New Research on Community Reaction to Aircraft Noise in the United States

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ABSTRACT

In the U.S., the so-called "Schultz Curve" (a relationship between surveyed noise annoyance and associated noise exposure, formalized now as the FICON curve) has been a primary basis for FAA's noise and land-use compatibility guidelines. FAA recognizes that the data supporting this dose-response relationship are decades old, and that more recent noise annoyance surveys in other countries produce relationships that can differ significantly from the Schultz Curve. Consequently, the FAA has begun a process of developing and testing an aircraft noise annoyance survey methodology that will eventually be applied to the large-scale U.S. survey at about twenty airports that are served predominantly by jet aircraft. The survey is expected to use two survey modes: telephone interviews and a mail questionnaire. This paper describes the development and the validation of the methodology, some of the results, and the proposed approach to selection of the nation-wide survey sites. The expected approach to data analysis is provided.

THE FIRST STEP IN DETERMINING U.S. NATIONAL AIRCRAFT NOISE ANNOYANCE

Before devoting the resources necessary for a national level survey of jet aircraft produced noise annoyance, the U.S. Federal Aviation Administration (FAA) provided funding through the U.S. National Academy of Sciences for conduct of test surveys at three airports (ACRP 02-35). One of the prime objectives of ACRP 02-35 was to develop and validate a research protocol for a large-scale study of aircraft noise exposure-annoyance response relationship in the United States (U.S.). The test survey design included use of both a telephone survey and a mail survey. A literature review provided the basis for developing a survey methodology and questionnaire specifics. The noise exposure level around airports was modelled using FAA's Integrated Noise Model (INM) program. Thereafter respondents were randomly selected within five decibel annual average day-night sound level (DNL) noise exposure contours. Primary analyses examined response rates by survey mode and consistency between telephone and mail annoyance responses.

LITERATURE REVIEW

A literature review was conducted to support plans for the new national survey of aircraft noise in the U.S. The measure of impact for this survey is the privately-expressed noise annoyance that is documented in social surveys (U.S.C, 2010), not the visible, publicly-expressed actions such as complaints to authorities, lawsuits or public protests. This residential annoyance is expressed in percent of "highly annoyed" (HA) response. To construct a dose-response curve, the percent of HA

respondents is plotted versus noise levels expressed in DNL. The review includes identifying and evaluating methods for estimating non-acoustical factors that are hypothesized to affect noise annoyance, and identifying other unresolved noise annoyance issues.

Findings Applied to both Telephone and Mail Survey Instruments

Based on the literature review, telephone and mail surveys were identified as the most cost-effective and consistent with the methods of previous annoyance surveys. Some findings could be applied to both telephone and mail surveys. However, because respondents would be able to read through the mail questionnaire before answering, the mail survey was designed to provide no suggestion that it was an aircraft noise annoyance questionnaire. Therefore it was made to be quite brief, could not address all findings in the literature, and would provide data for only the main purpose of the survey: determining probability of annoyance as a function of observable objective data, such as noise exposure, location relative to the airport, percent of night time operations, etc. The telephone interview included 49 questions about residents themselves, their level of annoyance due to aircraft noise, road traffic noise and other potential irritants. The following issues identified in the literature were included in this study:

- Mode of questionnaire administration may affect responses: interviewer-administered or self-administered. Consequently, a primary goal of the test surveys was to determine whether annoyance responses for these two modes were significantly different.
- Use the pair of questions published in International Organization for Standardization (ISO) Technical Specification (ISO, 2003).
    - Verbal: “Thinking about the last (12 months or so), when you are here at home, how much does noise from (noise source) bother, disturb or annoy you: not at all, slightly, moderately, very, or extremely?”
    - Numeric: “Next is a 0-to-10 opinion scale for how much (source) noise bothers, disturbs or annoys you when you are here at home. If you are not at all annoyed choose 0; if you are extremely annoyed choose 10; if you are somewhere in between, choose a number between 0 and 10.”
    - The first question was included in both the mail survey and telephone survey and was implemented as in Figure 1.
    - The second question was included in the telephone survey, Figure 2.
- Residents in different geographic areas (neighborhoods, cities, airports, etc.) may have significantly different annoyance reactions to the same noise level. Geo-locations are used to compute sound metrics for each respondent and could be used to explore neighborhood variations.[1] For the national survey, if differences in airports are to be analyzed, airports must be randomly selected with statistical probability selection methods. Also, survey design will have to include sufficient numbers of respondents at each airport to yield the precision necessary for valid cross-airport comparisons.

[1] Confidentiality of responses is guaranteed however, so this analysis, if done, must be reported in a way that preserves this confidentiality.

