

# A Disaggregate Noise Interference Model for Estimating Airport Noise Impact

ALBERT T. STODDARD III and GORDON P. FISHER

## ABSTRACT

Airport noise is a major problem facing the air transport industry. The noise intrusion on nearby communities not only leads to hard feelings but has also resulted in court action, forcing airport operators to pay large sums and to alter airport operations. To evaluate noise mitigation measures, a means of estimating the change in impact that will occur because of this mitigation measure is required. However, existing measures of airport noise impact are inadequate. Presented in this paper is a new, improved method of measuring noise impact and of estimating the changes that will result from noise mitigation efforts. Previous methods have been based on the notion of human annoyance. However, noise per se is not annoying; rather, it becomes annoying when it interferes with human activities. Therefore, this study bases the prediction of noise impact on activity interference. Because of the large random element in individual response to aircraft noise, residential interference is estimated by using a probabilistic model. A residential model is developed from the concept of household loss of utility due to increased noise. Comparisons of aggregate predictions show the model that was calibrated by using disaggregate data to be more reliable in predicting total impact than were other models.

One of the most important problems facing the air transport industry today is the disturbance of people by aircraft noise in the vicinity of airports. Several means of quantifying and predicting the impact of noise have been proposed; however, none have been shown to be highly reliable. In this study, the problem is approached from a new standpoint, which has been shown by Stoddard (1) to be an improvement over other possible means of predicting impact. A mathematical relationship between residential activity interference and noise is developed based on microeconomic theory. A binary logit model, estimated by using disaggregate data, is proposed for predicting the noise impact that results from aircraft operations.

## BASIS FOR THE MODEL

The interference of aircraft noise with residential activities is approached from the standpoint of the economic utility derived from a residence by a household or family unit. Lancaster (2) viewed goods as having no utility themselves; rather, the attributes represented by the good provide utility. In this view, household utility can be defined as a function of the utility provided by each of the attributes. Microeconomic theory holds that a household may be expected to maximize its utility, subject to some budget constraint. In selecting a residence, the household maximizes utility by considering all of the attributes; it pays a market price reflecting that utility. The problem may be constrained by assuming that, after a residence is chosen, income and prices remain constant as an increase in noise exposure is introduced. This assumption may be expected to hold only in the short run, until market conditions begin to reflect this change in the attributes of a residence. In the short run, then, the impact of noise is a change in the utility experi-

enced by the household. It is not necessary to know the total utility of the household; rather, it is sufficient to know only the amount of change in that utility.

It is necessary to identify those attributes that may be affected by noise exposure. Quiet is one attribute that is directly affected. Rylander et al. (3) found that there is a strong relationship between social class and noise impact, social class being a combination of income group, residential neighborhood, occupation, family relationships, and other characteristics. As in Rylander's work, social class is often represented by income group. Socioeconomic characteristics other than social class do not show as strong a relationship. Other attributes of residential choice are not expected to change as a result of the noise intrusion. Thus, the utility function of interest contains two independent variables: the change in quiet and the social class of the household. The change in quiet may be estimated by measuring the noise intrusion and assuming that ambient noise levels do not change. The noise characteristics that must be accounted for are noise level, frequency distribution, and number of events. The average of single-event sound exposure levels (SELs) is used to represent the noise because the measure incorporates noise level, frequency components, and duration. Social class is represented by household income relative to the mean household income in the standard metropolitan statistical area (SMSA).

If a relationship between activity interference is known and change in utility can be estimated, then residential impact may be measured. Activity interference must be determined from the subjective responses of individuals, for example as reported by Tracor (4) and Rylander et al. (3). In these surveys, respondents indicated on a semantic scale which activities are disturbed by noise and what level of disturbance they experience. Interference may be said to occur when the value reported by a

respondent is above a given threshold, or interference level, on the semantic scale. Interference therefore may be represented as a binary variable, occurring for respondents who report values above the threshold and not below. Griffiths and DeLauzun (5) reported that the variance in response is due as much to randomness as to other factors; therefore the utility function must include a random term. The random element is included because of sampling errors and incorrect model specification. Factors that have a causal relationship to noise interference but that are not included in the model also appear as random errors when the individual variance is examined. The probability of there being residential interference is equal to the probability of the observed utility being reduced by the introduction of noise.

