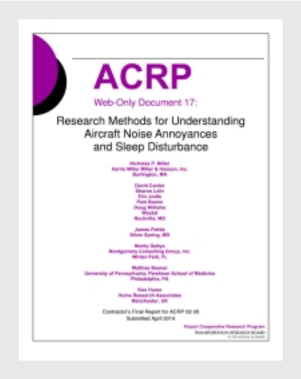
ACRP
Web-Only Document 17:
Research Methods for Understanding Aircraft Noise Annoyances and Sleep Disturbance

Research Methods for Understanding Aircraft Noise Annoyances and Sleep Disturbance

DETAILS

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AUTHORS

Miller, Nicholas P.; Cantor, David; Lohr, Sharon; Jodts, Eric; Boene, Pam; Williams, Doug; Fields, James; Gettys, Monty; Basner, Mathias; and Ken Hume

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1 Executive Summary

This report presents the final documentation for the two parts of this ACRP 02-35 project. This executive summary addresses first the aircraft noise annoyance survey tasks, and second, the sleep disturbance effort. Then, Sections 2 through 10 describe the annoyance survey methodology that was developed and applied and the results relevant to the goals of the study. Section 12 examines airport-community relations. Section 13 lists the references cited in the discussion of annoyance. Sections 14 through 17 present the final sleep disturbance study designs and the budget estimates for each type of study. Section 17 presents the references cited in the discussion of the sleep study design. Appendices provide materials referenced throughout the report.

1.1 Annoyance

The first phase of this ACRP Study included collection of data for the purpose of testing an aircraft noise annoyance survey that can be used in a national study to update the dose-response relationship between noise exposure and the percentage of people who are highly annoyed. Two modes for collecting the survey responses were tested.

1. The first mode was a telephone interview, in which respondents were asked 49 questions about themselves, their level of annoyance due to aircraft noise and other potential irritants such as road traffic noise. The telephone survey also asked about views on the actions of local airport officials for controlling aircraft noise.

2. The second mode used a shorter mail questionnaire containing the questions about level of annoyance due to aircraft noise and a much smaller number of potential irritants.

The main goals of the annoyance portion of this study were to:

- Compare response rates and yield for the mail and telephone surveys, and

- Evaluate whether the relationship between percent highly annoyed (HA) and aircraft noise exposure differs for the two survey modes.

Four different survey designs were reviewed: 1) in-person, 2) telephone, 3) mail and 4) web-based. In-person interviews give the highest data quality, response rate, ability to select the respondents and permit the greatest complexity of the questionnaire. However, the cost of the in-person interviews was judged too high for practical implementation, especially for the ultimate national survey. A web survey may be the least expensive, but it requires access to the internet, cannot very well control who responds to the survey, and may not be able to yield sufficient respondents across all noise exposures of interest. Unlike many large social surveys, this annoyance survey requires that subjects be chosen based on their location / noise exposure level and that, to the extent possible, the sample sizes at different exposure levels should be approximately equal. This rough equality ensures that a dose-response curve may be developed with roughly equal confidence bounds across all noise exposures of interest. Based on team experience and the literature review, the decision was made to conduct both a telephone and a mail survey at each airport for the purpose of comparing the responses to both survey modes.

A literature review identified best practices for the design of the survey instruments and determined what policy-relevant issues could be addressed from this design's strengths. Sixty-two survey topics were identified in the noise literature as were the types of data needed to address these topics. The topics most likely to succeed were chosen and a survey instrument developed. The basic noise annoyance response question was selected for use in both the mail and the telephone surveys see Figure 1. A full questionnaire developed for the telephone survey is included in Appendix A.

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 Basic Aircraft Noise Annoyance Question

Three airports agreed to be airports where the test surveys could be conducted. These airports were chosen because they are located in different geographic areas and climates.

For each airport, annual day-night average noise exposure (DNL) contours were computed and five noise exposure strata used to select candidate respondents: 50-55 dB, 55-60 dB, 60-65 dB, 65-70 dB and over 70 dB. The goal was to attempt to survey a total of 6,580 addresses, 2,193 per airport or approximately 439 in each DNL noise stratum. Two airports were surveyed first, so that the third survey could benefit from any lessons learned at the first two. For the initial two airports, residential locations and associated addresses were selected to reflect this distribution, in so far as was possible, and the resultant addresses were divided generally as shown in Figure 2 (more detail in Section 5). After the initial division, the addresses selected for the telephone survey were associated with telephone numbers. Increasingly, telephone numbers cannot be found for addresses and specific mailings are required to solicit phone numbers.

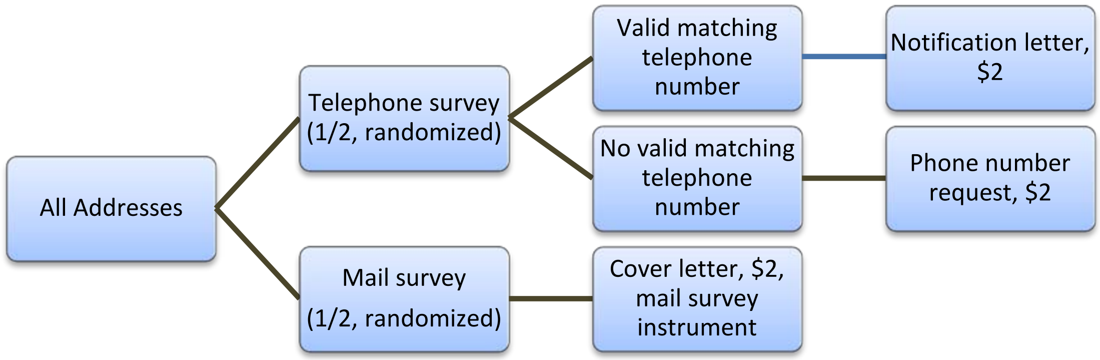

Figure 2 Division of Selected Addresses Among Survey Methods

Once all interviews / survey responses were complete, detailed noise metrics were computed for each respondent location, and responses associated with the location's noise exposure in terms of DNL, as computed by FAA's Integrated Noise Model (INM).

The major findings from the analysis of the data are:

- Response rates for the mail survey are much higher than those for the telephone survey (35.1% vs. 12.1%).
- There is no evidence that the response of percentage highly annoyed differs between the telephone and mail surveys.
- Statistical tests showed no significant difference overall between the mail and telephone surveys in percent highly annoyed.
- Respondents to the survey are disproportionately likely to be white non-Hispanic and age 50 or more, when compared with census figures, although the differences from the census are greater for the telephone survey than for the mail survey. Among the respondents to the survey, however, there is no statistically significant relationship, after accounting for the level of noise exposure and airport-to-airport differences, between these demographic characteristics and annoyance.

1.2 Sleep Disturbance

The main objectives of Phase II, the sleep disturbance portion of ACRP Project 02-35 are:

- Develop at least two general research protocols to improve the understanding of the relationship between aircraft noise and sleep disturbance in a field setting, and
- Identify criteria to be used to test and evaluate the protocols. The evaluation criteria should include, but not be limited to, cost, time, data quantity, quality, and validity, administrative effort, and comparability with previous and future studies.

The suggestions for conducting sleep disturbance research (Section 15) are based on both the literature review (summarized in Section 14) and recommendations developed by Dr. Basner in PARTNER Project

25B. In PARTNER Project 25B, Dr. Basner developed an optimal study design for a possible U.S. field study on the effects of aircraft noise on sleep. The research protocols described in this summary are consistent with the findings of PARTNER Project 25B, and those findings that are relevant for the Sleep Disturbance Study Plan, Section 15, will be discussed here. However, the reader is also referred to the Year 1 report of PARTNER Project 25B [1][1] and to two publications that resulted from this work.[2,3]

It should be stressed that, in general, there is no optimal study design that maximizes all the desirable attributes of a study. Rather, every decision will influence some study aspects positively and others negatively. What is considered "optimal" largely depends on the goal of the specific study. For the United States, current, precise, and valid exposure-response relationships between acoustical properties of single aircraft noise events (e.g., maximum sound pressure level or Sound Exposure Level, SEL) and physiological reactions (e.g., awakenings) are needed to inform policy and legislation. Precision requires the investigation of a large enough sample of subjects exposed to a large enough number of aircraft noise events. Power calculations inform how large these numbers need to be. Sample sizes need to avoid being either too small (relevant effect cannot be detected) or too large (additional funds could have been allocated for another study). Validity requires that the measurement of both the acoustical exposure and the physiological response are measured correctly and can be interpreted in a meaningful way. Additionally, the investigated subjects need to be representative of the population of interest for the results to be externally valid.

The two general research protocols discussed in Section 15.1 (Polysomnography or Actigraphy plus ECG) will be identical in aspects related to the selection of measurement sites, study population, acoustical measurements, and supplementary data gathered, as we think that the strategies identified here could be described as optimal. The two research protocols, will, however, differ in the methodology used to measure sleep. As explained below in Section 17, this will primarily affect the staffing level needed to collect the physiological data in the field and to analyze the data afterwards. The per subject costs will thus be higher for polysomnography, which will limit the maximum number of investigated subjects at the same level of funding. How the different methods affect staffing levels and funding will thus be explained in detail in the budget section of this report. The two protocols are outlined in Section 15.1.

[1] Numbers in brackets [ ] refer to Sleep References in Section 18.

PHASE I – AIRCRAFT NOISE ANNOYANCE SURVEYS

2 Annoyance Survey Method

2.1 Design Considerations

The goal of this ACRP Study was to test two methods of data collection that could be used in a national survey of community reactions to aircraft noise. In the study, a telephone survey was compared with a mail survey. These survey modes were selected for the study after considering the costs and possible sources of bias for the modes that could be employed in a survey. This section describes methods that can be used to collect data in a sample survey, and summarizes the advantages and disadvantages of each method in the context of an aircraft noise and annoyance survey. The study design used an address sample, based on the USPS Delivery Sequence file (DSF)[2] .

Table 1 ranks four methods of survey data collection along with different evaluation criteria. Each column in the table ranks the method using different criteria with a low value considered better than a higher value. Unit cost refers to the expense of completing and processing an interview. This cost is directly related to the total number of interviews (quantity) that can be collected. There are four measures related to data quality. Coverage refers to the correspondence between the population of interest (adults living around the airport) and the sample frame. The sample frame is the list or sets of procedures which produce the elements that are eligible to be sampled for the study. A data collection method has complete coverage if the sampling frame includes everyone in the population of interest. Response rate and respondent selection are additional quality measures. A respondent selection method is required to randomly assign the interview to a specific individual living within each sampled address, and a method receives a lower score if the survey researcher can ensure that the person who is randomly assigned to respond to the survey actually is the person who responds to the survey. A method scores well on follow-up if it is easy to determine whether a sampled unit is eligible for the survey and to follow-up with the household after the initial contact. Complex questionnaire refers to the capability of the method to accommodate complex skip and logic navigation patterns within the questionnaire. Comparability refers to whether the method allows comparison to prior surveys that have been completed on airport noise.

Table 1 Rank order of Survey Data Collection Methods by Quality and Cost Criteria

Method	Lowest Unit Cost	Highest Data Quality				Most Complex Questionnaire	Comparability
		Coverage	Response rate	Respondent Selection	Follow-up		
In-Person	4	1	1	1	1	1	1
Telephone	3	3	3	2	2	2	1
Mail	2	2	2	4	3	4	2
Web	1	4	4	4	3	3	2

2.1.1 Unit cost

A review of all columns in Table 1 reveals that if not for cost, in-person would be the best method of collection. However, because of the extensive travel requirements, in-person collection generally ranges between 6 – 8 times as costly per completed interview as a telephone interview. A web survey is the least expensive. An additional contributor to in-person cost is the need to cluster in-person interviews in small geographic areas to minimize travel costs and time. This can decrease the effective sample size (Groves et

[2] This is the list of all addresses where the USPS delivers mail.

al., 2004)[3], although the compact regions included in an aircraft noise survey would involve less travel than surveys that cover a larger geographic area.

2.1.2 Coverage

In-person surveys cover the largest portion of the population by allowing direct contact with both unit (in our case, households at specific addresses) and within-household eligible populations. Mail is rated second because the DSF frame has been found to have very good coverage for adults living in the civilian non-institutional population. Telephone and web surveys have lower coverage than in-person surveys or mail surveys because of their inability to efficiently contact particular units. A telephone survey relies on obtaining telephone numbers to call sampled households. This might be done using a random digit dial sample (RDD). However, because the ACRP sample has to be targeted within a relatively small area, it is not efficient to use RDD.[4] A second way to collect telephone numbers is to sample households based on addresses and then match these using a reverse phone directory that associates a phone number with addresses. This approach yields telephone numbers that are listed in the phone book, as well as telephone numbers from other data sources used by the sample vendor (e.g., warranties or subscriptions). For those addresses that do not match to a telephone number, a short mail survey can be sent to households, asking for a telephone number for purposes of participating in the survey. This two-pronged method has been found to yield telephone numbers for approximately 88% of households in the original address sample (Montaquila et al., 2010). Based on Table 1, the telephone method provides less coverage than both mail and in-person method because it results in a percentage of households for which no telephone number can be acquired (i.e., no reverse directory match; no mail survey returned with a telephone number; household has no telephone).

A web survey is lowest on coverage because it is limited to those with access to the internet. Approximately 73% of the population has internet access in some way (Pew, 2013). Those that do not have access tend to have lower income and are in older age groups (Groves et al., 2004), thus automatically creating a biased sample. If a web mode were to be used, the survey would have to also use another method that could reach those who do not have access to the web or those who are not willing to use the web (Messer and Dillman, 2011).

2.1.3 Response rate

In-person surveys have the highest response rates. The ability for the interviewer to make contact with the sampled unit and make a personal appeal is the most effective way to obtain cooperation. Up until several years ago, telephone surveys had relatively high response rates. However, there has been a dramatic decline in response rates over the last decade (Curtin, et al., 2005). Telephone survey response rates of approximately 20% to 30% are standard in the industry for random digit dialing at the present time (though for the three test airports of this study, the response rate was only 12.1%, see Section 7). Alternatively, mail and mail/web surveys are increasingly being used to replace telephone surveys because of the ability to achieve higher rates. For example, Westat conducted parallel mail and telephone surveys as part of the Health Information National Trends Survey and found the mail survey to have a higher response rate than the telephone survey. Similarly, Westat recently conducted a two-phase mail survey for the National Household Education Survey (NHES) and achieved response rates of approximately 45% (Montaquila, et al., 2010).[5]

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[3] References are listed in Section 13.
[4] It is possible to do some linking of area code and telephone pre-fixes to particular areas for landline telephones. This process, however, is subject to some error. This process is even more problematic for generating numbers for cell phone users.
[5] See also Messer and Dillman (2011) for a similar result.

With respect to response rates, mail surveys consistently outperform web surveys for a general population survey like the one contemplated in this ACRP study (Tourangeau et al, 2013; Messer and Dillman, 2011). Combined with the lower coverage of the web (see discussion above), at this point in time there do not seem to be any advantages of using a web survey rather than a mail survey if the goal is to increase the representativeness of the survey.

2.1.4 Respondent selection

Self-administered surveys, such as those conducted by mail or on the web, rely on respondents to find someone in the household to complete the survey. This is typically done by giving the household a rule to follow to determine who should participate (for example, the person with the next birthday, the oldest male, etc.). Prior research has found that respondents have some trouble following selection rules. For example, Battaglia et al (2008) found that approximately one-third of the survey respondents to a mail survey did not follow the birthday rule. In-person or telephone surveys have the interviewer follow the preferred procedures for selecting respondents.

There is some evidence that mail surveys lead to higher estimated levels of noise annoyance (Yamada, Kaku, Yokota, Namba, and Ogata, 2008). The suspicion is that the person who is most concerned about noise will respond. Despite these concerns, there is an increasing trend for noise surveys in other countries to use self-administered methods such as mail surveys (Janssen et al., 2011). The present test at three airports, however, found mail and telephone surveys produced similar annoyance response results, see Section 7.

2.1.5 Follow-up

All of these methodologies permit multiple follow-ups with sampled addresses. In-person surveys provide more information on the status of the units and thus allow for more efficient follow-up of eligible units. For example, interviewers are able to look at a unit and decide if it is a business and/or if someone is living there. Less information is available for a telephone survey if no one answers the telephone or the individual refuses to answer any questions. However, if the initial call is completed, interviewers are able to determine the status of the unit, its geographical location and eligibility for the survey (e.g., business or residential). In both an in-person and telephone survey, if an individual cooperates with the initial set of screening questions (e.g., eligibility; selecting someone in the household), follow-up can be tailored to the particular respondent.

Mail and web surveys provide the least amount of information for follow-up. Both require mailing a request to an address. If there is no return, neither the eligibility of the unit can be determined nor whether someone in the unit has actually seen the survey request. Though it is good practice to follow up non-responses from the initial mailings, the biggest difference from similar follow-ups for in-person and telephone is that the mail follow-up cannot be tailored to the status of the unit. For example, with a telephone survey it is possible to call back and ask for the individual who was selected to be the respondent. For a mail/web survey, this is not possible. A general request to the household has to be made because of the lack of any knowledge of the status of the initial request.

2.1.6 Complex questionnaire

The in-person, telephone, and web-based surveys may be administered using computers. In the case of in-person and telephone surveys, the interviewer reads the questions from a computer and enters the information directly. For a web survey, the respondent is performing the same task. In all three cases the computer is programmed to navigate the respondent through the questionnaire. This approach provides the survey with significant flexibility with respect to tailoring the questions. This approach eliminates the need for respondents to understand navigation instructions. Paper-mail surveys require special accommodations to simplify navigation instructions and survey procedures.

2.1.7 Comparability

Most of the previous annoyance surveys have been conducted using an in-person, interviewer methodology. As noted in the literature review, telephone and in-person surveys produce similar results from a measurement perspective. This is consistent with the survey literature, which does not find big measurement differences between these two modes (de Leeuw, 2005). Larger differences are generally found when comparing responses from interviewer and self-administered methods, such as a paper-mail or a web survey (de Leeuw, 2005). For this reason, a survey conducted in-person or by telephone would be most comparable to many of the prior studies. However, there is an increasing trend to move from interviewer-administered surveys to self-administered surveys. Paper-mail or web surveys are less expensive to administer and are becoming more common over time.

2.2 Final Design

While an in-person survey is rated 'best' on most criteria, the cost was deemed too high to implement on a national level. The final design adopted for this ACRP Study included parallel telephone and paper-mail surveys. A telephone survey has the advantage of maintaining control over respondent selection and being compatible with many of the prior noise surveys. The advantage of a mail survey is that it will have better response and coverage rates. It is also less expensive than a telephone survey. The main disadvantage of a mail survey is the possibility that respondents who are most annoyed will tend to respond to the survey. With a mail survey the respondent is able to review the questionnaire before filling it out. If there are a large number of questions about the airport and annoyance, the respondent is able to factor the topic of the survey into his or her decision to participate.

In order to minimize the effects of respondent selection on the mail survey, a short survey was designed that included 10 substantive questions, one of which was the primary measure used to assess annoyance with airport noise. This makes it difficult, if not impossible, for anyone to detect that the survey was specifically intended to measure annoyance with airport noise. The telephone survey is longer and collects more data on the local airport and the respondent's annoyance. These additional data provide information for analysts interested in trying to explain annoyance levels. By administering both types of surveys, the project can assess whether the levels of annoyance differ for mail and telephone surveys. If the mail survey results are similar to the telephone survey results, including a mail survey (which has a lower cost per response obtained) for a national survey could allow a larger number of airports to be surveyed with an increased sample size from each.

3 Literature Review

A literature review was conducted to support plans for a new national survey of aircraft noise in the United States. The review supports the planning by identifying methods for estimating a national dose-response relationship (the survey's primary announced goal), evaluating issues about non-noise factors that are hypothesized to affect noise annoyance, and identifying unresolved noise annoyance issues that could be secondary goals for the national survey. The measure of impact for this survey, as for all dose-response noise regulations, is the privately-expressed noise annoyance that is measured in social surveys, not the visible, publicly-expressed actions such as complaints to authorities, lawsuits or public protests.

3.1 Primary Goal

The announced primary goal is to ***form an accurate nation-wide estimate of the dose-response relationship: the function that predicts the proportion of the population annoyed (to varying degrees) by aircraft noise from acoustical data that characterizes the aircraft noise at their residences***.[6] The literature review supports a decision to use two noise annoyance questions from an ISO technical specification that are now widely used in noise annoyance surveys around the world. The review found that when multiple cities have been surveyed in a single study, the residents in different geographic areas (neighborhoods, cities, airports, etc.) have significantly different annoyance reactions to the same noise level. Despite many hypotheses, the causes of these differences have not been established. One of the implications of such geographical effects is that the national survey design should be based on a large number of randomly selected airports that are drawn with probability selection methods.

The literature review identified one major uncertainty concerning plans for estimating the dose-response relationship: the mode of administering a questionnaire. Noise annoyance surveys have always varied as to whether they are interviewer-administered (face-to-face or telephone) or self-administered (usually mail-in), but more recently the economics of interviewing have resulted in some large surveys being self-administered. There is enough uncertainty about the effect of interviewing mode to mean that the results of a new US survey could not be compared with many other surveys unless effects of the survey mode are evaluated with new data from the US survey.

The literature review identified 62 hypotheses about non-noise effects on annoyance and attempted to locate summaries that could be expected to provide evidence about each of the hypotheses. With over 600 noise surveys and over 1,000 publications it was not possible to conduct new summaries of evidence on each of the 62 issues. As a result the findings from previous published summaries were presented when available. Summaries are needed because individual studies often report contradictory findings and, as a result, conclusions can only be reached about average results when many studies are combined. These summaries were presented for 30 of the 62 issues for which a results-neutral search strategy produced the summary. For the remaining issues some study results are identified but the primary focus is on the implications for the new US survey.

Some broad conclusions about the 30 summarized hypotheses were reached. In general, demographic characteristics of residents (gender, age, education, socio-economic status, etc.) have no important impact on noise annoyance. As a result demographic characteristics do not explain differences between annoyance reactions in different geographical areas. Selected attitudes, on the other hand, have a consistently strong effect: ***fear of danger from the noise source, perception that authorities could better control the noise, and self-reported general sensitivity to noise***. A change in noise exposure affects reactions for road traffic and railway noise, but the effect on aircraft noise annoyance is uncertain. Ambient noise levels and time spent at home do not have an important effect on annoyance.

[6] Throughout this section, ***italics*** are used to identify significant issues that shaped the survey implementation.

Conclusions on many other issues are not clear for a variety of reasons: results are contradictory, study methods are weak, too few studies have been conducted, or no surveys have been conducted. In general, characteristics of geographic areas have been only occasionally studied, often with weak methodologies and almost no non-survey information about the areas. ***No studies have been located that presented evidence on how annoyance is affected by airport authorities' actions, activities, or community relations programs. Studies have not examined the correlation between public complaints and private annoyance.***

3.2 Secondary Goals

The secondary goals for a new national survey could be derived from the evidence from summary analyses in this literature review, knowledge about whether or not there are new methodological developments, estimates of costs, and a unique strength of the sample design - the large number of airports and neighborhoods to be studied. Of course all of these scientific and technical considerations must be weighed against policy judgments about the practical value of particular study goals. These various considerations suggest: ***a focus on the following factors that may help to explain the surveyed annoyance: characteristics of geographical areas, authorities' actions, characteristics of community relations programs, relations to aircraft operations (landing/take-off/flight path location), and complaint rates.*** A focus on these types of goals should help to answer a major policy question: ***Is a single, national dose-response relationship justified because it is not possible to objectively predict deviations from a national average for local geographic areas? Or, alternatively, are there readily-available variables that predict differences between geographical areas and form a legitimate basis for local exceptions to national policies?***

Progress could also be made in identifying the size of the geographic units that are associated with unexplained variations in annoyance reactions. With a nested, clustered sample design it would be possible to begin to estimate the portion of the unexplained variance that is due to individuals' situations (the variation between people in adjacent homes with identical exterior noise exposures), the portion that might be due to local factors (variation between nearby neighborhoods), the portion attributable to common aircraft operations (variation between larger areas exposed to similar aircraft operations) and the portion attributable to airport or city characteristics (the remaining differences between airports).

Additional variables will need to be estimated for the national study, even if they have been studied before or can only be imprecisely measured, in order to provide some evidence as to whether such variables' effects have or have not substantially biased the study results. Examples of such variables include demographic characteristics, recent changes in aircraft noise levels, estimates of ambient noise levels, meteorological conditions, and sensitivity to noise generally.

4 Survey Instruments - Questionnaire Rationale

The test surveys conducted at each of the three airports used a standard-length telephone questionnaire (Appendix A) and a briefer mail questionnaire (Appendix D). The mail questionnaire consists of only two questions: the first two questions from the telephone questionnaire which contain the primary measure of aircraft noise annoyance.

Each of the questionnaire items (i.e., the individual questions) have been developed to support objectives developed in the literature review, which are summarized in Section 3. Both questionnaires share the basic aircraft noise annoyance question (Question 1.e in the telephone questionnaire and in the long screener, and 5.e in the mail questionnaire – the 5-point verbal scale) that can be used to develop the dose/response relationship. This study found that the mail and telephone questionnaires yield sufficiently identical dose/response relationships and expect that the final national survey will be able to increase the sample size for dose/response analyses with the more economical mail sample. The mail sample would not, however, contribute to many other goals of the national study. For both questionnaires, the other subparts of Question 1 and Question 2, provide a context for the aircraft rating without revealing that the primary purpose of the study is to evaluate aircraft noise annoyance.

The remaining items in the standard telephone questionnaire support the objectives that are listed next. Each objective is followed by a description of the types of questionnaire items that support the objective. For most study hypotheses about community response differences, the critical evidence comes from a comparison of the basic dose/response relationship in different areas and not from the extended telephone survey questions. In these cases the proposed questions will not by themselves meet the objective, but they do provide supplementary evidence that would help to support and interpret study findings about dose/response relationships that researchers, acousticians or policy makers might otherwise consider to be of doubtful validity. The objectives are:

- **Increase the reliability of the response measure:** A second noise annoyance question, (a 0-10 numeric scale) that is recommended for use by ISO (ISO/TS 15666:2003) provides a multiple indicator and thus increases the reliability of the annoyance assessment; (Q2,3,4,5)
- **Determine whether aircraft noise sensitivity has changed in the United States:** A 5-point thermometer annoyance scale from a 1970 nine-airport study; (Q1,42)
- **Assess the impact of aircraft operation modes and possible relationships to noise levels produced by different operations:** Questions about perceived aircraft flight paths, ground operations, fear of crashes, being startled by aircraft; (Q16,17,18,19,20,21)
- **Assess the impact or effects of airport operators' community outreach programs and possible relationship to objective assessments of community outreach:** – Questions about perceptions of airport operators' actions, obtaining sound-proofing or other types of financial assistance, the extent to which airports could reduce noise exposure; note that separately, staff from each airport and possibly consultants who work for the airport will be interviewed to provide an alternative assessment of airport / community relations; (Q35,36,37,38,39,40)
- **Evaluate demographic explanations for community response differences: -** Questions about age, gender, education, income, race, household size, house type, home ownership, length of residence, airport usage, economic links to airport; (Q9,10,13,23,24,33,34,43,44,45,46,47,48)
- **Evaluate individual attitudinal differences:** Questions about general noise sensitivity, perceptions about whether aircraft noise could be prevented, fear of danger from aircraft; (Q7b,c,8b,c,18,19,32,41)
- **Evaluate the impact of media and communications on neighborhood response differences:** Questions on media exposure, knowledge about noise issues, awareness of local views, about neighborhood views and actions; (Q22,25,26,27,28,29)

- **Evaluate the effects of individual aircraft noise exposure differences: -** Questions about time away from home and outdoor space usage (Outdoor usage might also explain regional differences.)(Q11,12)
- **Provide linkage to the ACRP sleep study, other studies of sleep disturbance and sleep disturbance metrics: -** Question about sleep disturbance; (Q7a,8a)
- **Assess the effect of changes in aircraft noise exposure: -** Questions about the total aircraft noise exposure in the past and future; (Q14,15)
- **Evaluate aircraft noise complaints, their relationship to annoyance and airport records, if available:** Questions about complaint behavior; (Q30,31)

5 Sample and Experiment Design

A sample of approximately 2,200 addresses was selected for each of the three airport communities in the Study. These three airports were selected purposively from the international airports in the United States to represent a range of climate conditions and airport operations. Although the three airports in the ACRP Study are not representative of the population of airports in the United States, the purpose of the ACRP Study is to compare results of surveys conducted by telephone with those of surveys conducted by mail. This comparison is done by looking at potential differences between mail and telephone respondents separately within each airport community.

HMMH provided Westat with noise exposure contours for all three airports. These contours started at 50 dB for the day-night average sound level (DNL), and ended with the maximum noise exposure in areas off-airport. These contours were used to stratify the population from each airport community, using strata 50-55 dB, 55-60 dB, 60-65 dB, 65-70 dB and 70+ dB. The number of addresses falling in each of those strata was then determined for each airport community.

In Airport 2, there were sufficient addresses in all five DNL noise strata to allow sampling in all of them. Airport 1 had very few addresses in the population with noise exposure greater than 65 dB; therefore, for Airport 1, only three DNL noise strata were used: 50-55 dB, 55-60 dB, and 60+ dB. Previous literature indicates that, in general, the percent of the population who are highly annoyed increases with the noise exposure (see, for example, Schultz, 1978; Fidell and Silvati, 2004). To allow comparison of the percent highly annoyed (HA) for the telephone and mail respondents across the range of noise exposures, the sample was divided equally among the DNL noise strata for each city. In Airport 1, 732 addresses were sampled from each of the three DNL noise strata (50-55 dB, 55-60 dB , and 60+ dB); in Airport 2, 440 addresses were sampled from each of the five DNL noise strata (50-55 dB, 55-60 dB, 60-65 dB, 65-70 dB, and 70+ dB). The surveys for Airport 1 and Airport 2 were conducted between March and June, 2013.[7]

Preliminary returns from Airport 1 and Airport 2 showed a smaller than anticipated sample size of respondents in the higher (65+ dB) DNL noise strata. To obtain more information from households exposed to higher noise levels, in the Airport 3 sample, 384 addresses were selected from the 50-55 DNL noise stratum, 400 addresses from the 55-60 dB DNL noise stratum, 420 addresses from the 60-65 dB DNL noise stratum, and 986 addresses from the 65-70 dB and 70+ dB strata. The survey in Airport 3 was conducted between July and September, 2013.

The sample drawn from each airport community and DNL noise stratum was randomly divided into two halves: one-half of the addresses were randomly selected for the telephone interview (Appendix A), and the other half were sent the mail questionnaire, referred to as the Survey of Community Attitudes (Appendix D). The addresses selected for the telephone interview were matched against directory information to find telephone numbers associated with the address. For addresses found to have a matching telephone number, an advance letter was sent introducing the survey, and then the number was called.

Addresses for which no matching number was found, or where the matched number was invalid, were randomly divided into two subgroups in the Airport 1 and Airport 2 samples. Half of the nonmatching addresses within each airport community and DNL noise stratum were sent a “long” screener which included questions from the mail survey instrument and a question asking for the telephone number (see Figure 3). The other half were sent a “short” screener that asked only for the telephone number (Appendix B). The telephone numbers returned by respondents to either the long or short versions were

[7] Two additional surveys were returned by mail in July, 2013, and were included in the data analysis.

called and the telephone survey was administered. Figure 3 provides a schematic summary of the design of the study for Airport 1 and Airport 2.

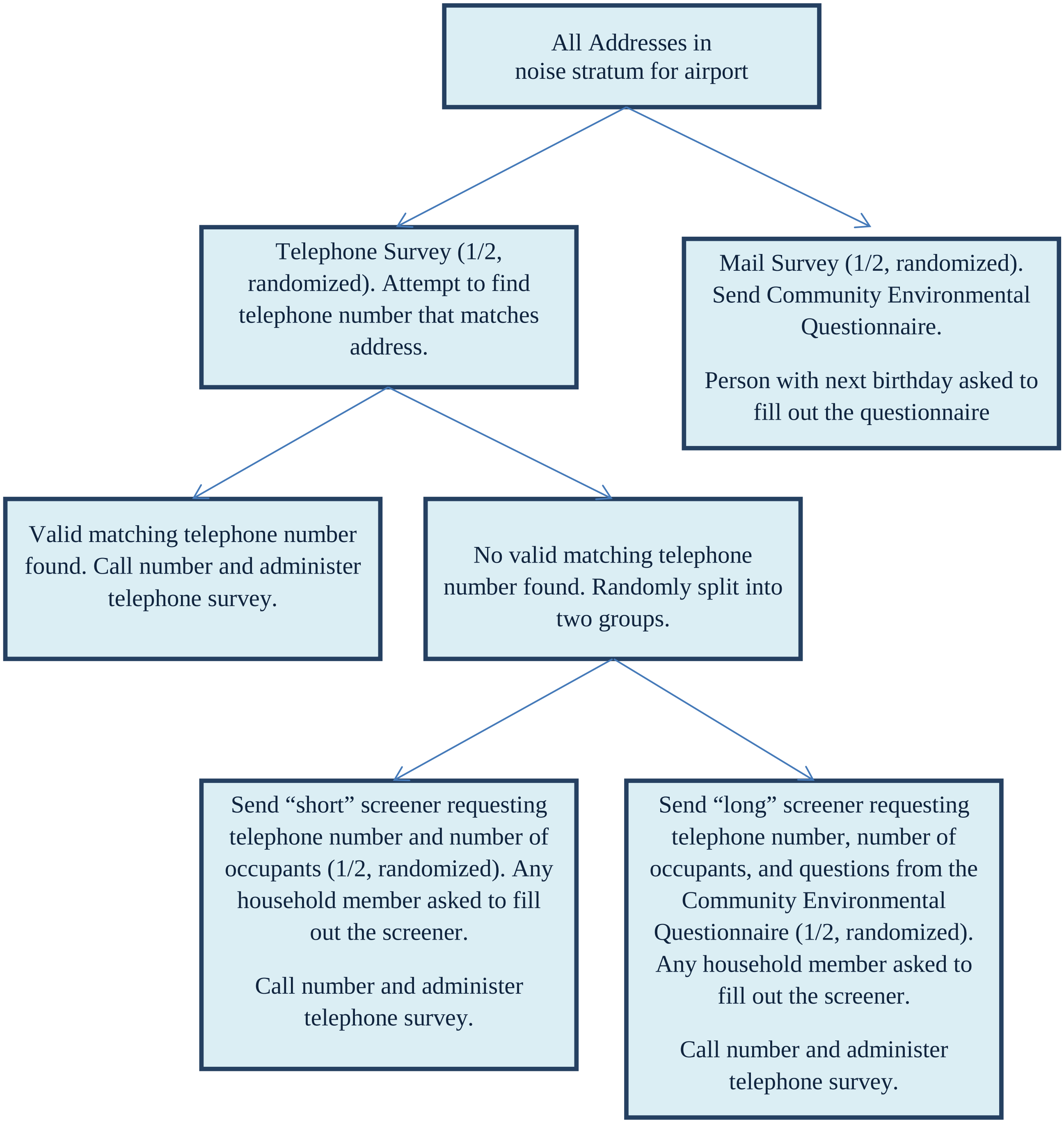

Figure 3 ACRP Study protocol for Airport 1 and Airport 2

As a result of the low response rates in the telephone groups in Airport 1 and Airport 2, the design was modified for Airport 3 as described in Appendix E. For the Airport 3 sample, all nonmatching addresses were sent the "long" screener to procure a telephone number. Figure 4 shows the procedure used in Airport 3.

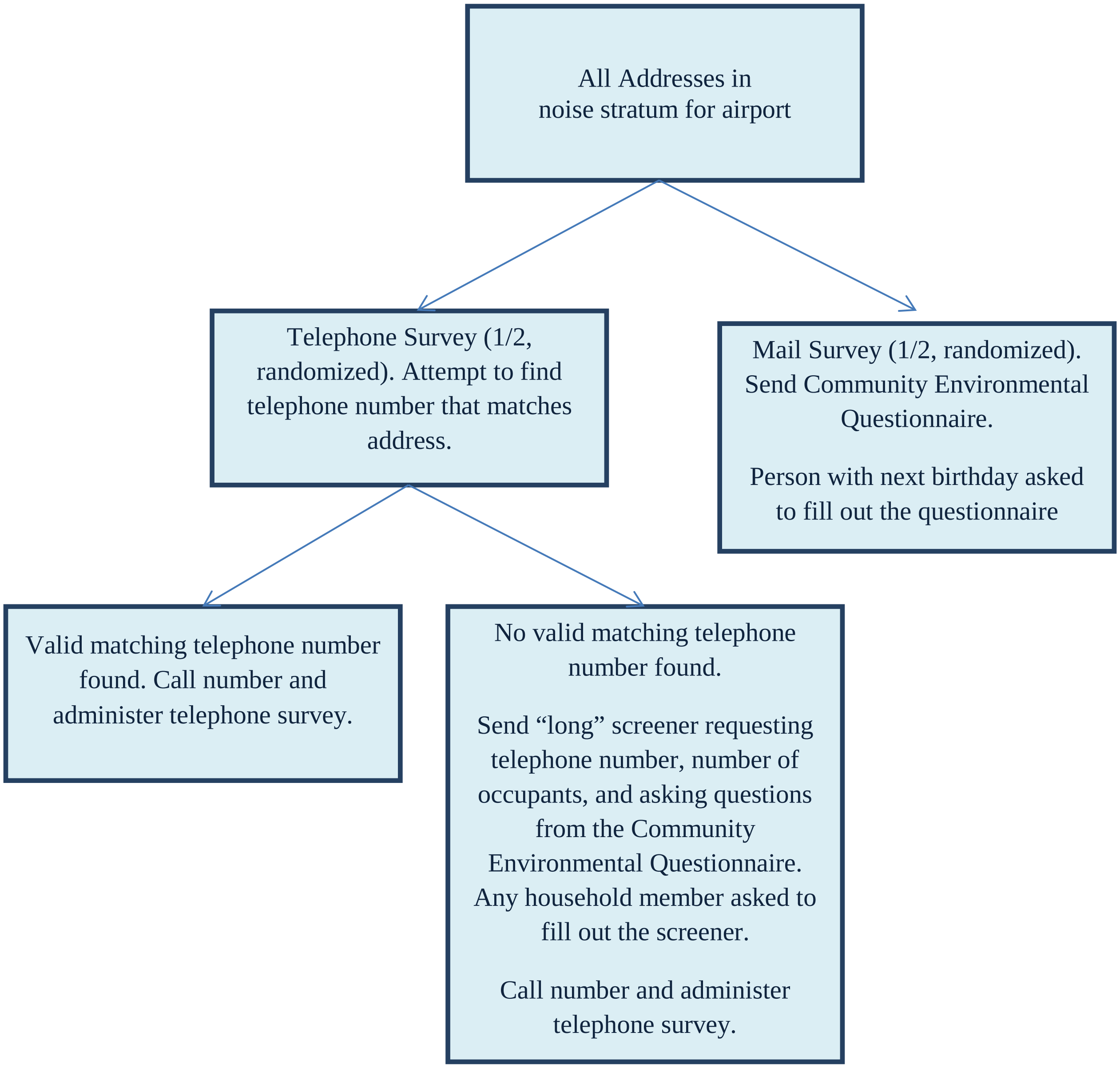

Figure 4 ACRP Study protocol for Airport 3

Any household member could fill out the long or short screener that was sent to request a phone number from households with no matching number in the telephone group. For the Survey of Community Attitudes sent to the mail group, the person with the next birthday was asked to fill out the questionnaire. All initial requests, including the advance letter for the telephone survey, were sent with a $2 bill to encourage cooperation. All survey instruments were available only in English.

6 Noise Metrics

The day-night annual average sound level, DNL, as computed with the FAA's Integrated Noise Model (INM) will be the independent "noise dose" variable. In addition to using DNL, we suggest including several other noise/aircraft operation based metrics in the annoyance response analyses. These metrics have been chosen as possible supplemental metrics that could account for some of the aspects of noise exposure not explicitly included in DNL. The INM will be used to either compute these metrics directly, or to provide the basic information from which most of the supplemental metrics will be derived.

Aspects that may not be sufficiently incorporated in DNL include:

- **Adverse Effects of Nighttime Noise** – DNL does provide a weighting factor of 10 for events occurring during the night, but then sums this weighted nighttime sound energy with the sound energy from the rest of the day, possibly obscuring the adverse effects of nighttime noise.

- **Speech Interference** – DNL does not explicitly count the number of times speech interference could occur.

- **Different Types of Aircraft Operations** – Sound level time histories and frequency content can be quite different for departures and arrivals, and can be different for locations adjacent to a runway as compared with locations affected by overflights. Table 2 lists all the metrics computed at the geographic location of each survey respondent.

Table 2 Annual Noise Related Metrics Determined for Each Survey Respondent

Energy Average, dB	Mean and Median
DNL	Time Above (TA): 55, 60, 65, 70, 75
Lnight	
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)
Locations Affected by Start of Takeoff Noise	

Lnight (outdoors) is the metric recommended by the World Health Organization for judging adverse effects on sleep, (WHO, 2009). Sleep disturbance, however, results from single events and Lnight averages events so that many combinations of aircraft event noise levels will produce the same Lnight. Nevertheless, we suggest including it to permit further analysis of its relationship to annoyance.

Leq24 is identical to DNL with no night time weighting and is included primarily as a means of distinguishing between the predominance of arrival and departure sound energy. Some airports operate almost entirely in one direction of aircraft operations so that some communities experience almost entirely departure noise while others primarily arrival noise. Do these communities judge the annoyance of aircraft with respect to DNL differently? Figure 5 (Brink, 2006) shows the reaction of a sleeping subject to two separate aircraft noise events of equal maximums. Apparently, the rapid rise and fall of the arrival noise was more disturbing, as measured by "motility" – movement of the body – than was the slower rise and fall of the departure noise event. Interestingly, though both events had equal maximums, their SEL values were quite different: departure SEL was 73 dB, while the arrival SEL was 67 dB. These findings suggest that human annoyance reactions to a dominance of departures may be different from that due to a dominance of arrivals.