- Demographic characteristics of residents (gender, age, education, socio-economic status, etc.) have no important impact on noise annoyance. Hence, differences between survey respondent demographics and census demographics should not suggest a bias in responses. Also, differences in demographics by area will not explain differences in responses.

5. Thinking about the last 12 months or so, when you are here at home, how much does each of the following bother, disturb or annoy you?

	Not at all ▼	Slightly ▼	Moderately ▼	Very ▼	Extremely ▼
a. Noise from cars trucks or other road traffic	☐	☐	☐	☐	☐
b. Smells or dirt from road traffic	☐	☐	☐	☐	☐
c. Smoke, gas or bad smells from anything else	☐	☐	☐	☐	☐
d. Litter or poorly kept up housing	☐	☐	☐	☐	☐
e. Noise from aircraft	☐	☐	☐	☐	☐
f. Your neighbors' noise or other activities	☐	☐	☐	☐	☐
g. Any other noises you hear when you are here at home If this bothers or annoys you, what is the noise? ☐	☐	☐	☐	☐	☐
h. Undesirable business, institutional or industrial property	☐	☐	☐	☐	☐
i. A lack of parks or green spaces	☐	☐	☐	☐	☐
j. Inadequate public transportation	☐	☐	☐	☐	☐
k. The amount of neighborhood crime	☐	☐	☐	☐	☐
l. Poor city or county services	☐	☐	☐	☐	☐
m. Any other problems that you notice when you are here at home If this bothers or annoys you, what is the problem? ☐	☐	☐	☐	☐	☐

Figure 1: Primary Mail and Telephone Survey Annoyance Question

Thinking about the last 12 months or so, what number from 0 to 10 best shows how much you are bothered, disturbed or annoyed by the noise from aircraft?

Figure 2: Second Annoyance Question, Telephone Survey

Findings Applied to Telephone Survey Only

The telephone survey instrument was designed to provide not only the type of information collected by the mail survey, but additional data that might help explain differences in annoyance reactions across individuals and across airports. Evidence in the literature supports a positive relationship between annoyance, personal characteristics and time:

- fear of danger from aircraft,
- individual sensitivity to noise, and
- annoyance increase with time for the same noise exposure.

There are several issues that could be of policy interest, but for which no studies have been located in the literature. They have been addressed in the test surveys:

- respondent perceptions of airport authority's actions and activities, including community relations programs,
- correlation between public complaints and private annoyance, and
- respondent awareness of airport issues through media and neighbourhood communications.

SURVEY METHODS

The general approach was to use a sample of about 2200 people per airport, half receiving the mail survey, half receiving an introductory letter which explained the telephone survey and informed recipients that they would later receive a telephone call. Figure 3 is a schematic of the process for each type of survey, where the percentages are based on the number of deliverables.

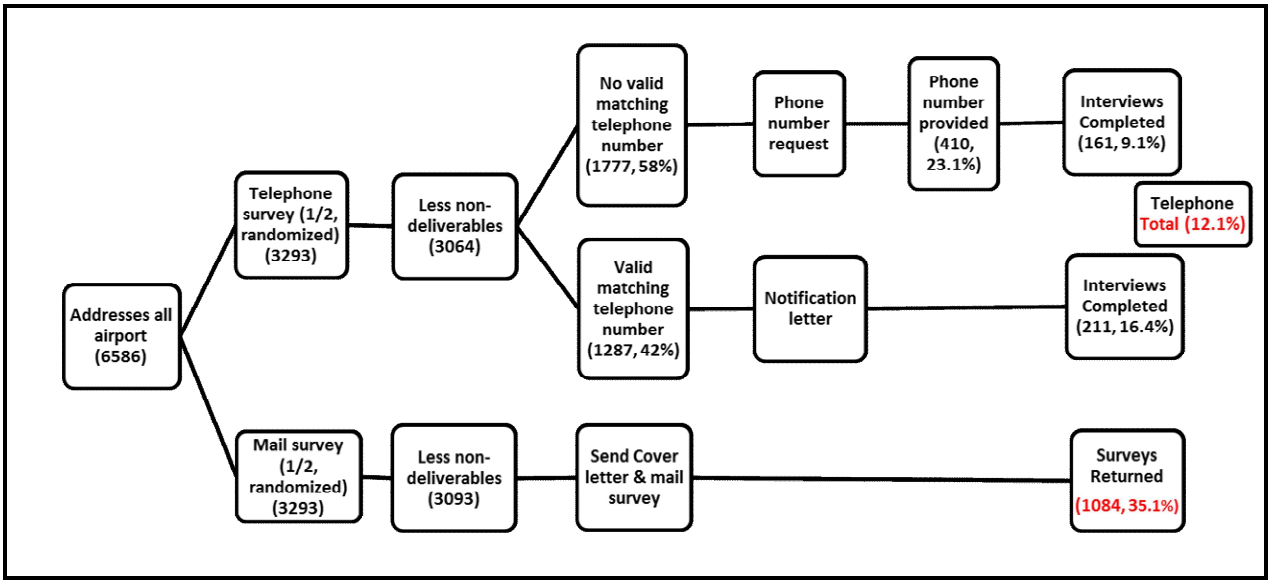

Figure 3: Schematic of Telephone and Mail Survey Process with Total Survey Numbers, All Airports