A mathematical relationship for activity interference in terms of the utility function is needed. The form of the relationship now depends on assumptions about the distributions of the error terms. Griffiths and DeLauzun (5) could not reject, on the basis of their data, the hypothesis that noise annoyance distributions are normal. If it is assumed that the distributions are multivariate normal, a probit model results; if the error terms are assumed to be independently and identically distributed in a Weibull distribution, the model takes the logit form (6-9). However, use of the logit model when the error terms are not Weibull distributed can give erroneous estimates of probabilities. Note that both Finney (7) and Daly (10) have found that there are not significant differences between the logit and probit models. Moreover, Daly states that a logit model is preferred, particularly because of convenience in estimation.

On the strength of these arguments, a logit model was used to represent the relationship between the change in utility due to noise and residential activity interference. The binary form of the model then is

$$P(I) = 1/(1 + e^{-U})$$

where  $P(I)$  is the probability of interference and  $U$  is a function representing a change in utility.

Data for estimating this function were obtained from the Tracor study, which contains information on activity interference, socioeconomic characteristics, and noise levels (4). This study differs from others in that it addressed activity interference rather than general annoyance, an important distinction.

For this study, Boston was chosen as the source of data in developing a model of activity interference. It is a Phase II city in the Tracor data set, comprising 1,166 respondents. The Logan International Airport Office of Noise Abatement worked to decrease the noise impact during the period from 1976 to 1980 and kept records of those efforts. The intention to use the proposed model in a case study made it desirable to estimate the coefficients of the model for the city selected for the case study. Boston provided the best possibility because it was surveyed as part of the Tracor study and records were available about operational changes directed at noise impact reduction. Problems associated with the transferability of model parameters between cities are thus avoided and only the problems of temporal transferability need be accounted for.

#### DEVELOPMENT AND TESTING OF THE MODEL

##### Residential Activities

A review of the literature and the foregoing remarks on nonresidential activity interference make clear

that some activities are much more likely to suffer interference from aircraft noise than are others. The more susceptible activities involve some form of auditory communication, for example, speech or audio transmission. The Tracor study identified 13 separate activities and asked respondents if they were ever disturbed by aircraft noise while engaged in these activities and, if so, how much they were bothered. The response to how much bother occurred was based on a semantic scale ranging from "not bothered at all" to "extremely bothered", represented numerically from 0 to 4.

The 13 activities addressed in the Tracor questionnaire were:

1. Relaxing or resting inside,
2. Relaxing or resting outside,
3. Young children sleeping,
4. Conversation,\*
5. Telephone conversation,\*
6. Going to sleep,
7. Listening to records or tapes,\*
8. Listening to radio or television,\*
9. Watching television,\*
10. Reading or concentrating,
11. Late sleep,
12. Eating, and
13. Other activities.

Those activities denoted by \* were considered to be those most susceptible to noise interference.

##### Statistical Tests

Four statistical tests were used to assess the quality of the mathematical relationship between activity interference and noise intrusion. The first test was the likelihood-ratio test evaluated for the prior probabilities, which gives an indication of the statistical significance of the model. The second test was the likelihood-ratio index suggested by McFadden (11), which indicates the goodness of fit of the model. The predictive success index, also suggested by McFadden, was used to show how well the model predicted the proper outcome. The final test was a t-test on the coefficient of each independent variable to determine the significance of that variable in the model.

##### Independent Variables

The explanatory variables used in the interference model initially were the average SEL per event, the number of noise events, and the social class of the respondents. It was necessary to estimate the values of each.

In the Tracor data set, noise is reported as the peak perceived noise level (PNL). However, this form was not suitable for the present purpose and had to be converted into SEL. SEL was calculated by converting peak PNL to peak dBA sound level and then estimating SEL. The average SEL value used as the variable in the model was obtained by taking the weighted average of the SEL values of all aircraft types for both arrivals and departures.

The numbers of flights for the major aircraft types are reported in the Tracor data. Flights, identified as arrivals or departures on different runways, are those that may be heard at the location of the residence. They are also broken down into day and night flights. The variable used in the model is the number of operations that would be discernible at the residence location during the time period being modeled.

