise from traffic
(c) the total noise round here

The response could be in terms of the four-point aircraft noise annoyance scale (ANAS) 'very much', 'moderately', 'a little' or 'not at all' annoyed; or on a zero to nine category rating scale, with the ends labelled 'not at all annoying' and 'extremely annoying'.

PRESENT STUDY

The results of a recent social survey on the influence of background noise on annoyance responses to aircraft noise round the London Airports (8) provided further general confirmation of the above mentioned findings, with two particular highlights:

(i) there was some evidence that aircraft noise annoyance was significantly higher in the low as compared to the high background noise zones but only in the 35-40 NNI range

(ii) total noise annoyance could be predicted by using the source specific annoyance of the most annoying of the noise sources, this suggests a *dominant source* model.

In order to help clarify some of these issues a repeated measures laboratory study was undertaken in a simulated domestic living room environment. A factorial design was used in which four aircraft noises (0, 40, 50 and 60 L_{Aeq}) were combined with each of four traffic noises (35, 42, 49 and 56 L_{Aeq}) to form sixteen treatments which lasted ten minutes each. These were presented to sixteen subjects according to a blocked but balanced Latin Square design. After each treatment subjects were asked to rate *aircraft, traffic* and *total* noise annoyance.

RESULTS

The preliminary results are shown in Figure 1, where *source specific* and *total* annoyance responses are shown as functions of aircraft and traffic noise levels. It may immediately be seen that in the presence of low traffic background noise levels *aircraft* annoyance is greater than *total* annoyance, and in the higher backgrounds traffic noise drives the *total* annoyance responses. This finding confirms both the field results of Taylor (4), and the CEC laboratory studies (6).

An analysis of variance (AOV) shows that there is a significant aircraft x background interaction which may be seen in Figure 2. Further examination of Figure 1 and the associated AOV table of means indicates that background may be split into a low (35 and 42 L_{Aeq}) and high (49 and 56 L_{Aeq}) effect. The significance of this split requires further analysis, but it is interesting to note that the effect is similar to the trend observed in the field study (8). The results are compared in Figures 7 and 8 where a 5 dB correction was made to correct the indoor L_{Aeq} levels to outdoor NNI (17 dB for inside-outside, and 22 dB for the L_{Aeq} - NNI difference).

The AOV for *traffic* annoyance shows no significant effect of aircraft noise, and the data may be pooled as shown in Figure 3. The AOV for *total* annoyance indicates a significant aircraft x background interaction. Figure 4 shows that *total* annoyance does not uniquely correlate with the total L_{Aeq} and is clearly a function of the separate source noise levels. This conclusion clearly substantiates the earlier doubts about the efficiency of the *energy summation* model, including the fact that it does not take separate account of the absolute levels of each source.

Other ways of modelling the *total* annoyance responses are shown in Figure 5, where it may be seen that *total* annoyance increases with increasing aircraft and traffic noise levels. Whilst these seem to be reasonable ways of representing *total* annoyance, they nevertheless ignore the fact that in some situations a particularly dominant source causes even greater annoyance. If the *dominant* *source* approach is taken, the data in Figure 5 become transformed to those of Figure 6. This means that the greatest annoyance response (*either total, aircraft or traffic*) given by respondents is chosen as representing annoyance in combined noise source environments. Reference to Figure 1 shows that in many situations *total* and *traffic* annoyance are not significantly different and a smoothed approximation of the *aircraft* and *traffic* annoyance can also be used to approximate to the data shown in Figure 6.

CONCLUSIONS

(1) Aircraft noise annoyance tends to be less annoying in high than in low traffic noise backgrounds, and although this is shown in Figure 7 it is only significant in the middle of the range of aircraft levels studied. This corresponds to an equivalent outdoor level of about 45 NNI which is consistent with the model derived from the field study shown in Figure 8.

(2) The *energy summation* model based on the total L_{Aeq} of all sources is insufficient to account for annoyance reactions to combinations of noise.

(3) The *dominant source* model seems to offer more possibility, although further analyses of existing data need to be undertaken before definitive conclusions can be drawn.

REFERENCES

(1) US-EPA 1974 Report 550/9-74-004. Information on levels of environmental noise...

(2) CHABA 1977 Report of Working Group 69. Guidelines for preparing environmental impact statements on noise.

(3) T.J. Shultz 1978 Jn. Acoust. Soc. Amer. 64(2), 377-405. Synthesis of social surveys on noise annoyance.

(4) S.M. Taylor 1982 J.Sound Vib. 81(1), 123-138. A comparison of models to predict annoyance reactions to noise from mixed sources.

(5) R.G. de Jong and D Commins 1984 Proc. 4th Int. Cong. Noise as a Public Healt Hazard 2, 1084-1093. CEC Joint research on annoyance due to impulse noise: field studies.

(6) C.G. Rice 1984 Proc. 4th Int. Cong. Noise as a Public Health Hazard 2, 1073-1084 CEC Joint research on annoyance due to impulse noise: laboratory studies.

