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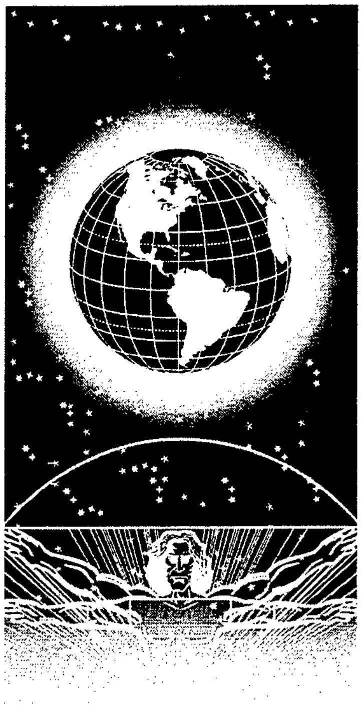

UNITED STATES AIR FORCE RESEARCH LABORATORY

The Effect of Onset Rate on Aircraft Noise Annoyance Volume 3: Hybrid Own-Home Experiment

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Final Report for the Period November 1992 to December 1993

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The voluntary informed consent of the subjects used in this research was obtained as required by Air Force Instruction 40-402.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

MARIS M. VIKMANIS
Chief, Crew System Interface Division
Air Force Research Laboratory

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13. ABSTRACT *(Maximum 200 words)*
This report presents the results of the third in a proposed sequence of studies to investigate human annoyance to noise from low-altitude military training route (MTR) flight operations. The sequence ranges from laboratory studies, in which the physical and social parameters are well controlled, but highly artificial, to field attitudinal surveys, in which these parameters are largely uncontrolled, but the setting is natural. In this third study, subjects were exposed to both real and recorded MTR noise events in their own homes for a period of four weeks. In the laboratory study it was found that MTR sounds having onset rates faster than 30 dB/second caused annoyance beyond what would be expected from the corresponding sound exposure level (SEL). The best fit to the data was found to be an onset rate adjustment to SEL, which has the form of a linear relation on a dB versus log (rate) scale, from 0 dB at a rate of 30 dB/second to 11 dB at 150 dB/second. The rented home study confirmed the laboratory onset rate adjustment, although the adjustment was found to begin at 15 dB/second rather than at 30 dB/second. The present study continued to confirm the existence of an onset rate effect. It also confirmed the equal energy principle. However, it did not show any dependence of annoyance on the sporadicity of the events.

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PREFACE

The work reported herein was performed under Air Force contract F33615-89-C-0574 during the period from November 1992 to December 1993. The work was conducted under Program Element 62202F, Workunit 7757C201, under the direction of the Aural Displays and Bioacoustics Branch of the Air Force Research Laboratory, Wright-Patterson AFB OH. Robert A. Lee was the project monitor.

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1.0 EXECUTIVE SUMMARY

This report presents the results of the third in a series of studies to investigate human annoyance to noise from low-altitude military training flight operations. These operations are conducted along military training routes and within low-altitude military operating areas. Environmental impact analyses are required whenever there is a modification to existing training procedures in these areas. An understanding of the factors which govern human annoyance to the noise from these operations is important in the prediction of environmental noise impact.

The series of studies began with a Laboratory Experiment in 1990 which investigated the individual annoyance response to each of a large number of recorded military jet aircraft overflights presented in a short time period (30 per hour in two 2-hour sessions) and in artificial laboratory settings (indoors in an auditorium and outdoors in a field). The principal finding was that, in addition to a dependence on the overflight's sound exposure level (SEL), the annoyance rating also had a statistically significant dependence on the overflight's onset rate.

In 1992 the series continued with a Rented Home Experiment in which fewer overflights were presented in a longer time period (3 per hour in two 6-hour sessions) and in a more realistic setting (a rented home similar to those of the subjects). The onset rate of the overflights continued to be a statistically significant variable as was the SEL. The magnitudes of the effects were similar to those found in the laboratory studies.

The Hybrid Own-Home Experiment, reported here, is an important step in the progression from laboratory to field setting. The study, which provided a controlled noise exposure of, on the average, eight overflights per day for one month, was the first in the series to be conducted in the natural environment of the subjects' own homes and the first to investigate the integrated response to all of the overflights that occurred each day. It is denoted "hybrid" because the subjects experienced both naturally occurring and experimenter-generated aircraft sounds.

The study was designed to investigate three different relationships:

- The effect on daily annoyance of the sporadicity of overflight events;
- The effect on daily annoyance of the number of overflight events, independent of the total sound exposure level; and
- The effect on individual event annoyance of the onset rate of the overflight.

The sporadicity analysis examined the relationship between the subject's daily annoyance rating and the regularity and total number of overflights to which the subject's home was exposed each day. No statistically significant relationship was found between daily annoyance and either of these two variables or their interaction.

The analysis of the relationship between the daily annoyance rating and the daily aircraft L_{eq} and number of overflights that were actually experienced by the subject showed that there was a statistically significant relationship between annoyance and L_{eq}. However, there was no statistically significant additional relationship between annoyance and the number of daily overflights (i.e., for a given L_{eq}, there was no statistically significant dependence of annoyance on the number of daily operations). Thus the equal energy principle, which states that annoyance depends only on the total amount of acoustic energy received and not on the manner in which it was spread out over individual events, was confirmed.

Finally, the examination of individual overflight annoyance ratings showed them to be a statistically significant function of both the SEL of the overflight and its onset rate. The magnitude of the effect is consistent with that found in the previous Laboratory and Rented-Home Experiments. Thus, even with the realism of a subject's undertaking normal household activities for an extended period of time in his or her own home, the onset rate effect was still present.

The remaining sections of this report provide a detailed description of the Hybrid Own-Home Experiment. Section 2 introduces the study, within the context of the continuum of studies. Sections 3 and 4, respectively, provide details of the experimental design and experimental procedures employed in the study. Section 5 discussed the results of the study. Appendices 1 through 7 provide copies of the forms, instructions, and questionnaires that were employed throughout the study.

2.0 INTRODUCTION

2.1 Background

To promote a state of air combat readiness, the Air Force routinely conducts low-altitude flight training operations along military training routes (MTRs) and in military operating areas (MOAs). The environmental assessment of noise from these operations has become an important factor in the design of these airspaces and is required to modify existing training procedures.

The noise environment associated with low-level military flight operations is characterized by individual events that are infrequent, irregular, sudden, short, loud noise events. These characteristics are quite different than those of conventional transportation noise sources; therefore it is prudent to investigate whether or not conventional methods of noise assessment are valid in this type of environment.

To validate the current methodology for predicting noise impact under high-speed, low-altitude flight training missions, the Air Force has undertaken a series of psycho-/socio-acoustic studies designed to investigate human annoyance to noise from operations occurring on MTRs. The first two elements of this sequence, the Laboratory Experiment and the Rented Home Experiment, have confirmed the dependence of annoyance on both sound level and onset rate.

The current Hybrid Own-Home Experiment, which is the third recommended study in the sequence, examines the effect on annoyance of the sporadic nature of MTR flight operations, including both the low number of daily flight operations and the regularity of their occurrence.

2.2 Proposed Sequence of Experiments

Reference 1 recommended a continuum of psycho-/socio-acoustic studies to more accurately assess human annoyance to noise from low-altitude military training flight operations. This continuum starts with laboratory studies, in which the physical and social parameters are completely controlled and in which, of practical necessity, the average exposure rate is much higher and the total exposure time is much lower than normally occurs.

The recommended continuum progresses through a series of studies which, at each stage, become less artificial in the sense that the average exposure rate continues to decrease, the exposure time continues to increase, and the associated social activities become more realistic. The final stage is a social survey, in which residents living under MTRs complete a series of questionnaires over a long-term period.

Table 1 lists the first four recommended studies along that continuum. The list here differs somewhat from that originally presented in Reference 1 by the addition of a "hybrid own-home" study. This additional study is necessary to fill the large gap in average exposure rate and exposure time between the "rented-home" study and the "own-home" study.

Table 1

Sequence of Studies to Validate Correction Procedures

Study	Sound Stimuli	Average Exposure Rate	Exposure Time	No. of Subjects
Laboratory	Artificial	30/hr	2 x 2 hr	80
Rented Home	Artificial	3/hr	2 x 6 hr	60
Hybrid Own Home	Artificial and Real	8/day	1 month	30
Own Home	Real	~2/day	3 months	15

In this sequence of studies, the sound stimuli for the laboratory and rented home studies are artificial, in the form of tape-recorded military jet plane overflights. For the own-home study, the sound stimuli are actual overflights. The hybrid own-home study uses a combination of artificial and real stimuli to obtain the desired average exposure rate.

The average exposure rate ranges from 30 events per hour in the laboratory to an estimated 2 events per day in the real world. The exposure times range from 2 periods of 2 hours each in the laboratory to a 3-month period for the own-home study.

The social activities which the subjects undertake range from a single defined activity in the laboratory study, to several defined activities in the "rented home" study, ending with multiple, undefined natural activities in the hybrid own-home and the own-home studies.

Finally, the environment in which the subjects experience the sound stimuli ranges from the artificial, foreign setting of a laboratory, to a normal, but unfamiliar, home setting in the rented-home study, ending with the normal, familiar setting of the subject's own home in the hybrid own-home study and the own-home studies.

2.3 Summary of Results of the Laboratory and Rented Home Experiments

The Laboratory Experiment[2] was conducted in 1990 to examine the effect on human annoyance of sound properties including: level, onset rate, and duration. The following conclusions were reached in that study:

- Sound level has a strong effect on human annoyance to individual events.
- Onset rate also has a significant effect on annoyance to individual events.
- An onset rate-adjusted SEL, SEL_r, was found to be a better predictor of annoyance to individual events than is SEL alone.

The Rented Home Experiment[3] was conducted in 1992 to confirm the existence of and quantify the onset rate effect under more realistic conditions than those in the Laboratory Experiment and, in addition, to begin to investigate the effects of the infrequency of occurrence and the regularity of the noise events on human annoyance. The results of this study are similar to those found in the Laboratory Experiment:

- The appropriateness of an onset rate adjustment was confirmed and the measured effect is similar to that found in the Laboratory Experiment.
- There is a preliminary indication that, when compared to the effects of sound level and onset rate, there is no statistically significant effect on annoyance of the infrequency of occurrence of noise events.
- There was no statistically significant dependence of the subject's responses on the activity in which they were engaged.

2.4 Hybrid Own-Home Feasibility Study

A preliminary study was conducted to examine the feasibility of assessing the effects of the sporadicity of MTR noise events occurring during a single day on a person's overall annoyance for that day.

An instrumentation system was developed to present the recorded sound of jet aircraft overflights within a subject's home, to assess noise levels both inside and outside of the home, and to collect subject response data.

Three pilot programs were conducted to test the instrumentation system and the experimental procedures and to collect data to asses the experimental design. The first two pilot studies were conducted in the Northern Virginia area near Wyle Laboratories' Arlington, Virginia facility; the third pilot study was conducted under VR-1074 in North Carolina. In each pilot study, the instrumentation system was installed in two or three homes for one week.

During these pilot programs, the instrumentation system was perfected to reliably reproduce experimental sounds and acquire data, the procedures were fine-tuned to ensure smooth implementation of the experimental design, and data were returned that were both consistent and in the direction of expected trends. The feasibility study was an essential element of preparation for the Hybrid Own-Home Experiment.

2.5 Overview of the Hybrid Own-Home Experiment

The Hybrid Own-Home Experiment had three primary goals. The first was to examine the effects of the sporadic nature of MTR flight operations during a given day on the subject's overall annoyance rating for that day. The second was to investigate how annoyance responses to individual overflights combine to form the overall daily response to those events. The third was to determine if the effect of onset rate on the annoyance to individual overflights, which was found in the previous studies, was still present in more normal environments. The natural setting of the subject's own home provided the opportunity to investigate these parameters under realistic conditions.

In the experiment, 69 subjects were exposed to recorded and real military aircraft overflight sounds for one month, as they engaged in normal daily activities. These subjects were recruited from four towns which were located in active MTR corridors.

An automated instrumentation system was installed in each home. This system was used to present recorded aircraft overflights, to monitor the sound levels of both recorded and real overflights, and to collect subject response data.

Recorded aircraft events were presented according to daily schedules in which the number and regularity of events were varied. These schedules were classified into one of six exposure categories. At times, a schedule was perturbed by the occurrence of real aircraft overflights which altered the daily exposure. When these events changed the daily exposure classification, one of the remaining schedules was modified to achieve a balance within the exposure categories.

Subjects noted their responses to individual real and recorded aircraft events using the same nine-point annoyance scale that had been employed in the Laboratory and Rented Home Experiments. In addition to rating individual events, the subjects provided similar responses to each daily and weekly exposure.

The Hybrid Own-Home Experiment was a departure from the earlier Laboratory and Rented Home Experiments in that it was conducted in the natural social setting of the subject's own home. This enabled the subjects to become more acclimated to their modified acoustic surroundings. Such a setting was necessary to examine the effect of sporadic exposure to MTR events and to confirm the previously measured effect of onset rate in a more natural environment. The quantification of these effects will improve the understanding of factors which govern human annoyance to low-altitude, high-speed military aircraft operations.

3.0 EXPERIMENTAL DESIGN

3.1 Objectives

As noted in Section 2, the objectives of the Hybrid Own-Home Experiment included the following:

- To investigate the effects of the sporadicity of MTR noise events occurring during a given day on the subject's overall annoyance for that day. The definition of sporadicity includes both the frequency of events and the regularity of events.
- To investigate how annoyance to individual MTR noise events is integrated over a daily exposure period to obtain the overall daily annoyance. This was accomplished by testing the equal energy principle.
- To confirm the existence of the onset rate effect under more realistic conditions than those in the Laboratory and Rented Home studies.

To accomplish these goals, the proposed transition from the controlled laboratory environment to the natural setting of the subject's own home was completed. The selection of subjects who lived in rural areas that were impacted by MTRs enhanced the realism of the study.

The study was designed to achieve an average subject exposure of approximately ten aircraft noise events per day (two real and eight recorded). In keeping with the recommended continuum of psycho-/socio-acoustic studies described in Table 1, this rate of exposure bridges the gap between the 18 simulated events per day in the Rented Home Experiment and the average of two real noise events per day expected along a typical MTR. This exposure was achieved using an automated instrumentation system to produce recorded aircraft overflights in the subject's home, along with any real aircraft overflights occurring on the MTR.

3.2 Facilities

3.2.1 Study Site

The study was conducted in the homes of subjects who were exposed to low-level MTR operations.

Four groups of six homes each were located in or near the towns of Belhaven and Beulaville, North Carolina, and Bowman and Blackville, South Carolina. Both towns in North Carolina were located within the VR-1074 corridor near the route centerline. Similarly located with respect to VR-88, were the towns in South Carolina. Figures 1(a) and 1(b) show these relationships.

The homes in each town were generally located in the same residential area and within a few miles of the associated MTR centerline. The homes naturally formed an array which was useful in detecting aircraft operations on the MTR.

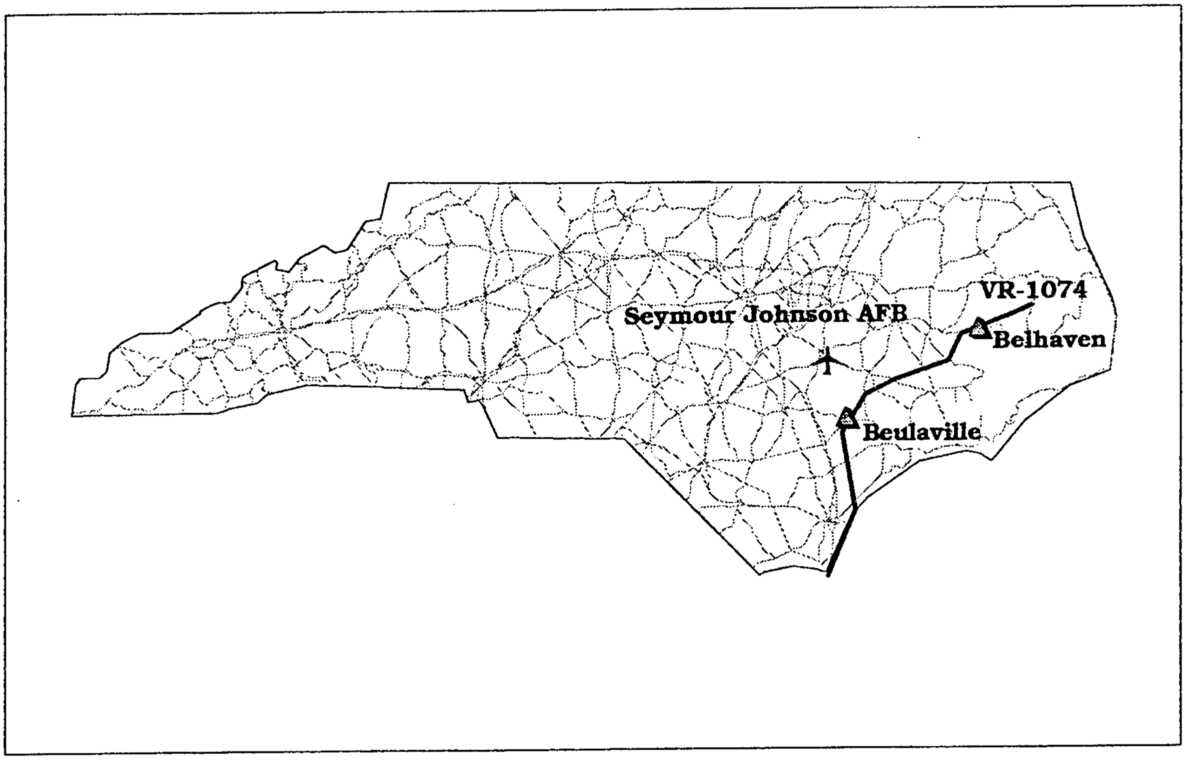
Military aircraft operations on VR-1074 originated from Seymour Johnson Air Force Base in North Carolina while those for VR-088 originated from Shaw Air Force Base in South Carolina. F-15 and F-16 training exercises were the dominant operations on both MTRs. Other operations occurring on these routes during the study included F-14, F-18, A-6, AV-8, and B-52 aircraft.