It is now necessary to address the variable social class, which is represented here by income group of the respondent, as reported in the Tracor survey. The model was initially estimated by segmenting the data set by income groups and estimating separate models for each group. The income groups were determined by the ratio of income to the mean income of the community; mean annual household income for Boston in 1970 was \$10,400 (12). Three groupings were selected for model development: 0 to \$3,999, \$4,000 to \$10,000, and more than \$10,000. These groupings were selected because they were combinations of the groupings in the data and could be related to the local mean income. The mean income for the neighborhoods surveyed was below that of the SMSA; approximately 30 percent of the respondents were above the \$10,000 income level.

Other socioeconomic variables were investigated to determine their suitability for use in the model. Home ownership was considered because it has a relationship to social class and might have a relationship to noise interference. For example, those who own homes have a vested interest in the community and in their property and thus would be concerned if they perceived an intrusion by aircraft noise. Renters, however, are much more free to move to other locations if they are bothered and are less likely to be concerned than owners about possible decrease in property value resulting from noise.

It may also be important to consider air conditioning because the amount of externally generated noise that is perceived inside a house is masked by air conditioning noise and attenuated by closed windows. Households with air conditioning consequently could be expected to be less affected by noise than those without air conditioning.

Education level serves as another possible surrogate for social class and is highly correlated with income. Cost of housing also is a measure of social status and reflects the nature of the particular neighborhood. Those who are willing to pay more for housing would be expected to value a quiet neighborhood more than those who pay less. This variable includes rent payments and equivalent market rents for homeowners.

Age is another possible variable to use in the model. Although no other researchers have found a strong relationship between age and noise interference, it appeared useful to examine it. The shortcoming in using age as a variable is that, as people become more appreciative of quiet in older age, they also suffer the effects of hearing loss due to long-term noise exposure (13,14).

The final socioeconomic characteristic considered for inclusion in the model was duration of residence in the neighborhood. There is some suggestion that persons who have resided in a neighborhood with a high noise level for a long time are those who are least bothered. Some may learn to live with the noise, whereas others, who are more disturbed by the noise, tend to move away over extended periods of time. Independently, noise intrusion may not be sufficient to prompt people to move, but may be one factor that spurs the move.

To determine the best variable for inclusion in the model from among these possibilities, a stepwise estimation procedure was used that added the most significant variable at each step until all significant variables were included. Of the possible variables, the only ones significant at the 95 percent level were noise level, number of flights, and home ownership. The parameters were estimated for the three major income groups and the results are given in Table 1. Note that the model for the lowest income group does not meet even the weak likelihood-ratio test. The other two income-group models, while

TABLE 1 Statistical Tests of Parameter Estimation by Income Grouping

Income Group (\$)	$\chi^2$	$\rho^2$	$\sigma$
0 to 3,999	4.92	0.026	0.068
4,000 to 9,999	13.02	0.051	0.241
More than 10,000	39.89	0.088	0.347

Note:  $\chi^2(2,0.5) = 5.99$ .

markedly better, are not satisfactory when tested by using the likelihood-ratio index and the success index. For those in the lowest income group, there apparently are significant factors other than the characteristics of the noise itself that influence the amount of interference that occurs.

#### Dependent Variable

A summation of the reported degrees of disturbance of various activities might be taken to give more weight to those extremely disturbed in many activities than to those only moderately disturbed in a few activities. Conversely, it is also possible to count persons who report any disturbance in any activity (for example, in specific activities such as conversing or watching television) more heavily than those who are highly disturbed in many activities. That is to say, small amounts of disturbance in a small number of activities may be more important. In selecting a dependent variable, therefore, several possibilities exist.

Rather than counting interference on the basis of representative activities, all responses to level of disturbance for all activities were summed. Different discrimination points were tested along with different activities variously weighted. It is realized that the selection of a discrimination point is arbitrary, so it was tested as part of the final estimation to determine the sensitivity of the point at which interference is defined to occur.

#### Utility Function

It was decided to test two different forms of the utility function in developing the model, a linear form and a log-linear form. The linear function was chosen because it is commonly used and is a simple form. The log-linear form was tested because previous researchers have used the logarithm of flights, as in the day-night average sound level (Ldn). The form exhibiting the strongest relationship to the data would be used in the final model.