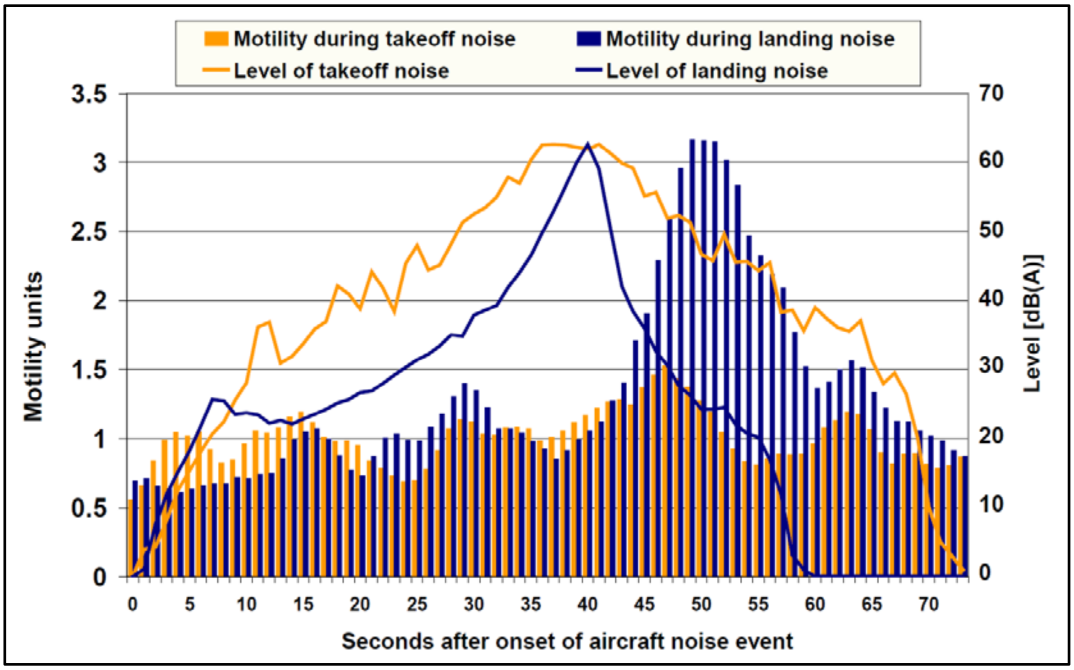

Figure 5 Departure and Arrival Time Histories compared with Motility (body movement) of Sleeping Subject

Time above a threshold (TA) and number above a threshold (NA) may correlate with duration or number of incidents of speech interference and may be related to the reported annoyance.

Probability of awakening, as computed using the ANSI standard 12.9/2008/Part 6, (ANSI, 2008), accounts for number and level of each night time noise event (10 p.m. to 7 a.m.) and may be better correlated with reports of sleep disturbance than is Lnight (Question 7, Telephone Survey, Appendix A).

Finally, the residents who experience start of takeoff noise may react differently from the residents who experience only overflight noise. The sound level time histories and frequency content of overflights and of takeoff differ considerably. Figure 6 and Figure 7 show the difference in time histories of an overhead departure and of a takeoff measured to the side of the runway.

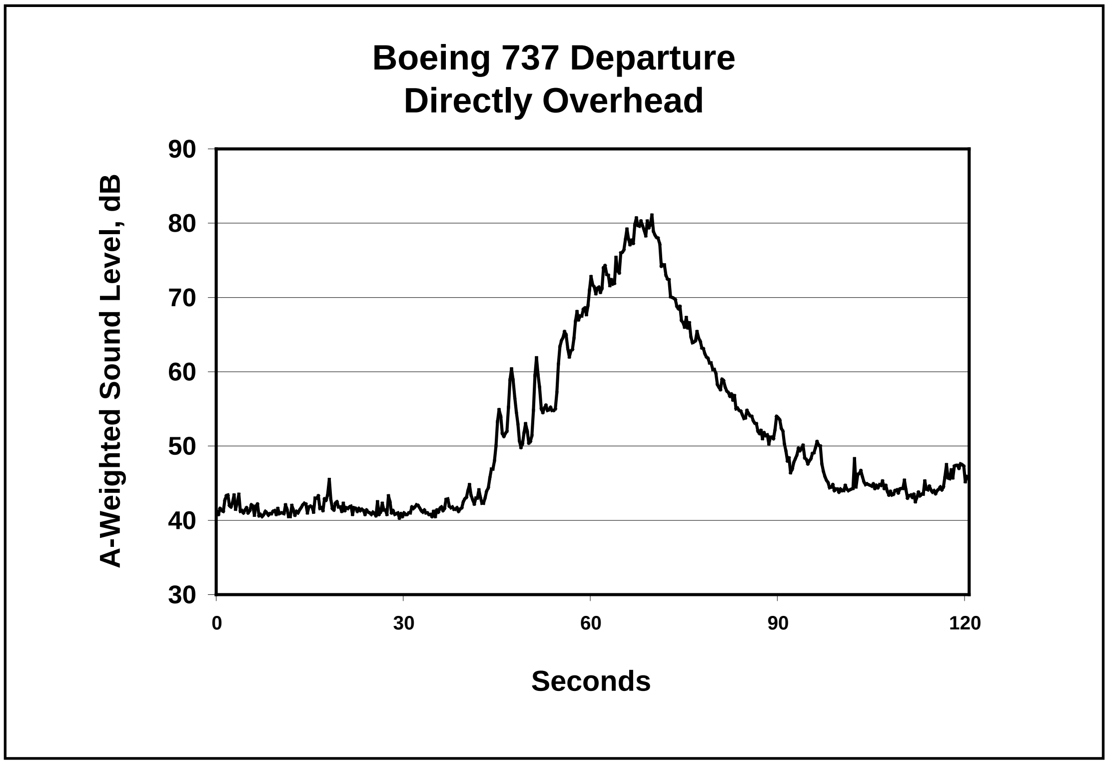

Figure 6 A-weighted Time History of Recorded Overhead Departure

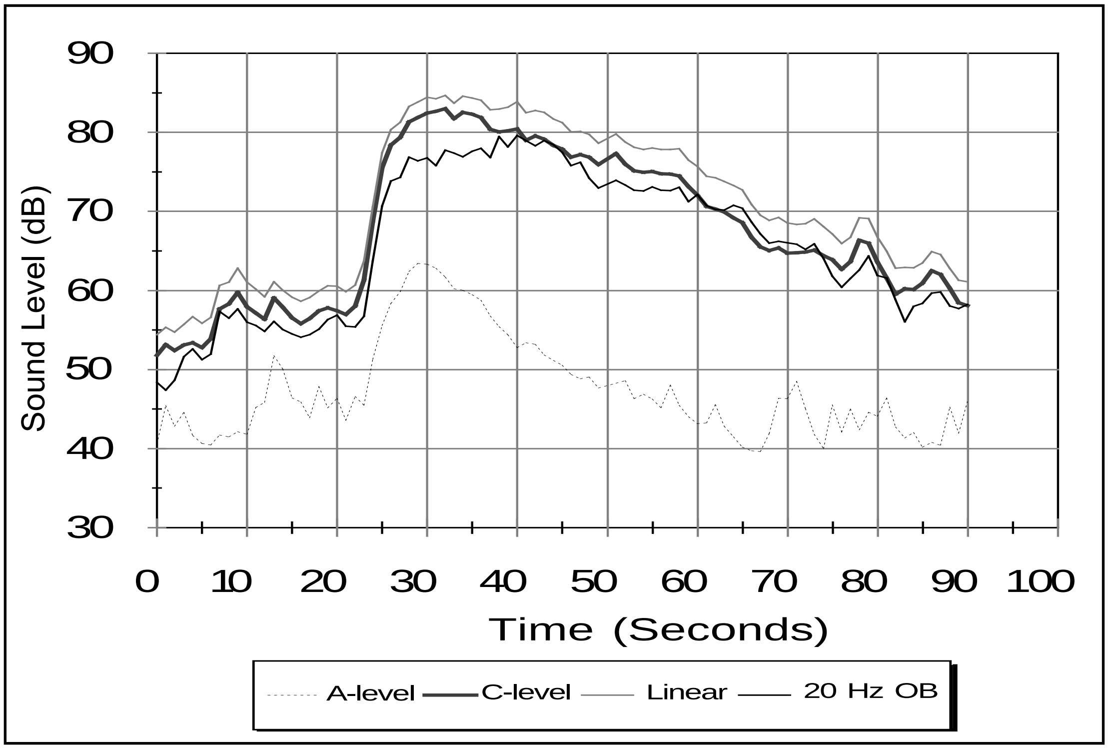

Figure 7 Time Histories of a Single Jet Takeoff as Recorded ~ 3200 Feet Adjacent the Runway

The following three sections provide graphics that demonstrate the inter-relationships of some of these metrics. They were developed primarily to verify the reasonableness of the INM computed values and to establish a process for efficiently generating the metrics for the national survey airports. The plots also suggest the degree of correlation of the various metrics: NA and TA might provide insight to annoyance versus DNL, while probability of awakening may better relate to awakening reports (and annoyance) than does Lnight.

6.1 Number above a Level *versus* DNL

Figure 8 compares at respondent locations the number of aircraft noise events above various threshold sound levels (dBA) with the DNL value at the same location. For a given threshold, there is considerable correlation at the higher values of DNL. These are locations close to the runway end, but at different distances from the runway, close to the centerline. Hence, the number of events does not vary with DNL (with distance from the runway). As distance increases, the aircraft are higher and hence quieter. However, at lower DNL values, many locations can have different numbers of events above a threshold but similar DNL. Analyses may be able to determine whether annoyance reports are affected by these differences.

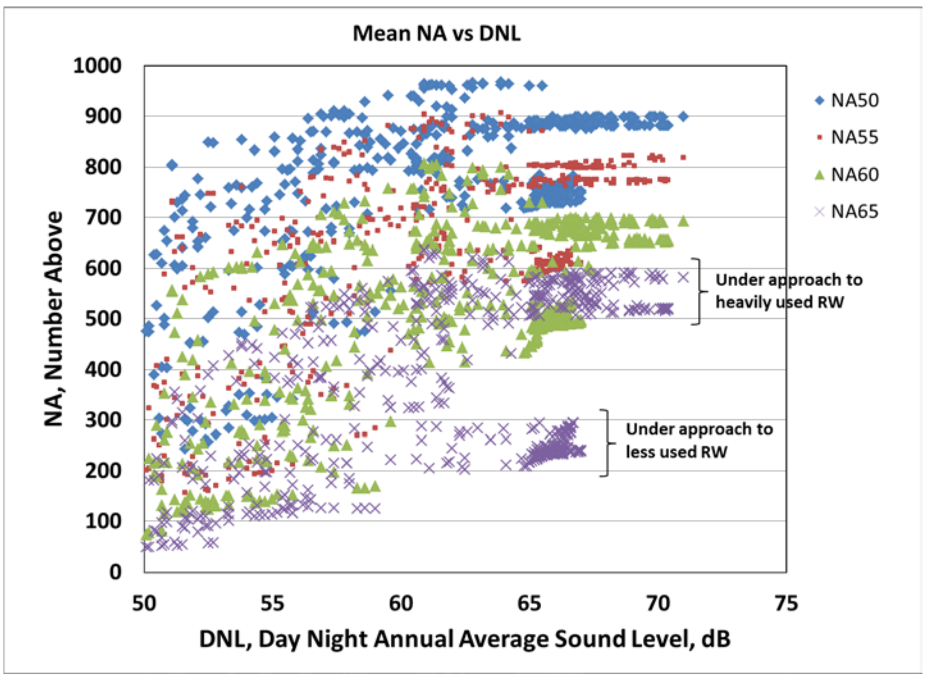

Figure 8 Number Above Different Threshold Levels versus DNL

6.2 Time above a Level *versus* DNL

Figure 9 shows time above and associated DNL values at the receiver locations. Time above appears closely correlated with DNL for the higher thresholds, but less so at the lower thresholds (blue points). This scatter appears to be in part related to the distance the locations are from the flight tracks / runways. Along runway sideline, but at some distance, presumably many aircraft operations may be heard, but at lower levels than close to the runway. Hence higher numbers are heard, but levels are lower and consequently so is DNL.

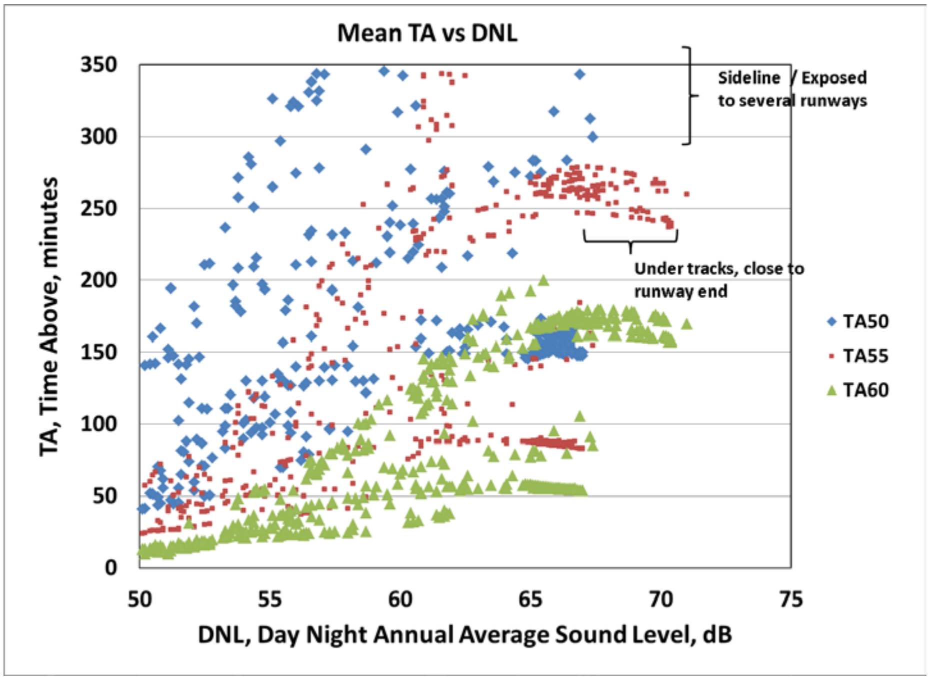

Figure 9 Time Above Different Threshold Levels versus DNL

6.3 Probability of Awakening versus Lnight

Figure 10 shows that the probability of awakening is quite correlated with Lnight, but differently at different locations. This differing relationship is because the probability of awakening is highly dependent on the number of night time aircraft noise events. Hence, locations that are affected by similar numbers of operations have similar ranges of likelihood off awakening, decreasing slightly with decreasing Lnight.

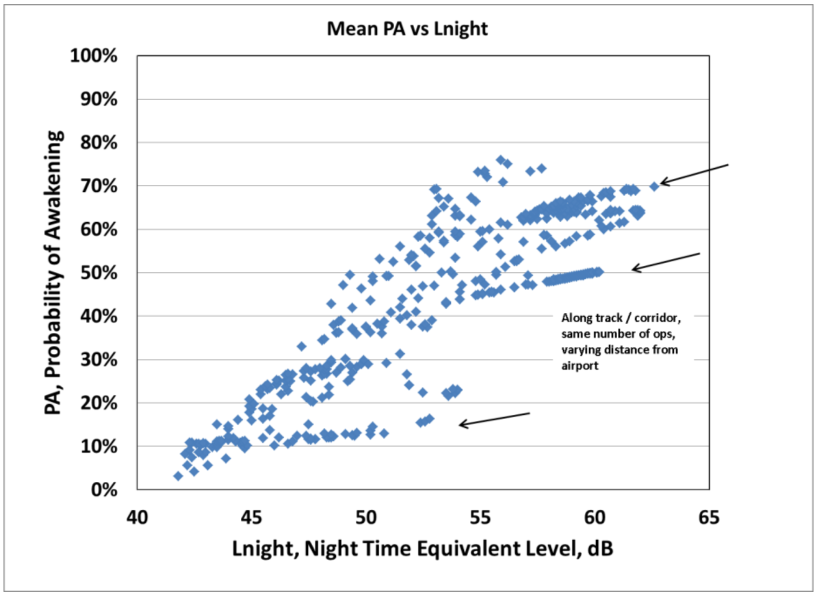

Figure 10 Probability of Awakening versus Lnight

7 Analysis of Response Rates

Table 3 and Table 4 show the response rates obtained for each airport community for the mail and telephone surveys, respectively. The denominator used for each response rate is the number of addresses selected for the sample minus the postal non-deliverables (PNDs).

The overall response rate for the mail survey is 35.1%, and the overall response rate for the telephone survey is 12.1%. These response rates are highly significantly different (Cochran-Mantel-Haenszel $\chi^2 = 455$, p-value < 0.0001).[8] Table 5 gives the number of completed interviews obtained, and Figure 11 displays the response rates for each DNL noise stratum by survey mode and airport.

The response rate for the telephone survey was higher for the addresses with a matching telephone number (16.4%) than those without a matching telephone number (9.1%). For an address without a matching telephone number to be counted as a respondent, first the household had to respond to the request on the mail screener to provide a telephone number, and then the selected person had to respond to the telephone survey.

Table 3 Response Rates for ACRP Mail Survey

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

[8] The Cochran-Mantel-Haenszel statistic is used to test association between two variables in stratified data (Simonoff, 2003, p. 317). In this analysis, it is used to test whether being a respondent (yes, no) is related to the survey mode (mail, telephone), after accounting for the airport and DNL noise stratum. The p-value, calculated from the value of the chi-square statistic, is the probability that you would obtain a value of the test statistic at least as large as the one observed from the data if the null hypothesis (that the response rates are the same for mail and telephone) is true. The smaller the p-value, the more evidence there is against the null hypothesis of no association between the two variables. Typically, a p-value less than 0.05 is considered to give a “statistically significant” result.

Table 4 Response Rates for ACRP Telephone Survey

Telephone Survey	Number Of Addresses	Number of Addresses Less Postal Non-deliverables	Number Of Households providing telephone numbers from screener	Response rate for request for telephone number on Screener	Number of Telephone Interviews	Telephone Response Rate
Airport 1, all	**1098**	**997**			**144**	**14.4%**
Matched telephone number	369	365			79	21.6%
Unmatched telephone number	729	632	140	22.2%	65	10.3%
Long screener	365	318	90	28.3%	38	11.9%
Short screener	364	314	50	15.9%	27	8.6%
Airport 2, all	**1100**	**1021**			**114**	**11.2%**
Matched telephone number	338	334			51	15.3%
Unmatched telephone number	762	687	171	24.9%	63	9.2%
Long screener	381	346	104	30.1%	27	7.8%
Short screener	381	341	67	19.6%	36	10.6%
Airport 3, all	**1095**	**1046**			**114**	**10.9%**
Matched telephone number	594	588			81	13.8%
Unmatched telephone number, long screener	501	458	99	21.6%	33	7.2%
All airports, all	**3293**	**3064**			**372**	**12.1%**
Matched telephone number	1301	1287			211	16.4%
Unmatched telephone number	1992	1777	410	23.1%	161	9.1%
Long screener	**1247**	**1122**	**293**	**26.1%**	**98**	**8.7%**
Short screener	**745**	**655**	**117**	**17.9%**	**63**	**9.6%**

NOTE: The matched telephone numbers in the table refer to those for which an initial match was found in the directory. Some of these numbers were later discovered to be invalid, and those addresses were subsequently mailed a screener requesting the telephone number.

Table 5 Number of Completed Interviews, by DNL noise stratum and Survey Mode

	DNL noise stratum					Total
	50-55	55-60	60-65	65-70	70+	
Airport 1, all	170	185	181			536
Telephone	49	44	51			144
Mail	121	141	130			392
Airport 2, all	105	90	91	116	100	502
Telephone	25	19	23	22	25	114
Mail	80	71	68	94	75	388
Airport 3, all	63	64	92	199		418
Telephone	21	14	26	53		114
Mail	42	50	66	146		304
All airports	***338***	***339***	***364***	***315***	***100***	***1456***
Telephone	***95***	***77***	***100***	***75***	***25***	***372***
Mail	***243***	***262***	***264***	***240***	***75***	***1084***

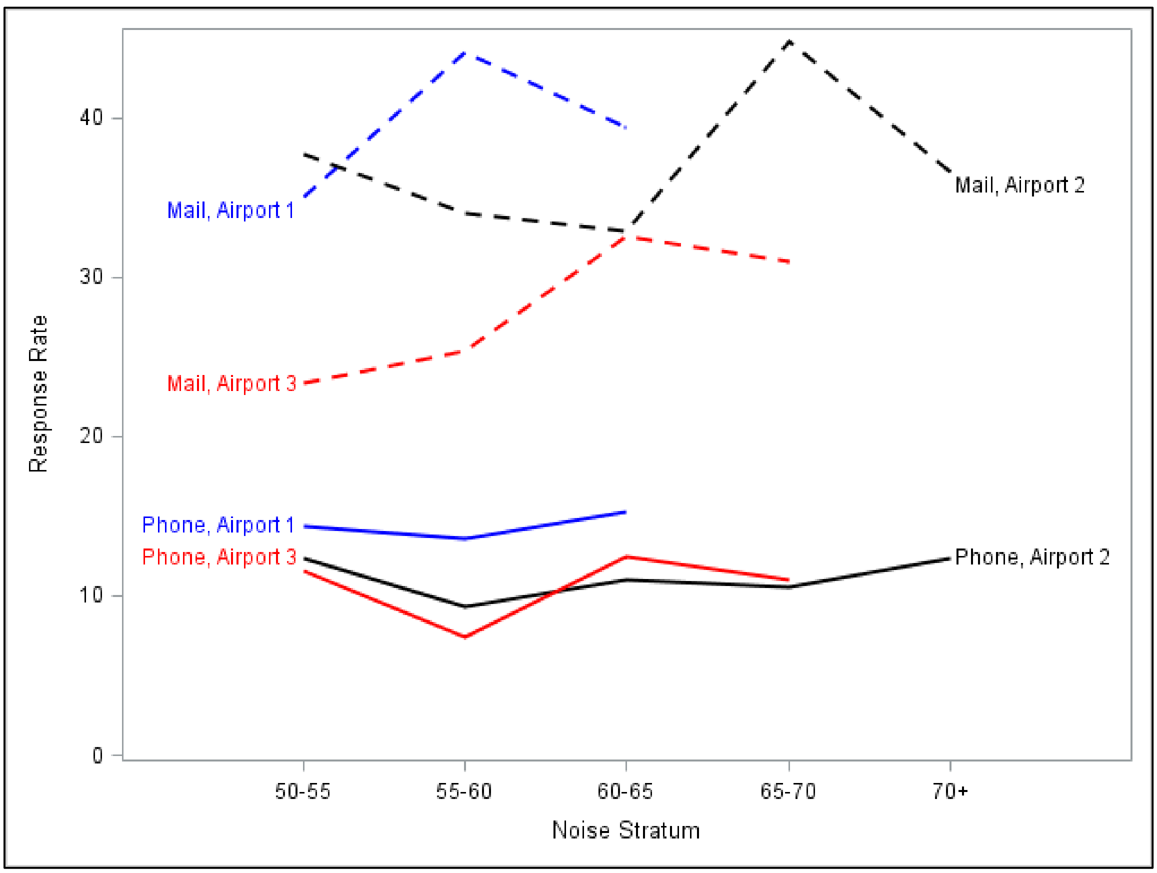

Figure 11 Response Rates by Airport and Mode of Survey

7.1 Comparison of Sample with Population Demographic Quantities

Demographic information was available from the 2010 Census for the census blocks containing the sampled households from each airport. The DNL noise strata used for sampling have irregular shapes because of the different noise exposures for households in the landing, takeoff, and sideline areas. The strata therefore do not match exactly with the census blocks; however, we can compare the demographic compositions of the set of census blocks containing the sampled regions surrounding each airport with the estimated demographic composition from the sample.

Two sets of sample statistics are presented in Table 6and Table 7. The first set in Table 6 referred to as "unweighted" estimates, subtracts the Census percentages from the percentages of respondents who fall in each demographic category. Thus, the percentage of respondents to the telephone survey at Airport 1 who are white non-Hispanic is 20.1 percentage points higher than the percentage of white non-Hispanics in the area from the 2010 Census. The second set of statistics in Table 7, the "weighted" estimates, account for the disproportionate sampling done in each airport community, where a higher fraction of the population is sampled in areas with high noise exposures than in areas with low noise exposures. We present both sets of estimates because the Census figures are available only approximately for the sampled area as a whole, and not for the individual DNL noise strata.

Both sets of estimates show the same pattern. Persons who are white non-Hispanic or are age 50+ are overrepresented among the respondents to the survey, while Hispanics are underrepresented. In the telephone survey, the percentage of persons age 50+ exceeded the true percentage in the area by 20 to 40 percentage points. Note, however, that although both mail and telephone surveys had deviations from the Census figures, the mail survey percentages are usually closer to the Census percentages.

Table 6 Difference between percentage estimated from sample and percentage from 2010 census (calculated without survey weights)

	Airport 1		Airport 2		Airport 3	
	Telephone	Mail	Telephone	Mail	Telephone	Mail
Percent white non-Hispanic	**20.1 (2.9)**	**22.1 (1.6)**	**25.2 (4.0)**	**19.6 (2.2)**	**30.2 (2.9)**	**24.7 (2.1)**
Percent male	-5.2 (4.1)	1.9 (2.5)	-8.5 (4.6)	-1.6 (2.5)	-7.9 (4.7)	-6.3 (2.8)
Percent age 50+	**39.4 (3.4)**	**28.1 (2.4)**	**26.1 (4.7)**	**12.4 (2.5)**	**30.7 (4.3)**	**22.5 (2.8)**
Percent Hispanic	**-13.2 (1.4)**	**-11.3 (1.0)**	**-14.2 (2.9)**	**-7.8 (1.9)**	**-20.5 (2.1)**	**-18.5 (1.5)**

NOTE: Standard errors are in parentheses. Boldface values are statistically different from zero at the 0.05 significance level, indicating that the estimate from the survey is significantly different from the census value.

Table 7 Difference between percentage estimated from sample and percentage from 2010 census, calculated using survey weights

	Airport 1		Airport 2		Airport 3	
	Telephone	Mail	Telephone	Mail	Telephone	Mail
Percent white non-Hispanic	**21.5 (3.5)**	**22.1 (2.8)**	**25.2 (5.5)**	**19.6 (3.6)**	**21.5 (8.0)**	**20.0 (4.5)**
Percent male	-5.2 (6.3)	1.9 (4.1)	-8.5 (6.1)	-1.6 (3.5)	-1.3 (9.5)	-8.4 (5.9)
Percent age 50+	**39.4 (5.5)**	**28.1 (4.2)**	**26.1 (6.3)**	**12.4 (3.5)**	**19.8 (9.5)**	**17.3 (6.0)**
Percent Hispanic	**-13.2 (2.3)**	**-11.3 (1.6)**	**-14.2 (4.0)**	**-7.8 (2.9)**	**-20.8 (2.8)**	**-20.1 (1.5)**

NOTE: Standard errors are in parentheses. Boldface values are statistically different from zero at the 0.05 significance level, indicating that the estimate from the survey is significantly different from the census value.

Appendix F presents a response propensity analysis, predicting the probability that a household selected to be in the sample completed 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. The results from the model are consistent with the analyses presented above: households sent the mail survey are much more likely to respond to the survey, after accounting for all other variables. In addition, households having a matching telephone number, living in a census block with a high percentage of persons aged 50 and over, or living in a census block with a low percentage of Hispanics are more likely to respond to the survey. Importantly, noise exposure, as measured by DNL, is not significantly related to the propensity to respond to the survey.

7.2 Selection of Within-household Respondent

The Community Environmental Questionnaire asked the person opening the envelope to write down the number of adults (age 18 or older) in the household, and to write down the first name, nickname, or initials of the person with the next birthday. The person with the next birthday was to complete the questionnaire. This within- selection method was used to attempt to obtain a randomly selected adult within the household to complete the questionnaire: otherwise, there might be bias if the person within the household who is most (or least) annoyed by aircraft noise is consistently more likely to provide the responses to the survey.

The last question on the survey, filled out by the person who completed the questionnaire, asked for the age and month of birth for each adult in the household. This question can be used to analyze the extent to which the instruction to have the person with the next birthday fill out the questionnaire was followed. Table 8 gives the results. In 856 households it appeared that the correct household member filled out the questionnaire. Among those households that had enough data to determine the birth month, this represents 86% where the correct respondent was selected.

Table 8 Did the adult with the next birthday fill out the mail questionnaire?

	Airport 1	Airport 2	Airport 3	Total
1 adult in household	170	160	99	429
2+ adults, respondent had next birthday	146	143	138	427
2+ adults, other adult had next birthday	42	55	41	138
Insufficient information: missing # adults in HH	29	22	18	69
Insufficient information: missing birthday month	5	8	8	21
Total	*392*	*388*	*304*	*1,084*

8 Comparison of Respondents by Survey Mode

One major item of interest is whether the relationship between noise exposure and annoyance differs in the telephone and mail surveys. Because the set of airports used in this ACRP 02-35 survey was selected purposively for carrying out the mode experiment, the data are not suitable for developing a dose-response relationship between noise exposure and annoyance. The statistics presented here are calculated solely for comparing the telephone and mail respondents surveyed within each airport community.

We performed a Cochran-Mantel-Haenszel test to assess whether the odds of being highly annoyed is the same between telephone and mail groups, aggregating the information across the twelve subgroups formed by airport and DNL noise strata combinations. The test statistic is $\chi^2 = 1.1$ with p-value > 0.20, showing no significant difference overall between the mail and telephone surveys in percent HA.

Table 9 displays the difference in percent HA separately for each DNL 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 DNL 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,[9] only one of the differences is significant at the 0.05 level: DNL noise stratum 65+ for Airport 3, where the percentage HA on the mail survey was 40 percentage points higher than on the telephone survey.

Table 9 Difference in percent HA (mail – telephone) by airport and DNL noise stratum

	50-55	55-60	60-65	65-70	70+
Airport 1	-5.0 (6.0)	-4.2 (8.2)	-2.5 (8.3)		
Airport 2	-0.6 (7.4)	-8.7 (11.2)	14.7 (12.2)	5.3 (11.9)	25.3 (11.3)
Airport 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.

We also looked at possible discrepancies between the telephone and mail surveys on the demographic characteristics of the respondents, again controlling for strata. Table 10 shows the results from Cochran-Mantel-Haenszel tests performed for the percentage of respondents who are male, white non-Hispanic, age 50 or over, and who live in a single-adult household, along with the previously reported test results on percentage highly annoyed. The telephone and mail surveys are highly significantly different with respect to the percentage of persons responding who are age 50 and over, and the percentage of responding households that have a single adult.

[9] When a significance level of 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. 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).

Table 10 Cochran-Mantel-Haenszel test statistics and p-values for testing difference between telephone and mail survey results

Characteristic	Statistic	p-value
Percent Highly Annoyed	1.12	0.29
Percent Male	2.92	0.09
Percent White non-Hispanic	1.45	0.23
Percent Age 50 and Over	14.97	< 0.0001
Percent with One Adult in Household	8.00	0.005

Table 11explores these demographic differences in more detail. Each entry in the table is the estimated percentage from the mail survey minus the estimated percentage from the telephone survey. The mail survey has a lower percentage of respondents age 50 or over for every airport and DNL noise stratum. Combining the results across strata using the Cochran-Mantel-Haenszel test gives a highly significant difference between the two survey modes.10 We saw in Section 7 that the mail survey estimates were closer to the Census figures on percentage of respondents age 50 or over. The mail survey also has a significantly lower percentage of respondents that report having one adult in the household.

Table 11 Difference in demographic characteristics (mail – telephone) by DNL noise stratum

		50-55	55-60	60-65	65-70	70+
Percent White Non-Hispanic	Airport 1	--0.5 (5.4)	2.3 (6.6)	5.0 (4.6)		
	Airport 2	-11.6 (11.3)	-20.7 (12.5)	-19.3 (10.7)	4.0 (9.5)	16.4 (8.1)
	Airport 3	-6.8 (11.9)	-3.4 (12.2)	-6.2 (7.6)	-6.0 (5.0)	
Percent Male	Airport 1	1.4 (8.4)	5.7 (8.5)	10.9 (8.2)		
	Airport 2	-7.3 (11.5)	21.3 (12.9)	12.3 (12.1)	19.5 (11.7)	-6.1 (11.7)
	Airport 3	-4.8 (13.3)	-8.9 (14.7)	11.5 (11.6)	2.3 (8.0)	
Percent Age 50 and Over	Airport 1	-18.1 (8.1)	-5.5 (7.9)	-10.5 (7.0)		
	Airport 2	-1.5 (11.5)	-19.0 (13.0)	-17.7 (12.0)	-29.4 (11.7)	-2.7 (11.7)
	Airport 3	-0.1 (13.2)	-12.2 (14.9)	-9.3 (10.9)	-9.8 (7.9)	
Percent in Single-adult Households	Airport 1	3.7 (8.1)	-7.9 (8.7)	-5.2 (8.3)		
	Airport 2	-14.8 (11.4)	-12.8 (13.0)	-15.3 (12.0)	-11.7 (11.7)	4.0 (11.6)
	Airport 3	0.0 (13.6)	-10.9 (14.5)	-6.6 (11.0)	-22.5 (7.7)	

NOTE: Standard errors are in parentheses.

[10] As for the analysis of individual DNL noise stratum differences shown in Table 11, a Bonferroni adjustment should be made for multiple testing if it is desired to examine the difference for a individually. The standard errors given in Table 11 are not adjusted for multiple comparisons. In Table 11, the only individual stratum percentage that is statistically significant at the 0.05 level is the percentage in single-adult households in the 65-70DNL noise stratum in Airport 3.

9 Analysis of Long and Short Screener Differences

In the telephone samples for Airports 1 and 2, half of the addresses without matching telephone numbers were mailed a short screener survey that requested the telephone number (Appendix B); the other half were mailed a longer screener survey that requested the telephone number (**Error! Reference source not found.**) which also contained the same questions included on the Mail Survey Instrument (Appendix D). The overall telephone response rates for addresses without matching telephone numbers that were mailed the long and short screeners are very similar: 9.8% for the long screener and 9.6% for the short screener (χ^2= 0.1, p-value > 0.30). The components for those response rates, however, differ for the two forms. Overall, 29.2% of the households mailed the long screener returned it, but only 17.9% of the households mailed the short screener returned it (χ^2= 24, p-value < 0.0001). After the mail screener was returned, however, the pattern reversed: only 34% of the households that returned the long screener provided a telephone interview, while 54% of the households that returned the short screener provided a telephone interview (χ^2 =12, p-value < 0.001).

The discrepancy in response rates for the long and short screeners is largely explained by the fact that a substantial number of respondents to the long screener did not provide a telephone number (Table 12). A total of 136 out of the 194 households (70%) returning the long screener included the telephone number on the form, while 105 out of the 117 short screener households (90%) provided the telephone number. The conditional telephone response rates for the households providing a telephone number on the screener are 48% for the long screener and 60% for the short screener (χ^2 =3.5, p-value = 0.06).

Table 12 Number of unmatched telephone cases by screener type

	Long	Short
Number Mailed	746	746
Number Mailed Minus Number PNDs	664	665
Number Returned Mail Questionnaires	194	117
Number Providing a Phone Number	136	105
Number of Completed Telephone Interviews	65	63

There was high consistency between screener and telephone responses to the question on aircraft annoyance for the 103 households[11] who returned the long screener and also responded to the telephone survey. Overall, 38 of the 46 respondents who reported being highly annoyed on the long screener also reported being highly annoyed on the telephone survey; 53 of the 57 respondents who reported not being highly annoyed on the screener also reported not being highly annoyed on the telephone survey. Note that 7 of the 12 households where there was a discrepancy in the results had multiple adults, so it is possible that different persons in the household responded to the screener and telephone questionnaires.

[11] These included the original households without a matching telephone number plus additional households that were sent the long screener because their "matched" telephone number was found to be invalid.

10 Discussion of Annoyance Survey Results

Janssen et al. (2011, Table 1) list response rates for selected aircraft noise surveys that have been conducted previously. The most recent surveys in their review were conducted in Europe by mail or telephone, and they report response rates ranging from 52% to 39%. They do not, however, describe how these response rates were calculated, and response rates can vary drastically depending on what units are excluded from the denominator. In addition, response rates often differ between Europe and the United States because many European surveys can take advantage of detailed population registers for a sampling frame, thereby excluding ineligible addresses from the frame. For the Zurich Airport Study described in Brink et al. (2008), for example, population lists were obtained from 56 of the 68 municipalities surrounding the airport, and the response rate was calculated using only the 56 municipalities that provided listings. In each of these municipalities, the survey was mailed to a randomly selected sample of 60 persons who are known from the population lists to be age 18 or over and who have lived at the address at least one year. The reported response rate of 54% is thus achieved by excluding highly mobile persons, and persons who reside in municipalities that decline to provide population lists, from the sampled population. These exclusions mean that the survey does not include the entire adult population of the area, which can result in coverage bias. The Zurich Airport Study could also take advantage of the detailed information in the population lists by addressing the surveys to the desired sampled individuals, with a personalized approach that can increase response rates; mail surveys in the United States can only be sent to the selected address.

AAPOR (2011) provides standard definitions for calculating of response rates, and outlines how results can vary depending on the definition used. For the ACRP Study, a very conservative response rate was calculated, in which only the postal non-deliverables were subtracted from the denominator for both the mail and telephone surveys. This was done so that both surveys would use comparable denominators for the response rates.

Recent research indicates that a low response rate is not necessarily indicative of nonresponse bias. Langer (2003) provides an overview of issues involved in interpreting response rates. Groves (2006), reviewing 30 studies in which nonresponse bias was investigated, found no relationship between response rate and nonresponse bias. In an airport survey, the estimate of a dose-response relationship would exhibit nonresponse bias if nonrespondents were systematically more (or less) likely to report annoyance than respondents to the survey with the same noise exposure and demographic characteristics. This cannot be determined from the ACRP Study: to evaluate whether nonrespondents are more (or less) annoyed than respondents it would be necessary to obtain responses from a random subsample of the nonrespondents. TNO and RIVM (1998) followed up with a small subset of nonrespondents to their 1996 survey around Amsterdam Schiphol airport, and found that nonrespondents reported less annoyance to aircraft noise and were more likely to have lower educational levels and to be members of ethnic minority groups.

In the ACRP Study, there is evidence that respondents differ from the general population in the airport communities surveyed: respondents to both surveys are more likely to be over age 50 and to be white non-Hispanic, although the respondents to the mail survey more closely match the population characteristics given by the 2010 Census. Among the respondents to the survey, however, there is no statistically significant relationship, after accounting for the level of noise exposure and airport-to-airport differences, between these demographic characteristics and annoyance.

The ACRP Study itself may be viewed as testing possible nonresponse bias in annoyance, because two modes with different response rates found similar annoyance levels. The analyses presented in Section 8 found no relationship between the survey mode (mail or telephone) and annoyance, even though the response rate to the mail survey is approximately three times as great as that to the telephone survey. It is possible, however, that the nonrespondents to both surveys might differ from the respondents with respect to percent HA.

In Section 2.1 , the potential survey modes that could be used for surveying the population in an airport community about reactions to airport noise were rated with respect to cost, suitability, and possible bias due to undercoverage, nonresponse, respondent selection, and other sources. In Table 1, the mail survey mode was ranked above the telephone survey mode on response rate and coverage, but below the telephone survey mode on respondent selection and follow-up.

The results of the ACRP Study show that the mail survey mode is indeed superior to the telephone survey mode on response rate and coverage, with a response rate approximately three times that of the telephone survey. The potential concerns about respondent selection bias in a mail survey do not appear to be borne out in this study. Overall, it appears that in the majority of households, the adult with the next birthday filled out the mail questionnaire as requested. In addition, there is no evidence that there is a difference in annoyance between respondents to the mail survey and respondents to the telephone survey. Although both modes have a higher percentage of older adult and white non-Hispanic respondents than reported by the Census for the areas, the mail survey is closer to the Census figures on these demographic variables than the telephone survey.

A mail survey does not obtain response rates that are as high as those from an in-person survey. If a mail survey were adopted for a national airport and annoyance survey, however, it is possible that the response rates could be increased from the 35.1% observed in the ACRP Study by varying incentive amounts, employing a Spanish-language questionnaire, making use of Express Mail for follow-ups, and other means (Montaquila et al., 2010).

11 Analysis of Responses to Selected Survey Questions

11.1 Community Responses to Survey Questions

In addition to the question about annoyance with aircraft noise, responses to several questions were judged as possibly important to airports' policies on public outreach. These questions and responses were suggested for inclusion in the national survey. Specifically, responses from the community to the telephone survey regarding outreach-related questions could help airports understand how well their outreach is received or, if no outreach program is active, whether its development might be of value to the airport. It is important to note that the numbers / percentages reported here are raw data, not weighted by populations. However, the responses to these non-annoyance questions may illuminate respondent reactions to what may be sensitive or confusing topics.

Overall, the raw responses to these questions of interest gave the following general results.

- 25% - 48% of community respondents indicated that residents' actions and views can moderately to very greatly influence airport officials;
- 58% - 69% of community respondents indicated airport officials moderately well to extremely well understand resident's feelings;
- 40% - 63% of community respondents indicated airport officials keep community residents moderately to extremely will informed;
- 54% - 75% of community respondents indicated airport officials can be moderately to completely trusted to work fairly with the community; and
- 79% – 99% of community respondents indicated the airport as moderately to extremely important to their community.

Raw community responses to the outreach-specific questions are identified below:

- Question 31. If someone wants to make a complaint about aircraft noise these days, do you know if there is a convenient way to contact Airport?

Question 31 Results	Airport 1	Airport 2	Airport 3
Refused	0.9%	0.0%	0.0%
Don't Know	23.7%	36.1%	34.2%
Yes	50.0%	31.9%	36.0%
No	25.4%	31.9%	29.8%

- Question 32. How much do you think that residents' actions and views can influence Airport noise policy?

Question 32 Results	Airport 1	Airport 2	Airport 3
Don't Know	3.5%	2.1%	1.8%
Very Greatly Influence	0.9%	0.7%	0.9%
Greatly Influence	10.5%	11.1%	23.7%
Moderately Influence	14.0%	30.6%	23.7%
Slightly Influence	41.2%	38.2%	38.6%
Not At All Influence	29.8%	17.4%	11.4%

- Question 33. Has your household ever received assistance from the government or Airport to soundproof your home against aircraft noise?