3.2.2 Instrumentation System

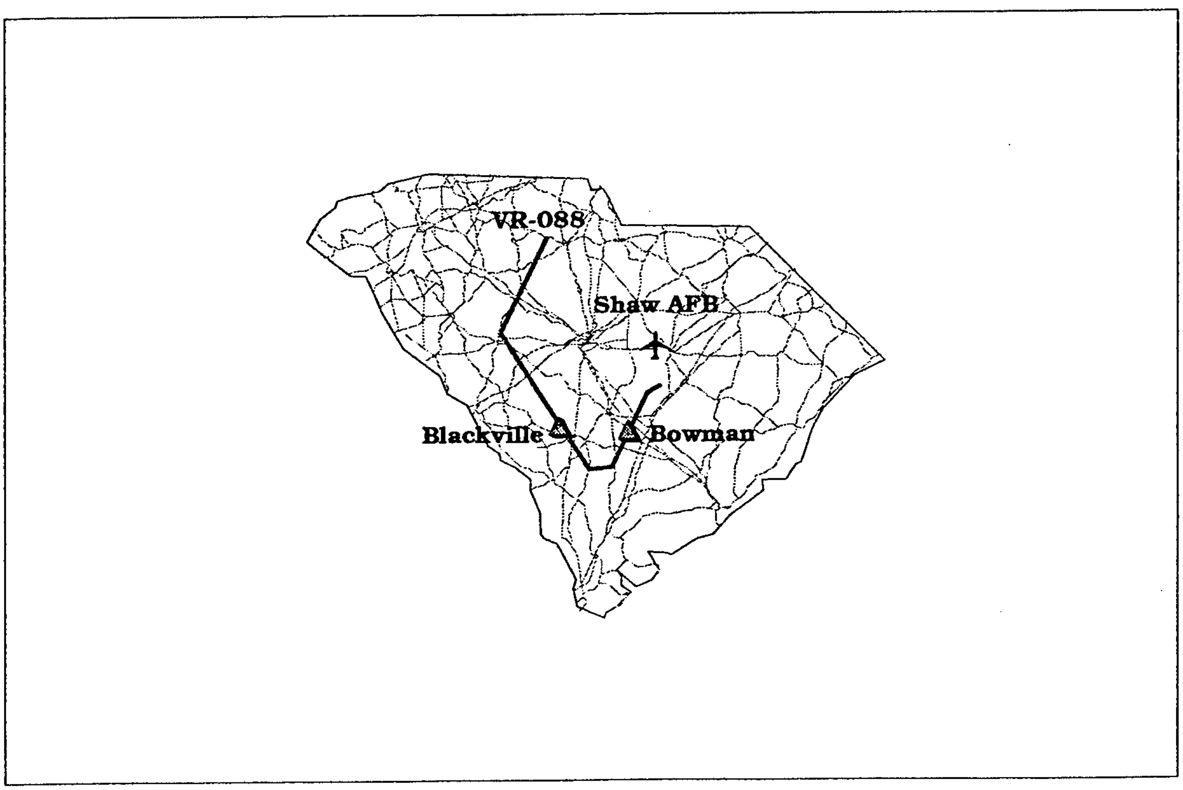
An automated instrumentation system composed of a computer, an audio reproduction system, and a dedicated telephone line was installed in each home. The components of this system are shown in Figure 2. The deployment of this system in a typical home is shown in Figure 3.

The system was used to present the recorded sounds of military aircraft overflights in two rooms within each home, to monitor the sound levels of both recorded and real overflight events, to collect resultant daily and weekly subject response data, and to transmit these data to Wyle Laboratories.

The computer system developed for the study was an Intel 80386-based microcomputer with peripherals which included a color monitor, a keyboard, a trackball, and a sound card. Two integrating sound level meters were connected to one serial port on the computer. One of these meters monitored the acoustic signal within that room in the home which was most often occupied during daytime hours; the other monitored the acoustic signal just outside the home. A modem, connected to the second serial port on the computer, was used for remote communications. The sound card was used to reproduce the recorded aircraft overflight events.



(a) North Carolina



(b) South Carolina

Figure 1. Study Locations.

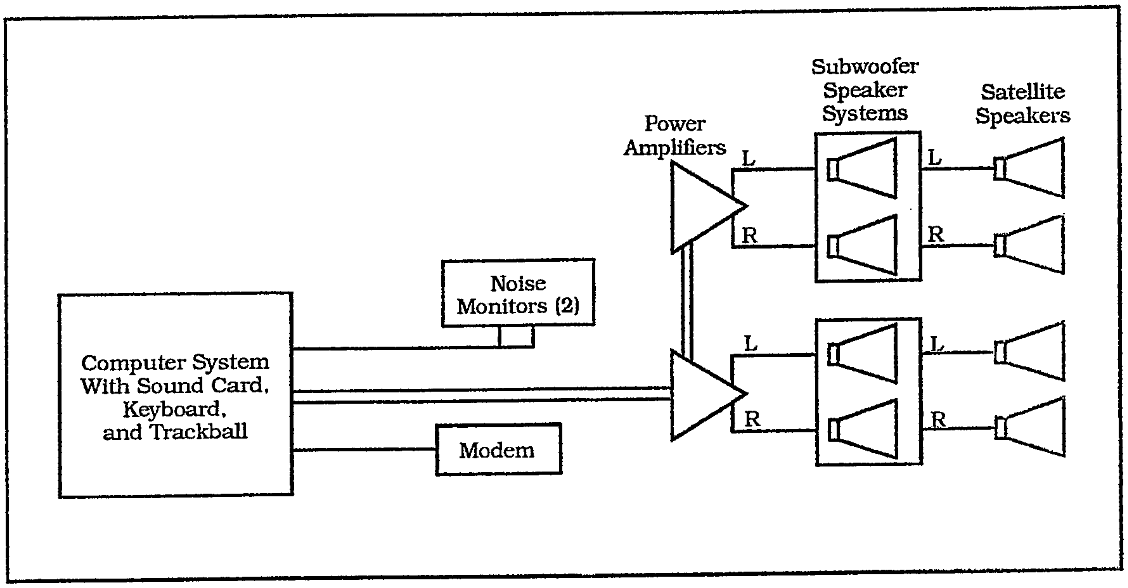


Figure 2. Instrumentation System.

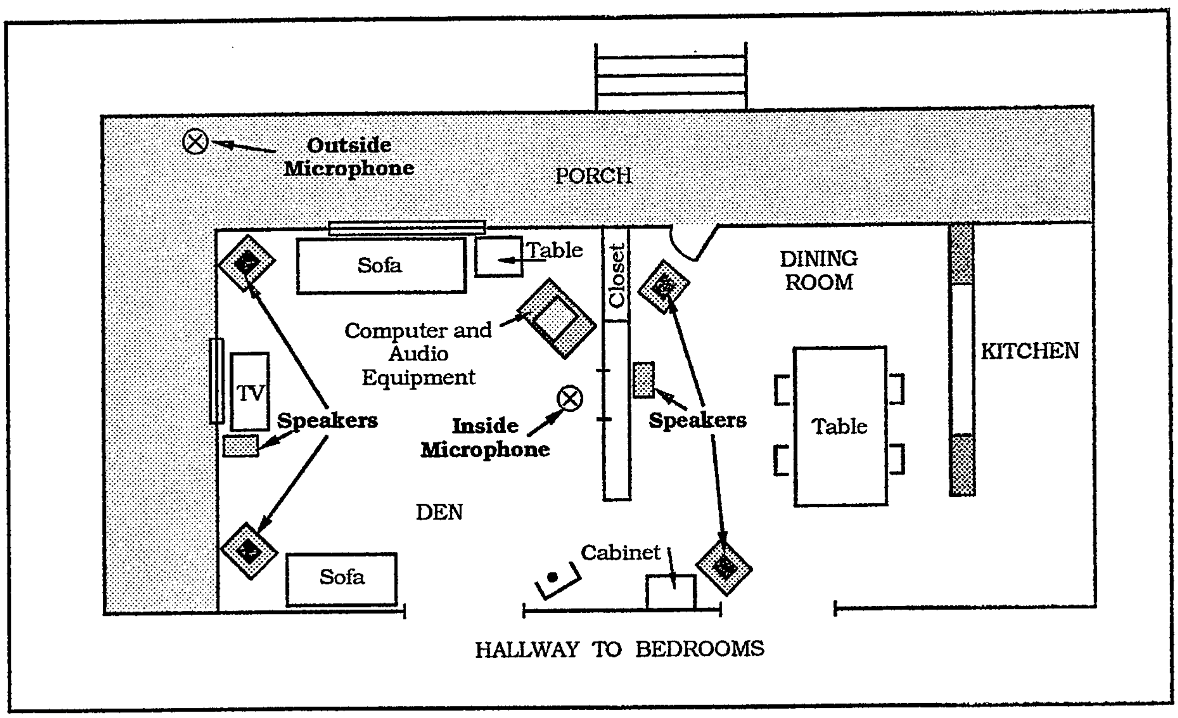


Figure 3. Typical Hybrid Own-Home Study Site.

Software was developed to control each hardware component in the system. This software was sufficiently flexible to accommodate a wide range of modifications to the experimental design, with no or minimal reprogramming effort. Most of the system parameters were read into the program through data files which could be easily changed with a text editor, thus eliminating any need to modify the software itself.

The computer produced military jet aircraft overflight sounds using a Media Vision ProAudio Spectrum 16-bit stereo sound card to play back digitized sound files. The sound card was programmed to play the sound files according to daily time and sound event schedules stored on the computer's hard disk. The sound files used in the experiment are described in Section 3.3.

The stereo output of the sound card was connected to an audio reproduction system composed of two Carver TFM-15cb power amplifiers and two Polk Audio RM-3000 Reference Monitor Speaker Systems. The speaker system components included a subwoofer module and two satellite speaker enclosures that contained mid-range and high-frequency drivers. These audio components formed an integrated part of the instrumentation system and were configured to produce the aircraft sounds at the design levels at the measurement position in each room.

Each of the two sound level meters was programmed to acquire acoustic data continuously throughout the study. Event data were obtained each time the sound level exceeded a preset threshold, which could be independently set on both meters. These data included the event time, event duration, sound exposure level, and maximum sound level. A short sound level time history was also acquired for each event measured by the outdoor meter. The onset rate of the event could be measured from the time history record, and used as an additional means to identify actual jet overflights. Hourly interval data were also acquired from both sound level meters to provide a record of the background noise levels occurring throughout the day.

Data files containing setup parameters for each sound level meter were stored in the computer and could be modified at any time. At the beginning of each day, the computer re-initialized both meters. This process included an upload of the setup parameters specific to each meter, and a reset of each meter's data base and clock.

The computer also provided, through a series of menus with associated trackball input, a simple interactive means for the subjects to enter their cumulative annoyance responses at the end of each day and week.

Through the use of a telephone modem, communication was established between a computer located at the Wyle Laboratories' Arlington, Virginia facility and with the remote computer in each home. This communication could be established manually, by an experimenter, or automatically by software. Both methods were used throughout the experiment.

Each remote computer stored data files that were organized in directories by Julian date. These files included: acoustic data downloaded from both sound level meters, subject response data, and a log file which reported system operations. Under normal operation, a computer at the Wyle facility would automatically call each remote field system on each day of the study and download all pertinent data files that were generated on the previous day.

At times, it was necessary for an experimenter to manually call a remote system. This procedure was used to check the status of the system; transfer data files to the system; and, on several occasions, make changes to the software. The file transfer capability was used primarily to change existing sound event schedules, when necessary. When this manual procedure was used, all modifications to the remote system were made in an unobtrusive manner.

3.3 Sounds

3.3.1 Sound Selection

Three sounds were employed in the study: overflights of an F-15, an F-16, and an F-4. All were derived from Air Force flight test recordings of aircraft under MTR operating conditions.

Several digital recordings of F-15 and F-16 low-level flyovers were reviewed and one recording of each type of aircraft was selected. These two sounds were chosen because the F-15 and F-16 aircraft are the predominant users of the two MTRs selected for the study.

Several monaural recordings of each aircraft type were auditioned through loudspeakers and the spectra and onset rate were measured. The measured sound characteristics were similar among individual recordings of each aircraft type. Therefore the two recordings used were selected for the study primarily because of their sound quality and dynamic range.

In addition to the F-15 and F-16 recordings, a recorded F-4 overflight was chosen to expand the range of onset rates employed in the study. The onset rate of this sound is significantly higher than that of the F-15 and F-16 sounds. This recording had been used in the previous two experiments in the current research program.

Table 2 lists the original recorded characteristics of the three sounds employed in the experiment.

Table 2

Aircraft Noise Recordings Used as Source of Experimental Stimuli

Aircraft	**Altitude (Ft)**	**Speed (Kts)**	**SEL (dB)**	**L_{Amax} (dB)**	**Onset Rate (dB/sec)**
F-16	281	444	113.3	113.4	30
F-15	201	565	122.4	126.4	71
F-4	108	597	122.9	128.0	152

3.3.2 <u>Sound Editing</u>

The three recordings selected for the study were modified to produce the experimental stimuli. Each sound was equalized with a 2 dB per octave rolloff to impose the typical filtering effect of a house structure. The sounds were then equated for SEL and rerecorded onto digital audio tape (DAT). Subsequent editing and mixing was performed on each sound using a Dyaxis digital editing system.[4]

- The sound was faded at the beginning and end of the recording, to reduce the effect of unwanted background noise.
- The sound was copied onto a second channel.
- A cross-channel fade was applied converting the monaural sound into stereo.
- The sound was copied with the new sound reduced in level by 15 dB, yielding two levels for each sound.

This digital editing/mixing process is described in more detail in Reference 2. From these modifications, six stereo sounds were produced and then recorded onto a master DAT. These were then transferred from the master DAT to the hard disk of each computer system in the digital format used by the sound card.

3.4 Experimental Test Plan

The experimental test plan for the study included the following features:

1. An examination of the effect on the daily annoyance ratings of sporadicity as defined by a 3 x 2 matrix of categorical values for the number of events per day (low, medium, and high) and the regularity of the interstimulus intervals (ISI) between these events (irregular or regular);
2. An examination of the "equal energy" principle by including a study of the effect on the daily annoyance rating of the number of aircraft per day independent of the energy-equivalent sound level (L_{eq}) for that day.
3. A continued examination of the effect on individual event annoyance of the onset rate (OR) of the aircraft overflights using two categories – low and high.

These features were integrated to produce the stimulus sequences used in the study.

3.4.1 Number of Events per Day

The number of recorded noise events each day was assigned to one of three categories, as follows.

- Low – 5 or fewer events,
- Medium – 6 to 11 events, and
- High – 12 or more events.

Each of these category boundaries is defined by the geometric average of the two adjacent nominal category means, which are 4, 8, and 16 events, respectively. The addition of real events to the recorded overflight stimuli required a redefinition of the category boundaries during the analysis phase of the program. If, as anticipated, an average of two real military jet overflights took place each day at homes along the MTRs under study, the mean total number of events per day, both recorded and real, in low-, medium-, and high-frequency categories would be 6, 10, and 18, respectively.

This mean number of recorded and real overflights for the medium frequency category is five times the anticipated normal rate of real MTR operations in the area where the subject's homes are located. This daily frequency of operations is the target for the present study, since it places the Hybrid Own-Home Experiment about midway on a geometric progression of daily operations between the Rented Home Experiment conducted earlier and the Own-Home Experiment proposed as the next phase of the current sequence of experiments.

The means of the other two categories, low frequency and high frequency, for the daily number of events correspond to an approximate halving and doubling of the medium frequency category, respectively. The boundaries between categories were defined as the geometric average of the adjacent mean values.

3.4.2 Regularity Variable

The regularity variable was established by examining the temporal characteristics of actual military jet overflights that had been observed over approximate one-month periods at selected points on each of three different MTRs – VR-1074, VR-223, and VR-1220.[5]

A prominent feature of actual MTR overflight events is that they may correspond to overflights of individual aircraft or of closely spaced groups of two, four, or more aircraft. Formations of more than one aircraft can result in acoustic signatures having two or more sound level peaks with time intervals of 5 to 30 seconds between adjacent peaks. In addition, a single peak in such a signature can represent several aircraft flying in a side-by-side configuration.

After a careful examination of the patterns of closely spaced overflights on the three routes, the following simplifying assumptions were made. Single-aircraft overflights were modeled as such: all multiple-aircraft overflights were modeled as two-aircraft overflights with a fixed time separation of 30 seconds. It was further assumed that, on the average, there were an approximately equal number of single-aircraft and multiple-aircraft overflights on any given day.

With these simplifying assumptions, the statistical properties of the ISIs for all of the measured overflights along each of the three routes were examined. The resulting distribution for each route is bimodal and, when plotted as a function of the logarithm of the ISI, can be approximately modeled as the sum of two Gaussian distributions, as shown in Figure 4.