#### Time-of-Day Weighting

An important issue related to noise impact is time-of-day weighting. It has been pointed out that weightings currently in use are based on some arbitrary assumptions and that research findings have since refuted the validity of those assumptions (15-19). The Tracor data on Boston show that people who report disturbance are most likely to report awareness of aircraft in the evening. It is possible that this evening disturbance occurs because more flights take place during this time period, or more people are at home then, or people are engaged in activities that are more likely to be disturbed by noise.

The operations at Logan International Airport were checked to determine the number of operations

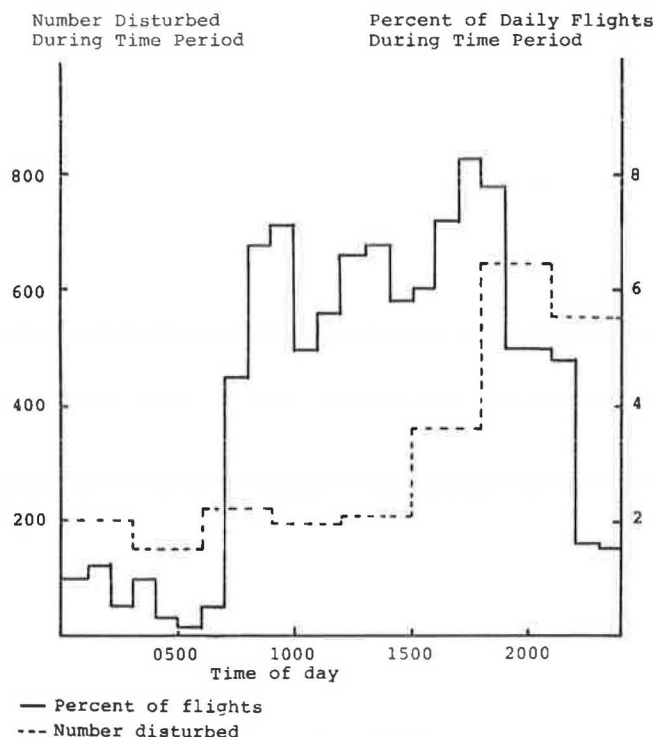


FIGURE 1 Comparison of number of flights and level of disturbance.

during the evening time period. Figure 1 shows the proportion of population disturbed each time period and the number of aircraft operations taking place during each hour of the day. Slightly more than one quarter of the daily flights occurred during the 6-hour period from 6:00 p.m. to midnight, the time period that differed significantly in the portion of the population disturbed. Approximately 80 percent reported some disturbance during the evening and only about 20 percent during other time periods. While the most aircraft activity occurred during the 3 hours preceding 6 p.m., the level of disturbance was only slightly higher than during other time periods. The evening period for many families generally is a time for more quiet activities that are sensitive to noise; it is the prime viewing period for television, the time for reading, and the time when families may gather for supper and conversation. It is also the time period when most people have returned home from their places of employment.

The principal reasons for the increased level of disturbance during the evening are the presence of more people and greater participation in noise-sensitive activities. It is important to note that level of disturbance during the night is no higher than level of disturbance during the day, contrary to night-weighting schemes such as Ldn. In view of these findings, two general models were adopted, one for the day and evening periods and another for the night period.

## RESULTS

With the general forms of the models established, it was necessary to define more fully the dependent and independent variables and the associated utility functions.

The statistical weakness of the disaggregate models called for further testing. Although the

logit formulation itself did not exhibit a strong statistical relationship, the models would be of value if it could be shown that the relationship was stronger than in previous formulations. The approach was to compare the model with a similar model that was estimated by using aggregated data and then to make comparisons of the total levels of interference predicted by various models with that interference reported in the survey data.

The two interference models that exhibited the best characteristics are shown in Table 2. The parameters are the coefficients for a linear utility

TABLE 2 Parameter Values for Estimation of Final Model

	Day-Evening		Night	
	t		t	
Constant	-9.01917	-8.44	-8.69396	-6.22
SELAVG	0.07662	-6.48	0.05786	3.81
Flights	0.02605	4.91	0.16114	4.26
Owner	0.28929	2.42	0.28165	2.29

Note:  $t_{\alpha} = 0.05 = 1.96$ .

function in the logit model. Because the statistical tests of the model were not definitive, the parameters were also estimated by using linear least-squares on the transformed function. The data were aggregated by noise level in SEL for the estimation. The model using the aggregate estimation procedure had an R-square value of 0.92 for the transformed function. The correlation between the predictive results of the disaggregate and the aggregate models was 0.92.