Question 33 Results	Airport 1	Airport 2	Airport 3
Don't Know	4%	1%	5%
Yes	45%	2%	17%
No	52%	97%	78%

- Question 35. How well do you think Airport officials understand the community residents' feelings about aircraft noise?

Question 35 Results	Airport 1	Airport 2	Airport 3
Don't Know	7.0%	18.1%	12.3%
Extremely Well	7.0%	9.7%	12.3%
Very Well	17.5%	19.4%	25.4%
Moderately Well	33.3%	31.3%	31.6%
Slightly	15.8%	11.8%	12.3%
Not At All	19.3%	9.7%	6.1%

- Question 36. How fully do you feel the Airport officials keep community residents informed about the planning for airport changes?

Question 36 Results	Airport 1	Airport 2	Airport 3
Don't Know	6.1%	7.6%	6.1%
Extremely Well	1.8%	2.8%	4.4%
Very Well	12.3%	21.5%	14.9%
Moderately Well	25.4%	34.0%	43.9%
Slightly	33.3%	17.4%	20.2%
Not At All	21.1%	16.7%	10.5%

- Question 37. To what extent do you think that Airport officials can be trusted to fairly work with the community by following official, agreed-upon procedures and providing accurate information?

Question 37 Results	Airport 1	Airport 2	Airport 3
Refused	0.9%	1.4%	0.0%
Don't Know	5.3%	10.4%	8.8%
Completely Trusted	4.4%	7.6%	6.1%
Considerably Trusted	8.8%	23.6%	21.1%
Moderately Trusted	35.1%	35.4%	38.6%
Slightly Trusted	30.7%	18.1%	21.1%
Not At All Trusted	14.9%	3.5%	4.4%

- Question 40. How important do you think that Airport is for the area?

Question 40 Results	Airport 1	Airport 2	Airport 3
Don't Know	2.6%	0.7%	0.9%
Extremely	28.9%	63.9%	77.2%
Very	26.3%	27.1%	18.4%
Moderately	23.7%	5.6%	3.5%
Slightly	12.3%	2.8%	0.0%
Not At All	6.1%	0.0%	0.0%

11.2 Airport Reactions to Community Responses

We provided the community responses given in the previous section to the airport operators and asked them to respond to three specific questions.

1. Are the results of interest to the airport? – All airports saw value in knowing the responses. The results may be considered sensitive and not to be shared, but the response could help the airports assess their outreach efforts.
2. Are they of too sensitive a nature to the airport and do you think they should not be asked as a part of a national survey? The airports responded that the responses may be difficult for airports to know, but still worth considering.
3. If they are part of a national survey, do you think the airports would want to keep these results confidential – to only themselves? The results are unlikely to be shared by most airports.

11.3 Respondent Reactions

Finally, several of the above questions were judged to possibly confuse the respondent or to be too difficult to answer. Westat asked the interviewers how respondents reacted to survey questions 33, 34, 37 and 38 (repeated below). Specifically the interviewers were asked:

1. Did the respondents have any trouble answering?
2. Where the questions sensitive?
3. Did the respondents offer any comments?

33. Has your household ever received assistance from the government or (…LOCAL AIRPORT…) to soundproof your home against aircraft noise?

- All reported there was no trouble answering this question- answered it very easily.
- Many respondents said it would be nice if they were offered assistance from the Government (they were not aware there was such a program).
- Some respondents reported that they had soundproofed on their own, again, either because they weren't aware they could get assistance or because they just wanted it done.
- Many respondents questioned the interviewers on how to get this soundproofing done thru the government.
- Many respondents offered that instead of soundproofing, that airports offered different solutions for the noise such as changing directions the aircraft flew, as well as the timing of take-off/landings.

34. Has the government or [LOCAL AIRPORT] done anything else to financially compensate you for the aircraft noise here?

- No trouble answering this question
- For one community this question was a bit sensitive in that many expressed disappointment that they may have missed out on the compensation. Not being aware that this may have been possible. Many asked how they could get information about compensating

37. To what extent do you think that [LOCAL AIRPORT] officials can be trusted to fairly work with the community by following official, agreed-upon procedures and providing accurate information? Do you think the officials can be completely trusted, considerably trusted, moderately trusted, slightly trusted or not at all trusted?

- In general respondents answered this question comfortably
- Question was not sensitive
- Respondents realize that the airports are huge money maker for the area so they didn't complain and thought officials were doing the best they could and apparently this question was answered in that most felt they were pretty much trusted.

38. How much do you think (the officials who run [LOCAL AIRPORT]) could reduce the aircraft noise around here if they tried: Could [the officials who run the airport] reduce the noise very greatly, greatly, moderately, slightly or not at all?

	Very greatly	Greatly	Moderately	Slightly	Not at all	Refused	Don't know
a. The officials who run [LOCAL AIRPORT]	☐1	☐2	☐3	☐4	☐5	☐-7	☐-8
b. Other government officials	☐1	☐2	☐3	☐4	☐5	☐-7	☐-8
c. The pilots flying the planes	☐1	☐2	☐3	☐4	☐5	☐-7	☐-8

- Many thought the response option 'c' was ridiculous in that pilots couldn't control the noise.
- The airport official (a) option seemed to cause a lot of respondents to open up about how these are the people who are to blame for the noise. That they could control it by changing flight paths.
- Interviewers reported that the other government officials could only do so much that it was the airport officials that should take charge of it.
- Some interviewers felt this question was a bit sensitive based on the comments given about the airport officials.
- Higher expectations for this question fell on the airport officials.
- Most were open and willing to answer this question with no issues.

12 Suggested Annoyance Survey Protocol

Appendix G presents our recommended annoyance research protocol to study aircraft noise exposure-annoyance response relationships across the U.S.

13 Annoyance References

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PHASE II – AIRCRAFT SLEEP DISTURBANCE STUDY PLANS

14 Sleep Disturbance Literature Review

14.1 Background

The principal aim of the literature review was to critically review the scientific literature concerned with the effect of aircraft noise on sleep while additionally explaining sleep assessment concepts for the non-specialist. Particular attention was given to the strengths and weaknesses of the literature with identification of gaps in the present state of knowledge. The ultimate purpose of the review was to provide a background on which to design further studies (described in Sections 15, 16 and 17) which are relevant, robust, cost-effective and achievable.

'A good night's sleep', in terms of adequate duration, depth, composition and continuity is generally accepted as a prerequisite for human health and well-being. Consequently most people would consider a quiet night time for undisturbed sleep as a reasonable expectation from society.

The link between aircraft noise and sleep disturbance is clear but the further link between sleep disturbance and long-term health effects, despite mechanisms being suggested, has not been conclusively established. There are some indications that night time noise can be linked to cardiovascular disease and stroke in the elderly but presently there is no clear evidence of a pathway that directly links noise (at commonly experienced levels) and disturbed sleep with cardiovascular disease.

The early studies (pre-1990) of noise disturbed sleep tended to be survey reports from residents living near to airports or small laboratory-based reports which showed clear effects of sleep disturbance due to pre-recorded aircraft noise events (ANE) with a direct causal relationship between noise level and the degree of sleep disturbance reported. However, limited subject numbers, lack of adequate controls and no generally accepted data gathering or standardized analytical techniques precluded any clear agreement on the exact relationship between aircraft noise and sleep disturbance in the field.

The predominant sleep research technique, over the last 40 years, has been polysomnography, which involves electrophysiological techniques based around electroencephalography (EEG), a measure of the electrical activity of the brain recorded from the scalp by electrodes. This technique is frequently described as the 'gold standard' for sleep recording and has given rise to the concept of sleep stages. The EEG provides a clear indication of an individual's level of physiological arousal. There is a continuum of arousal which ranges from very high levels of alertness to deep sleep.

The detailed analysis of sleep involves breaking the continuous electrophysiological recordings into short epochs (typically 30 seconds) and each epoch is ascribed one of seven epoch scores: Wake; Movement Time; stages 1, 2, 3 or 4 sleep, which can be considered as increasing progressively in depth and collectively known as non-REM sleep, while REM (rapid eye movement) sleep is typically associated with dreaming. The combination of sleep stages 3 and 4 can also be described as SWS (slow wave sleep)[12].

[12] According to a revision of the sleep scoring manual by the American Academy of Sleep Medicine in 2007, SWS would be classified as stage N3. Likewise, Movement Time does not exist in the new classification anymore, and would be classified as Wake instead.

In addition to investigating additional evoked arousals due to noise, the assessment of the degree of sleep disturbance involves noting: sleep onset delay, increased awakenings, decreased slow wave sleep[13], REM sleep, and early awakenings.

Polysomnography is very sensitive, extremely well standardized and the dominant method in modern sleep research particularly for identifying arousals which seem to be essential for the detrimental effects of sleep fragmentation on daytime functioning. However, polysomnography is very time consuming, needs highly specialized equipment and considerable staff expertise for attaching equipment and for data analysis which explains its one major weakness in its considerable expense compared to other simpler but less direct methods of assessing sleep disturbance. This cost tends to limit the sample size which in turn reduces the statistical power and generalizability of the studies, and prevents any firm conclusions being drawn from such studies. In addition, the electrodes attached to the subjects scalp and skin are somewhat invasive and may influence sleep, especially during the first measurement night. Finally, as sleep stages are scored visually by humans, high inter- and intra-observer variabilities have been reported in the past.

Therefore, a comprehensive consideration of other techniques available is essential as there is a requirement in this current work to propose alternative research methods for field studies to assess the relationship between aircraft noise and sleep disturbance for US airports.

Other less direct methods of assessing sleep disturbance are:

1) **Behaviorally confirmed awakening (BCA)** The subject ‘pushes a button’ to indicate an awakening, which is inexpensive and has high specificity but its major weakness is low sensitivity, as it will underestimate brief periods of arousal and wakefulness during sleep which may potentially be critical issues in any harmful processes. In addition, this method can be prone to subjective error.

2) **Heart rate response (HRR)** Involves assessing changes in the autonomic arousal level via the heart rate which on a noise can accelerate and display a heart rate response (HRR). Recent work showed that EEG defined awakenings and cardiac activations were positively related to increasing maximum sound pressure level (SPL) of the ANE and the two different measures of sleep disturbance were highly correlated. The HRR technique has the advantage of being relatively inexpensive, simple and robust particularly when looking for responses to specific events (e.g. aircraft noise).

3) **Actigraphy** monitors body movements via a movement device, about the size of a man’s wrist-watch attached to a limb (generally the non-dominant wrist.) Inside the device a programmable microprocessor logs displacements of a movement detector. The general assumption is that periods of quiescence are associated with sleep while movement is more likely to be associated with disturbance and wakefulness. This technique is very simple, inexpensive, data rich, has been used in previous large field studies in Europe particularly and has high sensitivity but low specificity similar to HRR. However if these methods are combined the specificity would be improved but both these methods can be criticized for not being able on their own to differentiate between sleep and wakefulness states.

4) **Post-sleep questionnaires** are common procedures in sleep research and a number of standardized formats are available which are designed in general to assess the quantity and quality of perceived sleep by the subject. The detailed form of the questionnaire is usually tailored to suit the particular objectives of the study.

There have been a few large field studies, mainly in Europe, funded by state agencies which have used primarily BCA and actimetry with some polysomnography for calibration, including a major German study which incorporated both laboratory and field studies. These studies showed that awakening probability increases with maximum SPL of the aircraft noise event (ANE).

[13] Slow wave sleep - SWS – is generally considered to be the deepest and the most recuperative sleep.

There have been many noise-response curves developed which indicate a threshold of significant disturbance where the response moves above background levels of internally generated arousals. The field studies, similar to laboratory studies, indicated a direct causal relationship between noise level and the degree of sleep disturbance. There have been recent attempts to update and enhance the analysis of previously recorded sleep awakening data. However there is still a large gap in our knowledge with an inability to produce a general consensus for a universally accepted noise –response curve that airports and regulatory bodies could use for policy purposes.

Previous reviewers on this topic have expressed the difficulties of designing sleep disturbance studies and integrating and summarizing the results of previous studies pointing out:

- The different methodologies and analytical procedures have led to a wide range of input and output variables;
- Large individual subject differences and predictive relationships that account for only a small fraction of the variance.

All of which have led to studies that are seemingly contradictory and inconclusive. However, there is an awareness of a need for further study which would ideally be longer term, employ larger samples and lower cost techniques adequately calibrated against accepted standards.

14.2 Summary of Noise Effects on Sleep

In general the following results have emerged from various studies concerned with the effects of noise on sleep:

- In a normal quiet night, polysomnography indicates that people experience about twenty arousals that result in brief periods (less than 1 minute) of waking and subjects are usually able to remember about two or three awakenings, when completing a post-sleep questionnaire in the morning.
- There is no doubt that awakening probability increases with maximum SPL (Lamax) of the ANE but there are considerable individual differences in the sleep responses.
- There are fewer noise related responses in children, but these responses increase with age. There are some indications that males have significantly more discrete movements than women and are more likely to respond to ANEs.
- There appears to be an inverse relationship between ambient bedroom noise levels and the chance of awakening due to aircraft noise i.e. in quieter backgrounds subjects are more likely to respond to ANEs. Also, sleep is more likely to be disturbed the longer the quiet period before an ANE.
- The size of the motility reaction and awakening probabilities were found to be dependent on the slope of the noise envelope associated with the ANE such that more rapid rise times gave greater likelihood of a motility response. There was more chance of a reaction to noise with a greater amount of high frequency (>3 kHz) components in its spectral composition.
- The autonomic responses (HRR) to noise were more sensitive but less specific and did not habituate while cortical (EEG) responses were more specific, displayed dose-response and habituation features. The HRR response is significantly larger if the arousal evokes an awakening response.
- Most responses occur in lighter sleep (stages 1 & 2) and REM. Also, awakening probability is lower from SWS (stages 3+4). Noise tends to delay sleep onset and can reduce SWS.
- Road traffic causes the most obvious changes in sleep structure and continuity whereas air and rail noise events were considered more disturbing subjectively. Subjective annoyance was greater for aircraft noise, while cortical and cardiac responses (HRR) during sleep were lower for air compared to road and rail traffic.

- The cumulative noise energy exposure (e.g. Lnight or Ln) did not predict sleep disturbance, supporting the notion that physiological responses depend on individual sounds not cumulative energy metrics.
- The overall correlation between actimetric measures of disturbance (motility) and indoor A-weighted sound exposure level (SEL) of individual noise events has been found to be relatively high, while correlation with measures of behavioral awakening (button pressing) were less.
- The filtered actigrams were able to detect 88% of all the EEG-determined periods of interim wakefulness longer than 15 seconds and movement time longer than 10 seconds but there were many false positives.
- Actigraphy has shown that below about 80dBA (Lmax) outdoors, there was hardly any increase in actigraphic response above the background movement activity associated with sleep. For ANE above this level there was a response rate of about 1 in 30, i.e. 3.3%.
- Only a minority of ANEs affected sleep while domestic and idiosyncratic items had more clear effects.

14.3 Considerations for Study Plan

A detailed consideration of recent reviews of this topic revealed considerable agreement on the weaknesses of the field studies to date: too few subjects and too many uncontrolled variables leading to results that tend to be inconclusive and contradictory. Such results are due to the difficulties of controlling such a large number of variables, e.g., individual differences in noise sensitivity; attitudes to airport operations; gender and age. Further complications arose in comparing studies due to different (1) methodologies for recording sleep (2) criteria for defining disturbance in terms of arousals and awakenings (3) analytical procedures employed.

The one major gap in this research area is the lack of a relatively inexpensive technique which could provide sufficient data to be able to boost the power of the analysis and offset the possible influence of uncontrolled variables.

Most recent reviews on this topic have advocated further field work with larger subject numbers for longer time periods and where possible simpler and more inexpensive techniques appropriately calibrated against traditional methods and building on the research already completed.

The literature review identified important associated issues that need careful consideration in planning future studies in this area, including:

- Field versus laboratory study, concluding the field (in people’s homes) being the most appropriate location;
- Noise recording methodology ideally requires indoor and outdoor (Lamax) and real time sound recording for identification of non-aircraft noises;
- Location should provide a range of aircraft noise levels across the nighttime and from subject to subject;
- The subject mix should reflect the base population whenever possible with comprehensive data gathered during subject selection.

15 Sleep Disturbance Study Plan

The following paragraphs describe the two suggested research protocols. These are followed by the procedures related to the selection of measurement sites, the selection of study participants, acoustical measurements, and supplementary data gathered will be outlined. These procedures do not differ between protocols #1, Polysomnography and #2, Actigraphy plus ECG.

15.1 The Two Protocols

15.1.1 Research Protocol #1: Polysomnography

This protocol will facilitate polysomnography (i.e., the simultaneous measurement of the electroencephalogram [EEG – brain activity], electrooculogram [EOG – eye movement], and electromyogram [EMG – skeletal muscle tone]) for the measurement of sleep. According to specific conventions (International 10-20-system), electrodes are attached to the scalp and the skin of the face of the subject. The electrical potentials generated by the brain, chin muscles and eye movements are amplified, converted into digital signals and stored on digital media. The signals are later analyzed by trained personnel according to specific conventions [4,5]. Polysomnography is considered the gold standard for measuring sleep, and it permits detection of subtle changes in sleep physiology induced by aircraft noise. The use of polysomnography will assure comparability to a series of studies on the effects of aircraft noise and rail traffic noise on sleep performed in the European Union.[6,7] At the same time, due to the high methodological expense, at a given level of funding, it will be possible to investigate only a single or a limited number of airports relative to research protocol #2, and the external validity will thus be limited. The advantages and disadvantages of polysomnography are summarized here (see Basner et al. [2]):

> <u>Advantages of Polysomnography</u>: Polysomnography is the gold standard for measuring sleep, the evaluation of sleep structure and the degree of sleep fragmentation. It is a method that covers most physiological aspects of sleep (with the exception of conscious awakenings, as we cannot tell with certainty from the polysomnogram whether a subject regained waking consciousness or not). It is a very sensitive method that will detect even subtle changes in sleep physiology. Also, the method itself is very well standardized.
>
> <u>Disadvantages of Polysomnography</u>: EEG, EOG, and EMG electrodes and leads are somewhat disruptive, may influence sleep, and thus at least one night is usually required for adaptation[8]. The measurement instruments are expensive and fragile. The instrumentation and de-instrumentation of subjects is cumbersome and has to be done by trained personnel. EEG and EMG electrodes are sometimes affected by movements or excessive sweating of the subjects, which may render the analysis of (part of) the data gathered during the night impossible. Finally, sleep stage classification requires trained personnel and is known to have high inter- and intra-observer variabilities [9,10,11]. Automated sleep stage classification systems exist, but so far validation studies reached contradictory conclusions [12].

15.1.2 Research Protocol #2: Actigraphy plus ECG

This protocol will facilitate the simultaneous measurement of actigraphy (skeletal muscle movement) and heart rate (ECG). Actigraphs measure acceleration of body movements (in one or more dimensions), are the size of a watch, and are worn like wrist-watches (usually on the wrist of the non-dominant arm). Some products have additional features, for example, light sensors measuring environmental light intensity (sometimes in different spectra), body position sensors, an event marker button (e.g., to signal lights out), or a display (e.g., for displaying clock time).Actigraphy is a well-established method in research on the effects of aircraft noise on sleep. It was used in studies around Heathrow [13], Amsterdam [14], and Cologne-Bonn Airport [6]. Therefore, using actigraphy ensures comparability of the results of a US field study with those of the above mentioned European studies. It is suggested that higher data storage rates are used than those commonly applied (1-2 samples/min) in order to allow for an event-related analysis. Newer equipment can continuously sample and store raw data at 30 -100 Hz for several days to weeks. The advantages and disadvantages of actigraphy are summarized here (see Basner et al.[2]):

> <u>Advantages of Actigraphy</u>: Actigraphs are inexpensive and comparatively robust. After an initial orientation, subjects can wear the device for several days and nights unsupervised (i.e., the methodological expense is low). The movement activity data gathered with actigraphy are the measure of interest, so there is no need to visually score data. Actigraphs are less disturbing than the sensors applied for polysomnography, and it is unlikely that actigraphs substantially influence normal sleep.

> <u>Disadvantages of Actigraphy</u>: Although actigraphs are an accepted measure to determine rest-activity cycles [15], more subtle physiological changes cannot be detected by actigraphy. Unfortunately, the degree of standardization overall is relatively low. Different models (i.e., hardware) will give slightly different results, there are several methods to determine activity counts (time above threshold, zero crossing, digital integration)[15], and each company has its own algorithm to differentiate wake from sleep periods. Therefore, it is not surprising that the results of comparisons between polysomnography and actigraphy vary widely [15-21]. Although CNS activations and body movements often occur simultaneously, both may occur independently from each other, and thus one cannot expect a 1:1 agreement. Rather, some misclassifications are obvious: For example, someone lying awake and not moving but trying to fall asleep would be misclassified as being asleep by actigraphy.

The ECG offers a unique opportunity to measure both subtle and more obvious changes in sleep physiology with less disruptive and less expensive methods than polysomnography. Self-instrumentation and automatic data analysis make this an inexpensive and objective method. Nocturnal vegetative activations may play an important role in the genesis of cardiovascular disease, and therefore the analysis of heart rate information alone delivers important insights. An ECG-based algorithm for the automatic identification of cortical arousals was developed [22] and validated [23] by Basner et al. This algorithm is currently adapted (to better match EEG awakenings) and extensively validated with polysomnographic data gathered around Frankfurt airport within PARTNER Project 25B. The current version of the algorithm shows almost perfect agreement with EEG awakenings (kappa > 0.8). This methodology will deliver meaningful data while being much more cost-effective. Therefore, it will be possible to investigate several US airports at the same level of funding that would be needed to measure a single airport with polysomnography. Preferentially, both actigraphy and the ECG will be recorded with the same device. This avoids data synchronization problems. The advantages and disadvantages of the ECG follow (see Basner et al.[2]):

> <u>Advantages of ECG</u>: Similar to actigraphy, devices measuring the ECG are relatively inexpensive and robust. After an initial orientation, subjects can attach and detach the ECG electrodes themselves and (depending on storage capacity) can wear the device for several days and nights unsupervised (i.e., the methodological expense is low). The data are scored automatically by the algorithm described above, so there is no need to visually score data. The ECG is less disruptive than the sensors applied for polysomnography, and it is unlikely that the ECG alone substantially influences normal sleep. Repeated noise induced autonomic activations may play a key role in the genesis of hypertension and associated cardiovascular diseases, and therefore measuring autonomic activations may be an advantage from a conceptual standpoint. In the recent past, the utility of specific aspects of the ECG signal (like heart rate variability [24] or cardiopulmonary coupling [25]) for sleep research has been acknowledged in the field. For this reason alone it will be worthwhile to sample the ECG in a field study on the effects of noise on sleep.

> <u>Disadvantages of ECG</u>: A certain period throughout the night is spent awake, and it is unclear how to interpret heart rate increases during wakefulness (the same is true for actigraphy, see above). Basner

et al.[23] discuss this the following way: "Situations where the subject was already awake before playback of the ANE started (10.3% of all events) were excluded from the analysis in this study …. Comparable to actigraphy, the ECG algorithm is not able to differentiate between wake and sleep unless polysomnography is performed simultaneously. If the ECG is sampled alone, cardiac activations during wakefulness may be misinterpreted as awakenings, potentially overestimating the number of traffic noise induced awakenings. However, in situations where the subject is already awake traffic noise may nevertheless adversely affect sleep by preventing the subject from falling asleep again, and therefore prolonging spontaneous or noise induced awakenings [26]. In these situations, noise induced cardiac activations may indicate an increased state of arousal and, therefore, a decreased likelihood of falling asleep again. Hence, although cardiac activations during wake periods may overestimate the number of EEG awakenings, they may nevertheless be a useful indicator of noise induced sleep disturbance. Further analyses on the association of cardiac activations during wakefulness and the time needed to fall asleep again should be performed in the future."

15.2 Measurement Sites

A US field study on the effects of aircraft noise on sleep should be performed at least at one airport with nocturnal air traffic and one control airport without aircraft noise exposure. Generalizability of the findings and exposure-response relationships will increase with the number and representativeness of the airports studied. An approach similar to the one recently described for the FAA sponsored aircraft noise and annoyance study could be adopted. For that project, HMMH has been asked to investigate twenty airports, including at least one from each of the eight FAA Regions located within the contiguous United States. It would also be valuable to investigate airports with traffic curfews or ones that have recently experienced a significant increase or decrease in traffic volume (e.g., opening of a new runway), but including such changes is not necessary for the success of the project.

Runway use depends on wind direction. Sites that are exposed to aircraft noise independent of wind direction (i.e., either by aircraft taking off or by aircraft approaching) will be preferentially chosen as measurement sites (as opposed to sites that are only exposed to aircraft noise under certain wind conditions). This assures that a high number of noise events per subjects will be measured (which increases the statistical power of the study and the precision of the exposure-response relationship), and that the likelihood of subjects receiving no aircraft noise at all during a measurement period decreases.

The choice of study regions around the airport will reflect varying degrees of aircraft noise exposure (i.e., high exposure regions in close proximity to the runways and low exposure regions farther away from the runways). Study regions will be identified using L_{night} contours using the INM or equivalent. The number of aircraft contributing to L_{night} and the expected maximum sound pressure level $L_{AS,max}$ at the exposure site will be used as supplementary criteria for site selection. Subjects will be sampled in equal parts from regions with $L_{night} > 55$ dB (high degree of sleep disturbance according to WHO,[27] more than one additional awakening per night according to Basner et al.[28]) and from regions with L_{night} between 40 dB and 55 dB (moderate degree of sleep disturbance according to WHO,[27] less than one additional awakening per night according to Basner et al.[28]). Subjects living in regions with $L_{night} < 40$ dB will be ineligible for study participation, as no relevant degree of aircraft noise-induced sleep disturbance is expected.

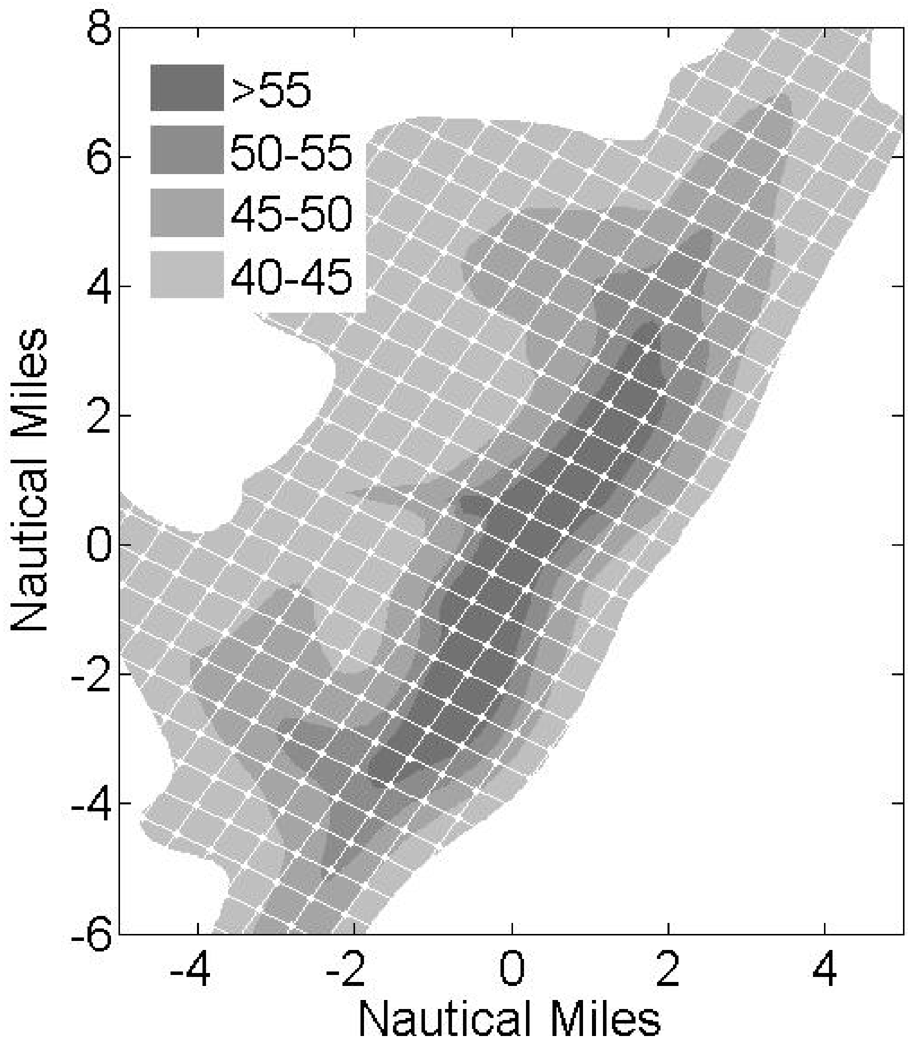

Figure 12 Lnight contours 40 to >55 dB, based on historical data from Newark International Airport.

The sampled noise regions will also be classified according to additional criteria (e.g., average family income per household) on zip-code level. Control sites will be selected to reflect the distribution of these additional criteria at the exposure sites. Measurement site selection will also ensure that exposure to road and rail traffic noise at the control sites is comparable to that at the exposure sites. For many communities, maps showing traffic noise exposure levels already exist. If not, the degree of traffic noise exposure can be estimated from the following variables: type of road (number of lanes, cul-de-sac, etc.), distance of most-strongly exposed façade from the roadway/railway, and bedroom window facing road/rail (yes/no).

For final subject recruitment blocks within designated exposure and control areas will be randomly selected. A selected aircraft noise exposure block will be matched to a selected control block that has similar road traffic noise. Recruiters will then go from door to door within each block and leave flyers to recruit subjects.

15.3 Assessment of the Consequences of Aircraft Noise-Induced Sleep Disturbance

In order to minimize methodological expense (and thus maximize response rates and generalizability of results), the assessment of the consequences of aircraft noise-induced sleep disturbance will be restricted to brief morning questionnaires (see Appendix I). However, as sleep fragmentation has been shown to cause transient increases in blood pressure during the night, which may over time contribute to more long-term effects, blood pressure will be measured twice (once during the distribution and a second time during the collection of the measurement equipment). Based on prior field studies on the effects of aircraft noise on sleep, a relevant change in cognitive performance due to the aircraft noise exposure is not expected, and thus the increase in methodological expense due to cognitive performance tests is not justified.

15.4 Assessment of the Acoustical Environment

It is suggested that actual sounds inside the bedroom are continuously recorded along with noise levels with class-1 noise level meters. Also, it is suggested that the study be done in cooperation with the airport so that detailed information on flight operations with a high temporal resolution can be collected. The combination of interior sound recordings and flight operations data should be sufficient for the identification of aircraft noise events.

If flight operations data cannot be obtained, the recording of outdoor sounds may be necessary to correctly identify aircraft noise events. If simultaneous measurements are being conducted at sites that are within a close vicinity it may be sufficient to record outdoor sounds at one central site. If this is not possible, outdoor measurements at each site should be made.

15.5 Data Synchronization

It is suggested that actigraphy and the ECG be recorded with the same device. If it is not feasible to use wireless technology, the internal clocks of all measuring devices should be synchronized immediately before the start of the measuring period and the data corrected for the time drift of each individual device (that would be established before the start of the study), in order to assure synchronization between acoustical and physiological variables.

15.6 Assessment of Non-Acoustical Extrinsic Factors Influencing Sleep

Temperature, humidity and light intensity as potential confounders should be continuously measured in the bedroom during the field study, in order to be able to control for the effects of these variables on sleep in the statistical analysis. Sampling should be alternated between exposure and control sites, so that exposure and control groups will be measured during the same season of the year.

15.7 Subject Selection Criteria and Sample Size

15.7.1 Selection Criteria

As few selection criteria as possible will be used in order to increase response rates and the generalizability of results (but with representation of both sexes and a wide age range). However, it will be possible to adjust for some of the standard selection criteria in the analysis phase of the study.

The following eligibility criteria should be applied:

- Subject is at least 21 years old.
- Subject does not use hearing aids during the day or ear plugs during the night.
- Subject understands and is able to speak/write the English language.

- Subject has no active alcohol or drug addiction.
- Subject has no history of cardiac arrhythmia (ECG algorithm not validated in arrhythmia).
- Subject has no history of and is not treated for obstructive or central sleep apnea.
- Subject does not consume sleeping medication on a chronic basis (more than twice per week).
- Measurement equipment can be securely stored in the subject's home.

After subjects have been selected for the study, they will fill out a general questionnaire (see 0), a Health Survey (SF-36),[29] the Pittsburgh Sleep Quality Index (PSQI),[30] and the Horne-Ostberg Morningness-Eveningness Questionnaire[31] to determine their circadian preference.

15.7.2 Sample Size Calculations

The power of the study and the precision of the exposure-response relationship depend on both the number of investigated subjects and the expected cumulative number of noise events per subject. The latter will depend on the traffic volume at the study site. Therefore, at busy airports it may be sufficient to investigate subjects for a single or a few nights, whereas at airports with low traffic volumes or traffic curfews it may be necessary to measure for several nights. Different combinations of "number of subjects" and "number of noise events per subject" can lead to the same power/precision, see Figure 13 below.

Figure 13 shows results of Monte Carlo simulation based sample size calculations for a study on the effects of aircraft noise on sleep. Dots show simulation results and best fit regression lines are presented. The left panel shows the precision of 95% confidence intervals surrounding exposure-response relationships for response probability depending on number of investigated subjects and number of expected noise events per subject. Exposure-response relationships are based on random subject effect logistic regression analyses with maximum sound pressure level as the only explanatory variable. The right panel shows the Statistical Power 1-β (i.e., probability to detect a statistically significant effect if in reality there is an effect) of a study on the effects of aircraft noise of maximum sound pressure level on awakening probability depending on number of investigated subjects and number of expected noise events per subject. This work was performed within PARTNER Project 25B.

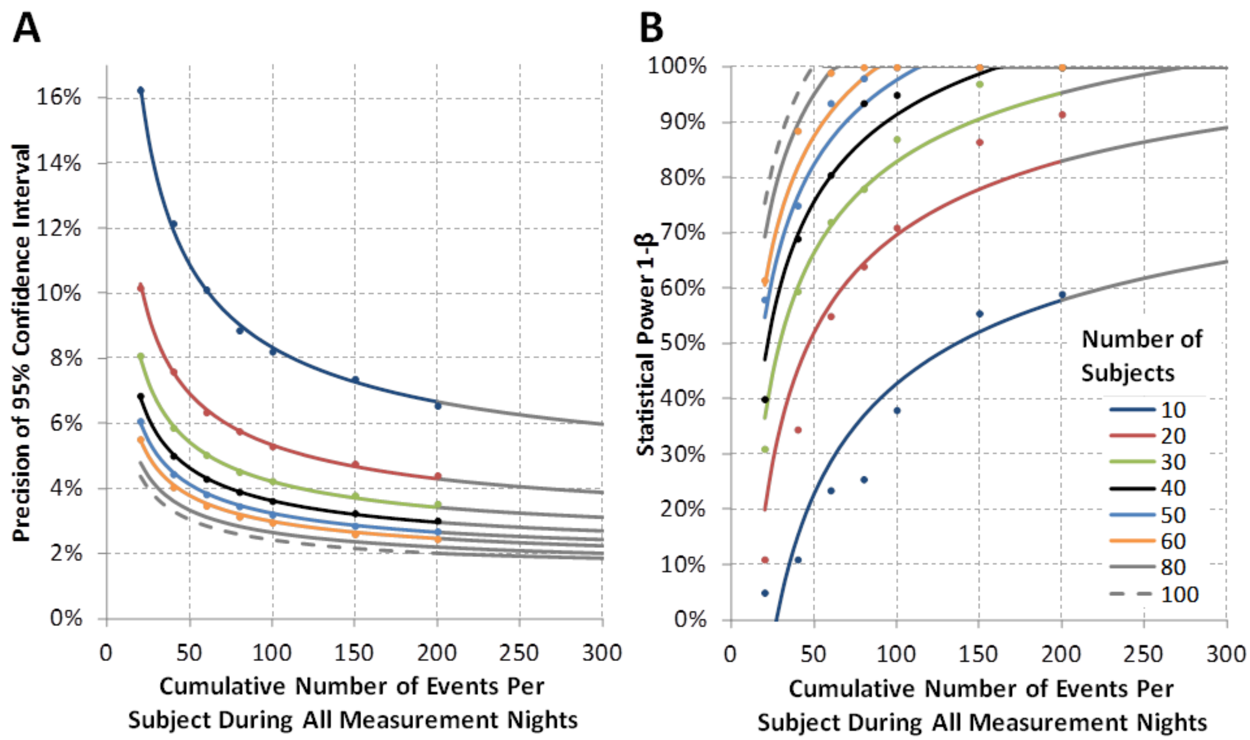

Figure 13 Effects of Subject and Cumulative Event Numbers on Confidence Interval and Statistical Power

For this proposed study, the preference should be given to increase the number of subjects, as we are more interested in getting precise information on a representative group of subjects than very precise information on a smaller group of subjects. The investigated number of subjects and number of nights per subject should be chosen in a way that at least 80% power is achieved even with some attrition or a lower than expected number of noise events per night.

If a single airport and a single control site are investigated, we suggest sampling at least 40 subjects per site (better: 60 subjects) with a target of gathering, on average, reactions to 60 aircraft noise events per subject at the aircraft noise exposure site. This would result in an average precision (i.e., width of the 95% confidence interval surrounding the exposure-response function) of 4.3% and a power of 80.5% to detect a statistically significant effect (3.5% and 91.7% for 60 subjects, respectively). If more than one airport is investigated, the power for the pooled data to detect a significant aircraft noise effect will be >99.9% and the precision for the pooled exposure-response function will be ≤3%. If individual airports are of lesser interest and the focus is on the pooled exposure-response function, sample sizes at individual airports could be further reduced.

16 Sleep Disturbance Data Analysis Plan

The primary outcome of this study is an exposure-response relationship between acoustical properties of single aircraft noise events (e.g., SEL, $L_{AS,max}$) and physiological reactions during the sleep period (here: EEG awakenings determined by either polysomnography [protocol #1] or by actigraphy and the ECG [protocol #2]).

Aircraft noise events will be identified by human scorers, if possible with the help of flight schedule data provided by the airport. The beginning and end of each aircraft noise event will be marked and several acoustical descriptors will be calculated (e.g., $L_{AS,max}$, SEL, rise time, spectral composition). Equivalent noise levels $L_{A,eq}$ will be calculated for the sleep period time (exposure and control group) and for aircraft noise events only (exposure group only) for each study night.

EEG awakenings (defined as EEG arousals ≥ 15 s to avoid the low temporal resolution of 30-s sleep stage epochs) will be either determined by trained scorers and blinded to the acoustical data according to the criteria of Rechtschaffen et al.[5] based on polysomnographic data (protocol #1) or by an automatic algorithm based on actigraphy and the ECG (protocol #2).

For each aircraft noise event, the physiological data will be screened for an EEG awakening for the duration of the noise event. The outcome is binary (awakening yes/no). A random intercept logistic regression model with $L_{AS,max}$ as the only explanatory variable will be used to derive the exposure-response relationship and 95% confidence intervals. This constitutes the primary endpoint of the study. Secondary analyses will include models that incorporate individual (age, gender), situational (elapsed sleep time), and acoustical (SPL rise time, spectral composition) moderators. Sleep fragmentation (defined as awakenings per h sleep period time) will be calculated for and compared between the exposure and the control group. It will also be investigated whether sleep fragmentation varies as a function of L_{night} calculated for each investigated study night. Spontaneous awakening probability will be both derived from noise-free intervals within the exposure group and from the control group.

17 Sleep Disturbance Budget Estimates

The budgets below are calculated for one exposure site with 40 subjects and one control site with 40 subjects. We assume that measurement devices will be distributed on Monday and collected on Thursday or distributed on Tuesday and collected on Friday (i.e., that subjects will be investigated for 3 consecutive nights). These conditions provided, it is easy to extrapolate the study costs to larger sample sizes.

For the actigraphy/ECG study (protocol #2), we made the following assumptions:

- With a team of 2 investigators, it will be possible to measure at 3 sites concurrently (although it is assumed that, on average, measurements will only take place at 2 sites at the same time).
- At each 3rd site, it will be possible to measure two subjects instead of one (which translates to an average of 1.33 subjects per site).
- This means it will be possible to measure 2.66 subjects per week on average (or 40 subjects in 15 weeks).
- As 2 weeks are needed for initial subject recruitment, this translates to roughly 1 month per 10 subjects.

For the polysomnographic study (protocol #1), the following additional assumptions were made:

- Instead of three sites, only one site can be operated by 2 investigators concurrently. Electrodes for polysomnographic measurements have to be applied by one investigator in the evening and detached by another investigator in the morning. The latter would also backup and check the quality of last night's data.
- The visual scoring of the EEG is time consuming and requires one additional research assistant during the data analysis stage.
- Obviously, different equipment has to be purchased for the polysomnographic study, which is reflected in the budgets. To keep costs for the polysomnography study low, we only budgeted 5 instead of 6 systems. This means that at two sites two subjects could be measured concurrently, and only one subject could be measured at the third site.

It is assumed that sounds and noise levels inside are measured with a class-1 sound level meter. If the airport does not collaborate, outside sounds will be continuously recorded with cheaper sound recording devices to more easily identify aircraft noise events.

For the budgets below, base salaries of $100,000 (senior faculty member), $40,000 (post doctoral researcher), $30,000 (telephone recruiter), and $25,000 (research assistant), and fringe benefits of 34% were assumed. The budget estimates only reflect direct costs. Indirect costs vary from institution to institution and would need to be added.

These budgets assume that both the exposure site and the control site are located in a reasonable distance from whoever is contracted to do the study. Studies involving multiple airports (across the US) would require a multi-center study or subcontracts to local universities or private companies for the field work, which would likely increase the overall cost of the study.

Assuming three concurrent measurement sites, the difference in equipment and consumable costs between protocols #1 and #2 amount to (marked orange in the budget for protocol #1):

$64,000 - $8,000 = $56,000

This is a one-time investment and does not depend on the sample size. If the number of concurrent measurement sites is doubled to six, this difference would increase by a factor two (i.e., 6 concurrent measurement sites: $112,000 difference).