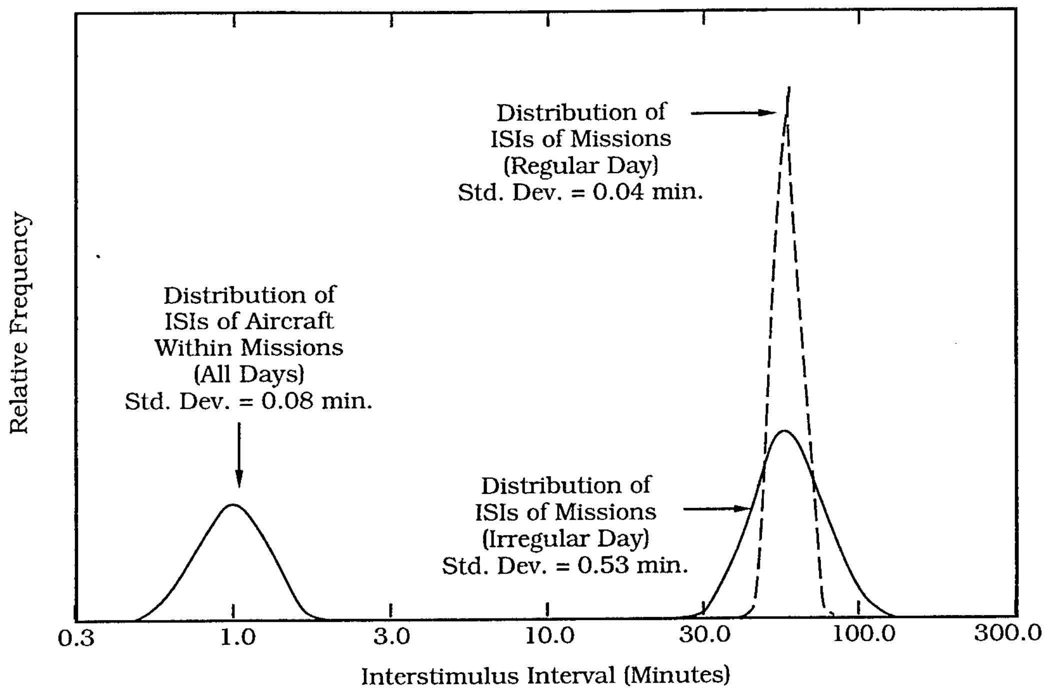


Figure 4. Distributions of Interstimulus Intervals for Regular and Irregular Days.

The first Gaussian distribution which accounts for 30 percent of the ISIs and which represents the time intervals between overflights of individual aircraft in a multiple-aircraft group, has a mean of $\log_{10}(1)$ and a standard deviation, σ, of 0.08 min. The second Gaussian distribution, which accounts for the remaining 70 percent of the ISIs and which represents the time intervals between aircraft or groups of aircraft, was given a mean of $\log_{10}(60)$ and a σ of 0.04 min. for the regular ISI category and of 0.53 min. for the irregular ISI category.

These two regularity categories are defined as follows:

- Regular: $\sigma < 0.28$ min., and
- Irregular: $\sigma \geq 0.28$ min.

where σ is the standard deviation of $\log_{10}$(ISI) for each category.

The mean value for the regular category is based upon an analysis of operations at a hypothetical busy airport. The mean value for the irregular category is based upon an examination of the daily standard deviations of the logarithms of the ISIs measured over a period of four weeks under VR-1074, which is the MTR under which the first two groups of subject families were chosen. The category boundary is the arithmetic average of the two category means, which are 0.04 min. and 0.53 min., respectively.

The 24 daily sequences of stimuli that were used in the study were chosen such that there were four days in each of the six events-per-day/regularity categories, as is shown in the first three columns of Table 3.

Table 3

Distribution of 95 dB and 80 dB SEL Events

Events/Day Category	Regularity Category	No. of Days In Month With Given Condition	GIVEN CONDITION				
			No. of 95 dB SEL Events	No. of 80 dB SEL Events	Total No. of Events	Total SEL	Daily Leq
Low	Regular	1	3	0	3	99.8	50.4
		2	3	1	4	99.8	50.4
		1	3	2	5	99.9	50.4
	Irregular	1	3	0	3	99.8	50.4
		2	3	1	4	99.8	50.4
		1	3	2	5	99.9	50.5
Medium	Regular	1	3	3	6	99.9	50.5
		1	3	4	7	100.0	50.6
		1	3	5	8	100.0	50.6
		1	3	7	10	100.1	50.7
	Irregular	1	3	3	6	99.9	50.5
		1	3	5	8	100.0	50.6
		1	3	6	9	100.0	50.6
		1	3	8	10	100.1	50.7
High	Regular	1	8	4	12	104.1	54.7
		1	8	6	14	104.1	54.7
		1	8	8	16	104.2	54.8
		1	8	10	18	104.2	54.8
	Irregular	1	8	6	14	104.1	54.7
		1	8	8	16	104.2	54.8
		1	8	10	18	104.2	54.8
		1	8	12	20	104.2	54.8

The distribution of events in each of the 24 daily sequences is illustrated in Figure 5. The right-hand vertical axis of this figure shows the events-per-day/regularity category for that sequence. The symbols L, M, and H signify low, medium, and high events-per-day categories, respectively; R and I signify regular and irregular regularity categories, respectively.

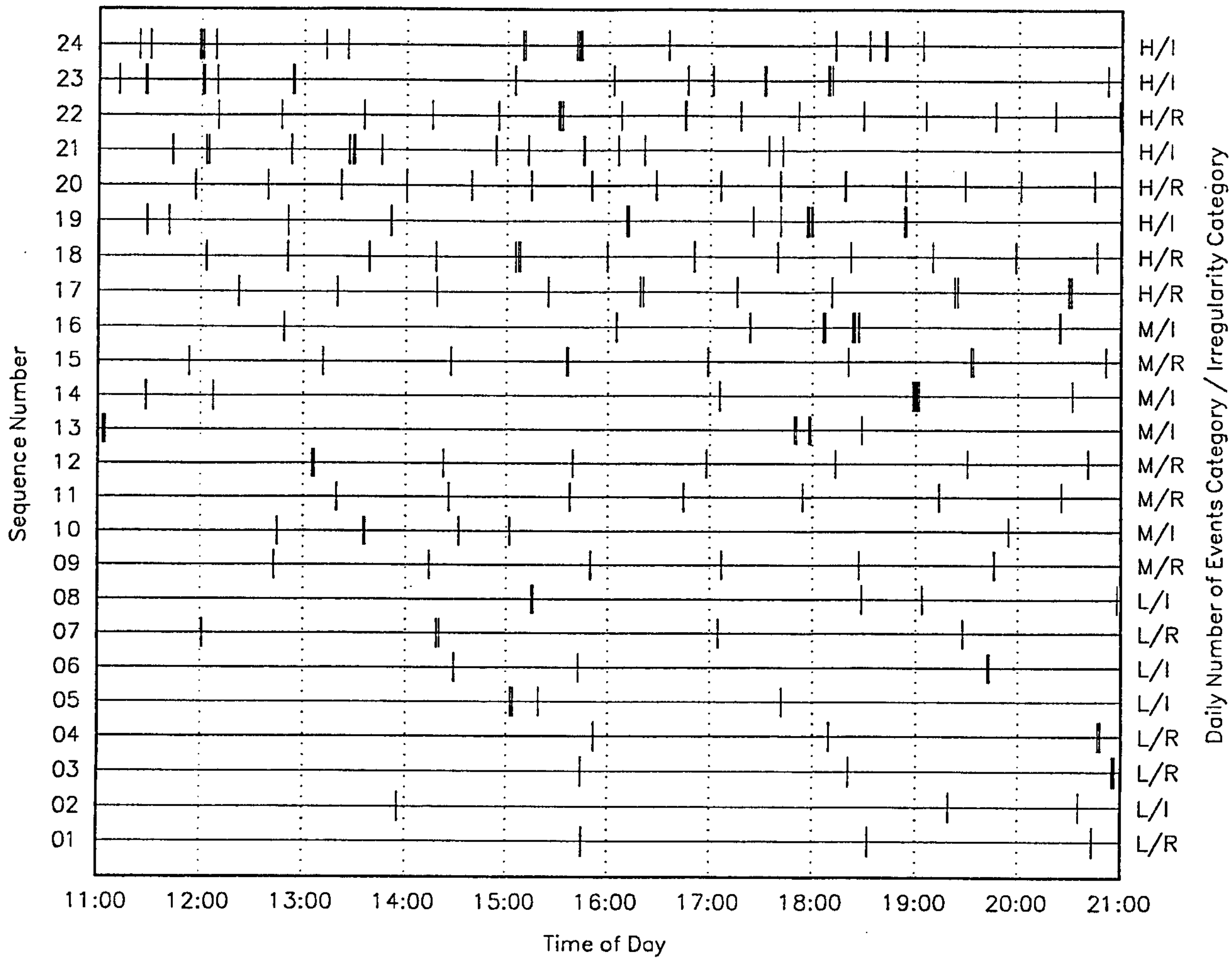


Figure 5. Schedule of Aircraft Event Sequences.

3.4.3 Sound Exposure Levels

The recorded events were reproduced at two different SELs to simulate the range of levels normally encountered on MTRs.

A mean indoor SEL of 95 dB represented the high-level category. Since typical home structures provide a noise reduction of 15 to 20 dB, this level corresponds to an outdoor SEL of 110 to 115 dB, which is typical of direct overflights on MTRs. The mean indoor SEL of the low level category was set at 80 dB, which is typical of moderately loud overflights.

3.4.4 Equal Energy Principle

Within the sequence of studies in the current research program, this study presents the first opportunity to examine the temporal integration of annoyance to MTR noise events.

To achieve this, the equal energy principle was tested by examining the relation between daily annoyance response and the total number of daily aircraft noise events independent of the daily L_{eq} of those events. The equal energy principle states that annoyance for a given period of time depends only on the total amount of acoustic energy received in that time period; there is no additional effect due to the number of events in the period.

Since it was intended to reproduce the recorded overflight events at two different SELs – 95 and 80 dB, the equal energy principle was tested by combining high and low sound level events in different ways to form essentially the same daily L_{eq} while having different numbers of events each day. This is shown in the last five columns of Table 3.

All sequences of events in the low and medium events/day categories have daily L_{eq}s that are between 50.4 and 50.7 dB. The 16 days in these two categories have total numbers of daily events that range from 3 to 11. Similarly, the sequences of events in the high events/day category have daily L_{eq}s that are between 54.7 and 54.8 dB. The 8 days in this category have total numbers of daily events that range from 12 to 20.

Thus separate examinations of the daily annoyance responses from the low or medium and from the high events/day groups provide the desired test of the equal energy principle as long as real acoustic events did not perturb the pattern significantly.

Tables 4(a) and 4(b) show the assignment of 80 and 95 dB SEL values to the artificial acoustic stimuli being presented to the subjects. The first column identifies each daily sequence of events using the sequence numbers from Figure 5. The second column shows the time, in minutes after 11:00 a.m., at which the acoustic stimulus will be presented. The third column identifies the SEL of that stimulus. The fourth and fifth columns show, respectively, the onset rate category and event type for the stimulus. These two features are described below.

3.4.5 Onset Rate

Since onset rate had been a statistically significant variable in the previous laboratory and rented home studies, it was prudent to continue to examine whether or not the effect remained under the more normal environment and activities of the hybrid own-home study. Since the nature of the onset rate correction had been exhaustively examined in the previous laboratory study and confirmed and extended in the previous rented-home study, it was decided that the examination of the onset rate effect in this study would be restricted to two onset rates – low and high. Thus, onset rate is included as a categorical variable. The onset rate categories are defined as follows:

- Low: OR $<$ 100 dB/sec or
- High: OR $\geq$ 100 dB/sec.

The aircraft used to represent the low OR category are the F-15 for the portion of the study under VR-1074 and the F-16 for the portion of the study under VR-88. The high OR category is represented by the F-4 for all portions of the study.

The "OR" column of Table 4 shows the allocation of onset rate category to the experimental stimuli. These assignments were made using a uniform random number generator in such a way that equal numbers of low (L) and high (H) were targeted. The achieved distribution has 52.4 percent of the events in the low OR category and 47.6 percent of the events in the high OR category.

Table 4

(a) Detailed Schedule of Regular Aircraft Event Sequences

Seq. No.	Time(1)	SEL	OR(2)	Event Type(3)
01	285.22	95	L	S
	452.37	95	L	S
	583.97	95	H	S
03	284.49	95	L	S
	441.07	80	H	S
	595.45	95	L	S
	596.56	95	H	S
04	291.86	80	H	S
	429.48	95	L	S
	586.95	95	L	S
	588.26	95	L	S
07	60.84	95	H	S
	198.46	80	L	S
	199.80	80	H	S
	364.82	95	L	S
	507.51	95	L	S
09	103.19	80	H	D
	193.89	95	H	S
	289.96	80	L	D
	366.83	95	H	S
	446.97	95	H	S
	525.93	80	L	S
11	139.36	80	H	S
	205.39	80	H	D
	278.00	95	L	S
	344.48	80	L	S
	414.48	95	L	S
	493.33	95	H	S
	565.84	80	H	S
12	125.14	80	L	S
	126.13	80	H	S
	202.15	95	H	S
	279.70	80	L	D
	357.88	95	H	S
	433.52	80	L	D
	510.18	95	L	S
	581.36	80	H	D

Seq. No.	Time(1)	SEL	OR(2)	Event Type(3)
15	53.37	80	H	S
	131.30	80	L	S
	206.66	95	H	S
	276.01	80	H	S
	276.89	80	H	S
	358.90	80	L	S
	440.94	80	H	D
	512.28	95	H	S
	513.51	95	L	S
	591.73	80	H	S
17	82.25	95	L	S
	139.75	80	H	D
	198.14	95	L	S
	265.08	95	L	S
	318.73	95	H	S
	320.43	95	L	S
	376.07	80	H	D
	431.29	95	H	S
	502.36	95	L	S
	504.10	95	H	S
	569.97	80	H	S
	571.44	80	L	S
18	63.10	80	H	S
	110.79	95	H	S
	158.25	95	L	S
	197.65	80	L	D
	245.22	95	L	S
	246.90	95	H	S
	248.09	95	H	S
	299.30	80	L	D
	350.49	80	H	S
	399.72	95	H	S
	442.11	95	L	S
	489.58	80	L	D
	538.64	80	L	D
	586.40	95	H	S

Seq. No.	Time(1)	SEL	OR(2)	Event Type(3)
20	56.53	80	L	D
	99.23	95	L	S
	141.62	95	L	S
	180.00	95	L	S
	218.45	80	H	S
	254.97	80	L	S
	290.28	95	H	S
	328.03	95	L	S
	365.99	95	L	S
	401.00	80	H	D
	438.48	95	L	S
	439.19	95	H	S
	473.74	80	L	S
	508.51	80	L	S
	541.50	80	H	D
	584.90	80	L	D
22	69.86	95	L	S
	106.92	95	L	S
	154.84	80	H	S
	195.07	80	L	D
	234.49	95	H	S
	270.69	80	L	S
	271.66	95	L	S
	273.07	80	L	S
	307.18	95	H	S
	344.65	80	H	S
	345.44	80	L	S
	377.66	95	H	S
	411.68	80	H	S
	449.03	95	H	S
	485.33	80	L	D
	526.44	95	L	S
	561.85	80	L	D
	599.14	80	H	S

(1) Time, in minutes, from 11:00 a.m.
(2) Onset rate category: H = high (OR>100 dB/sec), L = low (OR<100 dB/sec)
(3) Acoustic event type: S = single aircraft overflight, D = double aircraft overflight

Table 4

(b) Detailed Schedule of Irregular Aircraft Event Sequences

Seq. No.	Time(1)	SEL	OR(2)	Event Type(3)
02	175.51	95	L	S
	499.22	95	H	S
	575.96	95	L	S
05	242.72	95	H	S
	244.03	95	L	S
	259.68	80	H	D
	401.96	95	L	S
06	208.52	95	L	S
	282.90	80	H	S
	521.78	95	L	S
	522.81	95	L	S
08	255.29	95	H	S
	256.12	95	L	S
	448.46	80	L	D
	483.84	95	L	S
	598.15	80	H	D
10	105.16	95	H	S
	155.06	80	H	S
	155.90	80	L	S
	211.31	95	L	S
	242.08	95	L	S
	534.49	80	L	D
13	2.36	80	L	S
	3.23	80	L	S
	4.12	80	L	S
	409.57	95	H	S
	410.58	95	H	S
	417.80	80	H	S
	418.76	80	L	S
	448.72	95	L	S
14	28.01	80	H	D
	67.27	95	H	S
	365.68	95	L	S
	478.10	80	H	S
	479.05	80	L	S
	480.30	80	L	S
	480.92	80	L	S
	481.86	80	H	S
	572.11	95	H	S

Seq. No.	Time(1)	SEL	OR(2)	Event Type(3)
16	108.90	95	H	S
	304.74	80	L	D
	383.78	95	L	S
	425.84	80	H	S
	426.55	80	L	S
	427.40	80	L	S
	443.54	80	H	S
	444.57	80	H	S
	446.79	95	L	S
	564.33	80	H	S
	565.13	80	L	S
19	28.34	95	H	S
	41.24	95	L	S
	110.98	80	L	D
	171.14	95	L	S
	310.72	80	L	S
	311.85	80	H	S
	385.25	95	L	S
	401.20	80	H	D
	416.81	95	L	S
	417.77	95	H	S
	418.98	80	L	S
	419.80	80	L	S
	473.27	95	H	S
	474.08	95	H	S
21	43.12	95	H	S
	62.96	80	L	S
	64.15	80	H	S
	112.77	95	L	S
	146.45	80	H	S
	148.61	80	L	S
	149.55	80	L	S
	165.33	95	L	S
	233.28	95	H	S
	252.72	95	H	S
	285.49	80	H	S
	286.24	80	H	S
	305.75	95	H	S
	320.99	95	L	S
	394.30	80	H	D
	402.47	95	H	S

Seq. No.	Time(1)	SEL	OR(2)	Event Type(3)
23	11.64	80	L	S
	27.06	95	L	S
	28.02	95	L	S
	60.62	80	L	S
	61.43	80	L	S
	69.32	95	H	S
	113.43	80	L	S
	114.41	80	L	S
	244.56	80	L	D
	302.92	80	L	S
	346.59	95	H	S
	361.17	95	L	S
	391.28	95	H	S
	392.28	95	H	S
	428.54	80	H	S
	429.56	80	L	S
	430.97	95	H	S
	592.50	80	H	D
24	23.53	95	H	S
	29.88	80	H	D
	58.75	95	H	S
	59.61	80	H	S
	60.92	95	H	S
	68.25	80	H	S
	132.46	80	L	S
	145.21	80	H	D
	249.37	95	L	S
	250.69	80	H	S
	281.25	80	H	S
	282.39	80	L	S
	283.46	95	L	S
	284.33	95	H	S
	335.19	80	L	S
	432.87	80	L	D
	452.55	95	H	S
	461.64	80	L	S
	462.61	80	H	S
	483.62	95	L	D

(1) Time, in minutes, from 11:00 a.m.
(2) Onset rate category: H = high (OR>100 dB/sec), L = low (OR<100 dB/sec)
(3) Acoustic event type: S = single aircraft overflight, D = double aircraft overflight

3.4.6 Event Type

Since MTR noise events may correspond to overflights of single aircraft or to overflights of closely spaced groups of two or more aircraft, a pseudo-double event was introduced by playing a second single event 30 seconds after the first single event.