Aggregate predictions were made by using the disaggregate model; the results were compared with the aggregate impact reported in the data because although the disaggregate model did not meet all statistical tests, the predictions were highly correlated with those of a model that was estimated by using aggregated data. The model using aggregate data was able to meet relevant statistical tests. Moreover, the closeness with which the model was able to replicate the impact on the survey sample would indicate the usefulness of the model.

Two predictive tests were performed, the results of which are given in Table 3. The same approach was used for each test, although the first test used data only from Boston, whereas the second test used survey data from cities other than Boston. Two different cases were explored as part of each test; these cases differed in that the survey data was first considered as a population to be modeled and then as a representative sample of the population.

## First Test

In the first case of the first test, the survey sample was assumed to be the affected population. The actual number of persons experiencing interference was compared with the number predicted by using the model with data for each census tract. The prediction was made by calculating the probability of interference for homeowners and renters and multiplying these figures by the number of each. The two groups were then added to determine the total number of people affected. During the evening period from 6:00 p.m. to midnight, the actual number of persons experiencing interference was 403 whereas the model predicted that 380 persons would be af-



**TABLE 3 Comparison of Predictions Using the Model and Survey Data:  
Number of Persons Predicted To Be Disturbed**

	Boston		New York		Miami	
	Survey	Model	Survey	Model	Survey	Model
Case 1 (Comparison to Number in Survey)						
Day	259	281	323	266	98	111
Evening	403	380	560	504	114	146
Night	145	126	202	165	135	88
Case 2 (Predictions for Population)						
Day	53,000	68,600	110,700	92,100	33,600	40,800
Evening	87,000	96,600	201,900	198,900	43,400	63,600
Night	27,700	34,600	64,300	69,900	53,600	35,800

affected, a difference of less than 6 percent. The number of persons experiencing interference during the day was estimated by taking the proportion of the residential population present during the day and the number of flights occurring during the period from 7:00 a.m. to 6:00 p.m., and by using the model that had been estimated for the evening period. Based on the data, 259 persons experienced interference whereas the model predicted that 281 persons would be affected, a difference of 8 percent. An attempt was made to make a similar prediction for the night period, but the model greatly overpredicted the number of people affected. As has been noted, Ollerhead (18) reported that people are less sensitive to noise when sleeping than when engaged in wakeful activities; therefore, a separate model was estimated for the entire population by using reported night interference. The prediction was that 126 persons would be disturbed during the night compared with the actual number reported, which was 145.

The second case of the first test considered the survey data as a sample of the population in the area; for each census tract the proportion of the sample experiencing interference was used to estimate the number of residents who were disturbed. The model was used to estimate the interference by using the same population figures; these population data were taken from the 1970 census for the census tracts included in the survey (20). In this case, the numbers of owners and renters were determined by using the average occupancy for owner-occupied housing units and the number of those units in each census tract.

The impact was estimated only for those tracts having survey data and not for the entire area around the airport. Based on the survey, the number of persons affected during the evening is 87,000 whereas the model predicted 96,600 persons, a difference of 11 percent. Although the difference is greater in this case than in the first case, one would expect a survey to contain sampling errors. The 95 percent confidence interval for the prediction based on the survey data is from 21,900 to 152,200. The sample of 1,166 persons is less than 0.5 percent of the total population of 335,524. The same tests were performed for the day and night periods. For the night period, the prediction based on the survey was 27,700 with a 95 percent confidence interval from 0 to 70,000 whereas the model predicted 34,600. By using the model, the number of persons disturbed during the day was estimated to be 68,600 whereas by using the survey data the number was 53,000, with a 95 percent confidence interval from 0 to 106,200. In every case, the model results were well within the confidence interval of the prediction based on the findings of the survey.