From the budget calculations presented below follows that for every subject that is added to either the experimental or the control group roughly

- $197,547 / 80 = $2,470 for polysomnography (protocol #1)
- $106,213 / 80 = $1,328 for the actigraphy/ECG (protocol #2)

would have to be added to the total cost of the study for each subject, and the study would have to be extended by 1 month for every 10 subjects with the assumptions stated above (i.e., 3 concurrent measurement sites). Thus, if both the exposure and the control site should consist of 60 instead of 40 subjects, the total cost would increase by 40*$2,470 = $98,800 (protocol #1) and by 40*$1,350 = $54,000 (protocol #2), and run 4 months longer. The same is true if additional airports would be investigated.

Also, the need to visually score the polysomnogram requires one additional human scorer for the 8 months analysis period for 80 subjects total.

17.1 Budget Protocol #1 (Polysomnography)

I. Preparatory Phase (Duration: 8 months)							
Task Description							
Obtain IRB approval, hire and train research assistant, perform noise calculations for subject selection, select control areas based on sociodemographic and traffic noise characteristics, prepare flyers/letters/questionnaires, acquire and test hardware							
Personnel	**Total Cost**	**Base**	**% effort**	**Hours**	**Salary**	**Fringe**	**Months**
Assistant Professor (8 months @ 20%)	$ 17,867	100000	20%	277	$20,000	$ 6,800	8
Post-Doc (8 months @ 100%)	$ 35,733	40000	100%	1387	$40,000	$13,600	8
Research Assistant (7 months @ 100%)	$ 19,542	25000	100%	1213	$25,000	$ 8,500	7
Research Assistant (2 months @ 100%)	$ 5,583	25000	100%	347	$25,000	$ 8,500	2
Research Assistant (2 months @ 100%)	$ 5,583	25000	100%	347	$25,000	$ 8,500	2
Research Assistant (2 months @ 100%)	$ 5,583	25000	100%	347	$25,000	$ 8,500	2
Research Assistant (2 months @ 100%)	$ 5,583	25000	100%	347	$25,000	$ 8,500	2
Equipment/Consumables							
3 class-1 sound pressure level meters @ $4000 each	$ 12,000						
2 microphone calibrators @ $500 each	$ 1,000						
3 sound recording devices for outside sound measurements @ $500 each	$ 1,500						
5 portable polysomnography systems including licenses @ $12,000 each	$ 60,000						
2 Laptops for initializing/downloading data @ $1200 each	$ 2,400						
Total Cost Phase I	**$ 172,375**						
II. Data Acquisition Phase (Duration: 8 months)							
Task Description							
Recruit 80 subjects (40 exposed, 40 non-exposed), investigate 80 subjects for 3 consecutive nights each (on average)							
Personnel	**Total Cost**	**Base**	**% effort**	**Hours**	**Salary**	**Fringe**	**Months**
Assistant Professor (8 months @ 20%)	$ 17,867	100000	20%	277	$20,000	$ 6,800	8
Post-Doc (8 months @ 100%)	$ 35,733	40000	100%	1387	$40,000	$13,600	8
Research Assistant (8 months @ 100%)	$ 22,333	25000	100%	1387	$25,000	$ 8,500	8
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Research Assistant (8 months @ 100%)	$ 22,333	25000	100%	1387	$25,000	$ 8,500	8
Telephone Recruiter (8 months @ 10%)	$ 2,680	30000	10%	139	$ 3,000	$ 1,020	8
Equipment/Consumables							
Subject reimbursement (80 subjects * 3 nights * $50)	$ 12,000						
Rental car (8 months @ $1000 per month)	$ 8,000						
Gas (8 months @ $300 per month)	$ 2,400						
Parking (Garage, 8 months @ $150 per month)	$ 1,200						
Street parking (8 months @ $100 per month)	$ 800						
Highway fees (4 months @ $300 per month)	$ 1,200						
Consumables (Postage, ECG Electrodes, EEG Electrodes)	$ 2,000						
Equipment maintenance/repairs/replacement	$ 2,000						
Total Cost Phase II	**$ 197,547**						
III. Data Analysis and Report Phase (Duration: 8 months)							
Task Description							
Analyze the data, generate a report/publications							
Personnel	**Total Cost**	**Base**	**% effort**	**Hours**	**Salary**	**Fringe**	**Months**
Assistant Professor (8 months @ 20%)	$ 17,867	100000	20%	277	$20,000	$ 6,800	8
Post-Doc (8 months @ 100%)	$ 35,733	40000	100%	1387	$40,000	$13,600	8
Research Assistant (8 months @ 100%)	$ 22,333	25000	100%	1387	$25,000	$ 8,500	8
Research Assistant (8 months @ 100%)	$ 22,333	25000	100%	1387	$25,000	$ 8,500	8
Equipment/Consumables							
N/A							
Total Cost Phase II	**$ 98,267**						
TOTAL PROJECT COST	**$ 468,188**						

17.2 Budget Protocol #2 (Actigraphy/ECG)

I. Preparatory Phase (Duration: 8 months)							
Task Description							
Obtainb IRB approval, hire and train research assistant, perform noise calculations for subject selection, select control areas based on sociodemographic and traffic noise characteristics, prepare flyers/letters/questionnaires, acquire and test hardware							
Personnel	**Total Cost**	**Base**	**% effort**	**Hours**	**Salary**	**Fringe**	**Months**
Assistant Professor (8 months @ 20%)	$ 17,867	100000	20%	277	$20,000	$ 6,800	8
Post-Doc (8 months @ 100%)	$ 35,733	40000	100%	1387	$40,000	$13,600	8
Research Assistant (7 months @ 100%)	$ 19,542	25000	100%	1213	$25,000	$ 8,500	7
Equipment/Consumables							
3 class-1 sound pressure level meters @ $4000 each	$ 12,000						
2 microphone calibrators @ $500 each	$ 1,000						
3 sound recording devices for outside sound measurements @ $500 each	$ 1,500						
6 heart rate and actigraphy systems including software licenses @ $1000 each	$ 6,000						
3 temperature, humidity, light intensity measurement systems @ $400 each	$ 1,200						
2 Laptops for initializing/downloading data @ $1200 each	$ 2,400						
Total Cost Phase I	**$ 97,242**						
II. Data Acquisition Phase (Duration: 8 months)							
Task Description							
Recruit 80 subjects (40 exposed, 40 non-exposed), investigate 80 subjects for 3 consecutive nights each (on average)							
Personnel	**Total Cost**	**Base**	**% effort**	**Hours**	**Salary**	**Fringe**	**Months**
Assistant Professor (8 months @ 20%)	$ 17,867	100000	20%	277	$20,000	$ 6,800	8
Post-Doc (8 months @ 100%)	$ 35,733	40000	100%	1387	$40,000	$13,600	8
Research Assistant (8 months @ 100%)	$ 22,333	25000	100%	1387	$25,000	$ 8,500	8
Telephone Recruiter (8 months @ 10%)	$ 2,680	30000	10%	139	$ 3,000	$ 1,020	8
Equipment/Consumables							
Subject reimbursement (80 subjects * 3 nights * $50)	$ 12,000						
Rental car (8 months @ $1000 per month)	$ 8,000						
Gas (8 months @ $300 per month)	$ 2,400						
Parking (Garage, 8 months @ $150 per month)	$ 1,200						
Street parking (8 months @ $100 per month)	$ 800						
Highway fees (4 months @ $300 per month)	$ 1,200						
Consumables (Postage, ECG Electrodes)	$ 1,000						
Equipment maintenance/repairs/replacement	$ 1,000						
Total Cost Phase II	**$ 106,213**						
III. Data Analysis and Report Phase (Duration: 8 months)							
Task Description							
Analyze the data, generate a report/publications							
Personnel	**Total Cost**	**Base**	**% effort**	**Hours**	**Salary**	**Fringe**	**Months**
Assistant Professor (8 months @ 20%)	$ 17,867	100000	20%	277	$20,000	$ 6,800	8
Post-Doc (8 months @ 100%)	$ 35,733	40000	100%	1387	$40,000	$13,600	8
Research Assistant (8 months @ 100%)	$ 22,333	25000	100%	1387	$25,000	$ 8,500	8
Equipment/Consumables							
N/A							
Total Cost Phase II	**$ 75,933**						
TOTAL PROJECT COST	**$ 279,388**						

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Appendix A. Telephone Survey Instrument

Note that in the attached form, the survey instrument may be difficult to follow. In application it is coded into a CATI (computer aided telephone interviewing) instrument so that interviewers do not have to choose the next question or decide about follow-up questions.

SURVEY OF COMMUNITY ATTITUDES

COMPLETE THE FOLLOWING ITEMS BEFORE BEGINNING THE INTERVIEW.

Q1. INTERVIEW ID _ —
HOUSE PERSON

Q2. INTERVIEW DATE |__|__| / |__|__| / |__|__|__|__|
MONTH DAY YEAR

Q3. INTERVIEWER ID

Q4. TIME AT BEGINNING OF INTERVIEW

|__|__| : |__|__|
HOUR MINUTE

AM 1
PM 2

Hello. My name is ___ and I'm calling about a community attitude survey which is funded through a contract awarded by the National Academy of Sciences, and is being conducted by Westat, a social science research firm. We recently sent you a letter about this survey {DISPLAY D4}

Are you {DISPLAY D5}
at least 18 years old?

D4	*IF THIS IS A CELL PHONE (BASE.LANDCELL = 2)*	"If you are currently driving a car or doing any activity that requires your full attention, I need to call you back at a later time."
i	*IF CELL OR LANDLINE STATUS IS UNKNOWN (BASE.LANDCELL = 3)*	"If I have reached you on a cell phone and you are currently driving a car or doing any activity that requires your full attention I need to call you back at a later time."
	ELSE	BLANK
D5	*IF THIS IS A LANDLINE (BASE.LANDCELL = 1)*	"a member of this household and"
	ELSE	BLANK

PROGRAMMING NOTE: If probable business, continue to verify address (A3) to verify accuracy of phone match.

INTRO: This information is being collected as part of a community attitude survey which is funded through a contract awarded by the National Academy of Sciences, and is being conducted by Westat, a social science research firm. The information will be used to measure residents' attitudes about their environment.

A3. Before I get started, I'd like to determine the eligibility of your household. Is your home address {DISPLAY ADDRESS}

[VERIFY SPELLING. RECORD CHANGES OR PRESS ENTER IF NO CHANGE.]

PROGRAMMING NOTE: If address does not match, case is finalized, there is no need to ask A3_1.

A3_1. Is this address…

a business only,
a residence only, or
both?

PROGRAMMING NOTE: If business only, case becomes ineligible. This is after address has been verified and indicates that a business was sampled. This is for both the phone match and phone numbers collected by mail groups.

A4. How many adults at least 18 years old live in your household?

|__|__|

[Implement Rizzo respondent selection algorithm].

OBS. IS THE ORIGINAL RESPONDENT SELECTED TO DO THE SURVEY?

YES .... 1 (GO TO Short Intro)
NO ………………………………………………………..2 (Continue)

A5.1 [NUMBER OF ADULTS = 2] Please tell me just the first name of the other adult in this household.

Is this person male or female?

MALE 1
FEMALE 2
REFUSED .... -7
DON'T KNOW .... -8

A5.2 [NUMBER OF ADULTS > 2] Please tell me just the first name of the adult in this household, **other than yourself**, who will have the next birthday.

Is this person male or female?

MALE 1
FEMALE 2
REFUSED .... -7
DON'T KNOW .... -8

A6. May I speak to [NAME/GENDER].

<u>Full Introduction</u> *[If interview is with person who did not answer above questions.]*

My name is ___ and I'm calling about a community attitude survey which is funded through a contract awarded by the National Academy of Sciences, and is being conducted by Westat, a social science research firm. We recently sent you a letter about this survey.

We are contacting households in communities like yours to measure attitudes about the environmental living conditions in your area. Westat, a social science research firm, is collecting this information through a contract awarded by the National Academy of Sciences. The information will be used to measure residents' attitudes about their environment. Your household is one of a small number that has been selected from [CITY] area. Your participation will represent the views of many others in your community.

Participation in this survey is completely voluntary. You may skip any questions that you don't want to answer and you can stop at any time. The survey should take about 20 minutes.

The National Academy of Sciences and Westat have very strict safeguards to protect the information you provide us. Information collected for this study will be treated as confidential, except as required by law. No identifying information will be kept on the final survey file and the results will be used to produce statistical summaries. No individual answers you provide will be associated with you or your household.

If you have questions about the study you can call us toll-free at 888-289-2351. If you have questions about your rights as a research participant, please call Sharon Zack toll-free at 800-937-8281, ext. 8828.

May I continue with the survey?

CONTINUE.. 1
GO TO RESULT.....................................GT

Short Introduction

OK, it looks like you are eligible for the survey. As a reminder, we are contacting households in communities like yours to measure attitudes about the environmental living conditions in your area. Your household is one of a small number that has been selected from [CITY] area. Your participation will represent the views of many others in your community.

Participation in this survey is completely voluntary. You may skip any questions that you don't want to answer and you can stop at any time. The survey should take about 20 minutes.

The National Academy of Sciences and Westat have very strict safeguards to protect the information you provide us. Information collected for this study will be treated as confidential, except as required by law. No identifying information will be kept on the final survey file and the results will be used to produce statistical summaries. No individual answers you provide will be associated with you or your household.

If you have questions about the study you can call us toll-free at 888-289-2351. If you have questions about your rights as a research participant, please call Sharon Zack toll-free at 800-937-8281, ext. 8828.

May I continue with the survey?

CONTINUE.. 1
GO TO RESULT....................................GT

[IF SCREENER RESPONDENT IS SELECTED RESPONDENT]

A7.1 The following questions will ask you about things you may notice where you are "here at home". By here at home we mean the address that we confirmed with you.

[IF SCREENER RESPONDENT IS NOT THE SELECTED RESPONDENT]

A7.2 The following questions will ask you about things you may notice where you are "here at home". By here at home we mean the following address:

[DISPLAY ADDRESS CONFIRMED IN A3, CONTINUE TO QUESTION 1]

1. Thinking about the last 12 months or so, when you are here at home, how much does …… bother, disturb, or annoy you: not at all, slightly, moderately, very, or extremely?

	Not at all	Slightly	Moderately	Very	Extremely	Refused	Don't know
a. Noise from cars trucks or other road traffic	☐[1]	☐[2]	☐[3]	☐[4]	☐[5]	☐[-7]	☐[-8]
b. Smells or dirt from road traffic	☐[1]	☐[2]	☐[3]	☐[4]	☐[5]	☐[-7]	☐[-8]
c. Smoke, gas or bad smells from anything else	☐[1]	☐[2]	☐[3]	☐[4]	☐[5]	☐[-7]	☐[-8]
d. Litter or poorly kept up housing	☐[1]	☐[2]	☐[3]	☐[4]	☐[5]	☐[-7]	☐[-8]
e. Noise from aircraft	☐[1]	☐[2]	☐[3]	☐[4]	☐[5]	☐[-7]	☐[-8]
f. Your neighbors' noise or other activities...........................	☐[1]	☐[2]	☐[3]	☐[4]	☐[5]	☐[-7]	☐[-8]
g. Are there any other noises you hear when you are here at home? 1= YES 2= NO [IF YES] What is that noise? [DESCRIBE IN BOX BELOW.] Thinking about the last 12 months or so, when you are here at home, how much does (DESCRIBED NOISE) bother, disturb, or annoy you: not at all, slightly, moderately, very, or extremely?............................	☐[1]	☐[2]	☐[3]	☐[4]	☐[5]	☐[-7]	☐[-8]
Describe: ______________________________							
h. Undesirable business, institutional or industrial property	☐[1]	☐[2]	☐[3]	☐[4]	☐[5]	☐[-7]	☐[-8]
i. A lack of parks or green spaces	☐[1]	☐[2]	☐[3]	☐[4]	☐[5]	☐[-7]	☐[-8]
j. Inadequate public transportation............................	☐[1]	☐[2]	☐[3]	☐[4]	☐[5]	☐[-7]	☐[-8]
k. The amount of neighborhood crime..................	☐[1]	☐[2]	☐[3]	☐[4]	☐[5]	☐[-7]	☐[-8]
l. Poor city or county services	☐[1]	☐[2]	☐[3]	☐[4]	☐[5]	☐[-7]	☐[-8]

	Not at all	Slightly	Moderately	Very	Extremely	Refused	Don't know
m. Are there any other problems that you notice when you are here at home? 1= YES 2 = NO [IF YES]: What is that problem? [DESCRIBE IN BOX BELOW.] Thinking about <u>the last 12 months or so</u>, when you are here at home, how much does (DESCRIBED PROBLEM) bother, disturb, or annoy you: not at all, slightly, moderately, very, or extremely?	☐1	☐2	☐3	☐4	☐5	☐-7	☐-8
Describe: ____________________							

2. Now considering how you feel about everything in your neighborhood, how would you rate your neighborhood as a place to live on a scale from 0 to 10 where 0 is worst and 10 is best?

|__|__|

REFUSED .... -7
DON'T KNOW .... -8

3. Now please rate noise on a 0 to 10 opinion scale for how much the 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.

First about noise in general.

Thinking about <u>the last 12 months</u> or so, what number from 0 to 10 best shows how much you are bothered, disturbed or annoyed by the noise in general when you are here at home?

|__|__|

REFUSED .... -7
DON'T KNOW .... -8

4. 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 cars or trucks or other road traffic?

|__|__|

REFUSED .... -7
DON'T KNOW .... -8

5. 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?

|__|__|

REFUSED .... -7
DON'T KNOW .... -8

BOX 1

[IF RESPONDENT ANSWERS "NOT AT ALL ANNOYED" BY AIRCRAFT IN BOTH THE PREVIOUS 5-POINT VERBAL-SCALE AND 0-10 SCALE AIRCRAFT NOISE QUESTIONS → GO TO Q6.

OTHERWISE GO TO Q7.

6. [ASK ONLY IF "NOT AT ALL ANNOYED" BY AIRCRAFT IN BOTH THE PREVIOUS 5-POINT VERBAL-SCALE AND 0-10 SCALE AIRCRAFT NOISE QUESTIONS]

Have you ever heard the sound from an aircraft when you were here at home?

YES .... 1 (GO TO 7)
NO .... 2 (BOX 2)

BOX 2

Even if the aircraft noise has not annoyed you during the last year, we still need your views on particular aspects of aircraft. If you don't notice them, please say so. If you do notice them, that's fine, too. Just tell us about your views and we can move right along.

7. Has an aircraft ever [waked you or kept you awake at night] when you are at home?

	Yes	No	Don't notice aircraft	Refused	Don't know
a. waked you up or kept you awake at night?	☐1	☐2	☐-6	☐-7	☐-8
b. Startled or surprised you?	☐1	☐2	☐-6	☐-7	☐-8
c. Frightened you?..	☐1	☐2	☐-6	☐-7	☐-8

The next questions ask whether or not aircraft actually bothered, disturbed, or annoyed you in different ways during the last 12 months when you have been here at home.

[ASK ONLY SPECIFIC TYPES OF DISTURBANCES WHICH WERE IDENTIFIED IN QUESTION 7]

8. Thinking about the last 12 months or so, when you are at home, have the aircraft bothered, disturbed or annoyed you by [READ FIRST ITEM THAT WAS NOTICED]

Would you say: extremely, very, moderately, slightly, or not at all?

	Extremely	Very	Moderately	Slightly	Not at all	Refused	Don't know
a. Waking you up or keeping you awake at night	☐1	☐2	☐3	☐4	☐5	☐-7	☐-8
b. Startling or surprising you.............	☐1	☐2	☐3	☐4	☐5	☐-7	☐-8
c. Frightening you.............................	☐1	☐2	☐3	☐4	☐5	☐-7	☐-8

To understand why aircraft noise may or may not affect you, we ask you to consider your situation here at home, your observations about aircraft flights here and the actions authorities have been taking.

Your next answers provide background for understanding your living situation in this area.

9. Which of the following best describes the building where you live?

A mobile home?.. 1 (Go to 10)
A one-family house detached from any other house?.................... 2 (Go to 10)
A one-family house attached to one or more houses?................... 3 (Go to 10)
A building with two or more apartments? 4
Some other type of place?
What type of building is that? (Describe) ________________ 5 (Go to 10)
REFUSED... -7 (Go to 10)
DON'T KNOW.. -8 (Go to 10)

9a. Approximately, how many apartments are there in your building**?**

2 APARTMENTS 1

3 or 4 APARTMENTS	2
5 TO 9 APARTMENTS	3
10 TO 19 APARTMENTS	4
20 TO 49 APARTMENTS	5
50 OR MORE APARTMENTS	6

10. Do you own your home or are you renting?

OWN (INCLUDE OWING A MORTGAGE)	1
RENTING	2
REFUSED	-7
DON'T KNOW	-8

11. How many of the five weekdays from Monday through Friday are you usually out away from home most of the day, that is 8 hours or more? Are you usually away, on all five weekdays, or fewer weekdays, or are you usually not away on any weekday?

[PROBE IF NUMBER OF WEEKDAYS NOT VOLUNTEERED]

How many weekdays are you usually away?]

0 NOT AWAY ON ANY WEEKDAY	0
1 DAY	1
2 DAYS	2
3 DAYS	3
4 DAYS	4
5 AWAY ALL 5 WEEKDAYS	5
REFUSED	-7
DON'T KNOW	-8

12. Think about those weeks in the year when you spend the most time out-of-doors in your yard or on your porch, deck or balcony. At that time of year, how many hours a week would you say you are out-of-doors at home?

|__|__|
HOURS

REFUSED	-7
DON'T KNOW	-8

13. In what year and month did you move to your home here?

|__|__|__|__| |__|__|
YEAR MONTH

REFUSED .... -7
DON'T KNOW .... -8

14. Since you moved here, has the total amount of aircraft noise increased, decreased or stayed about the same?

INCREASED.. 1
STAYED ABOUT THE SAME 2
DECREASED 3
NEVER HEARD ANY AIRCRAFT (VOLUNTEERED).................... -6
REFUSED.. -7
DON'T KNOW.. -8

15. What do you think aircraft noise will be like here in the next few years: Do you think the total amount of aircraft noise will increase, decrease or stay about the same here?

INCREASE 1
STAY ABOUT THE SAME 2
DECREASE.. 3
WILL CONTINUE TO NEVER HEAR ANY AIRCRAFT
(VOLUNTEERED) .... -6
REFUSED.. -7
DON'T KNOW.. -8

Next we need to learn where the aircraft are flying in this area.

16. Are most of the aircraft that you notice from your home coming down for a landing at the airport, taking off from the airport, are about half landing and about half taking off, are they doing something else, or don't you know?

LANDING.. 1
ABOUT HALF AND HALF 2
TAKING OFF.. 3
DOING SOMETHING ELSE
(PROBE: **What are they doing**?) ________________________ 4
DON'T NOTICE ANY AIRCRAFT (VOLUNTEERED).................... -6
REFUSED.. -7
DON'T KNOW.. -8

17. Thinking about all the aircraft you notice when you are at home, about what percent fly directly over your property?

|__|__|__|%

DON'T NOTICE ANY AIRCRAFT
(VOLUNTEERED) .... -6
REFUSED .... -7
DON'T KNOW .... -8

18. When you are at home or around the neighbourhood, how fearful or concerned are you that an aircraft might crash nearby: Are you extremely, very, moderately, slightly, or not at all concerned that an aircraft might crash?

EXTREMELY.. 1 [CONTINUE WITH Q19]
VERY.. 2 [CONTINUE WITH Q19]
MODERATELY....................................... 3 [CONTINUE WITH Q19]
SLIGHTLY .... 4 [CONTINUE WITH Q19]
NOT AT ALL .... 5 [SKIP TO Q20]
REFUSED .... 6 [CONTINUE WITH Q19]
DON'T KNOW .... 7 [CONTINUE WITH Q19]

19. When you are at home, how concerned are you that an aircraft crash might actually hurt you or your own property: Are you extremely, very, moderately, slightly, or not at all concerned that an aircraft might hurt you or your property?

EXTREMELY.. 1
VERY.. 2
MODERATELY....................................... 3
SLIGHTLY 4
NOT AT ALL 5
REFUSED 6
DON'T KNOW 7

20. When you are at home, have you ever heard aircraft sitting on the ground or moving around the airport property?

YES 1
NO 2
REFUSED .... -7
DON'T KNOW .... -8

21. [ASK IF "HEARD" IN PREVIOUS QUESTION] Thinking about the last 12 months or so, when you are at home, how much have the aircraft sitting on the ground or moving around the airport property bothered, disturbed or annoyed you: extremely, very, moderately, slightly, or not at all?

EXTREMELY 1
VERY 2
MODERATELY....................................... 3
SLIGHTLY 4
NOT AT ALL 5
REFUSED 6
DON'T KNOW 7

Next we ask you to provide some background about this area and the airport.

22. How knowledgeable are you about noise and other community environmental issues in the [CITY NAME] area: Are you extremely knowledgeable, very knowledgeable, moderately knowledgeable, slightly knowledgeable, or not at all knowledgeable?

EXTREMELY KNOWLEDGEABLE 1
VERY KNOWLEDGEABLE 2
MODERATELY KNOWLEDGEABLE 3
SLIGHTLY KNOWLEDGEABLE.. 4
NOT AT ALL KNOWLEDGEABLE 5
REFUSED.. -7
DON'T KNOW.. -8

23. About how many trips a year do you and other members of your household make from the [LOCAL AIRPORT]?

One trip is considered as round-trip travel and includes all family members traveling together. If any family members travel separately, please count those as separate trips as long as they use [LOCAL AIRPORT].

|__|__|
NUMBER OF TIMES

REFUSED .... -7
DON'T KNOW .... -8

24. Do you or anyone else in your household work at [LOCAL AIRPORT] or work for a company or organization that does business with [LOCAL AIRPORT])?

YES 1
NO 2
REFUSED .... -7
DON'T KNOW .... -8

25. How much have you learned about your community's aircraft noise issues from media reports in the newspaper or on radio or TV: a great deal, somewhat, a little or nothing at all?

A GREAT DEAL	1
SOMEWHAT, ...	2
A LITTLE	3
NOTHING AT ALL	4
REFUSED	-7
DON'T KNOW	-8

26. **How about a more local information source? How much have you learned about your community's aircraft noise issues from a community newspaper or other more local organization, newsletter or local internet source: a great deal, somewhat, a little or nothing at all?**

A GREAT DEAL	1
SOMEWHAT, ...	2
A LITTLE	3
NOTHING AT ALL	4
REFUSED	-7
DON'T KNOW	-8

27. How about your closest neighbors making their views known about aircraft noise: Have they clearly made their views known, have they revealed only a little about their views, or have they kept their views to themselves?

MADE THEIR VIEWS CLEARLY KNOWN	1
REVEALED A LITTLE, ...	2
KEPT VIEWS TO THEMSELVES	3
REFUSED...	-7
DON'T KNOW..	-8

28. As far as you know, have there ever been disputes between airport authorities and community residents about aircraft noise around (…LOCAL AIRPORT…)?

YES	1
NO	2
REFUSED	-7
DON'T KNOW	-8

29. Is some local group or organization trying to get the authorities to do something to reduce aircraft noise or is no local group doing anything or don't you know?

GROUP IS	1
GROUP IS NOT	2
REFUSED	-7
DON'T KNOW	-8

30. Have you or anyone in your household ever tried to get something done about aircraft noise such as telephoning the airport, sending a message, writing a letter, contacting an official, going to a meeting, joining a group or doing something else?

YES	1	(GO TO 31a)
NO	2	(GO TO 32)
DON'T NOTICE ANY AIRCRAFT (VOLUNTEERED)	-6	(GO TO 32)
REFUSED	-7	(GO TO 32)
DON'T KNOW	-8	(GO TO 32)

30a. Was the airport contacted directly?

YES	1
NO	2
REFUSED	-7
DON'T KNOW	-8

31. If someone wants to make a complaint about aircraft noise these days, do you know if there is a convenient way to contact (…LOCAL AIRPORT…)?

YES	1
NO	2
REFUSED	-7
DON'T KNOW	-8

32. How much do you think that residents' actions and views can influence (…LOCAL AIRPORT…) noise policy? Do you think that residents' views can very greatly influence policy, greatly influence policy, moderately influence, slightly influence, or not at all influence policy?

VERY GREATLY INFLUENCE	1
GREATLY INFLUENCE	2
MODERATELY INFLUENCE	3
SLIGHTLY INFLUENCE	4
NOT AT ALL INFLUENCE	5
REFUSED	-7
DON'T KNOW	-8

33. Has your household ever received assistance from the government or (…LOCAL AIRPORT…) to soundproof your home against aircraft noise?

YES	1
NO	2
REFUSED	-7
DON'T KNOW	-8

34. Has the government or [LOCAL AIRPORT] done anything else to financially compensate you for the aircraft noise here?

YES	1	(GO TO 35a)
NO	2	(GO TO 36)
REFUSED	-7	(GO TO 36)
DON'T KNOW	-8	(GO TO 36)

34a. What did they do?

____

____

Next we ask for your views about the local officials and managers at the airport who are responsible for aircraft operations in this area.

35. How well do you think [LOCAL AIRPORT] officials understand the community residents' feelings about aircraft noise? Do you think the officials understand the residents' feelings extremely well, very well, moderately well, slightly, or not at all?

EXTREMELY WELL	1
VERY WELL	2
MODERATELY WELL	3
SLIGHTLY	4
NOT AT ALL	5
REFUSED	-7
DON'T KNOW	-8

36. How fully do you feel the [LOCAL AIRPORT] officials keep community residents informed about the planning for airport changes? Do you think the officials keep communities extremely well informed, very well informed, moderately well informed, slightly informed, or not at all informed?

EXTREMELY WELL	1
VERY WELL	2
MODERATELY WELL	3
SLIGHTLY	4
NOT AT ALL	5
REFUSED	-7
DON'T KNOW	-8

37. To what extent do you think that [LOCAL AIRPORT] officials can be trusted to fairly work with the community by following official, agreed-upon procedures and providing accurate information? Do you think the officials can be completely trusted, considerably trusted, moderately trusted, slightly trusted or not at all trusted?

COMPLETELY TRUSTED	1
CONSIDERABLY TRUSTED	2
MODERATELY TRUSTED	3
SLIGHTLY TRUSTED	4
NOT AT ALL TRUSTED	5
REFUSED	-7
DON'T KNOW	-8

38. How much do you think (the officials who run [LOCAL AIRPORT]) could reduce the aircraft noise around here if they tried: Could [the officials who run the airport] reduce the noise very greatly, greatly, moderately, slightly or not at all?

	Very greatly	Greatly	Moderately	Slightly	Not at all	Refused	Don't know
a. The officials who run [LOCAL AIRPORT]	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ -7	☐ -8
b. Other government officials	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ -7	☐ -8
c. The pilots flying the planes	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ -7	☐ -8

39. As far as you know, have the authorities at [LOCAL AIRPORT] ever taken steps to try to reduce or control the amount of aircraft noise here?

YES	1	(GO TO 40a)
NO	2	(GO TO 41)
REFUSED	-7	(GO TO 41)
DON'T KNOW	-8	(GO TO 41)

39a. What did they do?

____

____

40. How important do you think that [LOCAL AIRPORT] is for the [CITY NAME] area: Is [LOCAL AIRPORT] extremely important, very important, moderately important, slightly important or not at all important?

EXTREMELY	1
VERY	2
MODERATELY	3
SLIGHTLY	4
NOT AT ALL	5
REFUSED	-7
DON'T KNOW	-8

We just have a couple more opinion questions and then a little background information before we are finished.

41. How sensitive are you generally to noise of all kinds: extremely sensitive, very sensitive, moderately sensitive, slightly sensitive, or not at all sensitive?

EXTREMELY SENSITIVE	1
VERY SENSITIVE	2
MODERATELY SENSITIVE	3
SLIGHTLY SENSITIVE	4
NOT AT ALL SENSITIVE	5
REFUSED	-7
DON'T KNOW	-8

42. To summarize your opinion about aircraft noise in this neighborhood, please consider all we have discussed and use a zero to four opinion thermometer where zero is not at all annoyed, four is extremely annoyed and one to three are in between.

What number from zero to four shows how much you are bothered or annoyed by aircraft noise in this neighborhood?

|__|

REFUSED	-7
DON'T KNOW	-8

43. In what month and year were you born?

|__|__| / |__|__|__|__
MONTH YEAR

REFUSED	-7
DON'T KNOW	-8

44. What is the highest level of school you have completed or the highest degree you have received?

LESS THAN 1ST GRADE 01
1ST, 2ND, 3RD OR 4TH GRADE 02
5TH OR 6TH GRADE 03
7TH OR 8TH GRADE 04
9TH GRADE 05
10TH GRADE 06
11TH GRADE 07
12TH GRADE, NO DIPLOMA 08
HIGH SCHOOL GRADUATE - HIGH SCHOOL DIPLOMA OR EQUIVALENT (FOR EXAMPLE: GED) 09
SOME COLLEGE BUT NO DEGREE 10
DIPLOMA OR CERTIFICATE FROM A VOCATIONAL, TECHNICAL, TRADE OR BUSINESS SCHOOL BEYOND THE HIGH SCHOOL LEVEL 11
ASSOCIATE DEGREE IN COLLEGE - OCCUPATIONAL/ VOCATIONAL PROGRAM 12
ASSOCIATE DEGREE IN COLLEGE – ACADEMIC PROGRAM 13
BACHELORS DEGREE (FOR EXAMPLE: BA, AB, BS) 14
MASTER'S DEGREE (FOR EXAMPLE: MA, MS, MENG, MED, MSW, MBA) 15
PROFESSIONAL SCHOOL DEGREE (FOR EXAMPLE: MD, DDS, DVM, LLB, JD) 16
DOCTORATE DEGREE (FOR EXAMPLE: PHD, EDD) 17
REFUSED...-97
DON'T KNOW...-98

45. [IF GENDER COLLECTED IN A5.1 OR A5.2 FROM THE SELECTED RESPONDENT (SELECTED RESPONDENT WAS SCREENER RESPONDENT) THEN SKIP 45 AND CONTINUE WITH 46, OTHERWISE ASK IF NOT SURE. OTHERWISE CODE AND CONTINUE WITH 46.]

Are you male or female?

MALE... 1
FEMALE 2
REFUSED .... -7
DON'T KNOW .... -8

46. Are you Spanish, Hispanic, or Latino?

YES	1
NO	2
REFUSED	-7
DON'T KNOW	-8

47. What race or races do you consider yourself to be?

WHITE	1
BLACK OR AFRICAN AMERICAN	2
AMERICAN INDIAN OR ALASKA NATIVE	3
ASIAN	4
NATIVE HAWAIIAN OR OTHER PACIFIC ISLANDER	5
OTHER; SPECIFY ______________	6
REFUSED	-7
DON'T KNOW	-8

48. What is the approximate total income from everyone in this household including such things as wages, salary, interest, pensions, or government payments? Would you say [READ RESPONSES]:

[GO THROUGH LIST UNTIL RESPONDENT GIVES ANSWER]

Is it less than 25 thousand dollars a year, from 25 to 50 thousand, 50 to 100 thousand, 100 to 200 thousand, or over 200 thousand a year? [IF GIVE A BORDERLINE. PROBE "Would you say it was probably a bit more or a bit less than [BORDERLINE VALUE]?

LESS THAN 25,000	1
25,000-50,000	2
50,000 -100,000	3
100,000 – 200,000	4
Over 200,000	5
REFUSED	-7
DON'T KNOW	-8

49. Is there anything more you would like to tell me or are there any questions I can answer for you?

____

____

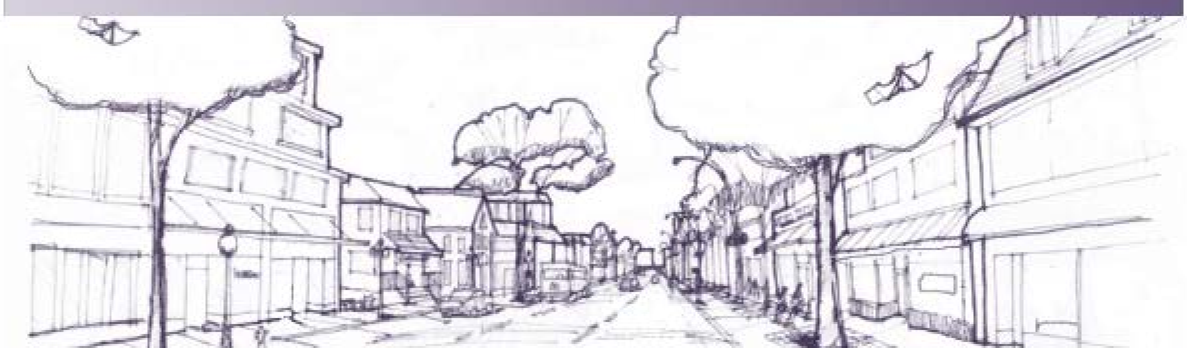
____

Thank you for participating in this very important survey.

Appendix B. Short Screener to Collect Telephone Number

Survey of Community Attitudes

A survey to better understand the environment around your neighborhood.



This survey is funded through a contract awarded by the National Academy of Sciences.

All information you provide on this survey will be kept confidential.

What is the Survey of Community Attitudes?
This is a survey of households that asks questions about your community. The survey covers different topics about what it is like living in your community.

Who is the Conducting this Survey?
Westat, a social science research firm, is collecting this information through a contract awarded by the National Academy of Sciences.

Why are you asking for my phone number?
We sampled your household by your address. Since the survey will be conducted by telephone, we need your number to call you to complete the survey.

How long will it take to complete this survey?
It will take 3 minutes to complete this mail survey. The follow-up telephone interview will take approximately 15 minutes to complete.

Am I required to complete this survey?
Participation is voluntary and there are no penalties for refusing to answer. However, your household was randomly selected for this scientific sample survey and you cannot be replaced with another household. Your cooperation is extremely important to help ensure the completeness and accuracy of the study.

Who will use this information?
Westat, a social science research firm, is collecting this information through a contract awarded by the National Academy of Sciences. The information will be used to measure residents' attitudes about their environment.

Who can I call with questions?
Westat, a private research firm is collecting the data. If you would like further information, you can contact Westat at 1-###-###-####.

How was my household selected?
Households were selected at random from all residential addresses in your community. By selecting households randomly, we will be able to create scientific estimates about households in your community. It's important to participate, so that we have an accurate picture of all communities.

This survey will be conducted by telephone. In order to get in touch with you, we need to collect some information on your household.

Please have this filled out by an adult household member living at this address.

Please use a blue or black pen if available.

1. Including yourself, how many people age 18 or older live in this household? (Please include both children and adults, as well as persons who are temporarily away at this time, for example, anyone temporarily hospitalized or on a vacation or business trip.)
   |__|__|

2. What is the best phone number to use to contact you? (This phone number will only be used for the purpose of this research study.)
   |__|__|__| - |__|__|__| - |__|__|__|__|

Thank you. Please return this form in the postage paid envelope provided or mail it to:

Community Environmental Survey
Westat
1600 Research Blvd. Room ## ###
Rockville, MD 20850

Toll-free number for questions: XXX-XXX-XXXX

Appendix C. Long Screener to Collect Telephone Number

What is the Survey of Community Attitudes?
This is a survey of households that asks questions about your community. The survey covers different topics about what it is like living in your community.

Who is the Conducting this Survey?
Westat, a social science research firm, is collecting this information through a contract awarded by the National Academy of Sciences.

Why are you asking for my phone number?
We sampled your household by your address. Since the survey will be conducted by telephone, we need your number to call you to complete the survey.

How long will it take to complete this survey?
It will take 3 minutes to complete this mail survey. The follow-up telephone interview will take approximately 15 minutes to complete.

Am I required to complete this survey?
Participation is voluntary and there are no penalties for refusing to answer. However, your household was randomly selected for this scientific sample survey and you cannot be replaced with another household. Your cooperation is extremely important to help ensure the completeness and accuracy of the study.

Who will use this information?
Westat, a social science research firm, is collecting this information through a contract awarded by the National Academy of Sciences. The information will be used to measure residents’ attitudes about their environment.

Who can I call with questions?
Westat, a private research firm is collecting the data. If you would like further information, you can contact Westat at 1-###-###-####.

How was my household selected?
Households were selected at random from all residential addresses in your community. By selecting households randomly, we will be able to create scientific estimates about households in your community. It’s important to participate, so that we have an accurate picture of all communities.

This survey should be filled out by an adult household member living at this address.

Please use a blue or black pen if available.
These first questions ask about your neighborhood.

1. 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?** ______	☐	☐	☐	☐	☐

Survey of Community Attitudes

A survey to better understand the environment around your neighborhood.

This survey is funded through a contract awarded by the National Academy of Sciences.

All information you provide on this survey will be kept confidential.

2. Now considering how you feel about everything in your neighborhood, how would you rate your neighborhood as a place to live on a scale from 0 to 10 where 0 is worst and 10 is best?

Worst 0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Best 10**
▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

These last questions are about your household.

3. Including yourself, how many adults at least 18 years old live in this household? (Please include any persons who are temporarily away at this time, for example, anyone temporarily hospitalized or on a vacation or business trip.)

|__|__|

4. What is the best phone number to use to contact you? (This phone number will only be used for the purpose of this research study.)

|__|__|__| - |__|__|__| - |__|__|__|__|

Thank you. Please return this form in the postage paid envelope provided or mail it to:

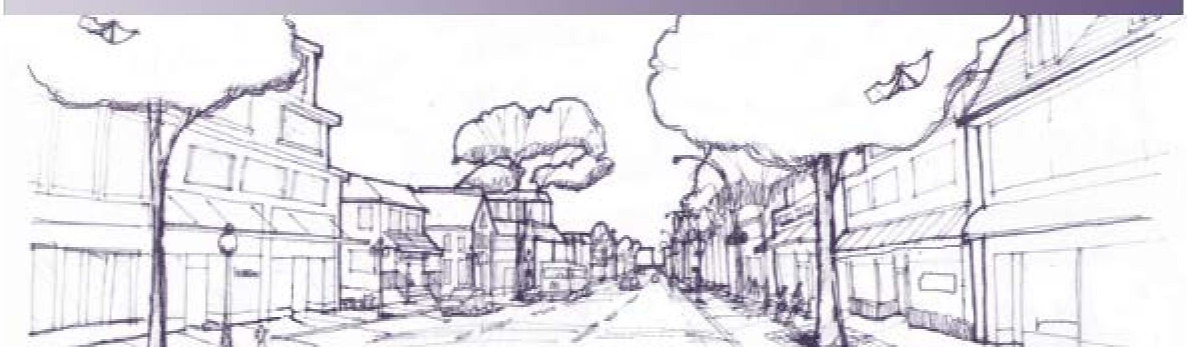
Community Environmental Study
Westat
1600 Research Blvd. Room
Rockville, MD 20850

Toll-free number for questions: XXX-XXX-XXXX

Appendix D. Mail Survey Instrument

Survey of Community Attitudes

A survey to better understand the environment around your neighborhood.