For purposes of counting the number of events per day, such pseudo-double overflights are counted as single events since the real events that they simulate normally occur too close together in time for them to be resolved into two events from the perspective of the subject's response.

As described in Section 3.4.2, the temporal statistics of three MTRs were used to determine the number of pseudo-double events that were included in the simulation. Approximately half of the events corresponded to isolated single events and the other half were multiple aircraft events. These estimates are similar to those estimated by potential subjects near VR-1074.

A uniform random number generator was used to assign the pseudo-double designation to those events which were not already part of a multiple-event mission (i.e., two isolated events for which the ISI between neighboring events was 3 minutes or more). The resultant pseudo-double events are identified with the letter "D" in the "Event Type" column of Table 4. Forty-two percent of the events in this table are isolated single events; 58 percent are pseudo-double events or single events that are part of a multiple-event mission.

3.4.7 Stimulus Sequences

The experimental design was implemented by constructing stimulus sequences of sound events using the statistical distributions described above. A uniform random number generator was used to determine the order in which the sequences in Table 4 were presented. Table 5 shows the resultant assignment.

Table 5

Order of Presentation of Event Sequences

Week	Day	Sequence Number	Events-Per-Day Category	Regularity Category
1	1	16	Medium	Irregular
	2	15	Medium	Regular
	3	7	Low	Regular
	4	13	Medium	Irregular
	5	9	Medium	Regular
	6	21	High	Irregular
	7	None	None	None
2	8	2	Low	Irregular
	9	22	High	Regular
	10	19	High	Irregular
	11	14	Medium	Irregular
	12	3	Low	Regular
	13	20	High	Regular
	14	None	None	None
3	15	24	High	Irregular
	16	10	Medium	Irregular
	17	6	Low	Irregular
	18	1	Low	Regular
	19	17	High	Regular
	20	12	Medium	Regular
	21	None	None	None
4	22	23	High	Irregular
	23	18	High	Regular
	24	5	Low	Irregular
	25	11	Medium	Regular
	26	8	Low	Irregular
	27	4	Low	Regular
	28	None	None	None

3.4.8 Response Measures

Three types of response measures were employed in the experiment.

The first response measure is shown in Figure 6. This form solicits a subject's response to each individual overflight event, both recorded and real, using the nine-point annoyance scale that had been employed in both of the previous studies in the current research program. Also noted are the date, time, and listening location for each individual overflight event. These response forms were bound into pads containing 50 tear-off sheets in a checkbook cover.

Individual Overflight Annoyance Rating Form

Initials ________ Date ________ Time ________ __ AM __ PM

THE SOUND WAS:

0	1	2	3	4	5	6	7	8
	Minimally	Slightly	Fairly	Moderately	Decidedly	Highly	Extremely	

ANNOYING. (Circle the appropriate number.)

Where were you? (Circle one.)

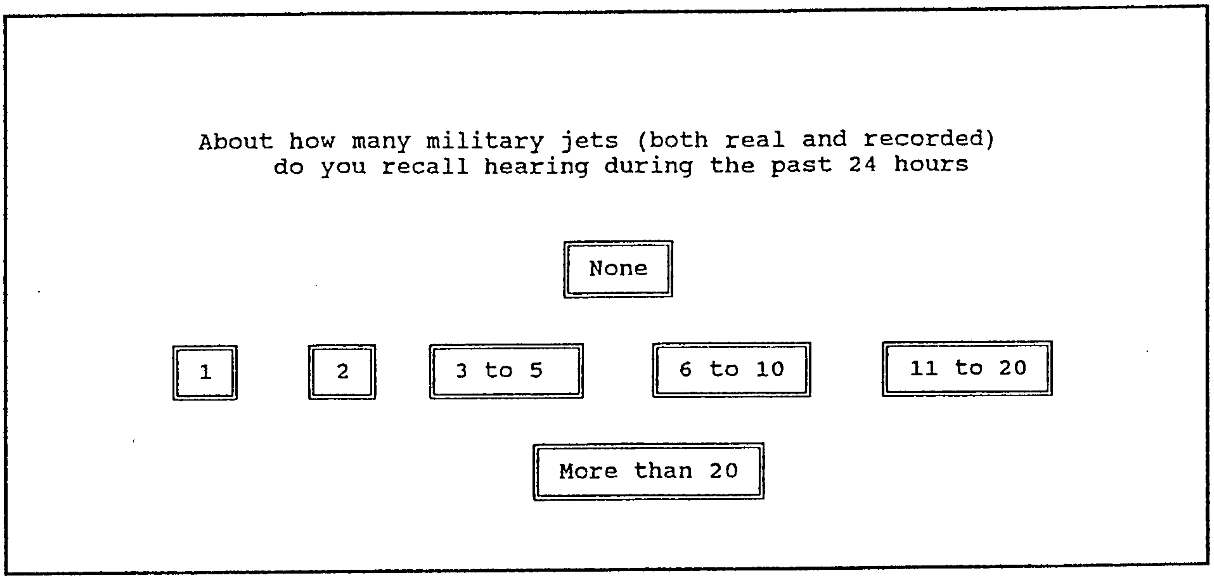
LR, DEN, KIT, DR, BATH, BR, BASM, GAR, Other ______________, OUTDRS

Figure 6. Individual Overflight Annoyance Rating Form.

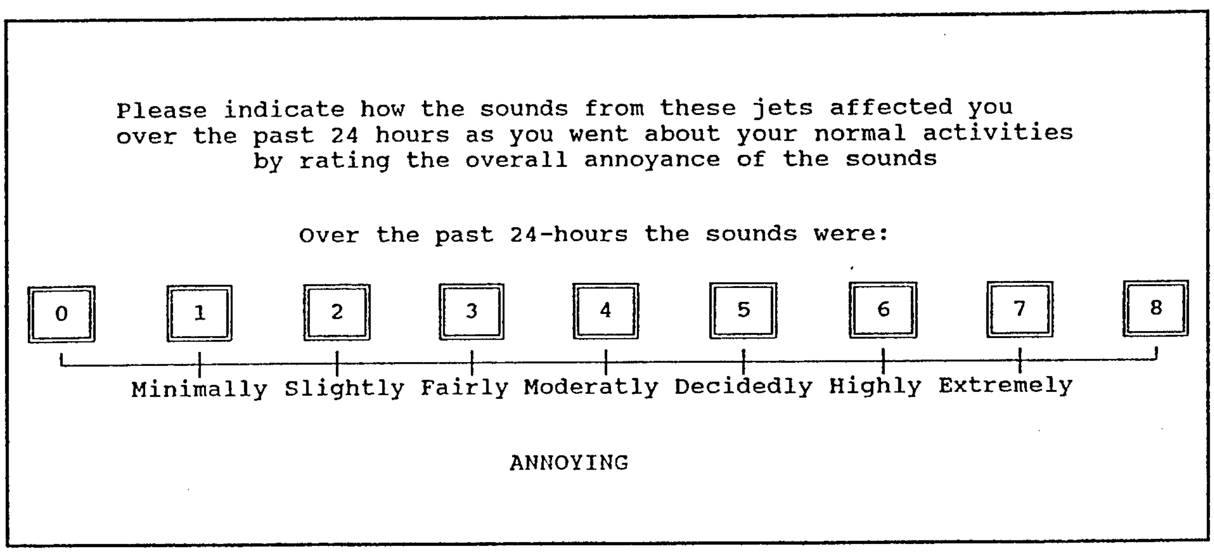
The second response measure used a computer-generated questionnaire to collect integrated responses to the overall daily (or weekly) overflight events. Two response screens prompted subjects to estimate the total number of events that they had heard that day and, using the nine-point annoyance scale, to provide the overall annoyance caused by these events. These response screens are shown in Figure 7. On Sunday evening, similar screens solicited this information for the past week (see Appendix 6).

The third type of response measure was a Post-Experiment Questionnaire administered to each subject during the debriefing session at the end of the experiment.

Further details of how these response measures were used in the experiment are provided in Section 4.2.



(a) Number of Events



(b) Annoyance

Figure 7. Daily Integrated Response Screens.

4.0 EXPERIMENTAL PROCEDURES

4.1 Subjects

4.1.1 Geographic Selection

Two Military Training Routes (MTRs) were selected for the current study: VR-1074 in North Carolina and VR-088 in South Carolina. Previous data had shown that both routes experienced relatively high usage and both were relatively close to the Wyle Laboratories facility in Arlington, Virginia. These MTRs and the four towns selected for the study are described in Section 3.2.1 and shown in Figure 1.

A brief preliminary informal survey of residents in each town indicated that military jets did fly "low and fast" over the town. Table 6 shows some of the salient characteristics of the four selected towns, as well as the dates of the experiment and the approximate number of real military jet aircraft overflights encountered during the four weeks of the study.

Table 6

Geographical and Temporal Sampling Parameters

Town	Population	Area, Sq. Mi.	Major Industries	Dates	No. of Real Flights
Belhaven, NC	2,500	2	Fishing Farming Lumber Tourism	17 May to 13 June 1993	86
Beulaville, NC	950	2	Textiles Farming Livestock	21 June to 18 July 1993	55
Bowman, SC	2,500	4	Textiles Farming Lumber	26 July to 22 Aug 1993	63
Blackville, SC	2,600	9	Nuclear Energy Farming Textiles	30 August to 26 Sept 1993	28

4.1.2 Household Selection

Six households were selected from each of the four towns. These households were selected by means of preliminary interviews in 12 to 18 candidate homes in each town about two weeks before the experiment began. In each town, households were selected according to the following criteria:

1. Two or more people were at home most of the time during the day and evening.
2. Houses were as close to each other as possible, never more than three miles apart.
3. As much as possible, houses were located in a linear pattern perpendicular to the centerline of the MTR.
4. There was a wide range of ages in the sample.
5. The sample constituted a representative spread of sex, socio-economic, and ethnic-racial backgrounds.
6. Any known disabilities did not interfere with participation in the experiment.
7. All members of the household reported having normal hearing for their age.

4.1.3 Subject Sample

The original sample of subjects included 24 households and 69 individuals. However, severe electrical storms during the first month of testing disrupted power and equipment in three of the homes in Belhaven, resulting in a final sample of 21 houses and 63 individuals. Some characteristics of the final sample of 63 subjects may be found in Table 7. The final sample of subjects was representative of the kinds of people likely to be exposed to MTR noise in the southeastern United States.

Table 7

Subject Characteristics (N = 63)

Occupation	Location	House Type	Economic Status	Racial Mix	Literacy	Sex
Homemaker: 11 Factory Worker: 7 Public Safety: 5 Business: 5 Retail: 5 Teacher: 4 Counselor: 4 Farmer: 3 Unemployed: 3 Secretary: 2 Auto Mechanic: 2 Public Service: 2	Belhaven, NC: 10 Beulaville, NC: 16 Bowman, SC: 20 Blackville, SC: 17	Air Conditioned: 49 Open Windows: 14	Middle Class: 18 Working Class: 25 Poor: 20	White: 40 Black: 23	Literate: 57 Marginal: 3 Illiterate: 3	Female: 36 Male: 27

4.2 Procedures

4.2.1 Initial Interview and Agreement

Each subject in each household took part in a group interview in the home about two weeks before the experiment. At that time, a Study Qualification Form was completed (see Appendix 1). This form elicited responses on: previous MTR noise exposure, the number of residents in the home and their daily schedules, locations for equipment installation, and electric and telephone service to the home. Then each subject signed an Agreement Form which specified the responsibilities of the subject, the schedule for the experiment, and the payment to be received (see Appendix 2). Each family received $1,000.00 for participation in the form of five checks for $200.00 each, paid at regular intervals over the period of the experiment.

4.2.2 Equipment Installation and Instructions

During the week prior to the start of the experiment a private telephone line was installed in each home. This line was dedicated to provide the communication link between the computer installed in the home and a computer at the Wyle Laboratories facility in Arlington, Virginia.

Between one and three days before the experiment began, the instrumentation system, described in Section 3.2.2, was installed in each home and the subjects were instructed in their tasks. This was accomplished by a two-person team of experimenters: a psychologist to instruct the subjects and administer hearing tests and an engineer to set up the equipment and calibrate the automated system.

First, each subject signed an Informed Consent Form (see Appendix 3), which specified the exposure levels expected from the artificial aircraft sounds, any risks to the subjects, safeguards on the confidentiality of the data being collected, and the voluntary nature of participation.

Next, a Pre-Experiment Questionnaire (see Appendix 4) was completed. This form elicited responses concerning the daily and weekly activity schedules for each subject, times that they were typically home, known appointments away from home, and current feelings about military jet aircraft noise.

Then each subject was administered a hearing test in each ear at octave frequencies from 250 to 8000 Hz by means of a Teledyne Avionics Model TA-20 automatic audiometer. Thresholds were referenced to the American National Standards Institute (ANSI) Standard S3.6-1989 and were generally within 20 dB of the age-corrected reference threshold level.

Next, the subjects read the Instructions for the experiment. These Instructions (see Appendix 5) explained the nine-point Annoyance Scale that was used to rate responses to individual military jet aircraft overflight sounds as well as responses to daily and weekly MTR noise exposure (see Figures 6 and 7). The instructions also explained how to use the annoyance response pads for each individual overflight heard and how to respond on the computer for the daily and weekly responses.

Meanwhile, the instrumentation system was installed in the home. The loudspeaker system was deployed in the two rooms used most frequently during daytime hours. These rooms were typically the living room/den and the dining area/kitchen. As much as possible, the satellite speakers were arranged so that the simulated aircraft overflights had an associated directionality that was similar to the flight path of real aircraft along the MTR. The computer and amplifiers were housed in a cabinet which was located to provide convenient evening responding for the entire family. The indoor microphone was installed in the most used room of the house, and the outdoor microphone was generally installed under a porch or shed attached to the house for protection from the rain.

With the instrumentation system in place, all subsystem components were tested, an initial software configuration was performed, and a three step calibration procedure was followed.

- Sound level meters were checked for calibration.
- Audio system gains were adjusted to produce the aircraft overflight sounds at the design SEL values at the measurement position in each room.
- A sample of calibrated pink noise was played through the audio system and measured at the designated position in each room. This system calibration served to monitor the individual output of each speaker and was independent of the experimental stimuli.

When the equipment installation was complete, several aircraft overflight sounds were played to the group of assembled subjects as a practice session to acquaint them with the stimuli and the responses required. Each subject completed several sheets on the individual overflight response pad and practiced answering the daily and weekly questions on the computer. The subjects were observed by the psychologist-experimenter and coached until they learned how to respond correctly.

4.2.3 Stimulus Presentation and Subject Responses

The experiment lasted 28 days, but recorded military jet overflight sounds were only presented Monday through Saturday. Thus there were 24 stimulus sequence days of recorded overflight sounds, as shown in Figure 5 and Tables 3 to 5. Recorded overflight sounds only occurred between 11:00 a.m. and 9:00 p.m.

The same schedule of stimulus sequence days for recorded overflight sounds was presented in all six houses in all four towns, except that toward the end of the experiment in any given town a few of the planned stimulus sequence days were replaced with other ones in order to balance the experimental design matrix. Since the random occurrence of real military jet aircraft overflights tended to transform low frequency of occurrence and regular days into higher frequency of occurrence and irregular days, adjustments to the planned schedule resulted in adding more low frequency and regular days to the schedule. Two such adjustments were made in Belhaven, three in Beulaville, and four each in Bowman and Blackville.