After the first mailings, about 200 addresses each for the mail survey and the telephone survey were non-deliverable. Also, for the telephone survey, a group of addresses could not be associated with a valid telephone number. These latter addresses were mailed a request for a phone number, and a portion of these responded. These telephone numbers were called, and an interview initiated and 39 percent of these completed. Each address, whether for telephone or mail survey, received a two-dollar appreciation incentive with the initial contact. The response rates were calculated using as the denominator the number of addresses selected minus the postal non-deliverables. As shown in Figure 3, the telephone response rate was 12.1 percent and the mail rate was 35.1 percent.

Detailed Metrics for each Respondent

The noise metrics at each respondent location were computed using the FAA's INM program. Twelve months of flight tracking data were used to compute noise exposure expressed in different metrics. It is custom to present dose-response relationship as a probability of annoyance as a function of DNL, but other metrics were also computed for later analysis of possible correlations with annoyance reactions.

Table 1 lists all the metrics computed. These metrics were chosen because they are not, in all locations, strongly correlated with DNL and may prove to be explanatory variables for the relationship between annoyance and DNL. Locations affected by takeoff noise were also identified since that noise can contain significant low frequency energy, which has little influence on the A-weighted DNL levels. The additional metrics beyond the energy average ones were computed to develop a procedure for deriving them for an entire year of flight operations. They will be analyzed as a part of the national survey.

Table 1: Noise Related Metrics Computed at Each Respondent's Location

Energy Average, dB	Mean and Median
DNL	Time Above (TA):
Lnight	55, 60, 65, 70, 75
Leq24: Total Arrival Only Departure Only	Number Above (NA) 55, 60, 65
	Probability of Awakening at least Once ANSI 12.9-2008 / Part 6 – (ANSI, 2008)
Identification of Locations Affected by Start of Takeoff Noise	

ANALYSES AND RESULTS

Response Rates

As shown in Figure 3, the mail survey rate was 35.1 percent and the telephone survey response rate was 12.1 percent and Table 3 present the response rates by airport, and by survey mode.

Analyses were conducted on the resulting responses to determine the probability that a household selected to be in the sample would complete a survey. Logistic regression analyses were performed to predict the propensity to respond as a function of the characteristics known for the sample: airport, noise exposure, survey mode (mail or telephone), and demographic characteristics for census blocks from the 2010 Census. This analysis demonstrated the important fact that noise exposure, as measured by DNL, is not significantly related to the propensity to respond to the survey.

Table 2: Response Rates for Three Airport Test Mail Survey

Mail Survey	Number of Addresses	Number of Addresses Less Postal Non-deliverables	Number of Questionnaires Received	Mail Response Rate. percent
Airport 1	1098	998	392	39.4
Airport 2	1100	1043	388	37.2
Airport 3	1095	1052	304	28.9
All	***3293***	***3093***	***1084***	***35.1***

Table 3: Response Rates for Three Airport Test Telephone Survey

Telephone Survey	**Number of Addresses**	**Number of Addresses Less Postal Non-deliverables**	**Number of Households Providing Telephone Numbers**	**Response Rate for Providing Telephone Number, percent**	**Number of Telephone Interviews**	**Telephone Response Rate, percent**
Airport 1						
Matched telephone number	369	365			79	21.6
Unmatched telephone number	729	632	140	22.2	65	10.3
All	**1098**	**997**			**144**	**14.4**
Airport 2						
Matched telephone number	338	334			51	15.3
Unmatched telephone number	762	687	171	24.9	63	9.2
All	**1100**	**1021**			**114**	**11.2**
Airport 3						
Matched telephone number	594	588			81	13.8
Unmatched telephone number	501	458	99	21.6	33	7.2
All	**1095**	**1046**			**114**	**10.9**
All Airports						
Total	**3293**	**3064**			**372**	
Average						**12.1**

Selection of Adult Respondent

The study was designed to randomly select an adult to be interviewed or to fill out the mail questionnaire. For the telephone survey, in households with two adults, a random number determined whether to interview the adult answering the phone, or the other adult. When there were more than two adults, the person with the next birthday was interviewed. For the mail survey, the adult with the next birthday was asked to complete the survey. In households with two or more adults, the correct person filled out the survey about 75 percent of the time. However, there were many single adult households so that overall, in 86 percent of the households, the correct respondent completed the mail survey.