This survey is funded through a contract awarded by the National Academy of Sciences.

All information you provide on this survey will be kept confidential.

What is the Survey of Community Attitudes?
This is a survey of households that asks questions about your community. The survey covers different topics about what it is like living in your community.

Who is Conducting this Survey?
Westat, a social science research firm, is collecting this information through a contract awarded by the National Academy of Sciences.

How long will it take to complete this survey?
It will take 10 minutes to complete this survey.

Am I required to complete this survey?
Participation is voluntary and there are no penalties for refusing to answer. However, your household was randomly selected for this scientific sample survey and you cannot be replaced with another household. Your cooperation is extremely important to help ensure the completeness and accuracy of the study.

Who will use this information?
Westat, a social science research firm, is collecting this information through a contract awarded by the National Academy of Sciences. The information will be used to measure residents' attitudes about their environment.

Who can I call with questions?
Westat, a private research firm is collecting the data. If you would like further information, you can contact Westat at 1-###-###-####.

How was my household selected?
Households were selected at random from all residential addresses in your community. By selecting households randomly, we will be able to create scientific estimates about households in your community. It's important to participate, so that we have an accurate picture of all communities.

<u>Starting with yourself,</u> please mark the sex, and write in the age and month of birth for each adult 18 years of age or older living at this address.

	Sex	**Age**	**Month Born (01-12)**
SELF	☐ Male ☐ Female	☐☐☐	☐☐
Adult 2	☐ Male ☐ Female	☐☐☐	☐☐
Adult 3	☐ Male ☐ Female	☐☐☐	☐☐
Adult 4	☐ Male ☐ Female	☐☐☐	☐☐
Adult 5	☐ Male ☐ Female	☐☐☐	☐☐

Thank you. Please return this form in the postage paid envelope provided or mail it to:

[Survey Name]
Westat
1600 Research Blvd. Room ## ###
Rockville, MD 20850

Toll-free number for questions: ###-###-####

This survey should be filled out by an adult household member living at this address.

Please use a blue or black pen if available.

These first questions ask about your household.

1. Is there more than one person age 18 or older living in this household?
   - ☐ Yes
   - ☐ No → **GO TO number 5 on the next page**

2. Including yourself, how many people age 18 or older live in this household?

   ☐☐

3. **The adult with the next birthday should complete this questionnaire**. This way, across all households, this survey will include responses from adults of all ages.

4. Please write the first name, nickname or initials of the adult with the next birthday. This is the person who should complete the questionnaire.

   ☐

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?** ________	☐	☐	☐	☐	☐

6. Now considering how you feel about everything in your neighborhood, how would you rate your neighborhood as a place to live on a scale from 0 to 10 where 0 is worst and 10 is best?

Worst 0	1	2	3	4	5	6	7	8	9	Best 10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

These last questions are about you and your household.

7. In what year were you born?

Y	Y	Y	Y

8. Are you male or female?

- ☐ Male
- ☐ Female

9. Are you Spanish, Hispanic, or Latino/a?

- ☐ Yes
- ☐ No

10. What is your race? One or more categories may be selected.

Mark ☒ one or more.

- ☐ White
- ☐ Black or African American
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ Other (Specify): ____________________

Appendix E. Sampling Design for Airport 3

Results from the Airport 2 and Airport 1 studies were used to modify the procedures used for the Airport 3 survey.

The first modification was for the sampling of vacant addresses in Airport 3.[14] These were sampled and considered as eligible for the first two airports. A total of 132 of the addresses in the Airport 1 / Airport 2 sample were coded as vacant. Of those, 8 households provided a response: 2 by CATI (one each in Airport 1 and Airport 2), and 6 by mail (5 in Airport 1 and 1 in Airport 2). The low yield from the vacant addresses in Airport 1 and Airport 2 led to a decision to exclude vacant addresses from the Airport 3 sample and replace them with additional occupied households in order to increase the yield for the sample.

The final telephone response rates for households without matching phone numbers were approximately the same for the short and long versions of the screener (Appendix B and **Error! Reference source not found.** respectively). The long screener, however, had higher response rate at the mail phase with a lower percentage of households providing a telephone number on the form and a similar overall response rate. The long screener therefore provides partial information on annoyance for the households that do not complete the telephone interview while the short screener does not include this information. Since the final response rates were approximately the same, it was decided that the Airport 3 survey would use only the long form screener for unmatched telephone numbers. This has the added benefit of providing information on the relationship between the reported annoyance on the telephone survey and the reported annoyance on the screener within the same household.

The estimated relationship between annoyance and noise exposure is similar for the mail and telephone surveys in Airport 1 and Airport 2 for noise exposures up to 65 dB. Above that noise exposure, however, there are too few respondents to the telephone survey to evaluate the relationship. For the Airport 3 survey, we adjusted our sampling to counter the previous deficiency and included a larger number of addresses at the high noise exposure levels to obtain more data at those values.

---

[14] Vacant addresses are those that are classified as unoccupied on the U.S. Postal Service Computerized Delivery Sequence Files. Sometimes those addresses are eligible housing units, particularly in high-turnover areas.

Appendix F. Response Propensity Analysis

Logistic regression models are commonly used for predicting a binary (taking on values of 0 or 1) response from covariates. We fit a logistic regression model to 6516 addresses[15] in the selected sample to examine the relationship between being a respondent to the survey and characteristics known for all sampled addresses of each airport community. The general logistic regression model used for the analysis has the form.

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 DNL + \beta_2 x_2 + \cdots + \beta_k x_k$$

where p is the probability that someone at the sampled address responds to the survey, DNL is the noise exposure level at that address (from the detailed grid computation of DNL provided by HMMH), and $x_2 \ldots x_k$ are other characteristics that are known for that sampled address. Using this model, the predicted probability of responding to the survey can be found by exponentiating both sides of the equation and solving for *p*, giving:

$$p = \frac{\exp(\beta_0 + \beta_1 DNL + \beta_2 x_2 + \cdots + \beta_k x_k)}{1 + \exp(\beta_0 + \beta_1 DNL + \beta_2 x_2 + \cdots + \beta_k x_k)} = \frac{1}{1 + \exp(-\beta_0 - \beta_1 DNL - \beta_2 x_2 - \cdots - \beta_k x_k)}.$$

Table 13 lists the covariates used in the response propensity modeling. Indicator variables are created for the airports and Airport 2 is arbitrarily chosen to be the baseline category for the airport indicator variables. The models also include interaction terms that are constructed from these covariates. Thus, Airport1*Mode is formed by multiplying Airport1 by Mode, and takes on the value of 1 for addresses in the telephone survey at Airport 1 and the value 0 for all other addresses. The other interaction terms are formed similarly. Looking at the Airport1*Mode and Airport3*Mode interactions allows us to assess whether the relationship between propensity to respond and survey mode differs across airports.

Table 13 Covariates used in logistic regression model for predicting whether a response will be obtained from a sampled address

Variable Name	Description
DNL	Day-Night Average Sound Level (dB), obtained from contours provided by HMMH
Airport1	= 1 if sampled address is from Airport 1, and 0 otherwise
Airport3	= 1 if sampled address is from Airport 3, and 0 otherwise
Mode	= 1 if telephone survey is used, 0 if mail survey is used
PctAge50+	Percentage of persons in the census block containing the address who are age 50 and over
PctBlack	Percentage of persons in the census block containing the address who are black, where “black” is defined to be black alone
PctHispanic	Percentage of persons in the census block containing the address who are Hispanic (includes all races)
PctRented	Percentage of housing units in the census block containing the address that are rented (as opposed to being owned)
Nomatch	= 1 if no matching telephone number is available for the address and 0 if a matching telephone number is available (including matches that are later determined to be invalid).

Table 14 gives the coefficients for the logistic regression. A positive coefficient means that higher values of the covariate are associated with higher response rates, while a negative coefficient means that higher

[15] We excluded addresses that did not match to the Census block files from the original sample of 6586 addresses.

values of the covariate are associated with lower response rates. From the model, the following values are significantly associated with having a higher response rate: living near Airport 1 or 2 (as opposed to Airport 3), having a matching telephone number, living in a census block that has a high percentage of persons aged 50 and over, and living in a census block that has a low percentage of Hispanics. The last three variables have been demonstrated to be related to higher response rates in many other surveys, and the ACRP Study fits the general pattern. Most importantly, households sent the mail survey are highly significantly more likely to respond to the survey, after accounting for all the other variables. Note, however, that the noise exposure level, measured by DNL, is not significantly associated with the probability of responding to the survey.

The coefficients in the logistic regression model may be interpreted as follows: each coefficient gives the expected change in the log odds ratio $\ln\left(\frac{p}{1-p}\right)$ associated with a change of one unit in the covariate when all of the other covariates are held the same. Alternatively, the exponentiated value of the coefficient gives the percentage change in the odds ratio $\frac{p}{1-p}$ associated with a unit change in the covariate. Thus, in the model, the exponentiated coefficient for Mode is $\exp(-1.6049) = 0.20$. This may be interpreted as meaning that the estimated odds of responding to the survey are one-fifth as great for a household that receives the telephone survey as for a household with the same level of the other covariates that receives the mail survey.

The coefficients in the model may be used to obtain an estimate of the probability that a household with specified characteristics provides a response to the survey. Thus, a household in the Airport 3 community that has DNL 60; receives the mail questionnaire; has a matching telephone number; and lives in a census block in which 21% of residents are age 50 are over, 2.5% are black, 62.1% are Hispanic; and lives in a census block in which 66.9% of households rent the housing unit has the following predicted probability of responding to the survey:

$$\hat{p} = \frac{\exp(-\,1.2187\,)}{1+\exp(-\,1.2187\,)} = 0.228$$

where the value $-\,1.2187$ is calculated using the regression coefficients in Table B-2 as

$$-\,1.2187 \;=\; -0.5172 +\; 0.0065(60) - 0.4931 +\; 0.5883(.21) - 0.0755(.025) - 0.9389(.621) - 0.2048(.669)$$

Other logistic regression models were fit to evaluate the sensitivity of the model to different covariates, and all gave similar predictions.

Table 14 Coefficients and standard errors for logistic regression model predicting probability of responding to the survey

Variable	Logistic Regression Model	
	Coefficient	Standard Error
Intercept	-0.5172	0.3931
DNL	0.0065	0.0057
Airport1	-0.0545	0.1422
Airport3	-0.4931***	0.1290
Mode	-1.6049***	0.1192
PctAge50+	0.5883**	0.2048
PctBlack	-0.0755	0.3752
PctHispanic	-0.9389***	0.2074
PctRented	-0.2048	0.1178
Nomatch	-0.4590***	0.1154
Airport1*Mode	0.2677	0.1636
Airport3*Mode	0.4261*	0.1704
Airport1*Nomatch	-0.2382	0.1568
Airport3*Nomatch	-0.1696	0.1673

Note: * = significant at 0.05 level; ** = significant at 0.01 level; *** = significant at 0.001 level.

Appendix G. Suggested Annoyance Survey Research Protocol

The primary goal of this proposed new national survey of aircraft noise annoyance in the United States is to update previous estimated dose-response relationships and provide a best estimate of the relationship between aircraft noise exposure and the self-reported annoyance of residents for the nation as a whole.

The "Schultz Curve" has been a cornerstone of aircraft noise and land use compatibility policy for the past 30 years. Yet, the data providing the basis for that relationship are out-of-date, drawn from multiple transportation modes, and generally from non-US surveys. It is important to note that the reactions are to be surveyed as distinct from reactions that are manifest as complaints. There may be some correlation between the two forms of personal reactions, but surveyed results are not biased by such factors as knowledge of how and where to complain.

Highly annoyed was chosen by Schultz because it is the response of those who have "attended to the outdoor noise," and can be thought of as exhibiting "a definite and conscious response to it." (Schultz, 1978). They are also the ones more likely to view noise as a problem that should be dealt with. Note that the U.S. EPA (1974) also used "highly annoyed" as a part of the basis for its recommendation of levels "requisite to protect public health and welfare with an adequate margin of safety."

Projected noise exposure is the annual exposure consistent with the recommendation of the U.S. EPA – annual average day-night sound level, DNL or Ldn (U.S. EPA, 1974).

The following sections discuss our approach to each Phase of the proposed work.

Phase 1 – Test Plan

Summary

The test plan will consist of six basic components:

- Selecting airports
- Developing noise exposure contours
- Sampling respondents
- Surveying respondents
- Determining noise exposures for respondents
- Analysis of results

In brief, we are suggesting selecting 16 airports based on precision considerations (see "Stage 1 Sampling: Selection of airports" in Phase 3 discussion).

For these 16, we will first determine DNL contours so that sampling of households may be stratified by noise exposure (for sampling of households, see "Stage 2 Sampling: Selection of Households," Phase 3).

Individuals within the sampled households will be selected (see "Stage 3 Sampling: Respondent Selection," Phase 3), and surveyed (see "Surveying Methods," Phase 3).

For completed interviews, specific values of DNL and other noise metrics will be determined, (for our proposed methods for determining the noise contours and respondent noise metrics, see “Determining Noise Exposure,” Phase 3).

Analysis will then examine three methods for developing dose-response relationships: logistic regression; an alternative based on human judgments of loudness; and Schultz’ original cubic polynomial function (see “Proposed Analysis Plan” in Phase 4 discussion).

Airport Coordination

Once the survey airports are identified, we will contact each and coordinate a visit. Each airport should be kept informed of the eventual survey so that staff can respond appropriately to questions that may be raised by citizens or the press.[16] We propose making the upcoming survey widely reported and known because it is almost certain that airport communities will become aware of it as the identification of survey subjects takes place.

We will visit the airports to discuss the survey and provide information about its conduct. We also expect to collect specific information about the airport: recent controversies related to noise, last completed FAR Part 150 Study, if any, community outreach programs, if any, etc.

Phase 2 – Survey Instrument

Survey Content

The fundamental annoyance question will be based on one recommended by Fields (2000):

“Thinking about the last 12 months or so, when you are here at home, how much does the noise from aircraft bother, disturb or annoy you: not at all, slightly, moderately, very, or extremely?”

There are some variables that previous studies have found to be either insignificantly or significantly correlated with surveyed annoyance.

Most personal variables (gender, level of education, occupation, household size, etc.) have been investigated and shown to have little influence on reported annoyance (Miedema and Vos, 1999). However, there are a few significant factors, such as fear of aircraft crashes, and reported sensitivity to noise that could be of importance in understanding individual annoyance reports (Miedema and Vos, 1999).

Our effort proposed here is to produce results that guide national policy, and are based on national level results. For example, the geographic distribution of individual noise sensitivities, fear, etc. is likely random and would not, in any case, aid in national policy formation.

Two factors that have been found to correlate with annoyance and may do so in our national survey results are differences in annoyance at different airports or in different communities (Fields 2000), and differences in reported annoyance in different climates (Miedema 2005), though the latter is less significant.

[16] We will discuss whether and how this information should be disseminated with FAA.

Our survey instrument will, nevertheless, include some questions about personal variables to confirm that they still remain, for the most part, insignificant. On the other hand, our analysis will test for differences in annoyance in different communities, at different airports and in different climates.

Testing for the significance of different airports or different climates is straight-forward in terms of categorizing respondents: it is simply a matter of which airport they live near. Testing for the significance of different communities is more of a challenge. What is a community? How is it defined geographically? We will test characterizing respondents by the predominant type of aircraft operation that produces their noise exposure: departure, arrival or sideline (start of takeoff, reverse thrust) and associated runway used. These variables, at a given exposure level, should characterize relatively small geographic areas, possibly communities. At a minimum, we should learn whether annoyance correlates with type of operation – possibly useful information for land use compatibility, at the local level, if not the Federal level. We will draft the questionnaire for review.

OMB Review

OMB approval of the instrument will be necessary. The approval is of more than the instrument, but will also require a "Supporting Statement" and, because our information collection will use statistical methods, details about the methods must be provided including:

1. Describe (including a numerical estimate) the potential respondent universe and any sampling or other respondent selection methods to be used.
2. Describe the procedures for the collection of information including:
   - Statistical methodology for stratification and sample selection,
   - Estimation procedure,
   - Degree of accuracy needed for the purpose described in the justification,
   - Unusual problems requiring specialized sampling procedures, and
   - Any use of periodic (less frequent than annual) data collection cycles to reduce burden.
3. Describe methods to maximize response rates and to deal with issues of nonresponse.
4. Describe any tests of procedures or methods to be undertaken.
5. Provide the name and telephone number of individuals consulted on statistical aspects of the design and the name of the agency unit, contractor(s), grantee(s), or other person(s) who will actually collect and/or analyze the information for the agency.[17]

The OMB recommends that agencies need to allow at least 120 days for consideration of initial public comments, the second public comment period and OMB review, plus additional time for preparation of the Information Collection Request (ICR), as well as time lags for publication of Federal Register notices (OMB, 2006).

We will coordinate with OMB to alert OMB of the pending submission. Once finalized, the completed OMB Form 81-I and Supporting Statement will be submitted.

[17] OMB Form 83-I, available: http://www.whitehouse.gov/sites/default/files/omb/inforeg/83i-fill.pdf

During the time of the OMB review, we will simultaneously conduct work that falls conceptually under Data Collection, Phase 3. We propose to conduct these efforts – mainly noise exposure computations – so that once the OMB review is complete and our approach approved, we can immediately start identifying possible respondents and quantifying their noise exposures and be ready to commence surveying immediately after the first year. We recognize that Phases 3 and 4 are intended to occur after the first year, but we propose this Phase 3 work for the first year so that a reasonable schedule is maintained.

Phase 3 – Data Collection

No nationally representative survey of aircraft noise has been conducted in the US. The largest previous coordinated studies in the US were conducted at nine airports from 1967 to 1970 (Tracor Inc., 1971). This proposed survey provides an opportunity to not only update the "Schultz Curve" on a national basis, but to do so with improved understanding of what variables are likely to be important in affecting annoyance, with a widely accepted form of survey instrument, with improved statistical analysis capabilities and with much improved methods for determining noise exposure metrics.

Sampling Respondents

The sampling plan is developed to meet the study's primary goals of estimating the relationships between aircraft noise exposure and the responses of annoyance and sleep disturbance. Additionally, the plan will allow exploration of variations in that relationship across different airports, including variations that may be due to climate, airport size, location, and other factors.

A three-stage sampling plan is proposed, in which the first stage is a sample of airports to represent a national range of locations and airport types, the second stage is a probability sample of addresses with diverse noise exposure in the selected airports, and the third stage is selection of an adult at each sampled address to take the survey.

Stage 1 Sampling: Selection of airports

We propose surveying sixteen airports, with two airports selected from each of the eight FAA Regions. The airports sampled in the ACRP 02-35 project will be excluded. The list of airports eligible for sampling will be compiled in conjunction with the sponsor's needs, and the airports will be selected in collaboration with the sponsor so that they represent a wide range of climates, urban development, size, number of runways, and fleet mix. Sixteen airports are proposed to obtain an acceptable precision for national estimates as described below.

The airports are to be sampled first one, then three at a time as specified in the RFP. Information from the first airport and possibly from other early sampled airports may be used to change the sample allocation (see Stage 2 Sampling, below) for airports to be sampled later. For example, it may be discovered in the initial surveys that stratification by community characteristics does not increase precision, so later airport surveys would not need to use that stratification. Such changes in the sampling design could be accounted for in the analysis although some ability to compare airports would be lost if the changes were too great.

An alternative that could be considered would be to sample all airports concurrently, but with fieldwork spread over a 12-month period for each airport. This alternative would accelerate study completion, would allow more efficient use of fieldwork, and would ensure that all airports are surveyed under comparable conditions to allow ready comparison and pure estimates of airport heterogeneity. It would also allow seasonality to be considered for each airport, and would decrease the airport-to-airport variability, since the seasonality effects would be removed from the variability. This alternative would result in a more precise estimate of the overall dose-response relationship as well as decreased costs. We can discuss the strengths of this approach with the sponsor.

Anticipated precision for national estimates: Previous surveys have exhibited a great deal of variability in the dose-response relationship among different airports. As occurs in many studies with multiple levels of sampling, the airport-to-airport variability is the driving factor for the anticipated precision for the national estimate of the relationship between noise exposure and %HA (see Lohr, 1995; Jenney and Lohr, 2009). Using data from Fidell and Salvati (2004) and Fidell et al. (2011) to estimate the heterogeneity among airports, we anticipate that with 16 airports and 700 households sampled per airport, the margin of error for the slope and intercept in the logistic model will be approximately 0.04 and 1.8, respectively. Consequently, the anticipated margins of error for estimating the percentage of persons who are highly annoyed (%HA) for DNL values between 55 dB and 65 dB are between 4 and 5 percentage points. Of course, if the historical relationships do not hold or the variability among airports has changed, the precision from this study will differ from the anticipated values.

Because of the high anticipated variability among airports, as estimated from the historical data, the only way to obtain more precision for estimating a national overall dose-response curve is to increase the number of airports surveyed; increasing the sample sizes at each airport beyond 700 will have minimal effect on the precision of the national estimates. If ten airports were sampled, the margins of error would be about 35% larger than from the sample of 16 airports we propose. Surveying more than 16 airports would reduce the margins of error commensurately.

Stage 2 Sampling: Selection of Households

For each selected airport, HMMH will provide a map of DNL contours (see Determining Noise Exposure, below). These contours will be used to stratify addresses into groups based on the DNL exposure, for example, 5 strata with DNL exposure 50-55 dB, 55-60 dB, 60-65 dB, 65-70 dB, 70+ dB. Alternative DNL noise stratum will be constructed for airports with unusual noise exposure profiles, for example, airports where few households are exposed to noise greater than 65 dB. Additional stratification may be considered based on types of noise exposure conditions (for example, sideline or under flight path) and/or community characteristics within DNL noise stratum. The stratification will guarantee that the sample at each airport contains households with diverse values of noise exposure.

To implement the noise stratification, noise levels will be computed for each census block, with each block and all its addresses then being assigned to the appropriate stratum. As discussed below, we are considering the addresses on the US Postal Service computerized Delivery Sequence File (DSF) as the likely household sampling frame. These addresses can be geo-coded to the appropriate census blocks with a relatively small degree of geocoding error that will be of no real importance for the allocation to strata. In general, since the proportions of households in the highest DNL noise stratum are expected to be small, these strata will be sampled at higher sampling rates (generally termed "oversampled") in order to generate sufficient sample sizes for model fitting.

The greatest precision for estimating the airport-specific relationship between noise exposure and annoyance will be obtained if addresses are selected randomly within each stratum.

For each address selected into the sample, the precise latitude and longitude will be determined, and an accurate value of noise exposure and of other noise-based metrics will be assigned for each specific address.

Sample sizes and allocation at Stage 2: The anticipated precision for estimating quantities of interest for each airport depends on the sample size and the allocation of sampled points to strata; additionally, since the major models considered are nonlinear, the anticipated precision depends on the model quantities themselves.

Many surveys have as their primary goal estimation of a population mean or proportion such as the percentage of persons who are unemployed, and specify a survey design that provides high efficiency for estimating such a quantity. This survey is different: the primary goals are estimating the relationship between DNL and %HA and estimating the heterogeneity of that relationship at different locations. The standard sampling designs used to estimate population means efficiently will not necessarily be the most cost-effective for estimating the regression or covariance parameters of interest.

Instead, the desired allocation of observations to strata will give high precision for estimating model parameters and for estimating the predicted value of %HA at desired noise levels. The measures of information and optimal experimental designs studied by Abdelbasit and Plackett (1983) and Chaloner and Larntz (1989) provide useful guidance for the allocation of sampled addresses to strata. We used data from Fidell and Salvati (2004) and Fidell et al. (2011) as a basis for estimating the anticipated precision with different allocations and sample sizes, using a logistic dose-response model. Anticipated precisions were similar when other models were used.

Westat statisticians have developed computer programs for calculating the anticipated precision of model parameter estimates and predictions under different models, sample sizes, and allocations of observations to strata. If the historical relations hold, and each of five DNL noise strata (55-60 dB, 60-65 dB, 65-70 dB, 70-75 dB, 75+ dB) is allocated one-fifth of the observations, it is anticipated that a sample size of 700 households near an airport would give a margin of error of approximately 4 percentage points for predicting %HA at DNL levels between 55 and 65 dB. The anticipated margins of error for the slope and intercept for a single airport are 0.03 and 2, respectively (somewhat different from the values estimated previously for all 16 airports). Some airports may not have noise exposures across the full range; if, for example, households are sampled only at DNL levels between 55 dB and 65 dB the anticipated margin of error remains at 4 percentage points for predicting %HA at DNL 55 dB or 60 dB, but increases to 7 percentage points for predicting %HA at DNL = 65 dB. For most airports we expect the anticipated margin of error for predicting %HA at DNL=65 dB to be less than 5 percentage points when a sample of size 700 is taken.

Stage 3 Sampling: Respondent Selection

The final sampling stage is to select at each selected address a sample of eligible adults to take the survey. One possibility is to select all persons at sampled addresses. However, while this procedure avoids the need for another stage of sampling, it has the disadvantage that the responses of people in the same household are likely to be similar to one another, making the sample results less precise than they would be if the same sized sample were more widely spread across households. For these reasons, we propose administering the survey instrument to only one adult per household, to be randomly selected from the eligible adults using the Westat-developed Rizzo method (Rizzo et al., 2004).

Development of survey weights: For analyses involving "population" characteristics such as the demographic characteristics of persons living in the sampling region, we propose to construct weights for the data as is done for most representative samples. The first step applies the reciprocal of the sampling rate within each airport (the higher the probability of being sampled, the lower the weight and vice versa), the second step incorporates the reciprocal of the sampling rate within each household, and the third step adjusts for nonresponse.

Determining Noise Exposure

Noise exposure determinations will be made with the FAA's INM. These computations will serve two purposes. First, noise contours will permit selection of potential survey respondents by DNL noise exposure band: 50-55 dB, 55-60 dB, 60-65 dB, 65-70 dB, and 70-75 dB, see Stage 2 Sampling, above. Second, it will permit computation of specific noise exposure (DNL) values at each respondent location. We plan also to compute additional noise-related metrics for each respondent, including number of aircraft noise events that exceed a specified level, referred to as "number above" or NA. Often this metric is NA70, meaning number of aircraft events that produce a Sound Exposure Level (SEL) louder than 70dB at the location.[18] Other noise related metrics such as probability of awakening (ANSI, 2008)[19], arrival, departure or sideline noise predominance will also be considered.

We propose to use the HMMH proprietary software RealContours™. RealContours™ automates the preparation of INM inputs directly from flight track data to permit modeling of the full diversity of activity as precisely as possible, at a cost equivalent to the more simplified and less accurate manual approach.

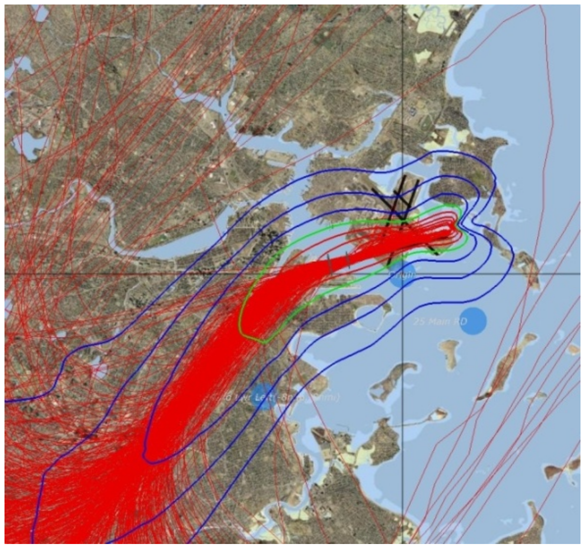
RealContours™ improves the precision of modeling by utilizing operations monitoring results in four key areas:

- It directly converts the flight track trace for every identified aircraft operation to an INM track, rather than assigning all operations to a limited number of prototypical tracks.
- It models each operation on the specific runway that it actually used, rather than applying a generalized distribution to broad ranges of aircraft types.
- It can use each aircraft's actual climb performance on departure to select the "best-fitting" climb profile for that aircraft type in the INM database.

[18] SEL is a sound energy integrated metric. The SEL value for most jet aircraft operations is about 7 to 10 dB higher than the maximum level. Outdoors, speech interference commences when background levels exceed approximately 60 dBA. Consequently NA70 is a rough measure of how many times speech interference occurs outdoors.
[19] HMMH was instrumental in developing the standard and it is based on Anderson and Miller (2007).

- It selects the specific airframe and engine combination to model on an operation-by-operation basis, resulting in a far more detailed and truly representative fleet mix.

RealContours™ does not modify any of the noise and performance data in the INM, nor does it modify the computational algorithms. The FAA has reviewed RealContours™ and has stated that it is does not require any special approvals for applying the INM because of the aforementioned characteristics. RealContours™ was used for the approved Part 150 at Baltimore Washington International Airport, has been used for the Environmental Impact Statement at Providence Rhode Island International Airport, and is used for annual updates of DNL contours at Boston Logan International Airport.



Application of RealContours™ using departures from runway 27, Boston International Airport: *It depicts a collection of departures plotted over a photo of Boston and vicinity. The contours that follow the radar traces are DNL noise exposure levels computed using HMMH's RealContours™ to compute annual DNL contours directly from radar systems. The green is the 65 dB DNL contour; the blues are in 5-dB increments down to 50 dB DNL.*

The RFP mentions possible use of monitoring data as part of determining noise exposure. We use monitoring data on a site-by-site basis to compare with INM computed levels. Our experience comparing monitored levels with those computed using RealContours™ for INM input preparation has shown how accurate the INM can be when realistic data are input.

Table 15 Comparison of Measured and Modeled Annual DNL Values gives a comparison of measured and modeled DNL values for BWI at 19 Remote Monitoring Stations. Though levels at four sites differ by more than 3dB, the average difference is less than 2 dB, with measured being both lower than and higher than modeled. We regard this agreement as excellent. We also note that determining reasons for differences between measured and modeled is a very time consuming task, and beyond the scope or need of this project. Sometimes, understanding these differences requires a site visit to identify the exact situation: e.g., monitor shielded from direct view of aircraft operations by building; monitor close to road with heavy truck traffic.

Table 15 Comparison of Measured and Modeled Annual DNL Values

Remote Monitoring Station	Measured	Modeled	Measured minus Modeled
RMS01	50.4	52.3	-1.9
RMS02	54.9	55.6	-0.7
RMS03	65.5	63.9	1.6

Remote Monitoring Station	Measured	Modeled	Measured minus Modeled
RMS05	53.5	53.6	-0.1
RMS06	53.4	53.9	-0.5
RMS07	61.2	59.1	2.1
RMS08	56	55.8	0.2
RMS09	59.2	62.5	-3.3
RMS10	51.8	51.1	0.7
RMS12	62.8	63.9	-1.1
RMS13	51.1	51.3	-0.2
RMS14	62.6	65.1	-2.5
RMS15	68.9	75.3	-6.4
RMS17	50	54.2	-4.2
RMS19	65	68	-3
RMS20	70.5	70.4	0.1
RMS21	62.3	63.8	-1.5
RMS22	57.8	57	0.8
RMS23	61.2	57.9	3.3

Use of this approach linked to use of a single survey instrument and consistent interviewing techniques will likely minimize if not eliminate methodological differences that traditionally affect comparisons of airport-to-airport surveys.

We will acquire flight track data for each airport. We expect to use up to one year of data for each when there is no cost for the data. In our pricing, we have assumed that access to these data, either from the airport or through FAA will have no cost, other than our labor to import and standardize format.

Surveying Methods

We suggest the survey be conducted by telephone, using an address-based sample. A telephone survey offers a number of advantages over other modes of data collection. An in-person collection would offer higher quality data with respect to response rate and coverage, but would be 6-8 times the cost of data collection. A more viable alternative to a telephone survey might be one that contacted the respondent by mail and asked the respondent to fill out the survey on paper or by the web. This method is likely to be less expensive and may provide data that is less subject to social desirability bias (Tourangeau and Yan, 2007). However, without interviewer involvement, it is up to the individuals in the household to follow a respondent selection rule (e.g., Battaglia, et al, 2008; Hicks, et al., 2012). There is some evidence that mail survey results may show higher estimated levels of annoyance (Janssen, Vos, van Kempen, Breugelmans, and Miedema, 2011; Yamada, Kaku, Yokota, Namba, and Ogata, 2008). The suspicion is that the person who is most concerned about noise will respond.

There are other advantages to a mail survey approach. For example it has fewer coverage issues when compared to a telephone frame (see discussion below). A mail survey is likely to have a higher response rate when compared to a telephone survey (e.g., Cantor, et al., 2007). Pending further discussions with the sponsor, we have assumed a methodology that collects the annoyance data by telephone. However at project award, we can review available evidence and re-consider this decision if deemed appropriate.

The data collection approach follows the sequential administration of the surveys as specified in response to questions to the RFP. Sampled households at a single airport will be administered the survey using the procedures specified below. This initial collection will be used to evaluate the data collection methods. These methods would then be modified based on the results and applied at subsequent administrations. The RFP states that data would be collected from no more than 3 airports during a single point in time. Our budget and procedures assumes this sequential approach, based on the rationale for the sequential design specified in the RFP. However, as discussed in the sample design section, this procedure may not yield the most efficient method. At the initiation of the project, we suggest discussing this design relative to alternatives that may be less expensive and/or provide greater analytic power.

Proposed Survey Data Collection Procedures

As specified in the sample design section, we are proposing an address-based sample. For a telephone survey, an alternative method of sampling would be a random digit dial frame (RDD). We suggest an address frame because it provides much more precision with respect to targeting the community surrounding the airports, as well as the ability to stratify according to the noise contours of interest. An RDD sample has significant disadvantages with respect to targeting at this level of geography which we will present upon request.

An address-based sample does require finding the telephone numbers for the specific address. This will initially be done by matching the address to existing ‘reverse directory’ data-bases that associate phone numbers with addresses, primarily from numbers listed in the phone book. They also include information from other data-bases that the vendor of phone numbers accesses (e.g., warranties; subscriptions). When initially making a call into the household, the protocol will verify the address with the respondent. If it is not the sampled address, the unit will be moved to the mail-survey stage of the process (see Mail Survey below). Prior experience with this method indicates that approximately 40% of the addresses will yield a telephone number that represents the sampled household.

For those addresses that have a correct telephone number, the annoyance survey will be conducted directly. For those addresses where a telephone number is not available, a short mail survey will be sent to the sampled address. This survey will ask recipients to provide their telephone numbers for the telephone survey. Once a telephone number is obtained from a returned survey, the telephone interview will be administered for the sampled address.

When initiating the telephone collection, we will use procedures to maximize the response rate (Dillman, et al., 2009):

1. Send a notification to explain the survey to all households with a telephone number.
2. Attempt to complete the interview (making follow-up calls to contact the respondent).
3. Follow-up with those households that do not express a specific objection.

Step 1 will include a token incentive ($2). The primary purpose is to draw attention to the notification letter and its contents. This methodology has been shown to significantly increase the response from households (Cantor, et al., 2008). With respect to step 3, the vast majority of the households that refuse the interview will do so without listening to the initial explanation of the survey. In many cases, calling these households back results in gaining cooperation once the respondent understands the legitimacy of the study.

The proposed protocol for the mail survey that is used to collect the telephone numbers will:

1. Send the survey to the sampled address
2. Send a 'thank you/reminder' postcard to all addresses
3. Send a follow-up survey to addresses that do not respond
4. Send a third survey to addresses that have not responded

As with the telephone procedures, an incentive of $2 will be sent in the initial mailing. Once a phone number is obtained from the mail survey, an attempt to complete a telephone interview will be made following steps 2 and 3 listed above for the telephone interview. No notification letter will be sent to these households, as they are already aware of the study and have proactively provided their telephone number.

We anticipate the entire process will take approximately 17 weeks to complete.

Phase 4 – Data Analysis & Final Report

Proposed Analysis Plan

The analysis plan is developed here for the primary goals of (1) modeling the national dose-response relationships between noise exposure (measured by DNL, day-night average sound level) and the effects on persons in surrounding communities such as percentage of persons who are highly annoyed (%HA) and percentage of persons reporting sleep disturbance, and (2) investigating the heterogeneity of the dose-response relationships at different airports, and relating deviations from the national models to airport-specific factors. For brevity, the following discussion focuses on the response %HA; analogous models are considered for other responses.

Schultz (1978) modeled %HA as a cubic polynomial function of DNL. FICON (1992) recommended continued use of the DNL metric for noise levels, and described other models for relating %HA to DNL including a logistic regression model (U.S. EPA, 1982):

$$\text{Logistic model: } \%HA = \frac{100}{1 + \exp(-\beta_0 - \beta_1 DNL)}$$

More recently, Fidell et al. (2011) proposed an alternative model:

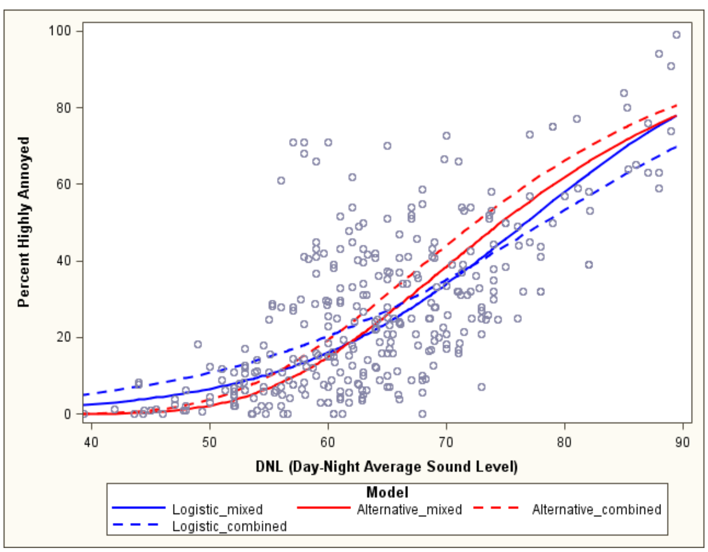
$$\text{Alternative model: } \%HA = 100 \exp(-\frac{\alpha}{m})$$

where $m = [10^{\frac{DNL}{10}}]^{0.3}$. The data are used to estimate β_0 and β_1 for the logistic model, or α for the alternative model. The logistic model has the advantage that additional household-level covariates (for example whether the household is under a flight path) can be included to supplement the basic relationship. The alternative model may also be modified to allow household-level covariates with some adaptations of the theory. The Schultz (1978) model does not allow individual household-level covariates to be used. We expect the fits from the three types of models to be similar, but will explore all the models.

Estimates of the dose-response relationship are sensitive to the method used to combine information from the sampled airports. Combining all observations across airports in a single model (called here a combined analysis), as has been done in several studies, gives airports with higher sample sizes or certain allocation patterns higher influence in determining the national relationship. An alternative method of estimation is to fit the model to each airport separately, then average the coefficients across the airports.

We propose using mixed models (Demidenko, 2004; Stiratelli et al., 1984) to estimate the overall relationship and investigate variations in the relationship among airports. Mixed models capture the best features of the combined analysis method and the averaging coefficients method. In a mixed logistic model, each airport is allowed to have its own slope and intercept, and these are estimated along with the slope and intercept that best describe the overall relationship among all airports. The models may be used to assess whether all airports have the same dose-response relationship as the overall curve. If there is heterogeneity among airports, the mixed models can estimate the degree of heterogeneity as well as investigate airport characteristics that are associated with divergence from the overall model. Mixed logistic models have been successfully used in other settings in which relationships are thought to vary across localities; see, for example, Kaufman et al. (2003). Westat statisticians have formulated a mixed model version of the alternative model that allows airports to have different levels of α, and have developed computer code for the SAS® statistical software package (SAS Institute, 2011) that can be used to fit and evaluate the mixed logistic and alternative models.

The figure to the right shows differences in model fit between the combined and mixed model approaches on the data in Fidell and Salvati (2004). Because the data set contains airports with unusual dose-response relationships, the estimates of the overall relationship between DNL and %HA depend on how the information from airports is combined. The combined fits (dashed lines), which use all the data in a single model, allow airports with unusual relationships and large sample sizes to unduly influence the estimates and result in a curve for the logistic model which appears too flat. The fits for the logistic and alternative models are very similar when the mixed model formulation (solid lines) is used; the mixed models provide a better description of the overall relationship.



Alternative Regression Methods for Computing Annoyance Dose-Response Curves

Two approaches will be taken to estimate the quantities in the models. First, each model will be fit directly. Second, the survey design will be incorporated into the model fit to account for the effects of unequal weighting. Recently developed statistical methods in Rabe-Hesketh and

Skrondal (2006) and Rao et al. (2010) will be adapted for incorporating the survey design when estimating model quantities. The fits of the models will be assessed and compared by analyzing residuals from the models as well as through goodness-of-fit tests (Vonesh et al., 1996; Hosmer and Lemeshow, 2000).

The representative sample of airports, uniform sampling design at selected airports, and use of modern statistical methods for analysis will give an updated version of the dose-response relationship between noise and annoyance that will likely give reliable information for setting aviation policy. The models proposed here allow investigation of household, airport and land use factors that may be associated with differences in the degree of annoyance in response to airport noise.

Reporting

The final report will include the elements in the RFP, in two broad categories: (1) A full documentation of the entire survey process, including sampling, data collection and data processing, weighting, and variance estimation. This includes selection of airports and rationale, development of noise contours, survey instrument, sampling of persons living around the selected airports, data collection approach, and procedures for processing the collected data, as well as detail on preparing weights. Response rates will be reported in accordance with established practice given in the guidelines of the American Association of Public Opinion Research. (2) Results from the data analysis. Summary statistics on noise exposure, annoyance, and other responses of interest will be provided for each airport and for the national sample. The report will contain technical details of the dose-response models fitted and their properties and implications. The results will be given for separate airports as well as the aggregated sample, and will include investigations into factors that may be associated with possible heterogeneity among airports or neighborhoods. The report will discuss the significance of additional noise-related metrics, such as arrival, departure, or sideline dominance, NA70, or probability of awakening for predicting annoyance.