Each time a low-flying military jet aircraft sound was heard in or around the house, whether it was a recorded sound created by the loudspeakers or a real sound from an actual military jet, each subject filled out the top sheet of an annoyance rating pad. Several such individual-event rating pads were left with each family so that the pads would always be conveniently accessible. The subject noted the date, the time, his/her location in the house, the annoyance rating for the sound, and initialed the form. Then the completed sheet was torn off and placed face down in the cover pocket of the checkbook, hidden from view. At the end of the day, one member of the family gathered all the completed annoyance rating forms for all of the individual military jet overflights heard that day and mailed them back to Wyle Laboratories. The instructions emphasized that "all questions refer to the sounds from low-flying military jet aircraft only." Subjects were told to ignore the sounds from "high-flying jets, propeller planes, and helicopters." Subjects rated military jet sounds only while they were in the house or outdoors on their property. They did not rate sounds heard while they were away from their homes.

At 10:00 p.m. each evening, the computer monitor screen illuminated and the computer produced a musical chime to signal the family to respond to the daily (or weekly) questions. Monday through Saturday, each night, the computer asked each subject two questions:

1. About how many military jets (both real and recorded) they thought they heard that day.
2. How annoying they judged these sounds to be.

On Sunday night, the computer asked the same two questions with reference to the past week (see Appendix 6 for a copy of the computer screens). The computer repeated the musical chime sound every 30 minutes as a reminder until all subjects in the house had responded or until midnight. The subjects were also instructed not to discuss their responses and feelings or impressions about the experiment among themselves or with others until after the experiment was completed. Every attempt was made to insure that responses represented personal reactions with a minimum of social interference.

4.2.4 Equipment Removal and Debriefing

Within one to three days after the completion of the 28-day experiment, the psychologist/engineer team returned to the home to remove the instrumentation system and debrief the subjects. Each subject completed a Post-Experiment Questionnaire (see Appendix 7). This questionnaire elicited responses on the perceived number and overall annoyance of all the military jet overflights heard during the month-long experiment, on exposure to other kinds of environmental noise, on any perceived temporal patterns of military jet noise and reactions to these patterns, and on factors that might contribute to the annoyance of military jet noise. Then each subject was administered another hearing test identical to the initial test to ensure that his/her hearing threshold had not changed. Post-experiment hearing threshold levels were always within ±5 dB of the initial test level, which was the resolution of the audiometer employed for the tests.

Meanwhile, the calibration of the instrumentation system was checked, using the same three-step procedure that was employed during the installation, to ensure that it had functioned properly throughout the experiment. The system was then dismantled and removed from the home. At the end of the session the family was thanked for their participation and was given their final payment check.

4.3 Data Processing

4.3.1 Data Collection and Qualification

Throughout the experiment, data were downloaded by modem to the Wyle Arlington Facility from the remote computer system in each home. This was accomplished automatically between the hours of 1:00 a.m. and 6:00 a.m. each morning. Daily responses, acoustic information, and a system log file were received. In addition to these data, responses to individual overflights were received through the mail, generally one to two days later.

The data were reviewed each day to screen the subject responses and to check the status of the instrumentation system. Both individual and daily responses were reviewed, checking that subject information was complete and that response scores in the proper range had been noted for each stimulus presented. The log file, which reported system operations, was examined to ensure that the system was functioning properly and acoustic data files were reviewed to track the performance of the sound level meters, to monitor background noise levels, and to identify the levels of real and simulated aircraft overflights.

Data collected from the outdoor sound level meter were reviewed to identify real aircraft operations which occurred on the MTR. This method proved to be less useful than reviewing subject responses to individual events. This was due, in part, to the meters event threshold of 95 dB. While this threshold is exceeded by most low-level direct overflights on an MTR, it is believed that there were many distant events during the study that were not recorded by the meter, but were noted by the subjects. This was confirmed by their relatively low ratings of these events. Schedules of operations provided by the MTR airspace managers were also used in this effort to identify real events.

The sound levels of the recorded events were identified from data collected by the indoor sound level meter. These were confirmed by correlating measured data with the stimulus schedule. These levels were monitored to track the audio system calibration. The average measured SEL for each experimental stimuli was consistent to within ±2 dB throughout the experiment. These values are shown in Table 8.

Acoustic data from both real and recorded events along with the corresponding response scores were entered into a computerized data base. This data base is divided into four separate data files, one for each study group. The complete data base contains approximately 16,500 records (15,000 individual event ratings and 1,500 daily ratings). Each record contains data pertinent to each subject rating throughout the experiment.

Table 8

Average Measured SEL (in dB) for Experimental Sounds

Sound No.	Aircraft	Design SEL	Group 1	Group 2	Group 3	Group 4	Overall Average
1	F-15	95	94.5	95.5			95.2
2	F-15	80	79.5	81.1			80.4
3	F-16	95			95.7	95.1	95.4
4	F-16	80			81.2	80.6	80.9
5	F-4	95	93.1	94.2	94.0	93.6	93.8
6	F-4	80	76.5	78.7	78.6	77.7	78.1

Upon completion of the experiment, a two-step review process was conducted to qualify the data base. Sorts on each column of data were performed to group similar data, making it easy to spot data entry errors. In the second part of the review process, randomly selected records from the data base were thoroughly reviewed and compared with raw data. Five percent of the data base was reviewed in this fashion.

5.0 RESULTS

As noted in previous chapters, this study was designed to investigate three different relationships:

1. The effect on annoyance of the sporadicity of overflight events;
2. The effect on annoyance of the number of overflight events, independent of the total sound exposure level; and
3. The effect on annoyance of the onset rate of the overflight.

The first two analyses involve the daily annoyance ratings, which were solicited by means of the computer system each evening. The third analysis involves the individual overflight annoyance ratings, which were provided manually on pre-printed forms.

5.1 The Effect of Sporadicity

5.1.1 <u>Summary of Response Data</u>

The sporadicity analysis requires an examination of the daily annoyance ratings, which represent the subject's integration of responses to all of the individual overflights which were experienced in a given day. Associated with each rating are two categorical parameters – the number of overflight events in the day (i.e., low, medium, or high) and the regularity of occurrence of those events (i.e., regular or irregular). A definition of the regularity variable was provided in Section 3.4.2.

One decision that had to be made early on in the analysis was whether to associate a subject's daily rating with the overflight events that he or she actually experienced or with all of the overflight events that actually occurred at the home. These two sequences of events are not always the same, since the subject may have been away from the home during part of the day.

If the objective of the analysis were to study the psychological effects of the number of events and their regularity, the proper association is with the events that the subject actually experienced. However, if the objective of the analysis is to determine whether subjects' responses can be changed by judicious scheduling of aircraft operations, the proper association is with the events to which the home is exposed since the subjects' presence in the home cannot be controlled. In the latter case, however, the unexplained variation in subjects' responses will be larger than in the former case because a given subject's response may be to a different sequence of events than that which occurred at the home.

The analysis presented in this report corresponds to the latter case, i.e., a subject's daily annoyance rating is associated with the sequence of overflight events that occurred at his or her home, not with the sequence of events that he or she may have actually experienced. This decision was made because it was felt that the Air Force would be more interested in the effects of parameters that it could conceivably control, such as schedule and number of events, and would want the effects of parameters that it could not control to be part of the unexplained variation. It was also felt that any procedure in which the subjects logged in all the times at which they left and returned home would be at least as intrusive as the aircraft noise to which they were exposed and, as a result, could quite easily bias the results of the study.

To minimize the unexplained variation in subjects' responses associated with their absence from the home, only those subjects whose responses indicated that they were home most of the time were included in the sporadicity analysis. This was accomplished by choosing a subset of the database for which the subjects' estimates of the number of overflights experienced in the day were equal to, or one category removed from, the maximum reported at any of the homes in the study group. For example, if the highest category selected by any subject on a given day was 5 (i.e., 6 to 10 events) and other subjects selected categories of 4 (i.e.. 3 to 5 events), 3 (i.e., 2 events), and 2 (i.e., 1 event), only the subjects who selected categories of 5 and 4 would be included in the subset. This procedure eliminated those subjects who had missed most of the events at the home.

As described in Section 3.4, the values of the number of overflight events per day and the regularity parameter were partially controlled by the experimental design. Daily schedules of recorded overflight events were adjusted so that occurrences of the six possible combinations – regular/low, regular/medium, regular/high, irregular/low, irregular/medium, and irregular/high – occurred equally often.

However, subjects were also exposed to real overflight events since their homes were located under active MTRs. These real events tended to move days from the low/regular and medium/regular categories to the medium/irregular and high/irregular categories, thus upsetting the balance among the categories. As each month's data gathering progressed, adjustments were made to modify the remaining schedule of recorded sounds to counteract this effect. However, this procedure was only partially successful in balancing the number of samples in each category.

To assign each daily rating to one of the six categories described above, it was necessary to identify all real overflight events and to determine the times at which they occurred. This information was then combined with the number and time of occurrence of recorded overflight events to identify the category into which the rating should be placed.

The original intent had been to rely primarily on the event data from the exterior and interior sound level meters, along with the flight schedules obtained from air space managers, to identify the occurrence of real overflights. However, because many competing acoustic events exceeded the preset threshold inside the house, it was usually impossible to identify unequivocally the real overflights from the sound level meter data alone.

Similarly, in order to avoid measuring many non-aircraft events, the threshold of the outside sound level meter had to be set so high (95 dB) that many distant overflight events were missed.

It soon became clear that the individual overflight annoyance rating forms, which had been completed manually by the subjects, were much more reliable indicators of real overflights than were the acoustic data. Any form that had a time entered which did not correspond to one of the scheduled recorded events, was assumed to represent a real overflight.

Using the rating forms to identify real overflight events meant that if no one was home in a given house when a real overflight occurred, the flight would not be identified by the occupants of that house. To obtain a more accurate house exposure count, it was decided that if nearby houses experienced an overflight, as indicated by responses of subjects who were in those homes, the house with no responses would be assumed to have been vacant at the time and would be considered to have experienced an overflight. Because, as much as was possible, homes close to each other were chosen to participate in the study, all but two of the 24 houses were near enough to each other to make this assumption.

The real overflight events so identified were combined with the scheduled recorded overflight events to determine the event count for the day and the standard deviation of the logarithm of the interstimulus interval (ISI) for the day. (See Section 3.4.2 for a description of this parameter.) The resultant database of annoyance rating, events per day, and standard deviation of log(ISI) contained 1,440 entries.

As described above, the analysis associated each subject's annoyance rating with parameters that corresponded to those events that were received at the subject's home. The fact that any given subject may have been away from home for some portion of the day and therefore may not have experienced all of these events is treated as an unexplained variable. The effect of this unexplained variable, however, is minimized by including in the analysis only those subjects whose responses indicated that they were at home most of the time. This resulted in a subset of the dataset containing 985 entries (68.4 percent of the original dataset).

Figure 8 shows the distribution of the standard deviations of the logarithms of the interstimulus intervals (ISIs) for the subset of subjects who were home most of the time. Using a procedure similar to that described in Section 3.4.2, the boundary between the regular and irregular categories was set at the arithmetic average of the modes of the two distributions, i.e.,

$$\text{Regular: } \sigma\,(\log(\text{ISI})) \le 0.20; \text{ Irregular: } \sigma\,(\log(\text{ISI})) > 0.20.$$

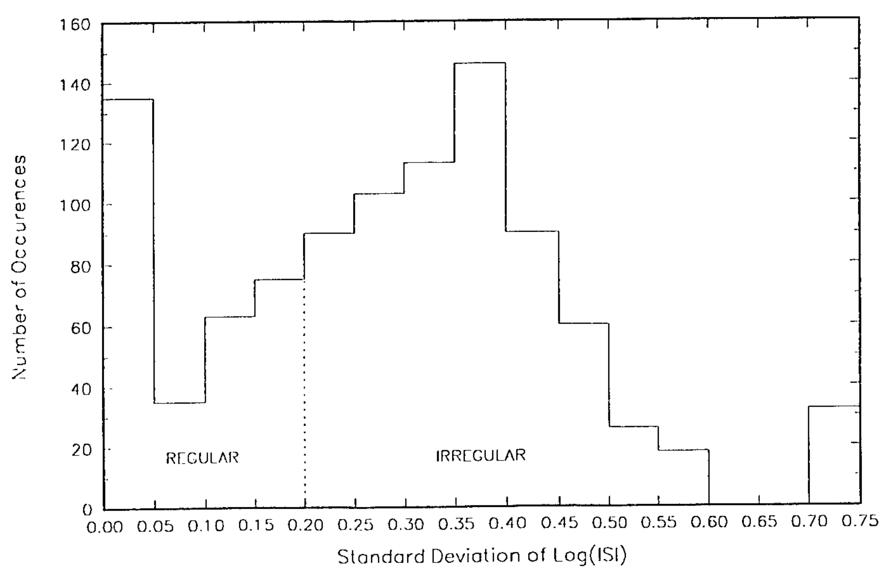


Figure 8. Distribution of the Standard Deviation of the Logarithm of the ISIs

Figure 9 shows the distribution of the number of real and recorded overflight events experienced at the subject's home. The boundaries between the low, medium, and high categories have been set one count higher than those discussed in Section 3.4.1 to account for the real events which occurred, i.e.,

$$\text{Low: } N \leq 6; \text{ Medium: } 7 \leq N \leq 12; \text{ High: } N \geq 13.$$

As will be seen below, the result of the ANOVA is insensitive to the choice of boundaries for this parameter.

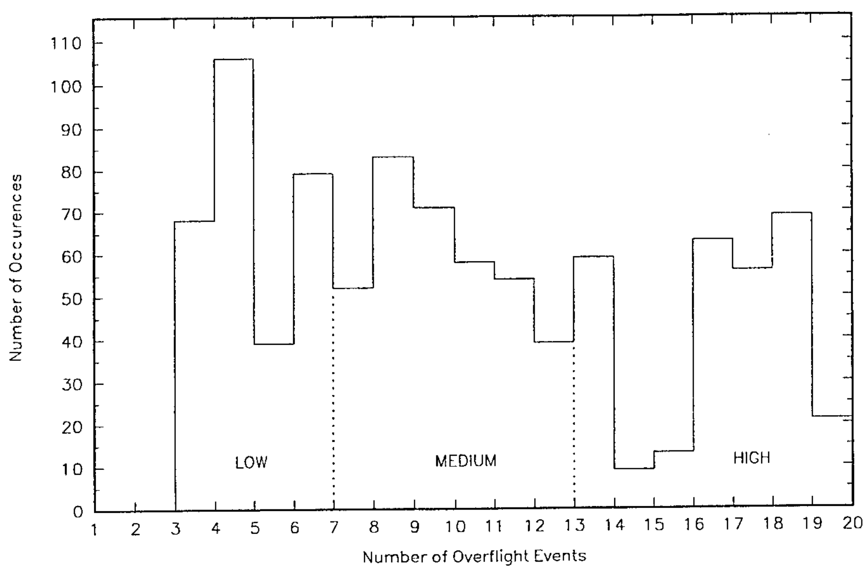


Figure 9. Distribution of the Number of Overflight Events Per Day to Which the House Was Exposed.

5.1.2 Analysis of Variance

Table 9 shows the analysis of variance (ANOVA) of the daily response data as a function of the categorical variables of regularity and total number of aircraft overflight events per day to which the home was exposed. As is indicated in the last column, both variables and their interaction are not significant (NS) at the 0.05 level of confidence. (At this level of confidence the critical F-value is 3.84 for one degree of freedom and 3.00 for two degrees of freedom.)

Table 9

ANOVA of Daily Responses to Aircraft Sounds as a Function of Regularity and Total Number of Overflight Events Per Day to Which the Home Was Exposed*

Source	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F	P
Regularity	1	0.82	0.82	0.23	NS
Events Per Day	2	5.79	2.90	0.82	NS
Interaction	2	14.21	7.11	2.01	NS
Residual	982	3469.04	3.53		
Total	987	3489.86			

* Using the procedure for unequal cell frequencies described in Reference 6.

Table 10 shows the means and standard deviations of the daily responses for the regularity variable, the number of events per day variable, and for the interaction between the two.

Table 10

Means and Standard Deviations of Daily Responses to Aircraft Sounds as a Function of Regularity and Number of Events Per Day To Which the Home Was Exposed

(a) For Regularity Variable

Regularity	Mean	Std. Dev.	Responses
Regular	3.82	1.86	308
Irregular	3.95	1.89	678

(b) For Events Per Day Variable

Events Per Day	Mean	Std. Dev.	Responses
Low	3.79	1.92	292
Medium	3.92	1.80	357
High	4.00	1.93	337

(c) For Interactions

Events Per Day	Regularity					
	Regular			Irregular		
	Mean	Std. Dev.	Responses	Mean	Std. Dev.	Responses
Low	3.59	1.86	157	4.03	1.96	135
Medium	4.10	1.63	69	3.88	1.84	288
High	4.01	2.00	82	3.99	1.92	255

To test the sensitivity of these results to the category definitions for number of events per day, ANOVAs were carried out for two other cases – the first in which the Medium category extends from 6 to 14 events per day, the second in which the Medium category extends from 8 to 12 events per day. In both cases there was no statistically significant dependence of annoyance rating on either number of events per day or regularity.

5.1.3 Regression Analysis

Figure 10 shows the multiple linear regression of the daily response data as a continuous function of the number of events per day to which the house was exposed and the standard deviation of the logarithm of the ISIs of those events. Figure 10(a) shows the raw data while Figure 10(b) shows the multiple linear regression of this data. Each solid circle in Figure 10(a) corresponds to one or more samples.