Comparison of Mail and Telephone Survey Results

Table 4 displays the difference in percent HA separately for each noise stratum and airport. Each entry in the table is the percent HA from the mail survey minus the percent HA from the telephone survey for that noise stratum and airport. Standard errors for the individual estimates are given in parentheses, and these standard

errors are large because of the small sample sizes of telephone respondents in each stratum. After adjusting the p-values for multiple testing using the Bonferroni method[2], only one of the differences is significant at the 0.05 level: noise stratum of DNL 65 dB and above for Airport 3, where the percentage HA on the mail survey was 40 percentage points higher than on the telephone survey.

Table 4: Differences in Percent Highly Annoyed (Mail – Telephone) by Airport and DNL Noise Stratum

Airport	Annual Average Day-Night Sound Level, dB				
	50-55	55-60	60-65	65-70	70+
1	-5.0 (6.0)	-4.2 (8.2)	-2.5 (8.3)		
2	-0.6 (7.4)	-8.7 (11.2)	14.7 (12.2)	5.3 (11.9)	25.3 (11.3)
3	-7.1 (10.6)	-1.0 (14.7)	**40.0 (10.5)**	-2.7 (7.4)	

NOTE: Standard errors are in parentheses. Boldface values are statistically different from zero at the 0.05 significance level, after making a Bonferroni adjustment for multiple testing.

LESSONS LEARNED FOR THE NATIONAL SURVEY

1. Due to low response rate for the telephone survey and higher cost in comparison with the mail survey, the phone survey is likely to be inadequate as the primary source of data for an updated dose-response relationship.
2. Mail survey response will likely form the basis for an updated dose-response relationship. The number of addresses selected for the mail survey should be increased above the 1100 used for each test airports. For example, assuming 40% response rate and a goal of 500 completed surveys, 1250 addresses are needed.
3. Lack of significant difference between telephone and mail survey annoyance results justifies heavy reliance on the mail survey.
4. The number of addresses selected at each airport should be sufficient to determine a statistically significant difference (if there is one) between the revised relationship and the “Schultz Curve” (FICON curve).
5. The derived dose-response relationship may vary from airport to airport; consequently, the number of addresses selected should be sufficient to explore any heterogeneity across airports.

NATIONAL SAMPLE OF AIRPORTS

A large-scale study of aircraft noise exposure-annoyance response relationships across the U.S. will be conducted based on the method described above. The statistical sample of twenty airports will be drawn to represent community response in all airports in the U.S. Several factors will be considered in drawing the sample: annual temperature range, number of daily operations, percent of night-time operations, fleet mix (large jet versus commuter jet aircraft), population within five

[2] P value is the probability of obtaining a given statistical result with additional tests. When a significance level of p equals 0.05 is used, one expects one out of every 20 hypothesis tests performed to be statistically significant even if all null hypotheses are true; i.e., if there is no statistical relationship between the measured results. Multiple comparisons procedures adjust the p-values for the number of tests performed to protect against possible “data snooping,” in which many hypothesis tests are performed and only the tests with significant results are explored further; see Oehlert (2000, chapter 5).

miles of the airport, and geographic scope. Since a random sample of the twenty airports is small compared to usual sample sizes and unlikely to provide a balance across all these factors, we anticipate using a "balanced sampling" technique. The balanced approach allows airport selection so that the sample has approximately the same proportion of airports as the population with respect to each of the balancing variables (Valliant, Dorfman & Royall, 2000).

ANTICIPATED ANALYSIS OF NATIONAL SAMPLE OF AIRPORTS

The primary analysis will be logistic regression of the dichotomized annoyance results by DNL level at each respondent's residence. The dichotomization will be between moderately and very annoyed. Heterogeneity among the airports' communities will also be analyzed. It is expected that any statistically significant differences in dose-response across airports will be explored to separate differences that could have policy implications from idiosyncratic differences. The dose-response curve will be constructed from obtained responses and compared to the existing Schultz-curve.

CONCLUSIONS

The methodology for the U.S. national survey of residential community reaction to aircraft noise was developed. The methodology is based on mail surveys and telephone interviews of individual residents; noise exposure is modelled with the INM. This method was tested around three U.S. airports. It was found that the response rate to the mail survey is about three times higher than response rate to the telephone interview. Adjustments to the methodology to improve response rates will be done and applied to the national survey. About twenty airports will be surveyed in different regions of the country. The study sites will be selected using the balanced sampling approach to represent all U.S. airports. The updated dose-response curve will be constructed based on the resulting data.

ACKNOWLEGMENTS

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