Appendix H. Annoyance Literature Review

EXECUTIVE SUMMARY AND CONCLUSIONS

A literature review has been conducted to support plans for a new national survey of aircraft noise in the United States. The review supports the planning by identifying methods for estimating a national dose-response relationship (the survey's primary announced goal), evaluating issues about non-noise factors that are hypothesized to affect noise annoyance, and identifying unresolved noise annoyance issues that could be secondary goals for the national survey. The measure of impact for this survey, as for all dose-response noise regulations, is the privately-expressed noise annoyance that is measured in social surveys, not the visible, publicly-expressed actions such as complaints to authorities, lawsuits or public protests.

Primary Goal

The announced primary goal is to ***form an accurate nation-wide estimate of the dose-response relationship: the function that predicts the proportion of the population annoyed (to varying degrees) by aircraft noise from acoustical data that characterizes the aircraft noise at their residences***.[20] The literature review supports a decision to use two noise annoyance questions from an ISO technical specification that are now widely used in noise annoyance surveys around the world. The review found that when multiple cities have been surveyed in a single study, the residents in different geographic areas (neighborhoods, cities, airports, etc.) have significantly different annoyance reactions to the same noise level. Despite many hypotheses, the causes of these differences have not been established. One of the implications of such geographical effects is that the national survey design should be based on a large number of randomly selected airports that are drawn with probability selection methods.

The literature review identified one major uncertainty concerning plans for estimating the dose-response relationship: the mode of administering a questionnaire. Noise annoyance surveys have always varied as to whether they are interviewer-administered (face-to-face or telephone) or self-administered (usually mail-in), but more recently the economics of interviewing have resulted in some large surveys being self-administered. There is enough uncertainty about the effect of interviewing mode to mean that the results of a new US survey could not be compared with many other surveys unless effects of the survey mode are evaluated with new data from the US survey.

The literature review identified 62 hypotheses about non-noise effects on annoyance and attempted to locate summaries that could be expected to provide evidence about each of the hypotheses. With over 600 noise surveys and over 1,000 publications it was not possible to conduct new summaries of evidence on each of the 62 issues. As a result the findings from previous published summaries are presented when available. Summaries are needed because individual studies often report contradictory findings and, as a result, conclusions can only be reached about average results when many studies are combined. These summaries are presented for the 30 of the 62 issues for which a results-neutral search strategy produced the summary. For the remaining issues some study results are identified but the primary focus is on the implications for the new US survey.

Some broad conclusions about the 30 summarized hypotheses were reached. In general, demographic characteristics of residents (gender, age, education, socio-economic status, etc.) have no important impact on noise annoyance. As a result demographic characteristics do not explain differences between annoyance reactions in different geographical areas. Selected attitudes, on the other hand, have a consistently strong effect: fear of danger from the noise source, perception that authorities could better control the noise, and self-reported general sensitivity to noise. A change in noise exposure affects

[20] Throughout this document, ***italics*** are used to identify significant issues likely to shape the survey implementation.

reactions for road traffic and railway noise, but the effect on aircraft noise annoyance is uncertain. Ambient noise levels and time spent at home do not have an important effect on annoyance.

Conclusions on many other issues are not clear for a variety of reasons: results are contradictory, study methods are weak, too few studies have been conducted, or no surveys have been conducted. In general, characteristics of geographic areas have been only occasionally studied, often with weak methodologies and almost no non-survey information about the areas. No studies have been located that presented evidence on how annoyance is affected by airport authorities' actions, activities, or community relations programs. Studies have not examined the correlation between public complaints and private annoyance.

Secondary Goals

The secondary goals for a new national survey could be derived from the evidence from summary analyses in this literature review, knowledge about whether or not there are new methodological developments, estimates of costs, and a unique strength of the sample design - the large number of airports and neighborhoods to be studied. Of course all of these scientific and technical considerations must be weighed against policy judgments about the practical value of particular study goals. These various considerations suggest: ***a focus on the following factors that may help to explain the surveyed annoyance: characteristics of geographical areas, authorities' actions, characteristics of community relations programs, relations to aircraft operations (landing/take-off/flight path location), and complaint rates.*** A focus on these types of goals should help to answer a major policy question: ***Is a single, national dose-response relationship justified because it is not possible to objectively predict deviations from a national average for local geographic areas? Or, alternatively, are there readily-available variables that predict differences between geographical areas and form a legitimate basis for local exceptions to national policies?***

Progress could also be made in identifying the size of the geographic units that are associated with unexplained variations in annoyance reactions. With a nested, clustered sample design it would be possible to begin to estimate the portion of the unexplained variance that is due to individuals' situations (the variation between people in adjacent homes with identical exterior noise exposures), the portion that might be due to local factors (variation between nearby neighborhoods), the portion attributable to common aircraft operations (variation between larger areas exposed to similar aircraft operations) and the portion attributable to airport or city characteristics (the remaining differences between airports).

Additional variables will need to be estimated for the national study, even if they have been studied before or can only be imprecisely measured, in order to provide some evidence as to whether such variables' effects have or have not substantially biased the study results. Examples of such variables include demographic characteristics, recent changes in aircraft noise levels, estimates of ambient noise levels, meteorological conditions, and sensitivity to noise generally.

Table 16 summarizes the data collection elements identified by the literature review. The remainder of this report develops these elements. Table 16 can also serve to organize a discussion of what elements should or should not be included in a new national annoyance survey.

Table 16 Possible Elements of a Complete, Complex Annoyance Survey

A. Primary Study Goal: Items that are required for the primary study goal

1. Resident questionnaire (Required to measure annoyance and the various demographic and attitudinal issues.)
2. Flight operation data and analysis (Required to estimate noise exposure and identify the characteristics of the operations near a respondent – relation to flight path, landings, etc.)

B. New Contributions to Understanding Community Annoyance: Elements that contribute to understanding community differences

3. Clustering of respondents into blocks in the sample design. (Needed to identify the size of geographical areas associated with different reactions.)
4. Field experiments comparing questionnaire administration mode. (Used to provide a basis for comparisons to other surveys and dose-response standards that are based on different questionnaire administration modes.)
5. Questionnaire for airport officials (Used to identify characteristics of community relations programs, perceptions of community differences, the existence of legal actions or other major community conflicts with the airport)
6. Content analysis of local media (Used to estimate the impact of media and to rate the visibility of airport officials' actions)
7. Analyze data from previous US surveys to create comparison for current survey (This will answer the question as to whether noise reactions have changed.)

C. Controlling for Previously Identified Explanations: Elements that control for commonly assumed explanations for community differences

8. Meteorological data – short -term and long-term
9. Detailed airport complaint data on number of complainants, number of complaints, and location of complainants
10. Aircraft noise exposure estimates for each of the past five or ten years (Needed to control for changes in aircraft noise exposure)
11. Aircraft noise exposure data for the previous days or months (Used to test hypothesis that annoyance reactions are actually directed at a short period.)
12. Indicators of ambient noise levels, especially traffic noise level (Rough controls for ambient noise might come from geo-coded information about road type or population density.)

D. Other Elements

13. Estimate outdoor to indoor attenuation of aircraft noise for each residence (A model to estimate attenuation based on respondent-provided information would need to be developed or, if already available, assessed.)
14. Supplemental sample of aircraft noise complainants (This would ensure sufficient complainants to compare complainants to non-complaining members of the population.)
15. Questionnaire data from knowledgeable authorities about the political activism of communities
16. Aircraft ground operation noise predictions

Introduction

Plans are being developed for a national survey of aircraft noise in the United States as part of an ACRP sponsored study. This report reviews the community noise-response literature for information that can contribute to the design of that survey. Since there have been over 600 prior social surveys of noise annoyance, a major objective is to determine what issues have been substantially settled by previous research and which unresolved issues should be studied to strengthen the new national survey.

Primary study goal: Updating the United States dose-response relationship for aircraft noise

The primary goal of a new national survey of aircraft noise in the United States is to update previous estimated dose-response relationships and provide a best estimate of the bivariate relationship between aircraft noise exposure and the annoyance of residents for the nation as a whole. At the present time the estimates that are used are based on averaging the results from transportation noise surveys that have been conducted since 1965 in at least eleven counties (Miedema and Vos, 1998; Schultz, 1978; American National Standards Institute., 2005; Federal Interagency Committee on Noise (FICON), 1992; International Standardization Organization, 2003). Some summaries of the dose-response relationship combine studies of all noise sources while others are based on only aircraft noise studies. No nationally representative survey of aircraft noise has been conducted in the US. The largest previous coordinated studies in the US were conducted at nine airports from 1967 to 1970 (Connor and Patterson, 1972; Patterson and Connor, 1973; Tracor Inc., 1971)

Consequences of the research strategy needed to meet the primary goal

Dose-response relationships are estimated by relating residents' noise annoyance to the noise levels experienced at their home. The residents' annoyance is measured in a questionnaire that is administered as part of a large social survey. The estimates of long-term aircraft noise environments are derived from measurements of aircraft noise or from aircraft noise estimation models. To obtain a statistically-sound national average it is necessary to obtain data from an adequate number of airports that have been selected on a probability (random) basis. Such an unbiased probability selection procedure also makes it possible to estimate the likely precision of the final measured dose-response relationship. In order to provide such an estimate, a sample of at least 30 airports is needed. The primary, national dose-response goal thus dictates a sample with a large number of airports. As is true of most aircraft noise studies, large and moderate size airports will be studied, not airports where there are large proportions of general aviation traffic. In addition the study will be confined to relatively high noise areas and thus to areas around airports.

No other aircraft noise survey has been conducted at such a large number of airports. The large number of airports provides this study with a unique opportunity to study differences between geographic areas such as areas surrounding different airports, local areas near each airport, and neighborhoods.

It is suggested that a secondary goal of the survey be to determine the extent to which dose-response relationships are uniform or different in different geographically-defined areas and, to the extent that areas differ, to identify factors that explain the differences. This goal addresses a fundamental noise policy issue: Are there local conditions that create important deviations from the average national dose-response relationship? Previous studies have only collected noise data and other data about individual respondents and have thus largely ignored airport and neighborhood differences that might or might not create different dose-response relationships. Very little attention has been directed at the effects of such geographically-specific variables as types of flight operations, airport authorities' actions, community relations programs, media coverage, community organization, and meteorological conditions. With only 30 airports statistical tests of purely between-airport differences will be imprecise and there are likely to be confounding effects for correlated variables. In so far as possible, every effort needs to be made to base conclusions on within-airport/between geographical area contrasts, but it is likely that even though this 30-airport study provides improved, best-available evidence on many issues, the evidence will not be conclusive for many geographic area variables.

Literature review strategy

The literature review strategy for this report has been designed to efficiently focus on issues that will best address the study goals that can be addressed with the unique, multi-airport study design. With over 600 previous social surveys of reactions to environmental noise it is not feasible to review and create a new synthesis of the results from the associated thousands of publications. In addition ***the goal of this literature review is not so much to form best summaries of findings, but rather to report multi-study summary analyses where available and to identify relevant study design challenges for issues that have not been the subject of summary analyses.***

Relevant literature and findings have been identified through the following procedures:

- Reading the entries in a catalog of noise surveys to identify surveys with relevant designs or study goals (Bassarab, Sharp, and Robinette, 2009). (This procedure was especially helpful in identifying multi-airport and multi-city studies.)

- Searching the contents of major acoustical journals and conference proceedings to identify summary analyses that synthesized the results on some topics that could relatively easily be identified with search terms.

- Using search engines to find keywords in the more than 1,000 publications from previous noise annoyance surveys that are locally available in PDF files. (This search was not a perfect search of all the publications because many articles had been optically scanned and could not be perfectly read by OCR (Optical Character Recognition) programs.)

- Using search engines to search the internet for publications that are not in standard acoustical journals.

- Reading reference lists in articles that were identified with the above procedures to locate additional articles and reports. (This was especially useful for identifying literature that was not in standard acoustical publications.)

- Corresponding with international noise survey experts to locate information or confirm the absence of information on important community characteristics that had not been the subject of summary reviews.

All the studies examine residents' reactions to environmental noise experienced at their homes. Almost all the studies concern transportation noise, primarily aircraft and road traffic noise, though some are of railway noise and a few are directed at noise from neighbors and industrial sources.

Of the 62 noise annoyance issues identified in the next section, about half have been addressed in summary analyses that used a results-neutral method to select publications for analyses. Many other issues have been discussed in detail and analyzed. The summary analyses included in the present literature review, however, are ones where the literature or data were selected using procedures that were not biased toward identifying positive findings. A bias toward positive findings can occur when the publication search procedure may miss minor reports that a variable that had no effect on annoyance while identifying all instances where a variable had a major effect on annoyance. This is a variant of the 'file drawer' problem that is encountered in experimental studies where studies with negative findings are left unpublished in a file drawer while studies with positive findings are prominently published. A similar problem could arise for studies of noise annoyance if only article abstracts are searched. A positive finding (e.g. annoyance increases with education) is likely to be featured in an abstract, while a negative finding (e.g. annoyance is not related to education) is likely to buried in a sentence or footnote in the body of a publication. The summary analyses utilized in this literature review are based on either reading all publications that could have reported results for the issue or on reanalyses of all the original, individual social survey data sets stored in a large data archive.

Issues Reviewed

This report concentrates on the factors, other than the acoustical characteristics of the noise source, which have been hypothesized to affect residents' annoyance with noise. Table 17 lists 62 issues that were compiled from consulting six publications that analyzed or listed factors that might affect transportation noise annoyance (Fields, 1993; Kroesen, Molin, and van Wee, 2008; Miedema and Vos, 1999; Vader, 2007; Vos, 2010; Wyle Research, 2011). The 62 issues are grouped under 10 broad topical headings. Some focus on the individual respondent, such as demographic characteristics and personal attitudes. Others focus on the interaction between noise officials and residents: for example, attitudes toward authorities, authorities' actions, and complaints directed to authorities. Others focus on local conditions such as neighborhood conditions or housing characteristics. Two issues concern the possible impact of the questionnaire administration mode on a survey's findings about levels of annoyance.

Although this list does not include all the issues that have been discussed in the noise literature, it does attempt to list all the issues that are likely to be relevant for the design of the new national survey. Several facets of a new national survey are not discussed. The choice of the primary dependent variable for a dose-response survey is not discussed. It is assumed that the annoyance response questions for the survey will be survey questions that were developed as part of a multi-national effort that involved coordinated studies in more than nine languages (Fields et al., 1997). The two following, almost identical, pair of questions have been published as an ISO Technical Specification (International Organization for Standardization, 2003) and are widely used in current noise annoyance surveys around the world:

> Q. 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?
>
> Q. 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.
>
> 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 (source) noise?
>
> It is anticipated that the final dose-response relationship will use one of these questions as the measure of response. Reporting a relationship with a single question provides an easily understood, transparent measure of noise impact that has come to be widely accepted for setting noise policies around the world.

One test-retest study that conducted 97 repeated interviews concluded that "pure annoyance" questions were less reliable and valid than "general questions" about "perceived affectedness" or "dissatisfaction" (Job, Hatfield, Carter, Peploe, Taylor, and Morrell, 2001). Due to question placement and additional question-wording differences between the "simple annoyance" and "general questions" in that study, it is difficult to know exactly why the questions performed differently. It should be noted that the suggested questions above are not purely "annoyance" questions since they introduce the general annoyance concept with the phrase "… bother, annoy, or disturb…"

Using a single annoyance question for the dose-response relationship does not, however, preclude the use of multi-question indices. Such indices should provide more precise estimates of the relative effects of different explanatory variables. One source of additional reaction questions could be questions from previous surveys with which a precise comparison is needed.

The list of 62 issues also does not include a discussion of the form of the dose-response curve. Recent publications have argued that the shape of a dose-response curve can be supported by theory from studies of loudness ratings (Fidell, Mestre, Schomer, Berry, Gjestland, Vallet, and Reid, 2011). Whether the data from the new national survey are better represented by this curve or a logistic curve or some other shape can, of course, be tested at the analysis stage. The issue is not discussed here because it does not affect the study design.

The list of 62 issues does not include the topics that are addressed in defining a noise index such as the relative importance of noise level and number of events, the impact of nighttime noise, the correct acoustical frequency weighting, and characteristics of individual noise events such as roughness or tonality. The acoustical data that will be available for the analyses will make it possible to consider some of these issues. However, it seems unlikely that much could be learned from the relatively homogeneous, long-term environments that are dominated by passenger jet aircraft at the moderate and large air carrier airports that will be randomly selected for the national survey. Making significant improvements in our knowledge about such noise-index issues would almost certainly require a survey design that would concentrate on unusual noise environments around unusual airports where normally correlated variables are not confounded. For example the impact of varying ratios of nighttime to daytime noise could only be estimated by including unusual airports or neighborhoods which have high nighttime to daytime flight ratios. Including multiple airports with such unusual exposure conditions would weaken the ability of the national survey to derive accurate dose-response relationships for the nation as a whole. Some of the survey data sets that are available for the study of such issues have been identified (Wyle Research, 2011). A secondary analysis of available data may be the most effective next step toward addressing these issues.

A close examination of the literature for many of the 62 issues would, no doubt, identify additional sub topics within the issues and identify other labels for these and other closely-related issues. The selection of labels for the issues and the divisions between closely-related issues are sometimes arbitrary. It is hoped, however, that the level of detail is sufficient for this review.

The 'Table 18 Summary?' column in Table 17 contains a 'Yes' if quantitative results are presented in Table 18for the issue. It should be noted, that many issues are only briefly discussed in this report. The bibliographic references that are given for each issue can provide more detailed information.

The literature on these 62 issues is summarized in the next two sections of this report. The first section, *Findings*, discusses conventional issues about the effect of individual characteristics, local conditions, aircraft operations, and the method of survey administration. The *Frameworks for assessing authorities' actions* section discusses a subset of the issues from Table 17 that are related to the effect that airport authorities' may have on annoyance. This separate section is needed to outline the framework for developing airport authority issues. These airport authority issues have not been systematically studied in previous surveys.

Table 17 List of Issues Reviewed

Issue #	Issue	Hypothesis[a]	Table 18 summary?
A. Effects of demographic characteristics			
1	Gender	Women are more annoyed	Yes
2	Age - (Older age)	Older age increases annoyance	Yes
3	Age - (Middle age)	Middle age increases annoyance	Yes
4	Education	High education increases annoyance	Yes
5	Status-occupation	High status increases annoyance	Yes
6	Income	High income increases annoyance	Yes
7	Household size	Mid-sized households (2 or 3 members) increase annoyance	Yes
8	Length of residence	Long-term residence decreases annoyance	Yes
9	Home ownership	Home ownership decreases annoyance	Yes
10	Dwelling unit type	Residents of single unit dwellings are more annoyed	Yes
11	Usage of noise source	Use of the transportation noise source decreases annoyance	Yes
12	Economic connection	Economic dependence on the noise source decreases annoyance	Yes
13	Country/culture	People from different cultures and countries differ in noise/annoyance reactions	- -
B. Effects of home conditions that modify exposure			
14	Time at home	Residents spending more time at home are more annoyed	Yes
15	Exposure individualized - (sum below: out-of-doors , attenuation, orientation, season)	Individuals with relatively less exposure are less annoyed	Yes
16	Out-of-doors usage	Residents who spend more time out-of-doors are more annoyed	Yes
17	House attenuation	Greater outside-to-inside transmission loss decreases annoyance	Yes
18	Room orientation	Quiet 'escape' rooms decrease annoyance	Yes
C: Effects of local community conditions			
19	Community differences	Airports and communities differ in annoyance responses	Yes
20	Ambient noise levels	Low-ambient noise levels increase annoyance	Yes
21	Sparsely settled areas	Rural or 'peaceful' suburban environments increase annoyance	- -
22	Media coverage	Positive or negative media coverage of the noise source creates corresponding annoyance reactions	- -
23	Activist community	Politically active communities increase annoyed	- -
24	Meteorological conditions	Comfortable weather (average climate or date-of-interview weather) increases annoyance	Yes
D. Effects of attitudes - general			
25	Fear/Danger	Fear of danger from a noise source increases annoyance	Yes
26	Sensitivity	General sensitivity with noise increases annoyance	Yes
27	Importance of source	Belief in the importance of the noise source decreases annoyance	Yes
28	Preventability by authorities	Belief that authorities could reduce noise increases annoyance	Yes
29	Exposure control - individual	Belief that the resident can control or avoid noise exposure decreases annoyance	- -

Issue #	Issue	Hypothesis[a]	Table 18 summary?
30	Expectations for future exposure	Expecting an increase in noise exposure increases annoyance	- -
E. Effects of attitudes toward authorities			
31	Transparency of process	The perception that authorities develop policy transparently and provide relevant information decreases annoyance	- -
32	Fairness of procedures	The perception that authorities follow procedures in a fair manner decreases annoyance	- -
33	Trust	The perception that authorities can be trusted decreases annoyance	- -
34	Understanding of residents' concerns	The perception that authorities understand or are concerned about residents decreases annoyance	- -
35	Residents can affect policy	The perception that authorities' actions are influenced by residents' views decreases annoyance	- -
F. Effect of aircraft operations			
36	Distance to flight path	Being under a flight path increases annoyance	Yes
37	Landing operations	Exposure to landing operations increases annoyance	- -
38	Ground operations	Noise from ground operations (including start of take-off noise) increases annoyance beyond the levels expected from airborne operations	- -
39	Airport size	Small airports create greater annoyance (adjusted for noise exposure)	- -
40	Predictable noise profile	A regular, predictable noise event profile decreases annoyance	- -
41	Vibration	Vibration of structures or rattles increase annoyance	- -
42	Non-noise (other)	Lights, odors, or other non-noise impacts increase noise annoyance	- -
43	Change-Immediate impact	Residents overreact to changes in noise exposure (either increase or decrease)	Yes
44	Change-Long-term adaptation	With time, annoyance with a changed noise exposure decreases	Yes
G. Authorities= actions and activities			
45	Operator noise abatement actions	Officials' programs to control noise decrease annoyance beyond levels expected from exposure	- -
46	Community relations programs	Strong community relations programs decrease annoyance	- -
47	Conflict - history	A history of noise operator/community conflict increases annoyance	- -
48	Compensation to residents	Receiving compensation from authorities decreases annoyance	- -
49	Operators' perceptions	Operators can predict residents' annoyance levels	- -
H. Correlated noise impacts			
50	Vibration	The belief that the noise source also causes vibrations increases annoyance	- -
51	Health	The belief that the noise source affects health increases annoyance	- -
52	Air pollution	The belief that the noise source's fumes or dirt pollute the air increases annoyance	- -
53	Activity disturbance	The belief that the noise interferes with daily activities (speech, concentration, listening, etc.) increases annoyance	- -

Issue #	Issue	Hypothesis[a]	Table 18 summary?
54	Sleep	The belief that the noise interferes with sleep increases annoyance	- -
I. Complaints and public actions			
55	Complaint rate: annoyance	High community complaint rates indicate relatively high annoyance	- -
56	Complaint rate: other correlates	What community or event characteristics are correlated with complaint rates?	- -
57	Complainant characteristics	Complainants' characteristics are representative of annoyed residents	- -
J. Other issues			
58	Self-selection by moving away	High noise levels cause annoyed residents to move out of the area	Yes
59	Long-term annoyance trends	Over the years noise annoyance has increased for the same noise exposure	Yes
60	Survey administration : Telephone vs. Face-to-face	A telephone interview yields higher annoyance ratings (than face-to-face)	Yes
61	Survey administration : Self- vs. interviewer-administered	Self-administered questionnaires (mail) yield higher annoyance ratings	- -
62	Relevant exposure period	Respondents' annoyance is determined by recent experiences not by the entire previous year	- -

Footnote to Table 17: In the interest of brevity, the hypotheses have all been stated in the form 'X increases annoyance' – a form which seems to imply a causal connection. In fact these are hypotheses about associations, not causation. Thus the listed variable might only be associated with some other variable that is a real cause – for example, aging might not cause annoyance, but a particular age cohort might have experienced some event that affected annoyance. In other instances the annoyance might be the cause. For example, feelings of extreme annoyance might lead some people to conclude that their health is affected by noise.

Findings

This section begins with a description of Table 18 where the results for the 30 issues with summary analyses are displayed. The remainder of the section discusses each of the 62 issues listed in Table 16.

Two different types of analyses provide the results that are presented in separate columns in Table 18. The two types of analyses are: meta-analysis and secondary analysis. Both types of analyses provide conclusions on the single issues by systematically and uniformly drawing on the data from a large number of studies that addressed the issue. A meta-analysis is an analysis that is based on a systematic analysis of publications. A secondary analysis is a re-analysis of the original, individual- level questionnaire responses from a number of different surveys using a single comparable analysis strategy for all the surveys.

One type of summary analysis in Table 18 is a count of the number of surveys that support or do not support a hypothesis. For a single study a hypothesis is considered to be supported if an effect is large enough to be "important" or is statistically significant. For most summaries an "important" effect is the equivalent of a 3-decibel change in noise exposure or a 5% difference in annoyance. The summaries based on this survey counting approach are provided in the column labeled "Do most studies support?" If more than 50% of the studies support a hypothesis a "YES" appears in that column. The next two columns report the number of studies [Studies (N=)] and number of respondents from those studies [Respondents (N=)]. Thus for Issue 4, the hypothesis that "High education increases annoyance" was not supported by more than 50% of the 18 studies (Studies N=18) and these 18 studies contained a total of 29,893 respondents. The source of the finding (Fields, 1993) is cited in the next-to-last column (Source for study support count). This meta-analysis by Fields counted ‘important’ effects where a study’s reported effect was considered to be ‘important’ “if it was the equivalent of a three-decibel difference in noise exposure or statistically significant.” Additional details for the analysis methods are given in the cited publication which gives the objective rules followed for combining diverse published results. The publication also describes sensitivity analyses that determined whether considering the relative sizes or methodological quality of the analyzed surveys would lead to different conclusions. For the particular summaries prepared on the issues in Table 17 in the meta-analysis columns, the study counts are based on meta-analyses, except for the counts for the noise-change Issues #43 and #44 which are based on secondary analyses.

The other summary analysis method in Table 17 is to calculate a measure of the size of the effect across all of the diverse data sets. For noise annoyance surveys, these types of summaries are only available from secondary analyses of the original study questionnaire data. The results for this summary method are given in the “Average effect (dB equivalent)” column of Table 17. These results are based on the number of studies and respondents given in the two following columns. The source of the summary analysis is then provided in the last column of Table 17. For Issue 4, “Education”, these columns show that this secondary analysis examined the answers from 30,427 respondents drawn from 26 different surveys. When the difference in the responses of the low education (not completed secondary school) and high education (completed university or higher) respondents were compared it was found that the percentage difference in annoyance scores was the same percentage difference that would be generated by a 2-decibel difference in noise exposure. This small effect is thus consistent with the meta-analysis results in the “Do must studies support?” column which also found that most studies did not find an important effect.

The summary secondary analyses that are drawn upon in this report consider the studies to be substantially equivalent in the sense that they do not test to determine whether there are statistically significant interactions between country or survey and the variables that are the basis for the issues in this review. For example, there is no test of the possibility that education might affect annoyance in some countries but not in others. A simple comparison of results from diverse surveys from different countries could be misleading because the country-of-survey could be confounded with the many methodological differences between surveys.

This literature review provides only the simplest, condensed results from the summary analyses. For example, Table 17 reports support for a hypothesis that two-member and three-member households are more annoyed by noise (Issue 7). The summary publication gives some important additional information such as the fact that this household-size effect was tested and found to not be due to correlations with age and that single-person households were considerably less annoyed than the large households of four or more members (Miedema and Vos, 1999). Additional details about the analysis methods used in the secondary analyses, including the definition of the subgroups that are compared for each variable, are not provided in the present report but are in the cited publications.

All of the analyses in Table 18 are based on analyses that have controlled for noise exposure. In every case, the findings should be interpreted as evidence about the effect of a variable on residents at the same noise level.

Table 18 Summary from Meta-analyses and Secondary Analyses

Issue #	Issue	Hypothesis	Meta-analysis results			Secondary analysis results			Source for study support count	Source for average effect
			Do most studies support?[a]	Studies (N=)	Respondents (N=)	Average effect (dB equivalent)[b]	Studies (N=)	Respondents (N=)		
A. Effects of demographic characteristics										
1	Gender	Women are more annoyed	NO	47	62,479	0 dB	34	38,255	Fields, 1993	Miedema and Vos, 1999
2	Age - (Older age)	Older age increases annoyance	NO	63	77,122				Fields, 1993	
3	Age - (Middle age)	Middle age increases annoyance				3 dB[c]	47	62,983		Van Gerven, Vos, Van Boxtel, Janssen, and Miedema, 2009.
4	Education	High education increases annoyance	NO	18	23,983	2 dB	26	30,427	Fields, 1993	Miedema and Vos, 1999
5	Status-occupation	High status increases annoyance	NO	22	33,701	2 dB	23	27,247	Fields, 1993	Miedema and Vos, 1999
6	Income	High income increases annoyance	NO	10	15,846				Fields, 1993	
7	Household size	Mid-sized households (2 or 3 members) increase annoyance				2 dB	27	29,993		Miedema and Vos, 1999
8	Length of residence	Long-term residence decreases annoyance	NO	44	61,322				Fields, 1993	
9	Home ownership	Home ownership decreases annoyance	NO	23	25,327	2 dB	25	29,463	Fields, 1993	Miedema and Vos, 1999
10	Dwelling unit type	Residents of single unit dwellings are more annoyed	NO	14	18,463				Fields, 1993	

Issue #	Issue	Hypothesis	Meta-analysis results			Secondary analysis results			Source for study support count	Source for average effect
			Do most studies support?[a]	Studies (N=)	Respon dents (N=)	Average effect (dB equivalent)[b]	Studies (N=)	Respon dents (N=)		
11	Usage of noise source	Use of the transportation noise source decreases annoyance	NO	6	12,089	2 dB	12	16,800	Fields, 1993	Miedema and Vos, 1999
12	Economic connection	Economic dependence on the noise source decreases annoyance	NO	12	16,364	2 dB	14	21,516	Fields, 1993	Miedema and Vos, 1999
B. Effects of home conditions that modify exposure										
14	Time at home	Residents spending more time at home are more annoyed	NO	17	19,765				Fields, 1993	
15	Exposure individualized - (summary of Issues 16, 17, 18 & five season studies)[i]	Individuals with relatively less exposure are less annoyed	YES	30	39,119				Fields, 1993	
16	Out-of-doors usage	Residents who spend more time out-of-doors are more annoyed	NO	2	1,000				Fields, 1992	
17	House attenuation	Greater outside-to-inside transmission loss decreases annoyance	Mixed support	14	18,725				Fields, 1992	
18	Room orientation	Quiet 'escape' rooms decrease annoyance	YES	9	8,522				Fields, 1992	
C: Effects of local community conditions										
19	Community differences	Airports and communities differ in annoyance levels	YES	19	55,000	7 dB	19	55,000	See cell to right	Fields, Ehrlich, and Zador, 2000
20	Ambient noise levels	Low-ambient noise levels increase annoyance	NO	16	15,512	1 dB[d]	20	57,000	Fields, 1996; p.37-39	Fields, 1996;
24	Meteorological conditions	Comfortable weather (average climate or date-of-interview weather) increases annoyance	YES	7	18,043	1-3 dB	41	51,130	Fields, 2004	Miedema, Fields, and Vos, 2005

Issue #	Issue	Hypothesis	Meta-analysis results			Secondary analysis results			Source for study support count	Source for average effect
			Do most studies support?[a]	Studies (N=)	Respon dents (N=)	Average effect (dB equivalent)[b]	Studies (N=)	Respon dents (N=)		
D. Effects of attitudes - general										
25	Fear/Danger	Fear of danger from a noise source increases annoyance	YES	21	44,713	19 dB	12	17,494	Fields, 1993	Miedema and Vos, 1999
26	Sensitivity	General sensitivity with noise increases annoyance	YES	23	36,435	11 dB[e]	29	33,977	Fields, 1993	Miedema and Vos, 1999, Miedema and Vos, 2003
27	Importance of source	Belief in the importance of the noise source decreases annoyance	YES	4	5,882				Fields, 1993	
28	Preventability by authorities	Belief that authorities could reduce noise increases annoyance	YES	11	19,462				Fields, 1993	
E. Effects of attitudes toward authorities										
F. Effect of aircraft operations										
36	Distance to flight path	Being under a flight path increases annoyance	NO	3	3,230				Fields, 1993	
43	Change-Immediate impact	Residents overreact to changes in noise exposure (either increase or decrease)	YES	43	- -[f]				Brown, van Kamp, 2009	
44	Change-Long-term adaptation	With time, annoyance with a changed noise exposure decreases	NO	14	- -[f]				Brown, van Kamp, 2009	
G. Authorities= actions and activities										
H. Correlated noise impacts										

Issue #	Issue	Hypothesis	Meta-analysis results			Secondary analysis results			Source for study support count	Source for average effect
			Do most studies support?[a]	Studies (N=)	Respondents (N=)	Average effect (dB equivalent)[b]	Studies (N=)	Respondents (N=)		
I. Complaints and public actions										
J. Other issues										
58	Self-selection by moving away	High noise levels cause annoyed residents to move out of the area	NO	7	5,877				Fields, 1993	
59	Long-term annoyance trends	Over the years noise annoyance has increased for the same noise exposure				8 dB[g]	22[h]	42,078		Janssen,Vos, van Kempen, Breugelmans, and Miedema, 2011
60	Survey administration : Telephone vs. Face-to-face	A telephone interview yields higher annoyance ratings (than face-to-face)	NO	4	3,393				Fields, 1993	

Footnotes to Table 18:

a. Most of these summary counts of study results come from one report (Fields 1992). For this report a study was counted as "supporting" a hypothesis if the published data indicated an "important" effect. The definition of an 'important effect', in order of precedence is: a difference in annoyance reactions that is the equivalent of the difference created by a 3-decibel difference in noise level, a difference of at least 5% in the percent annoyed, an explanation of at least 1% of the variance in annoyance, an effect that is statistically significant at the p<.05 level. A complete explanation of the counting protocol is available in the report.

b. The average decibel equivalent effect is the difference in noise exposure that creates the same difference in annoyance as that which is observed between subgroups for the variable being studied.

c. For the 'middle age' hypothesis those in the 30 - 49 age group were more annoyed than either younger or older respondents (Van Gerven, Vos, Van Boxtel, Janssen, and Miedema 2009). This most recent and comprehensive review, cited in Table 18, supports this pattern and provides a model to predict age effects but does not provide observed annoyance scores for different age groups and does not provide a measure of the decibel equivalent of the differences between age groups. As a result the estimated differences in Table 18 are the differences estimated between the age 30-40 age group and the age 70+ age group that were presented in an earlier summary secondary analysis (Miedema and Vos 1999).

d. The best estimate from this secondary analysis is that a 20-decibel lower ambient noise creates higher annoyance that is the equivalent of a 1-decibel increase in noise from the rated noise source.

e. The estimate that sensitivity has an effect that is the equivalent of an 11 decibel difference in noise exposure comes from an analysis that analyzed 15 surveys with 14,294 respondents which assumed that the impact of sensitivity was the same at all noise levels (Miedema and Vos 1999). When the analysis was repeated at a later date with additional surveys, and a total of 29 surveys and 33,977 respondents, an interaction of noise level and sensitivity was found that indicated that the influence of sensitivity increased with increasing noise level (Miedema and Vos 2003).
f. The number of respondents included in the meta-analysis is not reported (Brown and van Kamp 2009).
g. The value of 8 dB is the estimated decibel equivalent of the increase in annoyance scores over the 30 years between 1970 and 2000.Using the year coefficient (0.55) in Table 18from the analysis that controls for survey administration mode (Janssen, Vos, van Kempen, Breugelmans, and Miedema 2011), it is estimated that annoyance increases by a value of about 16.5 (30*0.55) annoyance points. This is the equivalent of approximately an 8dB increase in noise level as the estimate from a linear regression equation is that annoyance increases at a rate of approximately 1.98 annoyance score points per decibel (Personal communication with Sabine Janssen, January 27, 2012).
h. Some of the 22 studies included 34 airports because some studies included more than one city.
i. The summary for Issue 15 is based on the x studies reported for Issues 16, 17 and 18 as well as on 5 studies of seasonal effects that were available when this summary was reported in 1992.

Topic A: Effects of demographic characteristics

Issues #1 to #12:

The first 12 issues in Table 18 concern the basic demographic characteristics of the population: gender, age, education, social status (as measured by occupation), income, household size, length of residence, home ownership, type of dwelling unit (single family or multiple-family), extent of usage of the transportation noise source, and having an economic connection to the noise source. All of these issues have been examined in systematic summary analyses that could be expected to identify prominent as well as less prominent reports of findings. The results for all 12 are summarized under Topic A of Table 18 .

These demographic variables have very small effects on noise annoyance. In no case did more than half of the individual studies find an important effect of a demographic variable. When all of the results were pooled in the secondary analyses the estimated average difference between subgroups was never more than three decibels for any variable. Such small differences mean that any differences in annoyance in different neighborhoods or cities are not likely to be explained by demographic differences such as differences in income, education, employment by the noise source, or home ownership. ***While a new survey in the US is not likely to change these conclusions, there is a strong case for measuring most of these demographic variables in the questionnaire.*** By measuring the variables it will be possible to convince skeptics that the variables are not important in the US and to state that any demographic differences between areas have been controlled. In addition, these are relatively cheap and accurate variables, new questions do not need to developed, the questions take very little interview time, and they are easily analyzed.

Issue #13: Country/Culture

No systematic reviews have been located that examine all the evidence on cultural effects either between countries or, within one country between subcultures or immigrants from different countries. The Netherlands' TNO data archive contains data from many countries but no analyses have been published that examined differences between countries. Differences in survey methodology and differences between locations within a single country make accurate comparisons between countries uncertain. Though questionnaires do sometimes record ethnicity and country of origin, this review has not attempted to locate relevant findings. In the absence of large ethnic groups the number of minority group respondents is likely to be too small to provide accurate estimates.

Between country difference could be important. Summaries of surveys in Western countries have consistently found a 'railway bonus' – annoyance with railway noise is less severe than that with aircraft or road traffic noise at the same level (Fields and Walker, 1980;Miedema and Vos, 1998b). However, surveys in Japan have consistently found that railway noise is more, not less, annoying than other transportation noise sources (Yano, Sato, and Morihara, 2007).

Topic B: Effects of home conditions that modify exposure

Issue #14: Amount of time at home

The results in Table 18 for the first issue under Topic B, time at home, indicate that the annoyance with aircraft noise at home is not reduced for individuals whose total exposure at home is less because they are away from home more hours a week.

Issues #15 – #18: Other indicators of total noise exposure while at home

The second issue under Topic B, Issue 15, is an overall summary of all the studies summarized in Issues 16 to 18 as well as five studies of season effects. The common thread in all of these issues is the hypothesis that an individual's reaction to the noise level as represented in official regulations (the noise level outside the house at a fixed position relative to the noisiest location near the dwelling) is modified by the sum of the noise that is received at an individual's ear. The summary for all indicators in Table 18 finds that individualized exposure does affect annoyance. In an attempt to better understand the phenomena, the component studies are divided into smaller groups by their type of individualized exposure in the three following lines in Table 18 (Issues 16 – 18).

For Issue 16 in Table 18, there are only two studies and the evidence is weak: one study finds time spent outside increases annoyance the other study finds outside exposure has no effect. For Issue 17, the effect of acoustical isolation of the house structure, the evidence is very mixed and weak. Whether half the evidence supports the hypothesis depends upon whether the number of studies is counted or whether the studies are weighted according to their sample sizes. However, these studies may not provide a strong test because most of the measures of acoustical attenuation are weak. The respondent's report on whether there is any double glazing is often the only basis for estimating attenuation. In other studies, some respondents had received free insulation as a part of a noise reduction program. However, as one review of insulation effects notes (Amundsen, Klaeboe Ronny, and Aasvang, 2011), for such noise reduction programs it is unclear whether residents' annoyance is reduced because of the increased acoustical insulation or the fact that the residents were beneficiaries of a program that demonstrated the authorities' concern about noise. A substantial improvement in the method of measuring acoustical attenuation could provide strong new evidence on this topic.

At least two additional studies have been conducted since the meta-analysis in Table 18 was published. One showed no benefit from a noise insulation scheme (Fidell and Silvati, 1991). The other, a before/after study, showed a reduction in annoyance that was consistent with the reduction in noise level (Amundsen, Klaeboe Ronny, and Aasvang, 2011). This should not be regarded as a thorough up-dating of the previous meta-analysis since the keyword search of publication abstracts and titles might not have identified some studies, especially ones with negative findings.

For the remaining issue under Topic B (Issue 18, Room Orientation) , Table 18 presents evidence that annoyance is reduced in dwellings where major rooms are acoustically sheltered by being on the side of the dwelling that does not face a noise source. This issue is mainly relevant for ground-based noise sources where one side of the dwelling often has much higher exposure than the other. As a result the room-orientation issue is not particularly relevant for planning a new national survey of aircraft noise. Not surprisingly, none of the nine studies summarized in Table 18 for this issue are of aircraft noise.

Topic C: Effects of local community conditions

Issue #19: Community differences

There is clear evidence for differences in reactions in different geographical areas, but the extent to which these differences occur at a city level, airport level, or local neighborhood level has not been quantified. Comparisons of dose-response relationships from different surveys are often cited as evidence for differences in reactions (Fidell, Mestre, Schomer, Berry, Gjestland, Vallet, and Reid, 2011), however, it is not clear whether differences between these studies are due to genuine differences in reactions or to methodological differences between studies which were conducted by different survey organizations using different modes of administration (for example mail or telephone) with different questionnaires that asked different survey questions which were administered in different seasons in different years in different languages. Much stronger evidence comes from studies which gather survey data from many communities as part of a single study.

The results presented in Table 18 for this issue come from analyses of 19 surveys, each of which compared community response between subareas within their single survey (Fields, Ehrlich, and Zador, 2000). These 19 surveys were all the surveys that the researchers could obtain from archives which sampled at least 20 geographical areas, identified those areas on the respondent-level data file, and provided the individual respondents' ratings of annoyance on a multi-point annoyance scale. Six of the surveys measured noise reactions to two sources. The total resulting 55,000 annoyance reactions were analyzed and it was found that after controlling for noise level there were greater differences between annoyance rates in geographic areas than would be expected from the differences between respondents within areas. The study found community differences in every one of these 19 studies. The measure of the size of the community difference in Table 18 comes from the same summary analysis. The 7 dB average is the average of the 20 surveys' estimates of the standard deviation of the subareas' annoyance scores, expressed as the decibel equivalent value of the annoyance scores.