### Second Test

A second test was made using the model and data from both New York City and Miami. As in the first case of the first test, the survey was treated as a complete population. Based on the data, the period impact during the evening in New York City was 560 persons whereas the model predicted that 504 persons would be affected, a difference of 10 percent. The other results of using New York City data were comparable to the findings obtained from using the Boston data. However, the results obtained by using the Miami data were not as good as those of the other two cities. In each time period, the difference between the survey results and the model prediction was greatest for Miami. Interestingly, the night period exhibited the highest reported level of impact for Miami, directly opposite from the results of the other two cities and not the results that one would expect. Thus, the noise sensitivity of residents around the Miami airport appears to be higher at night than during any other time period; this raises questions about the transferability of the model to all cities, although the model may be transferable in some cases, as exhibited by the New York results. However, even though the results are significantly worse for Miami, the model predictions are still within the 95 percent confidence interval of the survey predictions.

The sensitivity of the model to selecting a point on the summation of the semantic scale responses was tested. The definition of the occurrence of interference was adjusted up and down from the original point of 20 out of a possible 50. The model parameters were estimated by using the new definitions of interference and were tested. This alteration, however, did not change the model's statistical significance. The original definition was retained because it was based on a reasonable amount of interference being reported before an observation was counted as experiencing interference.

The model was also compared with some of the impact models that have been proposed by others. The models used for comparison were the one developed by Schultz (21), the one used in ALAMO (22), and the one developed by Hall (23). All three of these models are based on noise exposure measured in Ldn and are full-day models. Each predicts the percentage of the population that will be highly annoyed.

Schultz's model was published first and was developed by using both traffic and aircraft noise. It is estimated strictly on aggregate data by using the proportion of the population highly annoyed at each noise exposure level. Because this model is a function of Ldn, it is a full-day model incorporating a weighting for the night period. Using this model, one can derive the prediction for Boston:

53,700 persons. This function predicts a much lower figure than is obtained from the data or by using the estimated disaggregate model. A major reason for this difference is that Schultz considered only those persons who responded at the upper end of this scale when asked a question about how much they were annoyed by noise. The model and the Tracor survey address activity interference that is expected to occur before an individual becomes highly annoyed. Kryter's criticism of Schultz's work suggests that the function predicts values that are too low for aircraft noise (12).

The noise annoyance function used in the ALAMO model developed by NASA is a transformation of Schultz's function. The function is normalized to unity at 75 Ldn. However, the use of 75 Ldn to yield 100 percent of the population is arbitrary and may be expected to overpredict the number of people highly annoyed at all but the lowest levels of exposure. This is indeed the case when comparing the noise weighting function in ALAMO with the model that has been developed here. The prediction using the ALAMO function is that 145,900 persons will be highly annoyed. This prediction is substantially higher than the one based on activity interference, although activity interference generally occurs before someone becomes highly annoyed. Those persons exposed to levels higher than 75 Ldn are weighted by a factor greater than 1 when actually indications are that a certain proportion are not annoyed at high exposure levels.

The function developed by Hall is similar to the other two in that it predicts the percentage of the population that is highly annoyed as a function of exposure in Ldn. This function, like the ALAMO function, predicts numbers of persons highly annoyed well above the number predicted as experiencing activity interference. The value predicted in the Boston test case was 147,400 highly annoyed persons.

The large discrepancies between the models all purporting to predict the percentage of population highly annoyed indicates the poor basis for these models. Because substantial interference may take place before a person is highly annoyed, using a measure of persons highly annoyed as an indication of impact misses a large portion of the actual impact that occurs in the form of interference with home activities. On the other hand, it is argued by some that the number of persons annoyed that are not included in the prediction (which is based on the number highly annoyed) is proportional to the share included, so that the models are of value in estimating impact. The rationale for this argument is the relative stability of aggregate proportions of respondents reporting annoyance at the various levels. A better argument can be made for a negative correlation between the various degrees of annoyance because each respondent is limited to a single response. The theoretical basis for the functions is weak in that impact occurs with interference and annoyance is a reaction to or manifestation of that interference.