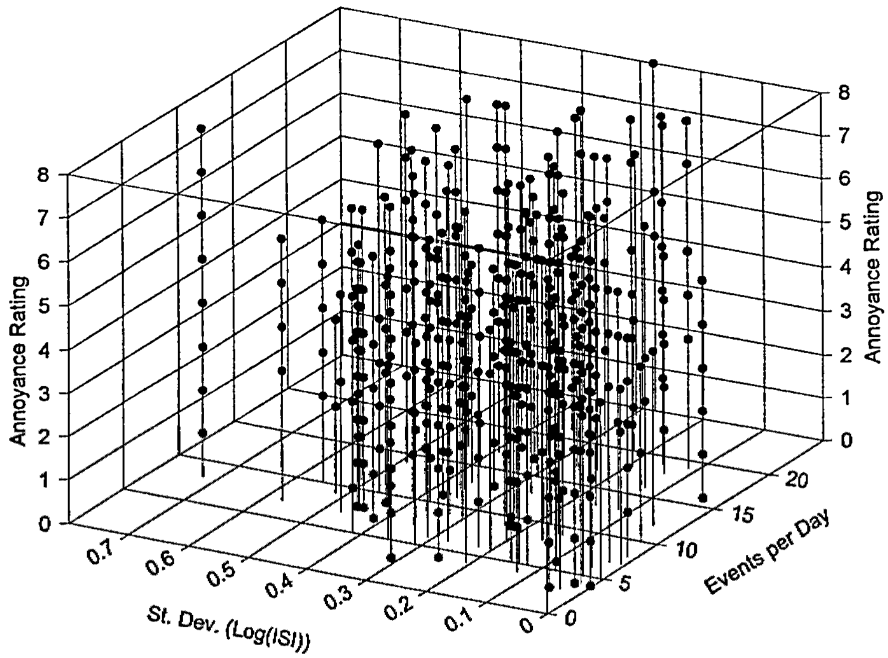
Table 11 shows the least-squares fit parameters corresponding to the multiple regression in Figure 10(b). The t-values of the parameters "b" and "c", which correspond to the number of events per day (N) and the standard deviation of the logarithm of the ISIs ($\sigma_{log(ISI)}$), respectively, are each less than the critical t-value at the 95 percent level of confidence. Thus, at this level of confidence, the null hypothesis – i.e., the hypothesis that the annoyance rating is independent of N and $\sigma_{log(ISI)}$ – cannot be rejected. This is entirely consistent with the results of the ANOVA described in Section 5.1.2.

Table 11

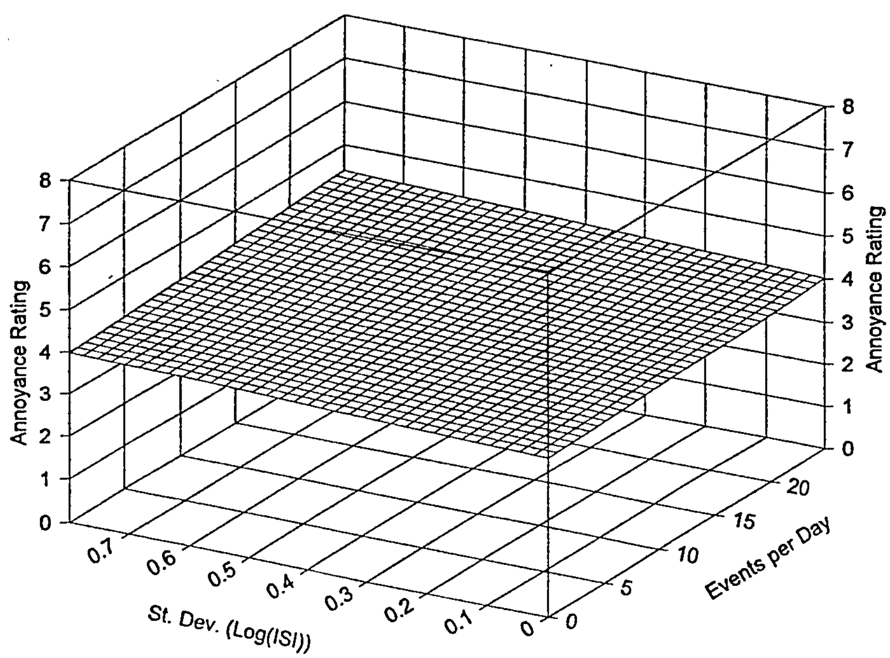
Multiple Regression of the Daily Annoyance Rating
As a Function of the Number of Events Per Day to Which
the Home was Exposed and the Standard Deviation of
the Logarithms of the Interstimulus Intervals of Those Events

$R = a + b\,N + c\,\sigma_{log(ISI)}$					
Parameter	**Value**	**Standard Error**	**t-value***	**95% Confidence Limits**	
a	3.597	0.154	23.351	3.295	3.899
b	0.017	0.011	1.503	-0.005	0.040
c	0.477	0.366	1.304	-0.240	1.195

* Critical t-value at the 95% Level of Confidence = 1.960.



(a) Raw Data (Each Solid Circle Corresponds to One or More Responses).



(b) Multiple Regression.

Figure 10. Daily Annoyance Rating as a Function of the Number of Events Per Day to Which the Home Was Exposed and the Standard Deviation of the Logarithms of the Interstimulus Intervals of Those Events.

5.1.4 Post-Experiment Questionnaire

An examination of the responses to the Post-Experiment Questionnaire (Appendix 7) qualitatively agreed with these quantitative results. Ninety-six percent of the respondents recognized that some of the days had more military overflight sounds than others. Of these, 76 percent thought that days with more flights were more annoying while 24 percent thought that days with fewer flights were more annoying. Seventy-eight percent of the respondents recognized that the pattern of overflight sounds was more regular on some days than on others. Of these, 44 percent felt that days with more regular flights were more annoying, while 56 percent felt that days with more irregular flights were more annoying.

5.2 The Effect of the Number of Overflight Events

5.2.1 Summary of Response Data

Unlike the sporadicity analysis, the analysis of the effect on annoyance of the number of overflight events, independent of the total sound exposure level, requires an examination of those events which the subjects actually experienced, rather than those to which the subjects' homes were exposed. Since a subject may not have been home to experience a scheduled recorded event or a real overflight event, the individual overflight annoyance rating forms were used to identify the events that each subject actually experienced. Ratings of 1,213 recorded and real overflight events were obtained in this manner.

A nominal sound exposure level (SEL) of 95 dB or 80 dB was assigned to each of the recorded events based on the scheduled level of the event. (See Tables 3, 4, and 5 in Section 3.4.2.) Measured sound exposure levels were assigned to all real events which had an interior SEL of 80 dB or higher. As noted in Section 5.1.1, real overflight events could often not be separated from other noise events on the basis of interior sound level measurements alone. Thus it was usually not possible to unequivocally determine the SEL of real overflight events if the value was below 80 dB.

The SELs which each subject experienced were combined to produce a daily energy-equivalent sound level (L_{eq}) for that subject. The omission from this computation of SELs of real events which were below 80 dB will affect the total SEL, and the daily L_{eq}, by only a fraction of a decibel (see Total SEL column of Table 3 in Section 3.4.2) if the subject experienced all or most of the recorded events. The ANOVA, below, is restricted to such subjects, since it includes only those responses corresponding to daily L_{eq} values between 46 and 56 dB (SELs of 95 to 105 dB). Even though the SELs of these low-SEL events were not included in the L_{eq} calculation, their annoyance ratings were included in the database.

Figure 11 shows the distribution of the daily L_{eq} values to which the subjects were exposed. For purposes of the ANOVA in Section 5.2.2, below, two L_{eq} categories have been identified in the figure, L_{eq} 46 to 50 dB and L_{eq} 51 to 56 dB. Categories were not defined for L_{eq} values below 46 dB, because there were no samples in the high ratings per day (see below) category for such low L_{eq} values. All of the data was included, however, in the multiple regression analysis in Section 5.2.3.

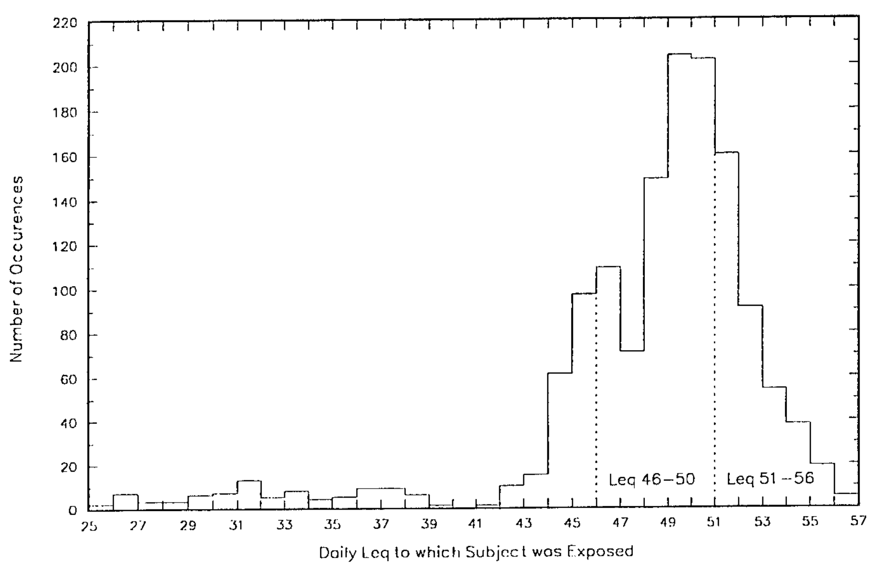


Figure 11. Distribution of Daily L_{eq} Values to Which Subjects Were Exposed.

Figure 12 shows the distribution of the number of individual overflight ratings per day reported by the subjects. Since the rating report was used to identify those overflight events which were experienced by the subject, this variable is equivalent to the number of overflight events to which the subject was exposed. As for the sporadicity analysis, the number of ratings per day has been divided into three categories – low, medium, and high – as shown in the figure. These are the same categories used for the sporadicity ANOVA in Section 5.1.2.

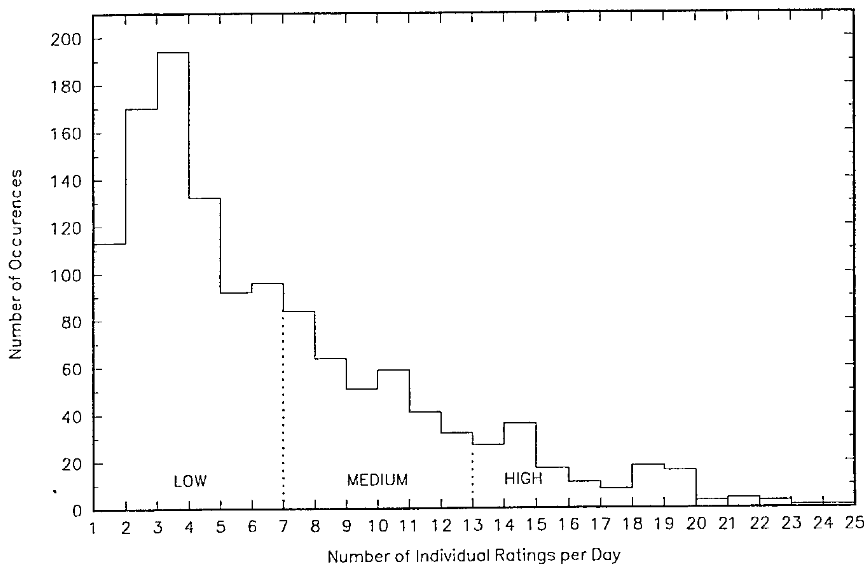


Figure 12. Distribution of the Number of Individual Overflight Event Ratings per Day.

5.2.2 Analysis of Variance

Table 12 shows the ANOVA as a function of the categorical variables of daily L_{eq} and number of individual overflight event ratings per day. As indicated in the last column, only the daily L_{eq} variable is significant at the 0.05 level of confidence or better. The number of ratings per day variable and the interaction are not significant (NS) at the 0.05 level of confidence. (At this level of confidence the critical F-value is 3.84 for one degree of freedom and 3.00 for two degrees of freedom.)

Table 12

ANOVA of the Daily Responses as a Function of L_{eq} Category and Number of Individual Event Ratings Per Day*

Source	Degrees of Freedom	Sum of Squares	Mean Sum of Squares	F	P
L_{eq} Category	1	49.23	49.23	13.03	<0.01
Ratings Per Day	2	14.99	7.49	1.98	NS
Interaction	2	6.47	3.24	0.86	NS
Residual	1,098	4,220.64	3.78		
Total	1,103	4,149.95			

* Using the procedure for unequal cell frequencies described in Reference 6.

Thus the data in this experiment have confirmed the equal-energy principle. That is, the principle that the annoyance response to a sequence of noise events is a function only of the L_{eq} (or total acoustic energy) of those events and not also a function of the number of events in the sequence.

Table 13 shows the means and standard deviations of the daily responses for the L_{eq} variable, the number of ratings per day variable, and for the interaction between the two.

Table 13

Means and Standard Deviations of the Daily Responses as a Function of L_{eq} and Number of Individual Event Ratings Per Day

(a) For L_{eq} Variable

L_{eq} Category	Mean	Std. Dev.	Responses
L_{eq} 46–50	3.51	1.97	735
L_{eq} 51–56	4.39	1.92	367

(b) For Ratings Per Day Variable

Ratings Per Day Category	Mean	Std. Dev.	Responses
Low	3.51	2.02	646
Medium	4.05	1.84	311
High	4.57	1.95	145

(c) For Interactions

Ratings Per Day Category	L_{eq} Category					
	L_{eq} 46–50			L_{eq} 51–56		
	Mean	Std. Dev.	Responses	Mean	Std. Dev.	Responses
Low	3.37	2.01	542	4.24	1.93	104
Medium	3.91	1.78	174	4.24	1.90	137
High	3.84	2.03	19	4.68	1.92	126

5.2.3 Regression Analysis

Figure 13 shows the multiple linear regression of the daily response data as a continuous function of the number of events per day that the subject experienced and the energy-equivalent sound level of those events. Figure 13(a) shows the raw data while Figure 13(b) shows the multiple linear regression of this data. Each solid circle in Figure 13(a) corresponds to one or more samples.

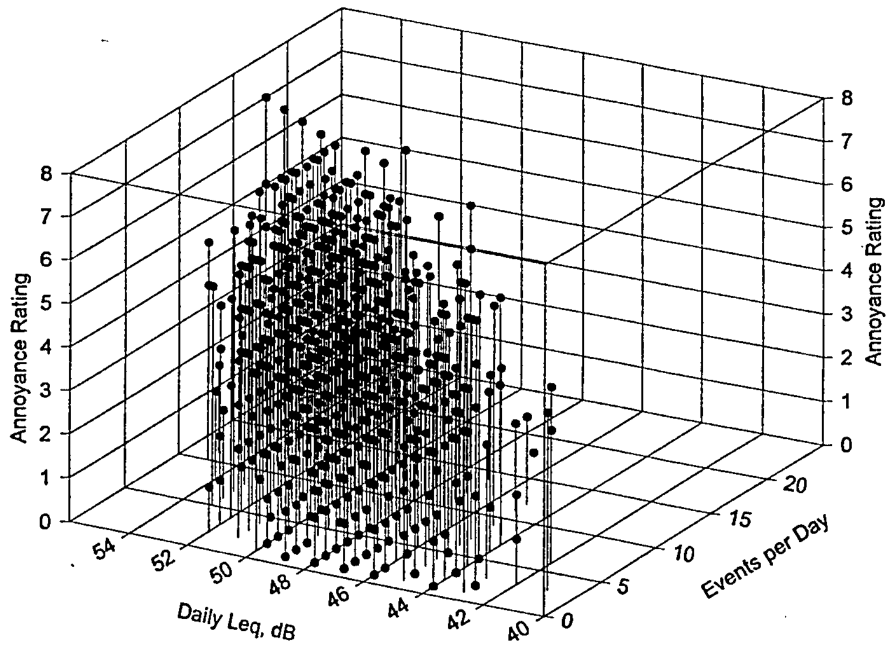
Table 14 shows the least-squares fit parameters corresponding to the multiple regression in Figure 13(b). The t-value of the parameter "b", which corresponds to the number of events per day (N), is less than the critical t-value at the 95 percent level of confidence. Thus, at this level of confidence, the null hypothesis – i.e., the hypothesis that the annoyance rating is independent of N – cannot be rejected. The t-value of the parameter "c", which corresponds to the energy-equivalent sound level (L_{eq}) of the daily events to which subject was exposed, is greater than the critical t-value at the 95 percent level of confidence. Thus, at this level of confidence, the null hypothesis – i.e., the hypothesis that the annoyance rating is independent of (L_{eq}) – must be rejected. These results are entirely consistent with the results of the ANOVA described in Section 5.2.2.