Most of the publications that propose explanations for community differences using a single survey are based on contrasts of a small number of communities. Many of these find the annoyance is different in two communities, then identify a single other difference between the areas, but do not consider other possible explanations for differences.

Differences in communities demographic characteristics are readily available from census data and are often reported to be associated with differences in community reactions. However, as the results from summaries in Table 18 demonstrate, social surveys have repeatedly found that an individual's demographic characteristics (age, income, education, gender) have too small an effect on annoyance to explain large community differences. For example, it is often assumed that high income can explain the difference between annoyance reactions of neighborhoods, but analyses of individual respondents income, education or other socio-economic status show only small effects (no more than 2 dB for individuals in Table 18) – much too small to explain major differences in the average annoyance in different communities.

The difficulties in explaining annoyance differences between small numbers of airports are well illustrated by social surveys that were conducted around nine US airports around 1970 (USA-022, USA-032, USA-044). After conducting social surveys at seven large airports, the last phase of the study turned to two smaller airports to determine whether annoyance reactions might be different at smaller airports (Patterson and Connor, 1973). After adjusting for noise exposure, it was found that respondents were less annoyed at these last two airports, but when the researchers considered many other characteristics of the airports they realized that these last two small airports' differed in other ways: the surveys were conducted at a cooler time of year (winter not summer), the populations were exposed to different types of operations (noise from take-offs dominated the noise environment at only the two small airports) and there was much less social interaction focused on aircraft noise. In short, though the two additional airports were originally chosen to represent a particular characteristic (airport size), the other differences between the two airports and the seven original airports made it impossible to come to a conclusion. A study of six airports in Spain came to a similar conclusion when authors offered hypotheses for airport differences that considered recent changes in exposure, the extent of military usage and the proportion of tourism flights (García, Faus, and García, 1993). ***For a national survey, it is clear that there needs to be a large number of airports and that, when possible, airport differences should be controlled by using identical survey methods at all locations and, when possible, testing hypotheses by comparing neighborhoods or small communities within airports.***

Issue #20: Ambient noise

Table 18 presents the evidence that in normal residential areas, ambient noise levels do not have an important effect on noise annoyance with a specified noise source, such as aircraft. The best estimate from this secondary analysis of 20 surveys with 57,000 interview responses is that a 20-decibel lower ambient noise creates the equivalent of a 1-decibel higher annoyance with the rated noise source. This is such a small effect as to not be relevant for most noise regulations. This small effect for private annoyance is not inconsistent with the observation that very active and effective anti-noise organizations may come from low-ambient areas and successfully organize public actions to try to modify noise policy. At least one additional study has been published that reports an ambient noise effect (Lim, Kim, Hong, and Lee, 2008), but an updated comprehensive review of the literature has not been conducted. Given the results from the previous 20 studies, it seems unlikely that there have been enough new studies with different conclusions to alter the judgment that ambient noise has little or no effect.

Issue #21: Sparsely settled areas

Although ambient noise does not by itself create higher reactions, it may still be hypothesized that annoyance will be much higher for rural populations or in areas in which there are widely spaced country estates. Three of the ambient noise studies in the previous meta-analysis classified some areas as rural although the definition of a rural area was not provided and might have included densely settled villages within a rural countryside. None of the three studies reported a 5% or greater level of annoyance in the rural areas (Borsky, 1965; Hawkins, 1980; Wehrli, Nemecek, Turrian, Hofmann, and Wanner, 1978). A more recent study of wind farms in the Netherlands reported, contrary to the hypothesis, that annoyance was lower, not higher in rural areas without main roads (Pedersen, van den Berg, Bakker, and Bouma, 2009). Consultants often see apparent support for the hypothesis because there are otherwise quiet, sparsely settled areas where well-organized residents complain about low levels of noise exposure from a single source. However, no studies have determined whether the private annoyance levels are particularly high in these areas or even if the number of such areas that complain about aircraft noise is large relative to the possibly enormous total numbers of such areas exposed to similar low-aircraft noise environments.

Issue #22: Media coverage

Although publications often note that media reports and other publicity about noise exposure may affect a community's reaction to noise, these publications almost always concern a single, complex situation and are not able to separate the effects of media attention from other factors. For example, a report on reactions to changed aircraft noise exposure around a Sydney, Australia airport notes that pre-change media reports may have affected annoyance reactions (Job, Topple, Carter, Peploe, Taylor, and Morrell, 1996a). However the principle author, Soames Job cautions that this study of a single situation does not provide proof (personal correspondence with Soames Job, December 2011). A suggestion that media may not be important comes from the finding that annoyance did not increase between a 2001 survey and a 2003 social survey around Zurich-Kloten airport despite greatly increased media attention due to planned changes at the airport (Brink, Wirth, Schierz, Thomann, and Bauer, 2008).

Several studies provide evidence that does not rely on a single city or location for information about the possible effect of publicity. In the only multi-city study that was located in the literature, a study about reactions to sonic booms found a weak relationship between measures of media coverage and residents' attitudes toward sonic booms (Tracor Inc., 1970). This sonic boom study could prove useful for future planning since it describes the methods used to analyze the content of media reports. More indirect evidence comes from a social survey in which residents' annoyance responses were weakly correlated with their self-reports as to whether they were "… aware of any recent comments or articles in the newspapers or on TV concerning the local airport" (Le Masurier, 2007). This is not, however, strong evidence about the effect of media coverage because it relies on the respondent's recall of media exposure to a specific topic.

Some support for a media effect comes from an experiment in Hong Kong in which subjects were given either a negative or positive fact sheet on noise exposure from a railway line; the two versions having been compiled from a collection of negative or positive newspaper articles about noise-mitigation measures for the newly opened railway line (Lam and Chan, 2007). When the subjects were tested a month later it was found that those who had read the positive fact sheet were slightly less annoyed.

Other support comes from a German study in which two communities that experienced very small reductions in railway noise from rail grinding differed in whether or not they were exposed to positive publicity from a leaflet, press report or other local contact. Only those exposed to the positive publicity expressed a statistically significant reduction in railway noise annoyance (Liepert, Hegner, Möhler, Schreckenberg, Schümer-Kohrs, and Schümer, 1999). Indications of the limits of media effects come from an airport noise study in England where residents were asked about a special nighttime operation trial. Despite a publicity campaign and media coverage of the sensitive night-flight trials, the social survey found that most residents were not aware of the trials (Flindell and Witter, 1999).

Although a comprehensive, detailed review of the literature has not been conducted, it appears that media may have some effect on reactions. ***This review also suggests that strong evidence could come from correlating a survey of residents' annoyance with independent content analyses of local media coverage.*** Although most of this evidence could come from comparisons between airports, differences between neighborhoods might be explored if some of the media coverage was focused on issues that only affected specific neighborhoods.

Issue #23: Activist community

Communities and, to a lesser extent, cities develop reputations as centers of political and environmental activism. It is hypothesized that these types of communities would sensitize residents to noise and other environmental issues and thus create higher noise annoyance among individuals. No studies have been located which test this hypothesis for noise annoyance.

Issue #24: Meteorological conditions

From the summary reported in Table 18 meteorological conditions appear to have at least a small effect on reactions. The secondary analysis of 41 surveys conducted in different countries at different times of year estimated the effect that a 15 degree (centigrade) difference in temperature would have on noise annoyance. A 15 degree range was chosen because this is the approximate difference between summer and winter. The summary analysis estimated that the 15 degree difference created a difference in annoyance that was the equivalent of a 1-db to 3-db difference in noise exposure depending upon the type of analysis that was conducted. However, these estimates were not statistically significant ($p>0.05$) (Miedema, Fields, and Vos, 2005). The large confidence intervals, ranging from -2 to +6 dB for a logistic regression of "high annoyance are almost certainly created by the fact that surveys from different countries and cities are being compared rather than surveys which were conducted of the same population at different times of year."

A study which surveyed the same population continuously for seven years, the population of the Netherlands, found a consistent, statistically significant seasonal pattern with the greatest annoyance in July, August or September (Miedema, Fields, and Vos, 2005) However, the difference in annoyance reactions could not be confidently expressed in terms of the equivalent decibel impact because that survey used an unusual, unique annoyance scale and the scales' relationship to noise level has not been analyzed. One set of assumptions generated the estimate that the 15 degree difference in temperature would be equivalent to a one-decibel difference in noise exposure. There was no evidence that long-term reactions are more strongly influenced by meteorological conditions on the interview day or the immediately preceding days than by the meteorological conditions that prevailed in the weeks and months preceding the interview. The independent effects of temperature and other meteorological variables such as precipitation or wind speed could not be accurately estimated from the data available for the summary analysis.

Meteorological conditions could be an important consideration in planning a national survey, because shared conditions at a single airport could increase airport-to-airport differences and because between-airport differences could be moderated through the timing of the survey administration***. For a national survey the best strategy is probably to conduct all interviews at the same time of year, when the temperature differences in the previous three months differ the least around the country.***

Topic D: General attitudinal variables

Issue #25: Fear/Danger

Every one of the 21 studies reviewed in Table 18 found that noise annoyance is associated with a respondent's perceptions of danger from aircraft or fear of airline crashes. The difference in the reactions of high-fear and low-fear respondents is the equivalent of a 19 decibel difference in noise exposure. Though fear is clearly important, the effect may have been overestimated in this analysis because some respondents who reported they did not 'hear' aircraft were not asked about fear. Fear is likely to be correlated with noise level as was reported for recent surveys around Schiphol (Janssen, Vos, Houthuijs, van Kamp, Breugelmans, and Miedema, 2010).

Some evidence for a linkage between fear and airline accidents comes from a study that found that residents near a recent aircraft crash site were more fearful and annoyed than other residents at the same airport who were not near the crash site (Moran, Gunn, and Loeb, 1981).

A primary reason for including questions about fear in the new national questionnaire is to understand reactions under flight paths. Being under flight paths would be expected to increase respondents' perceptions of danger to their personal safety even if it did not affect annoyance. The fear questions from previous surveys, however, are often ambiguous as to whether the fear derives from perceived threats to the respondents' personal safety or fear about an airliner crash anywhere in the area. Some relatively complex survey questions ask about fear from "aircraft flying overhead", but it is uncertain whether respondents limit their response to only those aircraft flying directly over them. New survey questions could distinguish between fear from all aircraft and from only the aircraft perceived as directly overhead which could directly threaten the respondent.

Issue #26: Sensitivity

All but one of the 24 studies reviewed in the meta-analysis summary in Table 18 found that self-reported sensitivity to noise is related to noise annoyance with a specified noise source such as aircraft noise. The estimate that sensitivity has an effect that is the equivalent of an 11-decibel difference in noise exposure comes from a secondary analysis that analyzed 15 surveys with 14,294 respondents which assumed that the impact of sensitivity was the same at all noise levels (Miedema and Vos, 1999). When the analysis was repeated at a later date with additional surveys and a total of 29 surveys with 33,977 respondents, sensitivity was still found to be an important variable but an interaction of noise level and sensitivity was found that indicated that the influence of sensitivity increased with increasing noise level (Miedema and Vos, 2003). This interaction effect does not appear to be consistent across surveys. The same analysis that found a very large interaction effect for the secondary analysis of 28 of the 29 surveys, found a much smaller interaction effect for one of the 29 surveys, an especially large survey of 10,939 respondents around Schiphol airport (Miedema and Vos, 2003). Other investigators examined large surveys from three different airports and found no evidence of interaction at any of the three airports (van Kamp, Job, Hatfield, Haines, Stellato Rebeccas K., and Stansfeld, 2004). Whether there is a strong interaction effect or none, it is clear that sensitivity has a strong effect on noise annoyance.

The 1993 Miedema and Vos article summarizes other important finding about sensitivity. These additional analyses of sensitivity confirm that the degree of sensitivity is only weakly, if at all, related to noise level. The social survey results are all based on respondents' answers to survey questions. The three most common measures are based on 1) a single global question about whether the respondent believes he/she is sensitive to noise generally, or 2) a set of questions about annoyance with common sounds (e.g. household appliances, fingernails on a blackboard, etc.) or 3) reactions to noises in specific situations. All measures are shown to affect annoyance with transportation noise in the residential situations. At least one laboratory study has shown that measures of auditory sensations or perceptions of noise levels are not related to the type of affective, self-reported sensitivity that is measured in survey questionnaires (Ellermeier, Eigenstetter, and Zimmer, 2001). Some early social surveys assumed that noise sensitivity was a form of neuroticism (McKennell, 1963). Miedema and Vos reviewed the current psychological literature and concluded that sensitivity and neuroticism and sensitivity are correlated but independent traits (Miedema and Vos, 2003).

Noise sensitivity is an important determinant of aircraft noise annoyance and should probably be measured the new US questionnaire. However, noise sensitivity appears to be too evenly spread a personality trait to help explain differences in annoyance in different areas and thus should probably not be a major focus for the new US study.

Issue #27: Importance of noise source

For Issue 27 in Table 18, three of the four studies found that the belief that the airport or flights are important reduces noise annoyance. Most of the ‘importance’ survey questions either imply or directly refer to the economic importance of the airport by asking about the importance for the region or city or other unit.

Issue #28: Preventability (authorities)

A range of labels are used for a variety of social survey questions that tap into residents’ general feelings about whether authorities have failed to take steps which could reduce aircraft noise levels. This concept has been given such labels as ‘preventability’, ‘malfeasance’, ‘misfeasance’, and ‘considerateness’. Support in Table 18 for this hypothesis is drawn from 11 surveys. All of these surveys found that the belief that the noise could be reduced was associated with greater annoyance.

Some surveys have attempted to determine which air transport authorities might be perceived as being able to reduce noise by asking parallel questions about such groups as pilots, airlines, government, airport operators, or the designers of aircraft. However, the present literature search has not identified detailed discussions about theories or correlates of preventability. Attitudes toward preventability are likely to contain components of various attitudes toward authorities which are discussed under Topics E and G.

Issue #29: Exposure control (respondents)

Several studies have attempted to test the hypothesis that stress leading to annoyance occurs because residents are unable to develop an effective strategy for coping with the noise. This hypothesis is derived from Lazarus’s theory that stress occurs when individuals believe they do not have the resources to cope with environmental stressors (Lazarus, 1966). In the noise literature this set of related concepts is explored in studies of ‘coping strategy’ or ‘perceived control’. No systematic searches of the noise survey literature have been conducted that summarize relevant studies.

Guski states that “Central to the coping concept is the belief and confidence of an affected person that he/she will somehow manage the problem. The coping strategy can be direct (e.g., in turning off the noise source, or negotiating with the people responsible for the stress) or indirect (mostly via cognitive control, e.g., by means of an exact knowledge of the time schedule of the noise source). Mostly, environmental noise sources cannot be turned off directly, but they could be negotiated, and indirect coping strategies can also be very effective in reducing the noise annoyance” (Guski, 1999). According to Guski, one study found that self-rated reports of being able to adjust to the noise were as closely related to noise annoyance as was sensitivity (Finke, Guski, and Rohrmann, 1980). Analysis of a large survey near

Schiphol also found that perceived control and coping capacity are closely related to noise annoyance (Kroesen, Molin, and van Wee, 2008).

While there is a psychological literature supporting the theory of coping and control (Lazarus, 1966), it is not clear whether some of the survey measures may be tautological. One item reported by Guski illustrates this problem: "If it is too loud outside, I simply close the windows, and then I am no longer disturbed". This questionnaire item seems to be close to stating that "I am not annoyed because I am not annoyed". The "coping and control" questionnaire item already contains the annoyance judgment. The questions solicit respondents' theories about why they are not annoyed, rather than directly measuring their coping strategies.

If a series of questionnaire items were devoted to coping in a new US national survey, the survey might make a significant contribution to knowledge about personal factors that affect noise annoyance. However this could require a substantial commitment in terms of questionnaire space and substantial work on question wording and concept development to overcome the tautological question issue raised above. Personal coping strategies are not directly tied to either the unique aspects of the proposed study's multi-airport design or to authorities' actions. A related concept, perceived effect of resident's opinions on public policy (Issue 35), is more relevant.

Issue #30: Expectations for future exposure

The expectation that noise exposure will increase in the future has been hypothesized as increasing annoyance. No systematic summaries have been compiled to determine whether studies consistently support this hypothesis. Two studies have supported the hypothesis (Öhrström, 1997; Schreckenberg, Schümer, and Möhler, 2001). With respect to public complaints and actions, it is often observed that complaints and other public actions around noise issues are strongest when proposals are introduce that would increase noise.

Topic E: Effect of attitudes toward authorities

Issues #31 to #35

Studies have not yet systematically explored the extent to which residents' annoyance is affected by their attitudes toward authorities who are in some way related to the noise source. The preventability issue (Issue 28, above) provides a broad judgment of whether authorities are doing all they can to reduce noise but does not explore other attitudes toward authorities which might influence judgments of preventability or have an independent effect on annoyance. The current review of the literature is consistent with a 2007 review that concluded that there is no substantial social survey research about the relationship between authorities' actions, residents' attitudes toward those authorities, and residents' annoyance (Vader, 2007). The literature reviewed in Section 4.0: (Frameworks for assessing authorities' actions) identifies factors that are hypothesized to affect the relationships between airport authorities and communities' public actions. In addition several laboratory experiments reviewed by Vos suggest that perceptions of authorities can affect ratings of noise (Vos, 2010). On the basis of that literature it is hypothesized that the following five perceptions reduce annoyance with aircraft noise:

31	Transparency of process	The perception that authorities develop policy transparently and provide relevant information decreases annoyance
32	Fairness of procedures	The perception that authorities follow procedures in a fair manner decreases annoyance
33	Trust	The perception that authorities can be trusted decreases annoyance
34	Understanding of residents' concerns	The perception that authorities understand or are concerned about residents decreases annoyance
35	Residents can affect policy	The perception that authorities' actions are influenced by residents' views decreases annoyance. (This is an extension of the coping and control attitudes from personal control within the home to control of public policy.)

For the purposes of the proposed national study, these perceptions provide an important link for understanding the impact of local authorities' actions and the neighborhood-to-neighborhood differences in annoyance reactions (Issue 19). Survey questions about the authorities' actions and attitudes could be explicitly directed at the best practices for community relations programs that are described in the section 4 *Frameworks for assessing authorities' actions* (Table 20) to determine whether particular aspects of community relations programs affect corresponding perceptions among residents and, in turn, affect noise annoyance. Such survey questions might also help to explain local neighborhood-to-neighborhood variations in annoyance by determining whether some of this variation is associated with neighborhood-to-neighborhood variations in perceptions of authorities or with acoustical or non-acoustical mitigation actions of authorities.

Topic F: Effect of aircraft operations

The acoustical dimensions of aircraft flights are captured in noise indices which, as was explained in the introduction, are not the subject of this literature review. Other aspects of aircraft operations are discussed here under Topic F: Effect of aircraft operations

Issue #36: Distance to flight path

It is often hypothesized that residents who live under a flight path will be more annoyed than those in a side line position, primarily because of a heightened fear of aircraft crashes. As the meta-analysis in Table 18 shows, only three studies were located in a 1993 summary report. A keyword search of reports for 628 surveys and a web-based search for additional references identified one additional report. The evidence is not consistent. An Oslo airport study found those under the flight path were more annoyed by the equivalent of about a 6-decibel difference in noise exposure (Gjestland, Liasjø, Granøien, and Fields, 1990). A survey around Toronto airport found that those under the flight path were more annoyed, but the authors were uncertain about the interpretation of the finding because those residents were not any more fearful than other residents (Hall, Taylor, and Birnie, 1980). A survey around Canadian general aviation airports did not find higher annoyance under the flight paths but the authors' expressed uncertainty as to whether the training routes used for touch-and-go flights were accurately specified (Hall, Taylor, and Birnie, 1980). One of the first aircraft noise surveys, conducted in the US in the 1950's, found higher annoyance under the flight paths in some areas but higher annoyance to the side of flight paths in other areas (Borsky, 1954).

A new national US study could provide much stronger evidence than the previous studies. ***The new study will have tracks for individual flights and thus be able to much more accurately specify residents' locations relative to the spread in actual flight tracks. The information will also make it possible to quantify the extent to which aircraft are directly above the respondents' dwellings***, unlike the previous surveys that simply classified dwellings as being below or to the side of a nominal flight path. Of course, a sample design with a large number of airports and flight paths will also reduce the possibility that correlated variables are confounding the interpretation of a relationship.

Issue #37: Landing/take-off operations

The sounds of take-off and landing aircraft are distinct. It is hypothesized that for the same noise exposure, sounds from take-offs will be more annoying. Although a thorough search of all the literature was not conducted, a keyword search of the content of reports for 628 surveys and a web-based search for additional references identified six studies that examined the correlation between annoyance and the ratio of take-off operations to landing operations. The findings are not consistent. Two surveys found that annoyance was higher for take-offs, but the relationship was not statistically significant for one, an Oslo survey (Gjestland, Liasjø, Granøien, and Fields, 1990), and the relationship for the other, a Heathrow survey, though statistically significant, was not strong enough to support a recommendation for a change in the noise metric (MIL Research, 1971). Two other surveys, one from Japan and one from the US, found the opposite to the hypothesized relationship: annoyance was greater for locations with relatively more landings (Nguyen, Yano, Nguyenhuy, Nishimura, Sato, Morihara, and Hashimoto, 2011; Patterson and Connor, 1973). However the US survey, as will be explained elsewhere, provided ambiguous findings because the take-off/landing ratios were strongly correlated with other airport characteristics (Patterson and Connor, 1973). In a Salt Lake City rating quasi-experiment, the groups of subjects who rated each flight passing over the test home were no more annoyed by take-off than landing noise (Dempsey, Stephens, Fields, and Shepherd, 1983). In a rating study around Frankfurt airport, the residents made hourly ratings of the aircraft noise environment over the course of a test day. It was found that the hours that contained both take-off and landing operations were more annoying than hours that contained only a single type of operation (Schreckenberg and Schuemer, 2010).

The evidence on this, as on many issues, is not consistent. The proposed US national survey should be able to provide stronger evidence than previously with a new hypothesis and strengthened sample design. ***With improved measures of the flight path location it will be possible to determine whether the landing/take-off difference might be found under flight paths***. Previous surveys have assumed that the landing/take-off effect would be found across the entire area even at extreme sideline positions where the direction of the flights may be less relevant. Another possible hypothesis is suggested by the Frankfurt study: consistency in types of operations or consistency in flight-to-flight noise signatures may reduce annoyance. The detailed flight operation data that will be available for the US survey should provide sufficiently accurate data to explore such a consistency hypothesis.

The improved sample design should also support a better test for the landing/take-off hypotheses. A large number of airports should help to reduce the correlations with other airport characteristics. Airports with considerable variation in landing/take-off ratios can provide within-airport estimates that are less likely to be confounded by between-airport differences although there may be, possibly weaker, within-airport confounding factors.

Issue #38: Ground operations

Standard aircraft noise indicators include only the noise from flying aircraft, not the noise from ground operations such as taxing, engine testing or ground run up. These noises can be annoying, but results from such studies have not been systematically summarized in the literature.

It is unlikely that the effect of ground operations can be accurately assessed within the planned new national survey due to small populations, correlated variables and requirements for expensive acoustical estimation issues. Only a small proportion of the aircraft noise population is exposed to ground operation noise. Those exposure situations occur very near the airport and are thus strongly correlated with noise from conventional operations as well as with many other impacts from the airport. The noise exposure from ground operation at residences is expensive to accurately predict due to uncertainties about the noise levels emitted by aircraft, the location and frequency of such emissions, and the attenuation of any such emissions by structures on the airport near the aircraft as well as structures in the neighborhoods near individual residences.

Issue #39: Airport size

A summary analysis has not been conducted of the differences between large and small airports or of the differences between air carrier and general aviation airports. Several published reports based on comparisons of small numbers of air carrier and general aviation airports come to different conclusions. A 1977 survey around a small airport in Hamble England with predominantly training operations for propeller aircraft (UKD-309) reported that reactions were about as expected at large, air carrier airports (Directorate of Operational Research and Analysis, 1982a). A 1981 survey around five general aviation airports in the United Kingdom (UKD-243) reported that the residents of four of the five study airports were less annoyed than would be expected at air carrier airports(Directorate of Operational Research and Analysis, 1982b). A later 1986 survey around five small airports in the United Kingdom (UKD-324) found some evidence that noise from general aviation was more annoying than that from air carriers (Diamond, Ollerhead, Bradshaw, Walker, and Critchley, 1988). A 1975 survey around four small airports in Germany (GER-114) concluded that annoyance was greater at these general aviation airports than would be expected at large air carrier airports (Rohrmann, 1976).

The reasons for such inconsistent findings may be the problems that were identified for the1970's comparison of small and large airports in the United States and mentioned above in the discussion of take-off/landing comparisons (USA-022, USA-032, USA-044) (Patterson and Connor, 1973): the airports of different sizes may differ in other ways and the survey and acoustical methodologies followed at the airports may have been sufficiently different to confound the comparison. The report of a Canadian survey around general aviation airports points out that small general aviation airports often pose an especially difficult, error-prone noise estimation problem because it is not feasible to accurately estimate the exposure from touch-and-go circuit flights (Hall, Taylor, and Birnie, 1980).

Issue #40: Predictable noise profile

No studies have been located that tested the hypothesis that noises are less annoying if the time-history course of the noise events are more predictable. This hypothesis has been offered as one possible explanation for the lower annoyance reaction to railway noise than to aircraft or road traffic noise (Miedema and Vos, 1998b). However, this is not consistent with the finding in Japan that railway noise is more annoying (Yano, Sato, and Morihara, 2007).

This issue may well be becoming more relevant for aircraft noise as new advances in aircraft air traffic control make it possible to more precisely specify flight paths. In addition, many airport authorities can use aircraft noise monitoring stations as a basis for monitoring individual flights' compliance with aircraft noise exposure norms. Whether this issue can be explored in a new national study depends upon the extent to which aircraft movement data and/or noise monitoring stations can accurately identify variations in aircraft noise events at individual respondents' locations.

Issue #41: Vibration

The impact of vibration on annoyance has been studied primarily for railway and impulse noises. The effects of sonic booms and other large amplitude impulsive noises have also been studied (Fields, 1997; Schomer, 1981). While these studies examined annoyance with vibration, they have not studied how vibration levels would affect the more general annoyance with aircraft noise events. Aircraft noise can excite the structure with the possibility that residents may see, feel or hear some items move. It is not clear whether most previous research on the most studied noise sources is highly relevant for commercial aircraft noise. Unlike some railway vibration, aircraft-induced vibration is exclusively caused by acoustical emissions from aircraft. Unlike sonic booms and major impulse sounds, vibration is less likely to be associated with being startled or with perceiving danger. For commercial aircraft the most frequent effect of vibration may be windows rattling, a noise source which may or may not be included in respondents' definitions of 'aircraft noise'. A recent study of annoyance with vibration provides some evidence that acoustical window treatments may have the side effect of reducing annoyance with vibration, presumably by reducing the rattling of windows (Fidell, Pearsons, Silvati, and Sneddon, 2002). The study did not assess any resulting effect on noise annoyance. A major seven-year program to assess vibration and combined vibration and noise impacts is being conducted in the UK, but may be of limited relevance as it is not studying aircraft noise induced vibration (Perkins, Grimwood, Stanworth, and Thornely-Taylor, 2011).

Issue #42: Non-noise other

While noise and vibration are the most obvious impacts from transportation noise, neighborhoods can also experience other impacts such as air pollution, odors, dust, dirt, lights, or the visual impact from seeing the source of the noise. Though subjective perceptions of these non-noise impacts are occasionally asked about in questionnaires, no publications have been located about the relationship between annoyance and objective measures of these non-noise impacts for aircraft noise. This may be partly because such impacts are limited to only the highest noise levels for aircraft noise and because they are difficult to objectively measure. Accurate objective measurements would be expected to be too expensive to conduct for a new national survey.

Issue #43, #44: Reactions to change in exposure

Issues 43 and 44 concern the difference between reactions to a static, long-term noise exposure and reactions to a recently increased or decreased noise exposure. The recent meta-analysis in Table 18 concludes that most studies find that residents overreact to such changes as if the change in noise exposure had been even larger (Brown and van Kamp, 2009). The analysis also found evidence that such a reaction was persistent and continued for at least the few years after the change that had been investigated in the available studies. The authors noted however, that most evidence was from ground-based transportation noise studies where the changes were clearly visible. They stated that there were too few, inconsistent aircraft noise change studies to determine whether the hypotheses also held for aircraft noise (Brown and van Kamp, 2009). While the impacts of changes in noise exposure on private annoyance are often small, difficult to detect and not found in some surveys, the impact on complaints and public reactions are reported to be large, vigorous and almost universal. Proposals for increases in aircraft noise exposure are also reported to universally create vigorous public opposition.

Even though the current evidence suggests that changes in noise levels may have only small persistent changes on annoyance with aircraft noise, a new national survey will need to obtain objective information about noise exposure trends and abrupt changes if for no other reason than to be able to test the wide-spread perception that changes in noise levels generate very large changes in annoyance. A questionnaire item about perceptions of changes in aircraft noise exposure should also be included to determine whether residents in some locations perceive changes even when airport operations are unchanged.

Topic G: Authorities' actions and activities

Issue #45: Operator noise abatement actions

When authorities take steps to reduce noise exposure it is hypothesized that residents may overreact with lower annoyance than would be expected from the noise level alone. This is similar to the earlier change hypothesis (Issue 43) but is based on the assumption that it is the knowledge of the authorities' efforts that creates at least part of a reaction to the changed exposure. This might occur if residents knew about a specific change that was instituted by authorities or if residents attributed any improvements to authorities' actions because the authorities were perceived as generally attempting to reduce noise. No summary analysis has been conducted of such changes. These actions are discussed further in the section *Frameworks for assessing authorities' actions* and listed there in Table 19 Some doubt is thrown on this hypothesis by the earlier cited study in which it was found that most residents were not aware of night time trials even though there was a publicity campaign and media coverage (Flindell and Witter, 1999).

Issue #46: Community relations programs

Airports have a range of programs for communicating with their impacted communities. These programs are often directed at community members who are involved in public actions or complaints against airport noise. There is very little information about the extent to which these programs impact the privately felt annoyance that is measured in social surveys. One quasi-experimental field study was conducted at the airports Augsburg and Kassel-Calden in Germany (Maziul, 2005). At each of the airports a sample of residents were interviewed with standard noise survey questions and then told about a noise complaint line, "NoiseCall". Residents who subsequently used the line were identified. In later follow-up interviews the original sample was followed up and the characteristics of those who used and those who did not use "NoiseCall" were compared. The perceived control and the coping strategies of residents were meant to be enhanced, and consequently, annoyance to be reduced and contentment with the management increased. When the data were analyzed the annoyance of Kassel residents who used the NoiseCall declined significantly and the contentment correspondingly increased – though the increase was not statistically significant. However at the other airport, Augsburg, no significant changes after the installation of the NoiseCall were detected. The evidence from this small experiment was thus mixed.

One problem in assessing the impact of a community relations program is that the effects of an airport's community relations program might be confounded with other airport characteristics. One way to at least partially address this problem is to measure the expected intermediate effects of a community relations programs on the various attitudes toward authorities that were outlined above under Topic E.

Issue #47: Conflict – history

A well-known study of an acoustics consulting firm's files, found support for the hypothesis that a history of conflict between an airport and its community would create heightened reactions to aircraft noise at an airport (United States Environmental Protection Agency, 1974; Wyle Laboratories, 1971). The methods for objectively measuring previous conflict were not published for the study. The study did not attempt to measure resident's private annoyance. No studies have been located that relate a history of conflict to residents' annoyance with noise.

Issue #48: Compensation to residents

Authorities sometimes offer some type of compensation to residents related to their noise exposure. No studies have been located that relate receiving compensation to noise annoyance.

Issue #49: Operator's perceptions

Airport authorities and other personnel who are involved in aircraft operations at an airport often believe that communities at similar noise levels react quit differently to equivalent noise exposures. This perception may be derived from objective data, such as counts of complaints and law suits, but may also be affected by less formal, difficult-to-quantify impressions formed from long-term contacts with some members of the communities. It is hypothesized that these operators' perceptions of community response are related to residents' annoyance. No studies have been located which tested this hypothesis. While it may be that such perceptions only reflect a few publically-expressed community leaders' views, it is also possible that the operators' experience does provide special insight into annoyance. ***Testing the hypothesis could determine whether noise impact on the population is best identified from statistical models of noise annoyance or whether the model's predicted impact should be adjusted for authorities' perceptions of local communities.***

Topic H: Correlated noise impacts

Survey studies of environmental reactions to noise have always found that the general annoyance reaction is closely related to other attitudes which measure various specific perceived impacts of noise. Frequently studied perceived impacts include those listed in Issues #50 to #54:

50	Vibration	The belief that the noise source also causes vibrations increases annoyance
51	Health	The belief that the noise source affects health increases annoyance
52	Air pollution	The belief that the noise source's fumes or dirt pollute the air increases annoyance
53	Activity disturbance	The belief that the noise interferes with daily activities (speech, concentration, listening, etc.) increases annoyance
54	Sleep	The belief that the noise interferes with sleep increases annoyance

Early social surveys created noise annoyance indices by summing the answers to questions about levels of disturbance or concern about these types of perceived impacts. However, this practice is almost never followed now since a general noise annoyance question provides a clearer, more direct measure of respondents' assessments. All of these topics have been reported upon in the noise literature, but no summary report has tabulated whether or not these perceived impacts are always related to annoyance. There does not appear to be a reason to believe that including these questions in a new national survey would strongly support the goals of the study. These are subjective, not objective, indicators of impact. In the absence of other evidence it is not even clear whether general noise annoyance influences assessments of these correlated impacts or whether, as is generally presumed, perceptions of these impacts cause general noise annoyance. Of course the sleep issue is being addressed in other ACRP studies with stronger methods. Perception of vibration could explain the linkage between the levels of vibration and noise annoyance, but in the absence of an accurate vibration estimation protocol, this national survey would not be expected to make an important contribution to understanding the effect of vibration.

Topic I: Complaints and public actions

The new national survey and previous noise surveys study the annoyance that people feel but may never share with others except in social surveys. This is accepted by the scientific community as the most accurate assessment of the feelings of residential populations toward noise. This private annoyance attitude measured in social surveys can be contrasted to actions that are expressed in public and directed at officials or other representatives of a noise source. The most frequent type of public action is individual complaints that are lodged with officials. Many airports have hot lines where complaints can be lodged. Stronger public actions include letters to newspapers, signing of petitions, attending meetings, meeting with officials, and lawsuits. Unlike expensive, infrequent social surveys, complaints and public actions are readily accessible to public officials and often demand their attention within the political system.

A key question for public officials is whether the information that is readily available in public actions provides good information about the general impact of noise as measured by annoyance in social surveys. This question is addressed in three issues: the relationship between action (primarily complaints) and annoyance in communities, the variables which are correlated with complaint rates, and the demographic characteristics of complainants. Individual complaints rather than other types of public actions are most often studied because complaint actions are more frequent and more easily studied. Analyses have not been reported that used meta-analyses or other techniques to provide a quantitative summary of the evidence on these issues. In addition there is no evidence that extensive searches were conducted based on a results-neutral search strategy.

Issue #55: Complaint rate: annoyance

It is widely acknowledged that complaint rates substantially underestimate the amount of annoyance in a population. For example, a recent study around Schiphol airport found that only 19% of the highly annoyed respondents reported having complained to authorities (van Wiechen, Franssen, de Jong, and Lebret, 2002). Accepting the undercounting of annoyance on the basis of complaints, the question still remains as to whether the relative intensity of complaints in different communities is an adequate indicator of the relative levels of impact and annoyance in those communities. The same Schiphol study concluded that “Although complainants do not seem to be representative for the total population, and do not reflect the full extent of noise annoyance, their prevalence does reflect the regional distribution of aircraft noise annoyance in a noise polluted area” (van Wiechen, Franssen, de Jong, and Lebret, 2002). Given some of the correlates noted below, however, there are reasons for thinking that complaint rates may not reflect annoyance differences between areas.

Issue #56: Complaint rates: other correlates

The primary question is: What characteristics of local areas and events are correlated with complaint rates? The implicit related question is whether these characteristics also are correlated with annoyance. At least one publication about telephone complaints in Australia has shown that complaint rates can misrepresent the relative importance of different sources of noise pollution (Avery, 1982). The social survey found that road traffic and aircraft noise were the biggest problems and were more than twice as likely as construction or industry to be a problem. The telephone complaint rates provided a diametrically opposed indicator; construction and industry were the biggest problems and were mentioned four times more often than road traffic or aircraft noise. Complaint analyses now regularly consider details that have sometimes been neglected in the past such as the effects that a few serial complainers can have on complaint rates. None-the-less the underlying concern remains that complaint rates may not be a good indicator of annoyance because of other factors that turn annoyance into complaints in some circumstances but not in others. Examples of such factors are knowledge about how to make complaints, the belief that a complaint will be noticed by authorities, and confidence that a complaint can lead to change.

Authorities often report that complaint rates increase when a change in noise exposure is proposed or occurs and when aircraft noise complaint hot lines are opened. A related question is whether the characteristics that lead to high levels of complaints are similarly correlated with private annoyance. It is widely acknowledged that plans for changes in airports create large numbers of complaints. For example, when complaint data from Manchester Airport since 1991 were examined, the annual number of complaints peaked in 1996 when the 'Manchester Airport Second Runway Public Inquiry' was a major local issue. But even though the number of flights increased since 1996 the number of complaints steadily fell from 50 to13 complaints per 1,000 movements from 1996 to 1999 (Hume, Terranova, and Thomas, 2002). An analysis of changes in complaint rates before and after a new runway opened in 2001 at Manchester Airport found that the complaint patterns followed the new traffic patterns (Hume, Morley, Sutcliffe, Smith, and Thomas, 2005. These striking patterns of reactions to changes and planned changes are in sharp contrast to the findings for the effects of changes in noise levels on annoyance where the evidence is sufficiently uncertain that a much weaker effect, if any, is likely (Brown and van Kamp, 2009).

Issue #57: Characteristics of complainants

Many discussions of community noise impact accept the hypothesis that complainants' characteristics are representative of the annoyed residents generally. For example, if public officials hold meetings and find that most of those complaining about aircraft noise are well educated, articulate residents, it is easy to conclude that annoyance is also concentrated among highly educated residents. Though no summary analyses have been published on this issue, the issue has been addressed by analyzing social surveys by comparing the characteristics of respondents who do complain with respondents who do not report having taken part in complaints or other public actions. At least two studies augmented their standard population sample with a sample of complainants and found considerable differences in their demographic characteristics. A 1960's survey in England found complainants are different than other residents at the same annoyance level in having more education, being of a higher occupation class, owning more expensive houses, participating at a higher rate in some type of organization that sought to make changes in the local area, having stronger preventability attitudes, but not being more sensitive to noise generally (UKD-008) (McKennell, 1963). A survey of aircraft noise in New York also found that complainants were more highly educated, had higher incomes, were more critical of airport operations, but were not more sensitive to noise (Tracor Inc., 1971).

A more recent study around Manchester Airport in England is characteristic of the types of studies that are easily conducted with only complaint data (Morley and Hume, 2003). The postal codes for complaints were used to determine the average socio-economic status in the complainants' postal codes. It was found that the complainants' postal codes were inhabited by residents in the highest socio-economic category who had higher house prices, and were more likely to own more than one car. This is a classic case of the well-known ecological fallacy when a correlation observed at the population level is assumed to apply at the individual level (Robinson, 1950). More accurate information about the effect of demographic characteristics on complaints comes from the demographic characteristics of complainants and non-complainants than from comparisons of the average of the characteristics of all residents of geographical areas.

Topic J: Other issues

Issue #58: Self-selection through moving away

It is often hypothesized that high noise areas contain a self-selected population, at least partly, because those who are most annoyed have moved out of the area. The tabulation of findings in Table 18 shows that most of the seven findings did not support this hypothesis. The available evidence does not support the selective-moving hypothesis. A secondary analysis of 28 studies (N=10,939 respondents) found that higher noise levels do not tend to be populated by more sensitive residents; if anything there is a weak relationship in the opposite direction (Miedema and Vos, 2003). There could, of course, be other mechanisms that would create an especially noise-resistant population at high noise levels, but the absence of strong relations between noise sensitivity and noise level suggests that any such mechanisms are weak. It seems likely that moving may be so difficult and expensive that moving is almost entirely determined by other factors. Noise sensitivity may have little effect on the choices of new residences if prospective tenants are unaware of noise levels, or are unable to predict their long-term reactions, have few realistic choices or are mainly affected by other factors such as price, unit size, distance to place-of-work, or other (non-sensitive) household members' preferences.

Issue #59: Long-term annoyance trends

In the last ten years at least six publications have examined a hypothesized long-term increase in the dose-response relationship such that the average annoyance response at given noise levels is higher than it was several decades ago (Guski, 2004 Breugelmans, van Wiechen, van Kempen, Heisterkamp, and Houthuijs, 2004;Brooker, 2009;van Kempen and van Kamp, 2005;Wirth and Bröer, 2004). The results of the most recent and comprehensive review are summarized in the secondary analysis for Issue 59 in Table 18 (Janssen, Vos, van Kempen, Breugelmans, and Miedema, 2011). The summary analysis is based on 22 studies of 34 airports that were conducted over the 39 years from 1967 to 2005 and finds that recent social surveys provide higher annoyance responses than earlier surveys. However, it is not clear whether this is due to methodological factors, the locations studied, or to genuine changes in annoyance. Methodological factors could be especially important for this secondary analysis because the evidence comes from contrasts only between surveys (22) and cities (34) not from contrasts between respondents within surveys. For example, the secondary analysis of the effect of education contains both high and low education respondents from each survey. For the present change-over-time hypothesis, however the comparison is solely between surveys, many of which had different annoyance questions, different modes of survey administration, and were conducted in different countries at different locations.