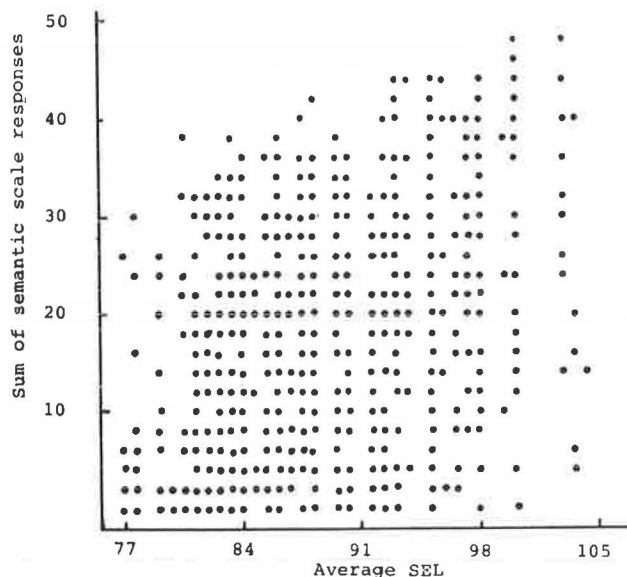
The disaggregate model was selected for use in predicting residential impact. This model meets several statistical tests and the results are highly correlated with those of the aggregate model. The disaggregate model prediction compares favorably both to the data as a population and to the prediction based on the data as a survey sample.

#### Individual Variance

The difficulty in obtaining a good model fit is best explained by observing plots of the summed responses to degree of disturbance against the independent

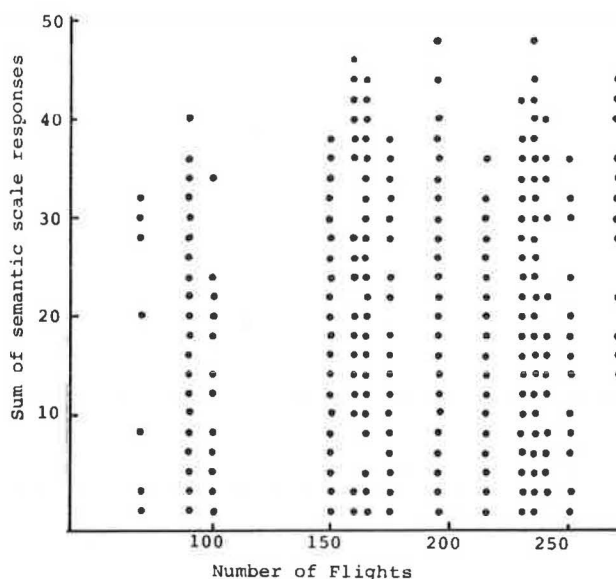
variables of noise level and number of flights. Figures 2 and 3 show individual responses. Although a trend is present and meets statistical tests for significant variables, it is clear that the individual variance in response is too large to be accounted for in the model. Griffiths and DeLauzun (5) reported the apparent randomness in response, noting that the individual variance was due as much to randomness as to any characteristics of the individuals.

It was this randomness that led to the use of a logit model in this research, but it is apparent that the random element is of such magnitude that a logit formulation is unable to account for all of it. It is likely that this randomness could be reduced by the use of independent variables similar to



Note: Each point may represent more than one observation.

FIGURE 2 Sum of semantic scale response versus average sound exposure level (SEL), excluding supersensitive respondents.

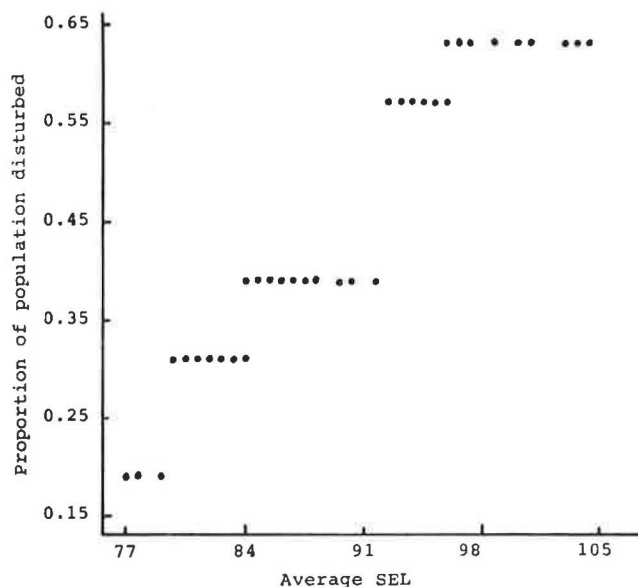


Note: Each point may represent more than one observation.