Table 14

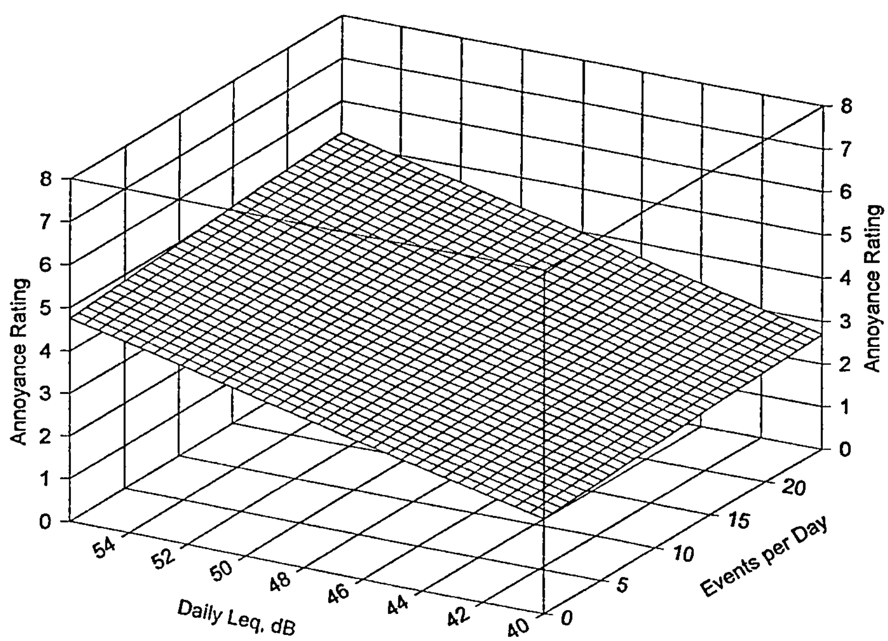
Multiple Regression of the Annoyance Rating as a
Function of the Number of Events Per Day That the Subject Experienced
and the Energy-Equivalent Sound Level of Those Events

$R = a + b N + c L_{eq}$					
Parameter	**Value**	**Standard Error**	**t-value***	**95% Confidence Limits**	
a	-4.239	1.249	-3.395	-6.685	-1.793
b	0.020	0.015	1.344	-0.009	0.050
c	0.161	0.027	6.046	+0.109	0.213

* Critical t-value at the 95% Level of Confidence = 1.960.



(a) Raw Data (Each Solid Circle Corresponds to One or More Responses).



(b) Multiple Regression.

Figure 13. Daily Annoyance Rating as a Function of the Number of Events Per Day That the Subject Experienced and the Energy-Equivalent Sound Level of Those Events.

5.2.4 Estimate of the Daily Number of Overflights

During the computerized questioning each evening, each subject was asked to estimate the number of overflights that she or he had heard during the past 24 hours. The categories from which the subject had to choose were: "None", "1", "2", "3 to 5", "6 to 10", "11 to 20", "More than 20".

Figure 14 shows the expected mean value (i.e., the center of the range for each category) and the observed mean value of the overflight event responses plotted as a function of the estimated number of overflights category. The expected mean value for each category is indicated by an open box, while the observed mean value of the responses is indicated by an "X".

Examination of this figure shows the observed mean value of the number of responses to be very close to the expected mean value for each category up to 6 to 10 overflights. Beyond this the observed mean value of the number of responses is below the expected mean value for the category. This result would indicate that, as long as there are less than approximately 10 events per day, a subject can remember the actual number of individual events. However, when the number of events per day exceeds this value, the subject can no longer remember the individual events. Instead, he or she perceives the number of events to be less than actually occurred.

5.3 The Effect of Onset Rate

5.3.1 Summary of Response Data

Since onset rate is a property of a single overflight, the analysis of the effect of onset rate on annoyance requires an examination of the individual overflight event ratings. These individual events consist of two types – recorded and real.

As discussed in Section 3.4.3, the recorded sounds were presented at two sound levels – low and high. The SEL of the low-level sounds was 80 dB; that of the high-level sounds was 95 dB. Since the SEL of most real sounds was under 87.5 dB, annoyance ratings for real events were assigned to the low sound level category.

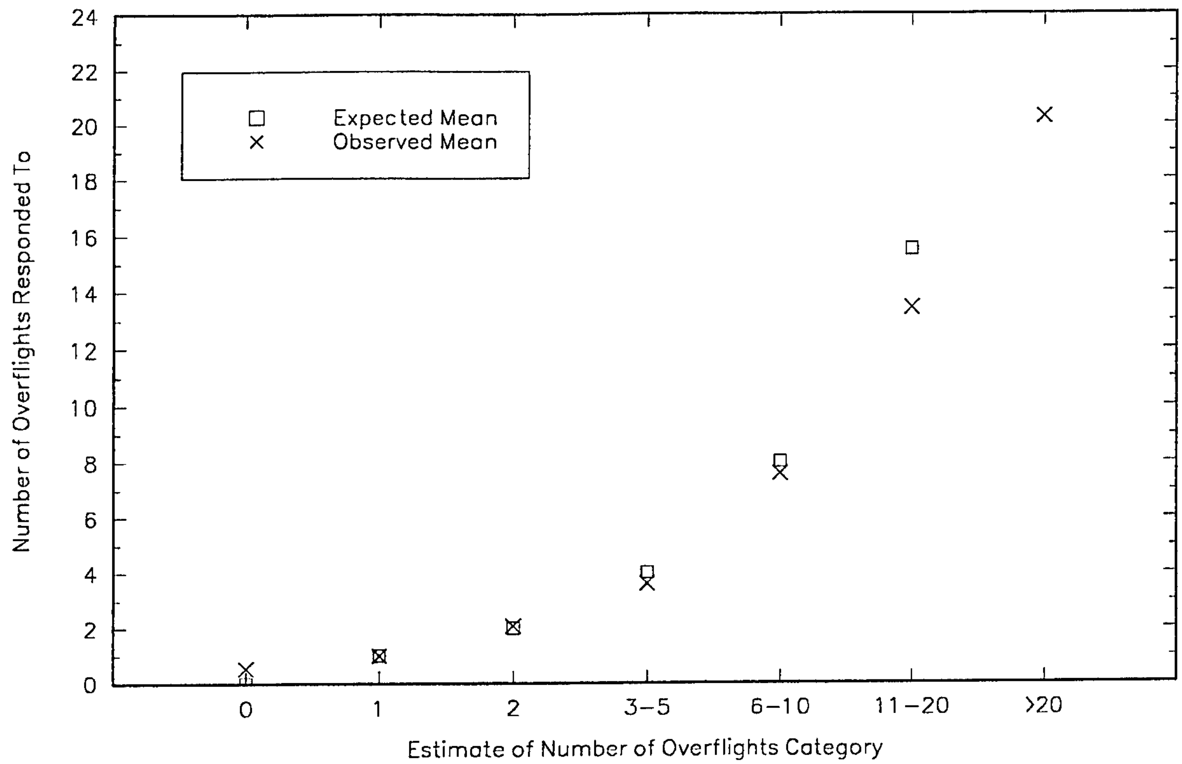


Figure 14. Number of Overflight Event Responses as a Function of the Estimated Number of Overflights.

As discussed in Section 3.4.5, the recorded sounds used in this experiment corresponded to two onset rate categories – low and high. The low onset rate category was represented by recordings of F-15 overflights (for the first two groups of subjects) and F-16 overflights (for the second two groups of subjects), having an average onset rate of 50.5 dB/sec (see Table 2 in Section 3.3.1). The high onset rate category for all groups was represented by recordings of F-4 overflights, having an onset rate of 152 dB/sec. Since all real overflights were of F-15, F-16, or slower aircraft, annoyance ratings for these events were assigned to the low onset rate category.

The numbers of responses in each category are shown in Table 15.

Table 15

Number of Responses in Sound Level/Onset Rate Categories

Sound Level		**Onset Rate**	
		High	**Low**
High		1554	2008
Low	Recorded	1889	1963
	Real	0	1044
	TOTAL	1889	3007

5.3.2 <u>Analysis of Variance</u>

Table 16 shows the ANOVA of the individual event response data as a function of the sound level and onset rate categories. As indicated in the last column, the sound level variable, the onset rate variable, and their interaction are significant at the 0.01 level of confidence. (At this level of confidence the critical F-value for one degree of freedom is 6.63.)

Table 16

ANOVA of the Individual Event Responses as a Function of Sound Level and Onset Rate Categories

Source	**Degrees of Freedom**	**Sum of Squares**	**Mean Sum of Squares**	**F**	**P**
Sound Level	1	4362.44	4362.44	566.63	<0.01
Onset Rate	1	145.77	145.77	18.93	<0.01
Interaction	1	55.55	55.55	7.21	<0.01
Residual	8454	65,089.61	7.70		
Total	8457	69,653.37			

As expected, individual event response is a function of the sound level. In addition, the dependencies of response on onset rate and the interaction, which were first discovered in the laboratory experiments and confirmed in the rented home experiment, continue to exist in the more natural own-home environment.

An examination of the responses to the Post-Experiment Questionnaire (Appendix 7) indicated that 91 percent of the respondents have been startled or surprised by military jet overflights. When asked to rate the qualities of aircraft sounds that are most annoying, "intensity" was rated most annoying, followed by "onset rate".

Table 17 shows the means and standard deviations of the individual event responses for the sound level variable, for the onset rate variable, and for the interaction of the two.

Table 17

Means and Standard Deviations of the Individual Event Responses as a Function of Sound Level and Onset Rate Categories

(a) For Sound Level Variable

Sound Level Category	Mean	Std. Dev.	Responses
Low	2.98	3.16	4896
High	4.45	2.14	3562

(b) For Onset Rate Variable

Onset Rate Category	Mean	Std. Dev.	Responses
Low	3.47	3.20	5015
High	3.79	2.00	3443

(c) For Interactions

Onset Rate Category	Sound Level Category					
	Low			High		
	Mean	Std. Dev.	Responses	Mean	Std. Dev.	Responses
Low	2.94	3.76	3007	4.26	2.10	2008
High	3.05	1.83	1889	4.69	2.19	1554

Figure 15 shows the individual event annoyance rating as a function of sound level and onset rate. The data has been superimposed upon a figure (Figure 11) from Reference 3, which reported the results of the Rented Home Experiment. The 95 dB data from the current experiment is consistent with the results of the earlier experiment. Of perhaps more importance is the fact that the onset rate effect remains at the lower 80 dB sound level.

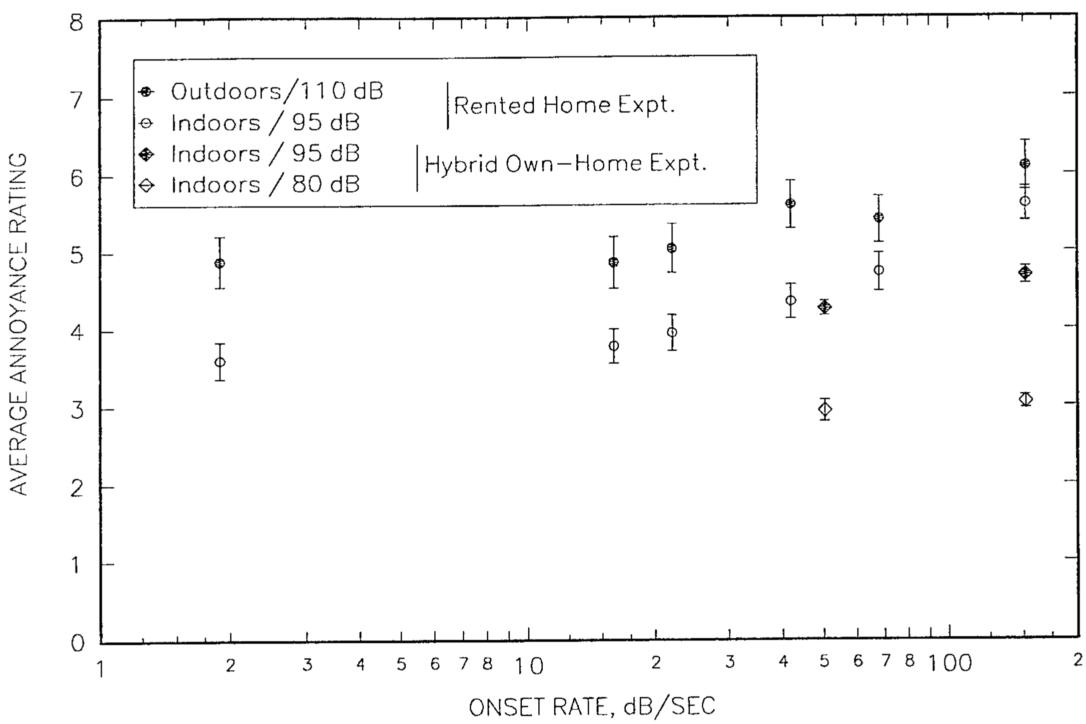


Figure 15. Individual Event Annoyance Rating as a Function of the Sound Level and Onset Rate.

(* σ_m is the Standard Error of the Mean for the data set.)

5.4 Conclusions

The Hybrid Own-Home Experiment has shown that in actual home environments human annoyance to individual MTR operations is most related to the sound level and onset rate of the aircraft overflights. Other effects are, at most, secondary.

On the basis of the results of the Laboratory, Rented Home, and Hybrid Own-Home Experiments, it is recommended that the L_{dnmr} acoustic metric[7,8] be finalized by formally adopting an onset rate adjustment. The most appropriate adjustment, based on these three studies, is shown in Figure 16. The adjustment, ADJ, in dB as a function of onset rate, OR, in dB/sec, is given by:

$$ADJ = \begin{cases} 0, & \text{for } OR < 15 \\ 11.0 \log_{10}(OR) - 12.9, & \text{for } 15 \le OR \le 150 \\ 11, & \text{for } OR > 150. \end{cases}$$

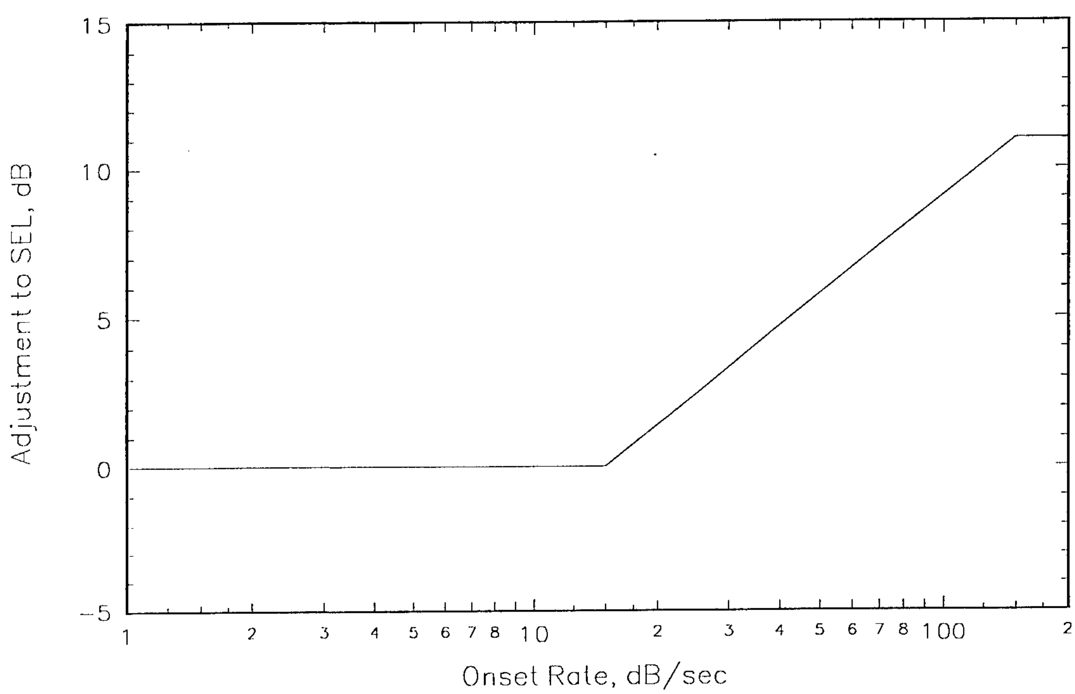


Figure 16. Recommended Onset Rate Adjustment.

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APPENDIX 1

Study Qualification Form

House ________ Town/City ______________ Code ________

Study Qualification Form

Name: ____

Address: ____

____

1. About how many low-flying military jets do you hear in and around your house on a typical week? ______________________

2. In which direction do the low-flying military jet aircraft usually pass over your house? From ______________ to ______________

   One Direction? ______ Both Directions? ________

3. Do most of the military jets fly directly over your house or off to one side? Directly Overhead ________ To Which Side ______________

   One Direction? ______ Both Directions? ________

4. How long has your family lived in this house? ___ years

   this area? ___ years

5. How many adults live in your home? ____

   Teenagers? ____

   Children? ____

6. How many of the adults would be willing to participate in the study? _____ Teenagers? ____

7. Do all of the people who would be participating in the study have normal hearing? ___ Yes ___ No If no, explain:

   ____

   ____

8. Do any of the participants have any other disabilities? ___ Yes ___ No If yes, explain:

   ____

   ____

9. Does anyone in your immediate family have any association with the aircraft industry, with the United States Air Force, Navy, or Air National Guard?
___ Yes ___ No If yes, explain:

____

____

10. Are there any animals living in the house? ___ Yes ___ No
If yes, please list:

____

Are any of these animals affected by the noise from low-flying military jet aircraft? ___ Yes ___ No If yes, which ones and how?

____

____

11. Are there any other loud noise sources in or around your home (i.e,. barking dogs, loud traffic, farm equipment, nearby railroad operations, etc.)?
___ Yes ___ No If yes, explain:

____

____

12. How many telephone lines do you have in your house? ______

Is your telephone service on a private or a party line? __ Private __ Party

Is the service touch-tone? ____ Rotary? ____

Is there a telephone answering machine on any of these lines? __ Yes __ No

Is there a fax machine on any of these lines? __ Yes __ No

Where is the telephone service entrance point to the house?

____

What are your home telephone numbers?

1. ______________________________

2. ______________________________

What are your work telephone numbers?

1. ______________________________

2. ______________________________

Are you willing to have a temporary new line installed? __ Yes __ No

13. Do you have a computer in your home? ___ Yes ___ No
    Is it connected to a telephone line? ___ Yes ___ No

14. How often does the electric service to your house get interrupted due to outages, storms, floods, etc.? ______ times per year.

15. How often does the telephone service to your house get interrupted due to outages, storms, floods, etc.? ______ times per year.