Though the recent review ruled out the number of annoyance scale points as an explanation for the increased annoyance, it was concluded that the trend might, at least partly, be explained by correlated trends in decreasing response rates and the use of self-administered surveys rather than interviewer-administered surveys. In addition, the surveys were drawn from different regions. All of the pre-1984 surveys (the first 18 years) were conducted in four English language countries (only one of which was European) and while all of the post 1984 surveys were conducted in northern European, non-English speaking countries. In the eleven years from 1985 through 1995, all three studies were conducted in Norway (from 1989 to 1992). Additional doubt about increased annoyance levels comes from the finding that there was not a corresponding trend in reported sensitivity to noise generally. ***Analyses that compare reactions at the same airports using similar survey methods but at different times would provide much stronger evidence. The national US study could do this by replicating a coordinated study at 9 airports that were studied around 1970(Connor and Patterson, 1972;Patterson and Connor, 1973;Tracor Inc., 1971) or by replicating some of the smaller studies that have been conducted at these and other airport since then (Fidell, Mestre, Schomer, Berry, Gjestland, Vallet, and Reid, 2011).***

Issue #60, #61: Survey Administration

Telephone vs. face-to-face administered questionnaires: and (#61) Self-administered vs. interviewer-administered questionnaires.

These two issues must be evaluated if the results of the proposed national survey are to be compared to previous surveys that used different modes of administration. Three modes of survey administration are most likely to be applicable for the national study:

1. Self-administered mail: A questionnaire that is mailed to a household which requests that an unnamed but uniquely-identified household member complete the survey.

2. Interviewer-administered – Telephone: An interviewer telephones a household, selects the respondent following standard procedures and reads the questionnaire.

3. Interviewer-administered- Face-to-face: An interviewer visits a household, selects the respondent following standard procedures and reads the questionnaire.

A variety of other steps can be used to increase response rates and identify respondents, but these three examples provide a framework for considering the implications and limitations of previous noise annoyance survey research.

Noise annoyance surveys have been regularly conducted since the 1950's. Most studies have been conducted as face-to-face interview surveys. Telephone surveys have been infrequently used, perhaps because telephone surveys would not realize sufficient costs savings for these surveys, almost all of which were conducted in a single city and, within that city, within a limited number of compact neighborhoods or blocks where residents had almost identical noise environments from a transportation noise source. More recently, however, self-completion surveys have come to be more widely used. Most are mail surveys, but in some countries, most notably Japan, many are drop-off/pick-up surveys where the blank questionnaires are left at a home (with or without personal contact) and the completed questionnaires are then picked up later. Face-to-face interviews are exceedingly expensive and thus there are strong economic reasons for considering alternatives to an interview for the national study.

Interviewer-administered telephone questionnaires have been compared to face-to-face questionnaires in at least the four studies that are summarized in Table 18. In these four US studies conducted before 1980 both modes were used in each study, the same annoyance question was asked in each mode, and noise levels were controlled in the analysis. None of the four studies found important differences in the answers to annoyance questions between the telephone and face-to-face questionnaires. This evidence thus suggests that the two modes will yield results that are not strikingly different. None of these trials were reported upon in sufficient detail to provide firm estimates of the precision of their results. In addition, most were conducted as part of the main study at a point when a finding of survey mode differences would have cast doubts upon the value of the study.

The first report on the comparison of a self-administered mail questionnaire to a telephone questionnaire found a very large difference in annoyance responses. For this 1996 Netherlands study (NET-371) the original mail survey estimate of 18% highly annoyed residents around Schiphol was revised to an estimate of 31% highly annoyed to make the results comparable to previous interviewer-administered studies. At the highest noise levels the highly annoyed estimate was increased from 48% to 65% (Franssen, Lebret, and Staatsen, 1999; Page 18). For this study it was not clear what characteristics of the two survey administration modes created the difference. As for many self-administered surveys this mail survey differed from an interviewer-administered survey in that the mail survey less tightly controlled the within-household respondent selection, informed respondents about the survey purpose before they decided to participate, obtained a low response rate, and informed respondents about the survey purpose before they answered the aircraft noise annoyance question. In addition the mail questionnaire was used in the main study whereas the interviewer-administered telephone survey was directed at only the nonresponse households.

Though the mail and telephone survey contained the same noise annoyance question, that annoyance question was preceded by different questions in the two surveys. A Dutch researcher familiar with the survey could not offer a firm judgment on whether or not mail respondents were likely to have followed the preferred within household selection instructions (personal communication with Sabine Janssen). The questionnaire itself did not specify the respondent while the cover letter contained only the statement in the middle of one paragraph that "We would greatly appreciate it if the person from your household…" with the nearest birthday "… would fill in the questionnaire"" (English translation by Sabine Janssen).

Some other studies and reports point to possible differences between survey modes but find small or no mode effects. The statistical analyses from the most comprehensive secondary analysis of annoyance trends over decades of noise/annoyance surveys found that the shift from interviewer-administered to self-administered surveys was a possible explanation for an increase in noise/annoyance ratings (Janssen, Vos, van Kempen, Breugelmans, and Miedema, 2011). This was not, however, a tightly-controlled survey-mode comparison since the surveys were conducted in different countries with different noise/annoyance questions and other aspects of survey administration, including respondent selection procedures, were not considered in the analysis. A Japanese study (JPN-616) that compared web, mail and interviewer-administered surveys found a weak trend toward higher annoyance responses for the mail survey but not for the web survey (Yamada, Kaku, Yokota, Namba, and Ogata, 2008; Figure 4). The respondent selection methods for the mail and interview survey were not reported.

Three studies that sampled named individuals did not find a differences between the mail-administered and interviewer-administered questionnaires used in their studies. Their study designs or analyses, however, may limit their relevance for a national USA study. A 1977 UK morning-after, sleep disturbance study (UKD-147) asked for ratings of the prior night, but did not have detailed noise data available at the time of the report (Directorate of Operational Research and Analysis, 1978). A 1999 UK study around 5 airports (UKD-482, UKD-489) found no differences in annoyance responses between the postal and interviewer-administered results even though the response rate from the mail survey was so low that the resulting small number of mail surveys were not used in the analysis. However, the report did not directly control for noise level in the analysis (Diamond et al., 2000). A strongly designed test in a 2003 Swiss survey (SWI-534) of named individuals which used identical questionnaires for two modes found "…no evidence for an effect of survey method (questionnaire versus telephone interviews) on annoyance…" (Brink, Wirth, Schierz, Thomann, and Bauer, 2008; Pages 2932-2933). However the report did not indicate that the dose-response relationship was directly evaluated. The applicability of the results is limited because the sample was predominantly drawn from low or moderate noise exposure areas - only 18% of the sample was above 57 Lden.

One of the most often cited concerns about noise/annoyance surveys is that respondents will give biased, overly annoyed answers if they know that the primary purpose and goal of the questionnaire is to provide authorities with residents' evaluations of a noise source in their neighborhood. As a result, most questionnaires are presented with a vague purpose such as "a study of living conditions" and the primary noise-specific annoyance question is included early in the questionnaire within matrices of questions about other environmental and noise conditions in the local area. With a mail survey it is not possible to conceal the purpose because a brief perusal of the questionnaire before it is answered reveals that most questions are about local aircraft noise issues. The possibility of such biases has been studied in at least three carefully designed interviewer-administered surveys, all of which were conducted in Great Britain in the 1970's (UKD-071, UKD-116, UKD—157). All three studies used two questionnaire forms that varied in when (early or late in the questionnaire) the interviewer read the noise annoyance question. All three studies found that asking the question after the purpose had been revealed did not result in higher annoyance ratings (Garnsworthy, 1977; Langdon, 1976b; Griffiths, Langdon, and Swan, 1980). Less tightly designed comparisons in the pilot stages for a UK aircraft survey in 2005 (UKD-605) found that respondents whose interviews were preceded by ratings of aircraft noise acoustical recordings expressed no greater annoyance than did respondents who did not know that the survey was about aircraft noise when the survey began.

This review of survey-mode effects has not explored all the relevant differences between the studies that could be hypothesized to affect the studies' results. The evidence seems to suggest that if biases occur they are most likely to derive from some aspect of the respondent self-selection process (including nonresponse) rather than from the specified respondents' responses being distorted by their knowledge of the survey's purpose. With respect to within-household respondent selection, it appears to be possible that knowledge of the survey subject will result in either less annoyed households not returning a questionnaire or the most annoyed member of a household answering a questionnaire if the questionnaire does not name the sample member.

One goal of pilot studies for a new national US survey could be to determine whether there are survey mode effects under the tightest feasible respondent selection procedures. The results from such pilot studies should aid in the selection of the survey mode for this study and provide a basis for comparing this survey's results with the results of prior US and European surveys that have been conducted using different modes. Although the evidence reviewed above from previous, primarily non-US, surveys is helpful; information from new US pilot surveys is needed to draw firm conclusions. Populations in different countries could react differently to survey instructions and procedures. Experience from previous surveys may no longer be relevant if recent changes in the populations' behavior, such as falling response rates, have modified the effect of survey mode on noise annoyance survey answers. Noise annoyance may also be a survey topic for which general professional experience with survey mode differences is not decisive. Strong within-household differences in annoyance reactions and interest in the local noise issues could bias within household selection more than for other survey topics.

Issue #62: Relevant exposure period

Noise annoyance survey questions generally ask for long-term annoyance either by vaguely asking about "annoyance around here" or by specifying a time period such as "this last year". The hypothesis is then that respondents provide an assessment of their annoyance with the aircraft heard over the entire period. Brooker has argued that some data indicate that respondents actually consider only a shorter period of roughly three months (Brooker, 2008). The earlier evidence for a seasonal effect (Issue 24) also suggests that annoyance may be affected more by recent experiences than by long-term experiences. The exposure period is likely to not be relevant for the new national study because aircraft movements do not often change over a year. None-the-less the detailed data about aircraft movements available for a new national survey will make it possible to determine whether the study results could be sensitive to different assumptions about the relevant exposure period.

Frameworks for assessing authorities' actions

As was noted earlier in this review, the proposed national survey with a large number of airports will provide a unique opportunity to explore the ways in which annoyance reactions are affected by airport characteristics. One of the most potentially important, but most often ignored, characteristics is the official policy environment set by airport authorities and other public institutions. For airport operators a major issue is whether their actions can reduce public complaints and residents' noise annoyance. Most airports are concerned about how their actions might affect the public's actions against an airport. Though airport authorities often have community relations programs and monitor the complaints and other public responses to the airport, they are not able to measure the impact of their particular programs on the residents' annoyance. As a result one of the goals of this literature review has been to identify research on the relationship between authorities' activities and residents' annoyance.

A major source of information on authorities' actions is a 2006 report by Ruud Vader (Vader, 2007). After searching the available literature and after listing 50 non-acoustic mitigation measures, Vader concluded that there was: 1) not a satisfactory theoretical scheme for classifying mitigation measures and 2) virtually no empirical research on the relationship between authorities' activities and residents' annoyance. Another major source of information is an ACRP publication; an airport operator's handbook for creating good community relations which is based on community relations research (Woodward, Friscoe, and Dunholter, 2009). Some recent publications by Kroesen, Bröer and their colleagues have provided a theoretical perspective for addressing one aspect of the public discourse/ private annoyance relationship (Kroesen and Bröer, 2009). They propose that dominant public discourse frameworks and individual community members' frameworks influence each other and affect the amount of conflict. However, this does not provide a comprehensive perspective for clearly integrating noise-mitigation activities. Their approach does not appear to offer a useful hypothesis for a new national survey.

Case studies have examined the acoustical and non-acoustical noise impact mitigation measures and the public's actions. There are not, however, studies that correlate these aircraft noise mitigation activities with the noise annoyance expressed by representative samples of airport community residents. While there is an extensive community relations literature, no research protocols have been located that the planned US survey could use to systematically and objectively rate the quality of authorities' noise-mitigation programs. The descriptions and inventories of existing programs and the guidance for designing noise impact mitigation programs do, however, provide the background material that could be used to begin to develop such a protocol

Various typologies of noise-mitigation strategies have been developed. Stallen has classified the strategies by whether they require accommodations from the aviation sector or from the social environment (Vader, 2007). After examining the components of 50 noise mitigation programs Vader classified the components into eight categories: Community Programs, Compensation, Consultation, Financial, Information, Insulation, Land use and Property (Vader, 2007). These classification schemes do not provide a satisfactory theoretical scheme for predicting the impact of noise-mitigation schemes on residents' annoyance. The lack of such a theoretical perspective for organizing the large number of disparate types of authorities' activities is a major challenge for designing hypotheses that can be tested in the new US survey.

This section attempts to provide some structure for this area by:

1. Listing types of aircraft noise mitigation activities that authorities can institute.
2. Listing some characteristics of community relations programs that have been hypothesized to promote good airport/community relations and thus to reduce annoyance.

Authorities can attempt to mitigate the impact of aircraft operations through a wide range of acoustical and non-acoustical activities. Many publications have described particular airports' activities. An especially complete description of acoustic and non-acoustic mitigation activities is available for Heathrow (Flindell and Witter, 1999). The search through the literature has identified many different mitigation activities. The FAA has provided guidance on noise mitigation through the Community Involvement Manual (Willkie, Madgwick, Sweatt, Frievson, and Carlton, 1990) since 1990 and an updated publication (Woodward, Friscoe, and Dunholter, 2009) both of which describe mitigation strategies.

No publication has been located with a clear theoretical framework for rating activities by their presumed effectiveness in reducing personal annoyance with aircraft noise. For acoustical mitigation procedures, the mitigation might be measured in decibels of exposure reduced by the program for specific neighborhoods or airports. Such a purely acoustical measure raises the issue discussed under Issue 22 about publicity and residents' knowledge and perception of the acoustical mitigation. For non-acoustical mitigation procedures it would be possible to rate community relations programs by features such as the resources expended, numbers of residents contacted, duration of the community relations efforts, or the number of different types of strategies pursued to communicate with residents. However, none of these are closely tied to a perspective that would predict the impact on annoyance. An alternative approach, to be discussed later in this section, is to rate programs by the extent to which they follow particular community relations principles. A necessary part of a framework for predicting impact is a list of acoustical and non-acoustical mitigation activities. Table 19 provides an outline of selected mitigation activities which, though not complete, indicates the scope of such activities.

Table 19 Outline of Selected Aircraft Noise Mitigation Activities

A. Acoustical mitigation (Controlling the aircraft noise)
  1 Emission mitigation (Controlling the total amount of aircraft noise)
    a. Regulating the type of aircraft (Moving airlines toward the use of relatively quiet aircraft through fee structures, fines, or outright prohibitions)
    b. Controlling the number of flights (Limiting the total number of flights for the airport as a whole or at different times of day often through allocations of movement slots, impositions of fines or outright curfews)
    c. Regulating aircraft operations to reduce noise emissions (Encouraging operators to fly aircraft in a manner that reduces their noise emissions through setting goals, monitoring, delivering warnings, assessing fines, etc.)
  2 Immission mitigation (Controlling the noise for individuals on the ground)
    a. Acoustical insulation of homes
    b. Purchasing property (Removing residents from impacted areas)
    c. Land use planning (Restricting the location of residences and other types of noise-sensitive land uses.)
  3 Operational modification (Controlling aircraft flights while not necessarily affecting the types or total number of aircraft movements.)
    a. Locations of flight paths
      i. Routing flights away from densely populated or other sensitive areas
      ii. Concentrating flights over a relatively small number of areas to create areas that are not impacted
      iii. Dispersing flights over many areas to equitably distribute the impact over the affected population
    b. Modifying flight profiles (Changing ascent or descent profiles to reduce exposure in some areas)
      i. Creating steeper profiles that concentrate noise near the airport while reducing it at more distant locations)
      ii. Creating shallower profiles that reduce noise near the airport while exposing a larger area at more distant locations
      iii. Other standardizations of profiles (e.g., creating regular, predictable aircraft noise emissions at particular locations)
    c. Varying flight paths over time (Creating breaks or quiet periods in areas that are otherwise exposed to aircraft noise.)
    d. Modifying ground-based aircraft operations

B. Non-acoustic noise annoyance mitigation activities
  1. Having a specially qualified staff member who manages community relations programs
  2. Supporting an ongoing, routine community advisory committee or other liaison group
  3. Regularly communicating with the community about airport developments through issuing press releases, holding public meetings, or attending other community meetings where airport noise might be discussed, ,
  4. Complaint monitoring (Processing information about individuals' complaints about aircraft noise)
  5. Compensating residents for exposure to aircraft noises

For the non-acoustic noise annoyance mitigation activities and to a lesser extent for the acoustic mitigations, the important community-relations aspects of the programs may be less the types of activities than the characteristics of the relationships that are developed between the airport authorities and the airport communities. Several publications list characteristics which are presumed to contribute to reductions in aircraft noise impact (Vader, 2007; Vogt and Kastner, 2000; Woodward, Friscoe, and Dunholter, 2009). Some previous research has identified specific characteristics that residents 'desire. For example, a survey around Düsseldorf International Airport and Dortmund Regional Airport, found that an open, personal and honest information exchange was the most mentioned desire of the residents (Vogt and Kastner, 2000). Such an exchange was ranked even more highly than acoustical noise abatement procedures.

The most comprehensive and relevant framework for the proposed US national study is provided by the previously-mentioned ACRP supported community relations guidebook (Woodward, Friscoe, and Dunholter, 2009). The handbook identifies both the practices that authorities should follow and the outcomes that are desired and thus provides the basis for developing a protocol to rate authorities on the quality of their community relations' programs. The handbook presents six "best practices". In the first two columns of Table 20 these practices are divided into component parts and augmented by practices identified elsewhere to suggest nine distinct practices.

Table 20 Best practices for community relations programs

#	Label	Practice	Indicators of success: **Authorities**	Indicators of success: **Community Members**
1	Establish two-way communication	Engage in two-way communication with the public (not just education, but listening)	Airport officials believe that the public offers ideas that should be considered	Community members believe that airport officials listen to and understand their views
2	Build trust	Build trust through two-way interactions with the public	Airport authorities trust representatives of the public with whom they regularly interact	Community members trust airport authorities
3	Build respect	Build respect through two-way interactions with the public	Airport authorities respect the views of representatives of the public with whom they regularly interact	Community members respect the views of airport authorities
4	Senior airport leadership out front	Senior airport leadership are present and involved in interactions with the public	Senior airport leaders attend airport/community interactions	Community members believe that senior airport leaders are attentive to community issues
5	Use of graphics	Graphics are used to illustrate and explain complex information	Graphics are included in airport presentations to improve communication	Community members feel they understand airport communications
6	Transparent planning process	Members of the public are kept informed about the planning process and issues	Airport officials inform the public as soon as possible about developments in a planning process and share information about the costs and benefits of alternative plans	Community members believe that they are kept informed about the planning process
7	People skills among staff	Noise staff members have a public service attitude and people skills	Staff selection criterion include public relations skills	Community members feel that airport staff are easy to communicate with
8	Communicate about long-term, future issues	The public is engaged in considering issues that may develop far in the future	Airport communications alert the public to possible changes in the far future	Community members feel that they are aware of future issues
9	Include the public in decisions	Include the public when making decisions	Airport officials include members of the public in discussions before decisions are made	Community members feel officials understood the issues and consider the community's views before airport decisions were made

At least two approaches could be taken to rate the quality of community relations programs:

1) The airports' documents and practices could be examined to determine the extent to which the best practices are being followed (indicators are listed in the third column of Table 20), or

2) The airport authorities and relevant involved community activists could be interviewed to determine whether the desired types of airport/community relationships had been established. The last column of Table 20 lists the types of community members' perceptions that would show that the community relations program was successful.

A 55-question questionnaire is included in the community relations handbook (Woodward, Friscoe, and Dunholter, 2009) that provides more detailed measures of the implementation of best practices than those proposed in the third column of Table 20. If rating of the community relations' programs were obtained from either program examinations or citizen/activist surveys, the next steps would be to determine whether the rating of the quality of the community relations program is related to the two goals of: 1) operating the airport and planning for future airport changes with a minimum of adversarial public resistance and 2) reducing noise annoyance levels among community residents. Although a number of publications have mentioned the possibility of assessing annoyance (Flindell and Witter, 1999; Woodward, Friscoe, and Dunholter, 2009), no studies have been located that correlated the quality of a community relation program with annoyance responses of the residents. Though various case studies have analyzed the place of an airport's community relations programs within-airport/community conflict situations, no studies have been located which attempt to trace the long-term effects of community relations programs on airport plans for expansion or development.

The planned US survey could provide insight into the effects of aircraft noise mitigation programs by tracing the chain of causation from:

Step #1) characteristics of the airport authorities' community relations program [Table 20***: Practices] TO***

Step #2) measured characteristics of the relations between airport officials and involved community activists [Table 20***: Indicators of success] TO***

Step #3) less involved community residents' perceptions of airport authorities actions and policies (Table 17***, Issue 28, Preventability and Topic E: Attitudes toward authorities), TO***

Step #4) those community residents' annoyance with aircraft noise.

Summary: Considerations for Studying Each Issue

This section summarizes the conclusions from the literature review with respect to the data collection for the annoyance survey. Related suggestions are based on the assumption that the primary goal is to provide a best estimate of the bivariate relationship between aircraft noise exposure and the annoyance of residents for the nation as a whole. A major secondary goal is to determine the extent to which dose-response relationships are uniform or different in different geographically-defined areas and, to the extent that areas differ, to identify factors that explain these differences. These goals guided the discussion of the questionnaire design and other data gathering activities in the text above. Table 21, below, summarizes this discussion by presenting suggestions for the 62 issues from Table 17. Some of these suggestions require data that are not available from the respondent questionnaire or aircraft noise models. Table 22 further summarizes the ancillary data collections that would be needed to address the issues.

The first columns of Table 22 repeat the issue number, issue, and hypothesis from Table 17. The following column, "Include to: Contribute? Control?", contains a "NO" if the subject is not suggested for the new study and either "Contribute" or "Control" if the topic is considered. "Contribute" indicates that the reason for studying the issue is to obtain important new findings about noise annoyance. "Control" indicates that the issue must be studied (sometimes with a single question in the questionnaire) in order to control for the effect of the variable in the analysis. For “Control” issues it is expected that no new findings will emerge, but that the study results might not be accepted unless there was evidence that the results were unbiased by the “control” variables.

The following column, “Questionnaire Items” provides a broad indication of how many questionnaire items, if any, might need to be added for the issue. The next column, “Require ancillary data” indicates whether data are needed from a source other than the resident questionnaire or the aircraft noise model data. The “Cost of Studying” column gives a very general idea of whether the cost for including each issue will be “High”, Moderate” or “Low”. Finally, the “Comments” column mentions a few factors to consider in a decision about including an issue in a new study. Of course, a more complete discussion of these and other factors has been given above in the body of the report.

Table 21 Summary of Considerations for Studying Each Issue

Issue #	Issue	Hypothesis[a]	Include to: Contribute?, Control?	Questionnaire item(s)?	Require ancillary data?	Cost of studying	Comments
A. Effects of demographic characteristics							
1	Gender	Women are more annoyed	Control	1	No	Low	
2	Age - (Older age)	Older age increases annoyance	- See Issue 3 -	- -	- -	- -	
3	Age - (Middle age)	Middle age increases annoyance	Control	1	No	Low	Ask for date of birth.
4	Education	High education increases annoyance	Control	1	No	Low	
5	Status-occupation	High status increases annoyance	NO	- -	- -	- -	Occupation is too expensive to obtain and code.
6	Income	High income increases annoyance	Control	?	?	?	Either include an income question or, if outside records are available, the value of the property.
7	Household size	Mid-sized households (2 or 3 members) increase annoyance	Control	1	No	Low	
8	Length of residence	Long-term residence decreases annoyance	Control	1	No	Low	
9	Home ownership	Home ownership decreases annoyance	Control	1	No	Low	
10	Dwelling unit type	Residents of single unit dwellings are more annoyed	Control	1	No	Low	
11	Usage of noise source	Use of the transportation noise source decreases annoyance	Control	1	No	Low	
12	Economic connection	Economic dependence on the noise source decreases annoyance	Control	2+	No	Low	May want more than one question. Must consider other members of the household.
13	Country/culture	People from different cultures and countries differ in noise/annoyance reactions	NO	- -	- -	- -	Do not expect enough minorities; Is not in literature; Has little value for policy.
B. Effects of home conditions that modify exposure							
14	Time at home	Residents spending more time at home are more annoyed	Control	1	No	Low	
15	Exposure individualized - (sum below: out-of-doors , attenuation, orientation, season)	Individuals with relatively less exposure are less annoyed	See Issues 16 - 18	- -	- -	- -	
16	Out-of-doors usage	Residents who spend more time out-of-doors are more annoyed	Control	1	No	Low	
17	House attenuation	Greater outside-to-inside transmission loss decreases annoyance	Control or contribute	?	?	?	If transmission loss were accurately predicted the study would contribute to knowledge.
18	Room orientation	Quiet 'escape' rooms decrease annoyance	NO	- -	- -	- -	Not relevant for aircraft.
C: Effects of local community conditions							

Issue #	Issue	Hypothesis[a]	Include to: Contribute?, Control?	Questionnaire item(s)?	Require ancillary data?	Cost of studying	Comments
19	Community differences	Airports and communities differ in annoyance responses	Contribute	?	Yes	High	Understanding community differences requires (1) special sample design (2) data about community.
20	Ambient noise levels	Low-ambient noise levels increase annoyance	Control	1	Yes	Low/Moderate	Might predict traffic noise from maps or other source. Probably need questions on other traffic and other noise to corroborate.
21	Sparsely settled areas	Rural or 'peaceful' suburban environments increase annoyance	Control	1	?	Moderate	Could ask respondent about distance to other houses or about whether rural or farm area.
22	Media coverage	Positive or negative media coverage of the noise source creates corresponding annoyance reactions	Contribute	2+	Yes	High	Need content analysis of local media records to identify publicity.
23	Activist community	Politically active communities increase annoyed	Contribute	1	Yes	High	Need a source (experts or media) to rate the activism of the communities.
24	Meteorological conditions	Comfortable weather (average climate or date-of-interview weather) increases annoyance	Control	0	Yes	Moderate	Need temperature and other meteorological data for recent days, months and long-term.
D. Effects of attitudes - general							
25	Fear/Danger	Fear of danger from a noise source increases annoyance	Contribute	2+	No (Only flight tracks)	Moderate	Additional questionnaire items could clarify the relevance of the flight path position.
26	Sensitivity	General sensitivity with noise increases annoyance	Control	1	No	Low	
27	Importance of source	Belief in the importance of the noise source decreases annoyance	Control	1	No	Low	The wording of the question needs to consider attitudes toward authorities.
28	Preventability by authorities	Belief that authorities could reduce noise increases annoyance	Contribute (Issues 31-35)	2+	No	Low	Preventability questions should be coordinated with other attitudes toward authorities.
29	Exposure control - individual	Belief that the resident can control or avoid noise exposure decreases annoyance	NO	2+	No	High	Time and pretesting is required to develop items. These are not related to the study goal.
30	Expectations for future exposure	Expecting an increase in noise exposure increases annoyance	Control	1	No	Low	A questionnaire item is available (Fields, Ehrlich, and Zador 2000).
E. Effects of attitudes toward authorities							
31	Transparency of process	The perception that authorities develop policy transparently and provide relevant information decreases annoyance	Contribute	1	Yes	High	Linking Issues 31-35 with community relations program characteristics requires a survey of authorities.

Issue #	Issue	Hypothesis[a]	Include to: Contribute?, Control?	Questionnaire item(s)?	Require ancillary data?	Cost of studying	Comments
32	Fairness of procedures	The perception that authorities follow procedures in a fair manner decreases annoyance	Contribute	1	Yes	High	(See Issue 31)
33	Trust	The perception that authorities can be trusted decreases annoyance	Contribute	1	Yes	High	(See Issue 31)
34	Understanding of residents' concerns	The perception that authorities understand or are concerned about residents decreases annoyance	Contribute	1	Yes	High	(See Issue 31)
35	Residents can affect policy	The perception that authorities' actions are influenced by residents' views decreases annoyance	Contribute	1	Yes	High	(See Issue 31)
F. Effect of aircraft operations							
36	Distance to flight path	Being under a flight path increases annoyance	Contribute	0	No (Only flight tracks)	Low	See discussion for Issue 25: Fear.
37	Landing operations	Exposure to landing operations increases annoyance	Contribute	1	No (Only flight tracks)	Low	A question might be asked about awareness of types of actions.
38	Ground operations	Noise from ground operations (including start of take-off noise) increases annoyance beyond the levels expected from airborne operations	Control	1	No (only if try to contribute)	Low (High if try to contribute)	Could ask a single question about awareness, but is probably too expensive to satisfactorily estimate noise exposure.
39	Airport size	Small airports create greater annoyance (adjusted for noise exposure)	Control	0	No	Low	The numbers of flights are known and would be expected to control for airport size effects. Airport annual movements are available. No general aviation airports will be studied.
40	Predictable noise profile	A regular, predictable noise event profile decreases annoyance	Contribute	1?	Yes	Uncertain	A question will ask about predictability. It is not yet certain if analyses of flight data would measure the predictability of time-histories.
41	Vibration	Vibration of structures or rattles increase annoyance	Control	2	- -	- -	Questions can document vibration and rattle annoyance but with contributing to knowledge or controlling for vibration effects because it is not possible to predict exposure.
42	Non-noise (other)	Lights, odors, or other non-noise impacts increase noise annoyance	NO	- -	- -	- -	Exclude because this seems to be rare for aircraft noise, not an issue, and no observation data would be available.

Issue #	Issue	Hypothesis[a]	Include to: Contribute?, Control?	Questionnaire item(s)?	Require ancillary data?	Cost of studying	Comments
43	Change-Immediate impact	Residents overreact to changes in noise exposure (either increase or decrease)	Control	1	Yes	Moderate/ High	Aircraft noise exposure is needed for each of 5-10 previous years for each residence. A survey question would demonstrate that many people believe noise is increasing regardless of exposure changes. Probably could not contribute because not enough changed environments.
44	Change-Long-term adaptation	With time, annoyance with a changed noise exposure decreases	Control	See Issue 43	See Issue 43	See Issue 43	(See previous.)
G. Authorities= actions and activities							
45	Operator noise abatement actions	Officials' programs to control noise decrease annoyance beyond levels expected from exposure	Contribute	2+	Yes	High	Official records may have some information. Otherwise interviews with officials are required as for Issue 31. Also need resident questions about awareness of actions or programs.
46	Community relations programs	Strong community relations programs decrease annoyance	Contribute	See issues 31-35	Yes	High	(See Issue 45)
47	Conflict - history	A history of noise operator/community conflict increases annoyance	Contribute		Yes	High	Media search and interviews with authorities as needed as for Issue 31.
48	Compensation to residents	Receiving compensation from authorities decreases annoyance	Contribute	2+	Yes	High	Need to develop questionnaire item and use authorities' records.
49	Operators' perceptions	Operators can predict residents' annoyance levels	Contribute	0	Yes	High	(See issue 31) It may be difficult to establish community boundaries for judgments.
H. Correlated noise impacts							
50	Vibration	The belief that the noise source also causes vibrations increases annoyance	Demonstrate confounding	1	No	Low	(See Issue 41)
51	Health	The belief that the noise source affects health increases annoyance	NO	- -	- -	- -	The remaining impact issues 50 to 54) provide little or no objective information about impact and require questionnaire time.
52	Air pollution	The belief that the noise source's fumes or dirt pollute the air increases annoyance	NO	- -	- -	- -	(See Issue 51 and Issue 42.)
53	Activity disturbance	The belief that the noise interferes with daily activities (speech, concentration, listening, etc.) increases annoyance	NO	- -	- -	- -	(See Issue 51.) Questions would not contribute to study goals, but can illustrate types of impact.

Issue #	Issue	Hypothesis[a]	Include to: Contribute?, Control?	Questionnaire item(s)?	Require ancillary data?	Cost of studying	Comments
54	Sleep	The belief that the noise interferes with sleep increases annoyance	Control	1	No	- -	(See Issue 51). A question would provide a weak indicator of between-site differences in nighttime noise impact.
I. Complaints and public actions							
55	Complaint rate: annoyance	High community complaint rates indicate relatively high annoyance	Contribute	0	Yes	High	Complaint data are needed for areas from airport records for collation with annoyance.
56	Complaint rate: other correlates	What community or event characteristics are correlated with complaint rates?	Contribute	0	Yes	High	Need information about communities
57	Complainant characteristics	Complainants' characteristics are representative of annoyed residents	Contribute	2+	No	Low	This is low cost if it only asks the random sample. It is high cost if there is a special sample of complainants.
J. Other issues							
58	Self-selection by moving away	High noise levels cause annoyed residents to move out of the area	NO	- -	- -	- -	Information about actually moving will not be available. Questions about intent could be asked but probably have low validity.
59	Long-term annoyance trends	Over the years noise annoyance has increased for the same noise exposure	Contribute	1-2	Yes	High	Need data from previous surveys and the ability to reproduce acoustical estimates. Also include previous survey annoyance questions.
60	Survey administration : Telephone vs. Face-to-face	A telephone interview yields higher annoyance ratings (than face-to-face)	Contribute	0	Yes	High	These data provide a basis to make comparisons to previous surveys.
61	Survey administration : Self- vs. interviewer-administered	Self-administered questionnaires (mail) yield higher annoyance ratings	Contribute	0	Yes	High	These data provide a basis to make comparisons to other surveys.
62	Relevant exposure period	Respondents' annoyance is determined by recent experiences not by the entire previous year	Contribute	0	No	Moderate	This requires calculations of exposure for additional time periods (e.g. previous month, 3-months).

Table 22 identifies 16 data collection elements of a complex, multi-objective study design, including the 14 that are not required by the basic dose-response goal. Although these 16 elements are implicit in Table 21, they are easier to isolate in Table 22. The elements are listed under four headings according to the function they would perform in the study.

Table 22 Possible Elements of a Complete, Complex Annoyance Survey

A Primary Study Goal: Items that are required for the primary study goal

1. Resident questionnaire (Required to measure annoyance and the various demographic and attitudinal issues.) [Issues 1 to 13, 25-35, 57]
2. Flight operation data and analysis (Required to estimate noise exposure and identify the characteristics of the operations near a respondent – relation to flight path, landings, etc.) [Issues 36, 37, 39, 40]

B. New Contributions to Understanding Community annoyance: Elements that contribute to understanding community differences

3. Clustering of respondents into blocks in the sample design. (Needed to identify the size of geographical areas associated with different reactions.) [Issue 19]
4. Field experiments comparing questionnaire administration mode. (Used to provide a basis for comparisons to other surveys and dose-response standards that are based on different questionnaire administration modes.) [Issues 60, 61]
5. Questionnaire for airport officials (Used to identify characteristics of community relations programs, perceptions of community differences, the existence of legal actions or other major community conflicts with the airport)[Issues 45 to 49]
6. Content analysis of local media (Used to estimate the impact of media and to rate the visibility of airport officials actions) [Issue 22]
7. Analyze data from previous US surveys to create comparison for current survey (This will answer the question as to whether noise reactions have changed. For TRACOR studies around 1970 a CNR to DNL transfer function is needed. For other surveys the social survey data would need to be obtained.) [Issue 59]

C. Controlling for Previously Identified Explanations: Elements that control for commonly assumed explanations for community differences

8. Meteorological data – short -term and long-term [Issue 24]
9. Detailed airport complaint data on number of complainants, number of complaints, and location of complainants [Issues 55, 56]
10. Aircraft noise exposure estimates for each of the past five or ten years (Needed to control for changes in aircraft noise exposure) [Issues 43, 44]
11. Aircraft noise exposure data for the previous days or months (Used to test hypothesis that annoyance reactions are actually directed at a short period.) [Issue 62]
12. Indicators of ambient noise levels, especially traffic noise level (Rough controls for ambient noise might come from r geo-coded information about road type or population density.) [Issue 20]

D. Other Elements

13. Estimate outdoor to indoor attenuation of aircraft noise for each residence (A model to estimate attenuation based on respondent-provided information would need to be developed or, if already available, assessed.) [Issue 17]
14. Supplemental sample of aircraft noise complainants (This would ensure sufficient complainants to compare complainants to non-complaining members of the population.) [Issue 57]
15. Questionnaire data from knowledgeable authorities about the political activism of communities [Issue 23]
16. Aircraft ground operation noise predictions [Issue 38]

It is unlikely that all 16 of the elements could be included in a final study plan. The first two elements under “A Primary Study Goals” are clearly required. The elements listed under the B and C headings are listed in approximate order of priority under each heading. The elements under heading D are probably lowest priority. A final decision about the elements should consider both the priority assigned to the study issues and the costs for including each element.

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Note: The six-character identifier, following many references is the unique survey identification code assigned in a catalog of residential noise surveys (Bassarab, Sharp, and Robinette 2009). The first three characters are an abbreviation for the country. The following three-digit number is a unique survey number.

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Appendix I. Sleep Study Questionnaires

a. Morning Questionnaire

Morning Questionnaire

1. **Current Date**: ___________ **Current Time**:______________
2. **At what time did you...**
   - go to bed and switch off the light last night? _______________
   - fall asleep last night? _______________
   - wake up this morning? _______________
   - get out of bed this morning? _______________
3. **How do you feel right now?**

   awake, active, refreshed |——————————————————————————| tired, sleepy, dull
4. **How do you feel right now? Choose one...**
   - ☐ extremely alert
   - ☐ very alert
   - ☐ alert
   - ☐ rather alert
   - ☐ neither alert nor sleepy
   - ☐ some signs of sleepiness
   - ☐ sleepy, but no effort to keep awake
   - ☐ sleepy, some effort to keep awake
   - ☐ very sleepy, great effort to keep awake
   - ☐ extremely sleepy, fall asleep all the time
5. **Please evaluate last night's sleep quality:**

   low |——————————————————————————| high
6. **How annoyed do you feel by last night's aircraft noise?**

   ☐ Not at all ☐ Slightly ☐ Moderately ☐ Very ☐ Extremely
7. **Other comments?**

   ....

   ....

b. General Questionnaire

Section 1: Demographic Information

1.1 Today's Date:	____________________	
1.2 Date of Birth:	____________________	
1.3 Height:	____________________	
1.4 Weight:	____________________	
1.5 Gender:	☐ Female	☐ Male
1.6 Do you consider yourself to be Hispanic or Latino?	☐ Hispanic or Latino	☐ Not Hispanic or Latino
1.7 What race do you consider yourself to be?	☐ American Indian or Alaska Native ☐ Asian ☐ Black or African American ☐ Native Hawaiian or other Pacific Islander ☐ White ☐ More than one race	
1.8 What is the highest level of education that you completed?	☐ Grade School ☐ Middle School ☐ Junior High School ☐ High School ☐ 2 years college ☐ 4 years college ☐ Graduate School	
1.9 What is your current employment status and occupation?	☐ Working full time ☐ Working part time ☐ Homemaker ☐ Unemployed ☐ Student ☐ Retired ☐ Other	Occupation:______________ Occupation:______________ Specify:______________

General Questionnaire Page 1

1.10 What is the annual yearly income for this household?	☐ less than $25,000 ☐ $25,000-$50,000 ☐ $50,000-$100,000 ☐ $100,000-$150,000 ☐ $150,000-$200,000 ☐ $200,000-$250,000 ☐ Greater than $250,000	
1.11 What is your marital status?	☐ Single ☐ Married ☐ Widowed ☐ Divorced ☐ Other-Specify:__________	
1.12 How many people live in your household?	__________	
1.13 Are there any children in the household?	☐ Yes	☐ No
If so, how many:	__________	
If so, what are the ages of the children:	__________	
1.14 How long have you lived at your current residence?	__________	
1.15 Has your residence been sound-proofed to reduce noise?	☐ Yes	☐ No

Section 2: Sleep History

2.1 Do you work night shifts?	☐ Yes	☐ No
2.2 Are you a morning or evening person?	☐ Morning	☐ Evening
2.3 How often do you take naps?	☐ Always ☐ Often ☐ Occasionally ☐ Rarely ☐ Never	
2.4 Have you been diagnosed by a medical professional with sleep apnea?	☐ Yes	☐ No
2.5 Have you been diagnosed by a medical professional with a sleep disorder other than sleep apnea?	☐ Yes	☐ No
If so, specify:	____________________	
2.6 Do you wear earplugs at night?	☐ Yes	☐ No
2.7 Do you have a bed partner?	☐ Yes	☐ No
If so, do they snore loudly?	☐ Yes	☐ No
2.8 Rate your overall Sleep Quality for the past month:		
low |————————————————————| high		

Section 3: Medical History

3.1 Do you have any allergies?	☐ Yes	☐ No
If so, specify:	______________________	
3.2 Do you have any medical conditions?	☐ Yes	☐ No
If so, specify:	______________________	
3.3 Do you have any of the following conditions?		
a.) Breathing problems?	☐ Yes	☐ No
b.) Heart conditions, arrhythmia?	☐ Yes	☐ No
c.) Hypertension?	☐ Yes	☐ No
3.4 Are you currently taking any medications?	☐ Yes	☐ No
If so, specify:	______________________	
3.5 To your best knowledge do you have normal hearing without the use of hearing aids?	☐ Yes	☐ No
3.6 How often do you smoke or use tobacco on average ...		
per day?	____________	
per week?	____________	

General Questionnaire Page 4

3.7 How many caffeine containing drinks do you have on average ...

per day? ____________________

per week? ____________________

3.8 How many alcohol containing drinks do you have on average ...

per day? ____________________

per week? ____________________

3.9 How satisfied are you with your overall health?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

3.10 Have you experienced any of the following in the last 12 months?

a.) Death of a family member or close friend?	☐ Yes	☐ No
b.) Change in your health?	☐ Yes	☐ No
c.) Change in the health of a family member or close friend?	☐ Yes	☐ No
d.) Child leaving home?	☐ Yes	☐ No
e.) Marital separation or divorce?	☐ Yes	☐ No
f.) Change in job?	☐ Yes	☐ No
g.) Changes at work?	☐ Yes	☐ No
h.) Financial difficulties?	☐ Yes	☐ No

Section 4: Noise

4.1 Thinking about the last 12 months, when you are here at home, how much does noise from **Aircraft** bother, disturb, or annoy you?

☐ Not at all ☐ Slightly ☐ Moderately ☐ Very ☐ Extremely

4.2 Thinking about the last 12 months, when you are here at home, how much does noise from **Road Traffic** bother, disturb, or annoy you?

☐ Not at all ☐ Slightly ☐ Moderately ☐ Very ☐ Extremely

4.3 How sensitive are you to noise?

☐ Not at all Sensitive ☐ Slightly ☐ Moderately ☐ Very ☐ Extremely Sensitive

Do you have any additional comments?

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