(7) C.G. Rice 1975 J. Sound Vib 43(2), 407-417. Subjective assessment of transportation noise.

(8) P.J. Cooper, I.D. Diamond, C.G. Rice and J.G. Walker 1984. Session C Paper. IOA Spring Conference. Influence of background noise on annoyance responses to aircraft noise.

ACKNOWLEDGEMENT

The authors would like to thank Andrew McKenzie of ISVR for his assistance in running the experimental part of the study.

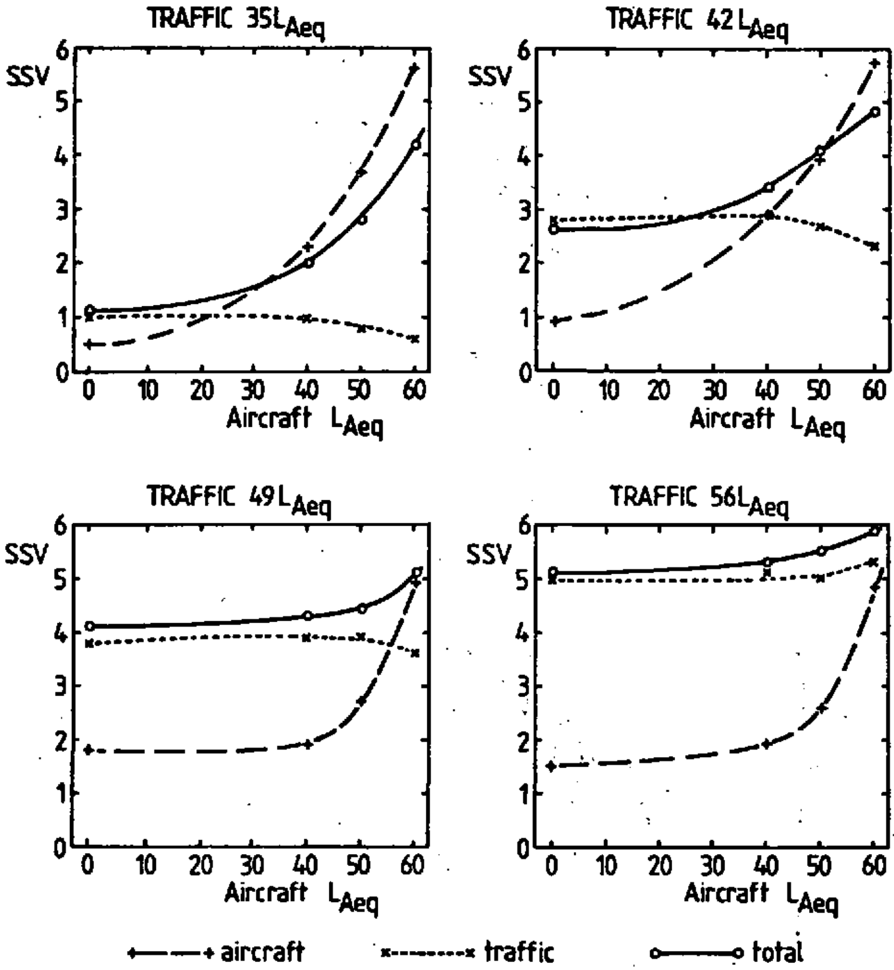

FIGURE 1: Annoyance responses: combinations of noises