FIGURE 3 Sum of semantic scale responses versus number of flights, excluding supersensitive respondents.

those used in the Tracor report. These variables included personality traits such as fear of aircraft crashing, susceptibility to noise, noise adaptability, and belief in misfeasance on the part of the airport operator. Because these variables are combinations of subjective responses, it is impossible to estimate these variables for any population without conducting a survey. There is no advantage in using a model if a new survey is required for every use.

It was initially hypothesized that the incorporation of socioeconomic characteristics would allow the development of a model that would reduce the random element to an acceptable level. This hypothesis was rejected, but it was found that the random effects are significantly reduced during aggregation; for that reason the aggregate predictions are reasonably good. The effects of aggregating the data are shown in Figure 4, and a trend is evident after the loss of most individual variance. It is significant to note that a disaggregate model by itself will not provide a good fit, but some aggregation must take place to reduce the individual variance. This finding holds with that of Hall and Taylor (24), who reported that reliability for individuals being resurveyed about noise annoyance was very poor, but that the aggregate percentages of persons annoyed were very reliable.



Note: Each point represents multiple observations.

FIGURE 4 Proportion of population disturbed by aircraft noise at various sound levels (SEL).

#### Residential Impact Prediction

The model that has been developed predicts the probability of interference occurring for a particular average SEL and number of flights based on home ownership. The probability of interference occurring is multiplied by the number of people in the same situation to determine the number of people affected. To estimate the actual impact, the amount of time that this interference occurs must be incorporated. This calculation is made by taking the TA75-- the amount of time that the level 75 dBA is exceeded during each time period (day, evening, and night)-- and multiplying it by the number of people affected during each period. The basis for selecting the TA75 has been described elsewhere (1). In the Boston test

case mentioned previously, the impact was estimated to be 39,800 person-hours/day. The same calculation using the survey data as a population sample estimates the impact to be 44,500 person-hours/day. The total number of person-hours for all impacted census tracts and time periods is the measure of the residential impact from the airport noise.

#### SUMMARY

The methodology for developing a model of residential activity impact due to aircraft noise has been described. The model is based on the concept of the loss of utility to a household as a result of a change in the attributes of the residential location. The primary residential attribute affected by aircraft noise is quiet in the neighborhood.

Based on economic theory, a mathematical relationship for activity interference in terms of the utility function was developed. The form of that relationship was a logit model that includes a random element, an important consideration in modeling airport noise impact. The data used for calibration of the model were described and the procedures used in developing the model were explained. Socioeconomic characteristics of the survey sample were explored to determine significant relationships between these characteristics and noise interference; the only characteristic that was found to be significant was home ownership.

Because the individual variance in response to aircraft noise was so high, a disaggregate model that met all statistical tests could not be developed. A similar model estimated by using aggregate data was found to be statistically significant.

Total impact predictions were used to determine the usefulness of the model in predicting impact. The model was able to provide predictions within 10 percent of that reported in survey data. The interference model predictions were also compared with the predictions of other impact models based on annoyance and were found to be more reliable. The procedure for calculating the residential impact using the interference model was described and an example provided. The model of residential noise interference is more reliable than other procedures that have been developed in the past. It cannot, however, be used in any location without consideration of the characteristics of the community being analyzed and the possible need for recalibrating the model parameters.

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# Design of Acoustical Insulation for Existing Residences in the Vicinity of San Jose Municipal Airport

C. MICHAEL HOGAN and JORGEN RAVNKILDE

## ABSTRACT

The vicinity of the San Jose Municipal Airport includes a large number of residences that lie in land-use zones that are acoustically incompatible with California state requirements. Analyzed in the current study was a sample of 10 residences of various ages, locations, and structure types within this incompatible residential class. Retrofit designs were developed for each structure to reduce interior sound levels, based on simultaneous indoor-outdoor sound level measurements and on architectural acoustical analysis of the structure. Follow-up sound level measurements were conducted to establish the success of original acoustical predictions for interior sound levels.