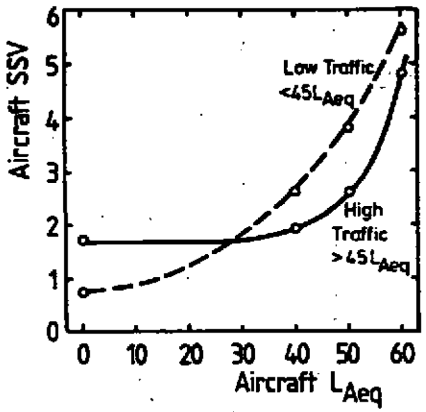

FIGURE 2: Aircraft annoyance

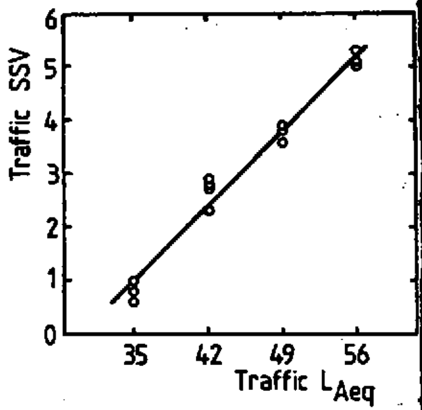

FIGURE 3: Traffic annoyance

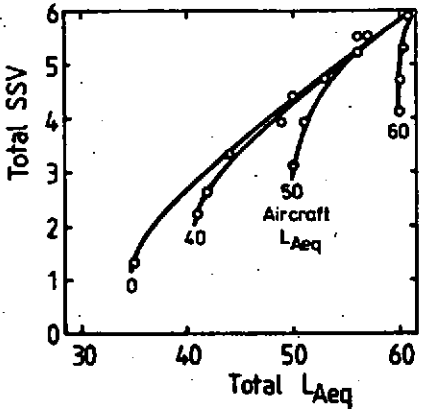

FIGURE 4: Total annoyance

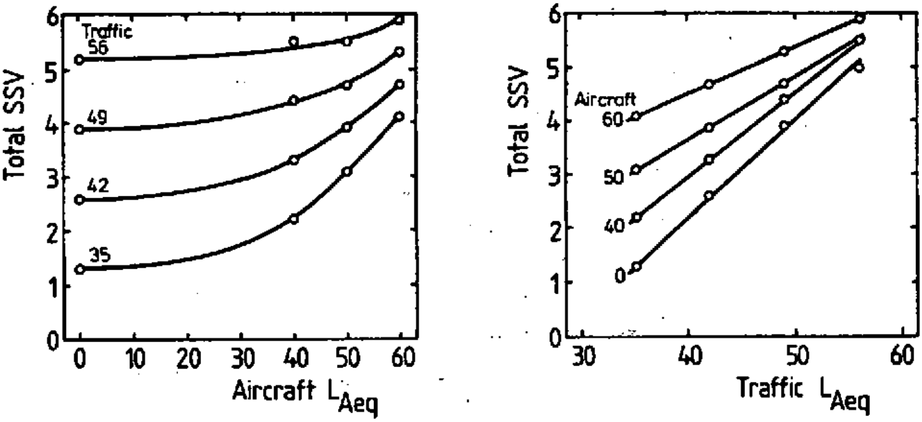

FIGURE 5: Total annoyance model

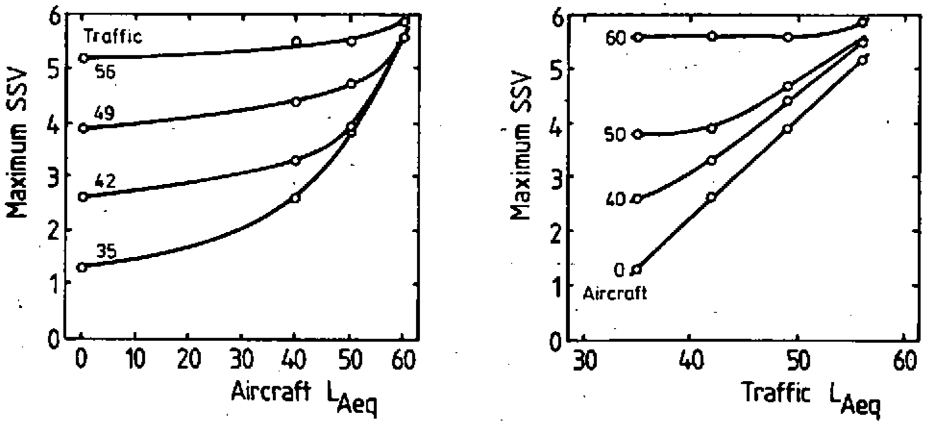

FIGURE 6: Dominant source model

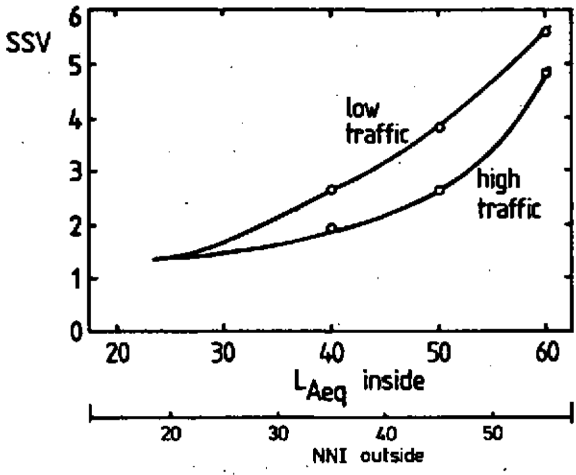

FIGURE 7: Aircraft annoyance: laboratory study

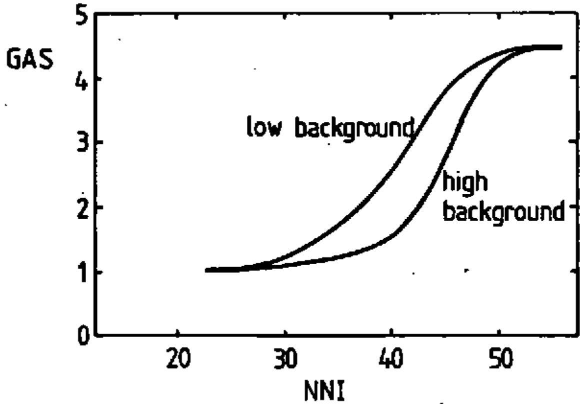

FIGURE 8: Aircraft annoyance: field model