16. When service is interrupted, for how long is it normally out?
    Electric: _____ hours
    Telephone: _____ hours

17. Which two (2) rooms, that are most often occupied during waking hours, could be used for installing the experiment loudspeaker systems?
    Room 1: ____________________
    Room 2: ____________________

18. Which room could be used for housing the experiment computer and electronics? ______________________________.
    How many amperes is the electric circuit to this room? ______ amps.
    Are the electric outlets in this room grounded (three-prong type)?
    ___ Yes ___ No
    Which outlet should we use? ____________________

19. Where is the best location to place an indoor microphone?
    ____

20. Where is the best location to place an outdoor microphone?
    ____

21. What is the best access point for the wire from the outside microphone?

____

22. Where is the easiest access to the house for a dolly or rack full of equipment?

____

23. Names and ages of all family members who are willing to participate.

	NAME	AGE	HOURS HOME
Adults: (Relationship)			
______ #1:			
______ #2:			
______ #3			
______ #4			
Teenagers:			
______ #1:			
______ #2:			
______ #3:			
______ #4			

24. What time does the family normally get up in the morning? ______

What time does the family normally go to sleep at night? ______

Are the following computer response times convenient for you?				Alternate
Regular evening screen-on time:	___ PM	Yes __	No __	____
Regular evening screen-off time:	12 Midnight	Yes __	No __	____
Make-up morning screen-on time:	__ AM	Yes __	No __	____
Make-up morning screen-off time:	__ AM	Yes __	No __	____

25. Any unusual features about house or access? Yes __ No __

Describe: ____________________________________

____

26. Please draw an approximate plan view of each of the two or three rooms identified above, showing:

    1. Doors
    2. Windows
    3. Major furniture
    4. Counters
    5. Electric outlet for electronic rack
    6. Relevant existing telephone outlets
    7. New telephone outlet
    8. Possible loudspeaker placement
    9. Possible computer/electronic rack placement
    10. Possible indoor microphone placement

<u>Diagram of Room #1:</u> Name of Room: ______________________________

Diagram of Room #2: Name of Room: ______________________

Diagram of Room #3: Name of Room: ______________________

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APPENDIX 2

Agreement Form

AGREEMENT

____ and

____ of

____

____

____

Telephone number: ________________________________

agree to participate in an experiment concerning military jet aircraft flyby sounds being conducted by Wyle Laboratories. We agree to have a computer system, six (6) loudspeakers, and two (2) microphones placed at our house for one month (29 days). This equipment will reproduce military jet flyby sounds in our house. We will respond to these sounds as well as real military jet sounds on special response pads and on the computer.

We have been told the details of the experiment, and agree to participate. Wyle Laboratories agrees to pay our family a total of $1,000.00 for our participation. This payment will be in the form of a check for $200.00 on the 1st, 8th, 15th, and 22nd day of the study, and a check for $200.00 when the study has been completed.

We agree to the following dates for our participation.

	Day	Date	Time
1. Equipment setup and briefing	______	______	______
2. Start of experiment	______	______	______
3. End of experiment	______	______	______
4. Equipment removal and debriefing	______	______	______

Witness our hands and seals this __________ day of ____________, 1993.

PARTICIPANT NO. 1

____
Signature

____
Print Name

____
Date

PARTICIPANT NO. 2

____
Signature

____
Print Name

____
Date

PARTICIPANT NO. 3

____
Signature

____
Print Name

____
Date

PARTICIPANT NO. 4

____
Signature

____
Print Name

____
Date

WYLE REPRESENTATIVE

____
Signature

____
Print Name

____
Date

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APPENDIX 3

Consent Form

CONSENT FORM FOR MAIN EXPERIMENT

Informed Consent Form
For Aircraft Noise Experiment

You and your family are invited to participate in a study of people's response to military aircraft sounds. We hope to learn the best way to measure these aircraft sounds so as to reflect the individual and community response to such noise sources. This will help the government and communities to determine the impact of aircraft operations on the local population. You have been selected as a participant in this study because you live in an area where military aircraft fly.

If you decide to participate, we (Eric Stusnick, Kevin Bradley, John Molino, David Rickert, Marcelo Bossi, Marcio Avillez, and Alan Dent), the experimenters, will set up equipment to reproduce recorded military aircraft sounds in your house. These sounds will be reproduced for you by a system of loudspeakers and you will be requested to rate the annoyance of both recorded and real flyby sounds according to scales and questionnaires. You will listen to these sounds as you go about your normal activities. You will hear anywhere between 2 and 24 recorded aircraft sounds during a single day, as well as an unknown number of real aircraft sounds. You will participate in the study for about one month (29 days). There will be a short briefing and debriefing session both before and after the study. These sessions will take about three to four hours each.

Any potential risks to you or your family as participants in this experiment are minimal. Some of the aircraft flyby sounds that you will hear may be quite loud, but they will be very brief. They may be unpleasant or annoying, but they cannot damage your hearing. The average eight-hour sound level will not exceed 70 dBA. The Occupational Health and Safety Administration (OSHA) limit for eight (8) hours of exposure per workday is 90 dBA. The Air Force Regulation 161-35 limit for eight (8) hours of exposure per workday is 84 dBA. Thus the risk of hearing damage may be considered to be minimal to negligible. Other natural risks such as tripping, falling, or slipping are the same as would be normally associated with entering, moving about, or exiting your home, or engaging in your customary activities. Your entitlement to medical care or compensation in the event of injury is governed by federal laws and regulations, and if you desire further information you may contact Dr. Eric Stusnick at 800/783-1538.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. Only group average data or individual data identified by means of a code will be published or released. Only the seven experimenters named above will have access to confidential information which could be identified with you. Records of your participation in this study may only be disclosed according to federal law, including the Federal Privacy Act, 5 USC 552a, and its implementing regulations.

For your family's participation in this study, you will be paid a total of $1,000.00. This payment will be in the form of a check for $200.00 on the 1st, 8th, 15th, and 22nd days of the study, and a check for $200.00 when the study has been completed.

By signing this form in the space provided below, you are certifying the validity of the following statements: The decision for you and your family to participate in this research is completely voluntary on your part. No one has coerced or intimidated you into participating in this program. You are participating because you want to. The experimenter has adequately answered any and all questions you have about this study, your participation, and the procedures involved. You understand that Dr. Eric Stusnick at 800/783-1538 will be available to answer any questions concerning procedures throughout this study. You understand that if significant new findings develop during the course of this research which may relate to your decision to continue participation, you will be informed. You further understand that you may withdraw this consent at any time and discontinue further participation in this study, in which case you will be paid for the portion of the research that you completed. You also understand that the experimenter may terminate your participation in this study at any time, in which case you will be paid for the portion of the research that you completed.

You will be given a copy of this form to keep.

Date: ____________________ Time: ______________ AM PM

PARTICIPANTS:

Print Name: ________________________ Print Name: ________________________

Signature: ________________________ Signature: ________________________

Social Security No.: ________________ Social Security No.: ________________

Print Name: ________________________ Print Name: ________________________

Signature: ________________________ Signature: ________________________

Social Security No.: ________________ Social Security No.: ________________

EXPERIMENTER:

Print Name: ________________________________

Signature: ________________________________

Social Security No.: ____________________________

WITNESS:

Print Name: ________________________________

Signature: ________________________________

Social Security No.: ____________________________

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APPENDIX 4

Pre-Experiment Questionnaire

Pre-Experiment Questionnaire

Name: ______________________________ Participant #__________

Date: __________________ Time __________

1. How long have you lived in this community: _________ Years

We would like to get an idea of how much time you spend in and around your home. Please answer the following questions concerning your normal daily schedule, excluding vacations and special periods. Assume 16 waking hours in each day.

2. About how many hours of the day do you normally spend at home inside your house? (Not including sleeping hours.)

WINTER			SUMMER		
Weekday:	____	Hours per day	Weekday:	____	Hours per day
Weekend Day:	____	Hours per day	Weekend Day:	____	Hours per day

3. About how many hours of the day do you normally spend outdoors around your home on your own property?

WINTER			SUMMER		
Weekday:	____	Hours per day	Weekday:	____	Hours per day
Weekend Day:	____	Hours per day	Weekend Day:	____	Hours per day

4. About how many hours of the day do you normally spend away from your home or property?

WINTER			SUMMER		
Weekday:	____	Hours per day	Weekday:	____	Hours per day
Weekend Day:	____	Hours per day	Weekend Day:	____	Hours per day

5. Over the next four weeks of the experiment, do you have any normal re-occurring activities that take you away from your home and your property on a regular basis? These activities may include work, regular medical appointments, daycare, regular shopping, regular visits with relatives, etc.

Yes ___ No ___

If yes, please indicate next to each day of the week the kind of activity and the hour you leave and return in the table below.

		ACTIVITY 1	ACTIVITY 2	ACTIVITY 3
EVERY MONDAY	Activity	____________	____________	____________
	Leave	____________	____________	____________
	Return	____________	____________	____________

Participant #________

EVERY TUESDAY	Activity	________	________	________
	Leave	________	________	________
	Return	________	________	________
EVERY WEDNESDAY	Activity	________	________	________
	Leave	________	________	________
	Return	________	________	________
EVERY THURSDAY	Activity	________	________	________
	Leave	________	________	________
	Return	________	________	________
EVERY FRIDAY	Activity	________	________	________
	Leave	________	________	________
	Return	________	________	________
EVERY SATURDAY	Activity	________	________	________
	Leave	________	________	________
	Return	________	________	________

6. Over the next four weeks of the experiment, do you have any scheduled activities that are not re-occurring and you know will take you away from your home and your property only once or twice during the period? These activities may include trips, holiday visits, medical appointments, etc.

   Yes ___ No ___

   If yes, please fill in the table below.

Participant #________

	ACTIVITY	LEAVE	RETURN
FIRST WEEK			
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			
SECOND WEEK			
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			
THIRD WEEK			
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			
FOURTH WEEK			
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			

Participant #__________

7. The next few questions concern your perceptions about low-flying military jet aircraft (not high-flying jets, propeller planes, or helicopters) that you hear while you are at home inside your house or outside on your property.

   a. On the average, on days when the jets fly, about how many low-flying military jets do you hear per day in and around your house?

      ____

   b. On the average, about how many days a week do you hear low-flying military jets in and around your home? ____________________

   c. On the average, about how many low-flying military jets do you hear in and around your house during a typical week? ____________________

   d. On the average, about how many low-flying military jets do you hear in and around your house during a typical month? ____________________

8. During a typical month, how annoyed does the sound from low-flying military jets make you feel when you are in and around your house?

THE SOUND WAS:

0	1	2	3	4	5	6	7	8
	Minimally	Slightly	Fairly	Moderately	Decidedly	Highly	Extremely	

ANNOYING.

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APPENDIX 5

Instructions

Instructions for Aircraft Noise Experiment

Thank you for participating in our study. As you know, we are interested in learning about people's reactions to low-flying military jet aircraft sounds. You have just completed or are about to complete your initial hearing test to ensure that your hearing sensitivity does not change during the experiment. Once the experiment has begun, you will hear recorded military jet flyover sounds from the loudspeakers that have been placed in your home. You will also hear the sounds of any real military jet aircraft that fly low over your area. You will rate your annoyance from each low-flying military jet sound that you hear, both real and recorded, on special rating pads. At the end of the day the computer will prompt you to answer a few questions about all the low-flying military jet flyover sounds that you heard that day. There are a few things that you need to know in order to participate in this study:

1. When making your annoyance ratings, remember that all questions refer to the sounds of low-flying military jet aircraft only. We are not interested in the sounds from high-flying jets, propeller planes, or helicopters. In making your annoyance ratings, you will be asked to use the following scale:

   THE SOUND WAS:

0	1	2	3	4	5	6	7	8
	Minimally	Slightly	Fairly	Moderately	Decidedly	Highly	Extremely	

   ANNOYING.

   Please pay attention to the words which form the basis for the scale. Circle the number that corresponds to the word that best describes your annoyance response. You may use any number from "0" to "8", but only numbers "1" to "7" have words associated with them. Use numbers "0" and "8" when your rating falls outside the range of the words. Always circle whole number responses between "0" and "8". Do not use fractions or in-between numbers.

2. We will leave several annoyance response pads containing the above scale with your family. Each pad will be numbered and will have a cover with a pocket for placing completed response forms. Whenever you hear the real or recorded sound of a low-flying military jet, take out a pad and answer the questions on it regarding when you heard the sound, how annoying you judged the sound to be, and where you heard the sound. To record the time and date, you should always wear or carry a watch. The time of each flyover event, both real and recorded, should be written to the nearest minute. In recording the time of a flyover event, if two or more events occur in the same minute, put a number "two" in parentheses, "(2)", after the second event for that minute, a number "three" in parentheses, "(3)", after the third event for that minute, etc. You should always carry one of the pads around with you whenever you go out in the yard so that you can respond to any real low-flying military jet sounds that you might hear outdoors around your home. Some of the pads have an attached pencil for this purpose. By "around your home" we mean outdoors in the vicinity of your home, but still on your property. You should not respond to planes you hear while you are away from your property. After you have completed the response form, tear it off and place it in the cover pocket, face down so that you cannot see the information on the completed form. We do not want the responses to previous individual jet flyover sounds written on the forms to influence anyone's response to future jet flyover sounds, or to the day's (or week's) exposure to such sounds entered into the computer.

3. The recorded military jet sounds may not always begin in the morning. On some days the first recorded military jet sound may not be heard for many hours, or there may be very few recorded flyby sounds altogether. Do not be concerned; the equipment is probably working fine. Do not touch any of the equipment unless expressly instructed by one of the experimenters to do so, and then only do the exact operations that you have been told.

4. Every day, a designated family member will remove all the completed annoyance response forms from the cover pocket of all the response pads that we left with your family. Keeping them face down, this family member will place the completed response forms in a dated envelope for mailing back without looking at them. It is important that each of the numbered response pads be emptied every day and that all completed response forms be gathered into the envelope. Be sure that every numbered pad has been checked. After all the completed annoyance forms have been removed from the cover pockets of the numbered pads, and placed in the dated envelope, the designated family member should seal the stamped, addressed envelope and mail it back to Wyle Laboratories the next day.

5. At 10:00 p.m. each evening (or other agreed-upon hour), the computer will turn on and beep to signal you to answer a few questions about any military jet aircraft sounds that you may have heard. The questions will ask you about how many low-flying military jet flyover sounds you thought you heard that day (or week or month), and how annoying you judged them to be. When answering these questions, do not count or average your individual flyover response forms or consult any other tally or record. We just want your best guess at that time. The computer will continue to beep every 30 minutes to remind you that it is waiting for responses from the family. These beep signals will continue until everyone in the family who is participating has responded, or until 12:00 midnight. You should make every attempt to respond to the computer questions every evening that you are home between 10:00 p.m. and 12:00 midnight.

6. If you miss responding to the computer questions in the evening, you will have another opportunity to respond to the computer between 8:00 a.m. and 10:00 a.m. the next morning. This makeup opportunity should only be used on rare occasions, when you come in very late or you cannot respond during the normal 10:00 p.m. to 12:00 midnight period. When this morning makeup session is used, you should answer the questions as if they refer to the previous day. You may experience some computer delays during this morning makeup session and you may have to click on the button several times. Just be patient. The computer will respond to you.

7. Please read the questions on the computer screen carefully each day, since the questions are not always the same. On most days the questions will refer to the low-flying military jets you heard during the past 24 hours; on Sundays the questions will refer to military jets you heard during the past week; on the last day of the study they will refer to the military jets you heard during the past four weeks.

8. After the experiment is over, we will return to give you a final hearing test and debriefing, to have you complete a short questionnaire about the study, and to answer any final questions that you might have. This will be on a scheduled day shortly after the experiment has been completed as we agreed. At that time we will also remove all of our equipment from your home.

9. Please do not discuss your impressions or feelings about the study or the recorded aircraft sounds that you hear with the other participants in your house. Do not share your answers to the questions with any other family members. This is very important since we do not want your answers to be influenced by each other. Of course, you may discuss the study with your family members after the study is over and all participating family members have completed their final hearing test and debriefing.

10. In the event that any problems should arise, you should call one of the following people:

    Kevin Bradley: 800/783-1538 (office); xxx/xxx-xxxx* (home)

    Eric Stusnick: 800/783-1538 (office); xxx/xxx-xxxx (home).

    We would appreciate hearing from you if you run into problems, so that we can make any changes or adjustments that might be necessary.

11. Now we will try out some of the things that you need to do while I observe. In a moment the sound system will reproduce some military jet flyover sounds in your home. You will rate them on your response pad. Later you will put the completed responses in an envelope as you would for mailing them back. Then I will demonstrate how to respond to the computer queries each evening. You will have a chance to try out the computer. Do you have any questions?

---

* Home telephone numbers indicated in actual instructions.

APPENDIX 6

Integrated Response Screens

WEEKDAY OR SATURDAY EVENING

Initials ____ Date __________ Time ___ am__ pm__

About how many military jets (both real and recorded) do you recall hearing during the past 24 hours

None

1 2 3 to 5 6 to 10 11 to 20

More than 20

Please indicate how the sounds from these jets affected you over the past 24 hours as you went about your normal activities by rating the overall annoyance of the sounds

Over the past 24-hours the sounds were:

0 1 2 3 4 5 6 7 8

Minimally Slightly Fairly Moderatly Decidedly Highly Extremely

ANNOYING

SUNDAY EVENING

Initials ____ Date ________ Time ___ am__ pm__

About how many military jets (both real and recorded)
do you recall hearing during the past week

None

1 | 2 | 3 to 5 | 6 to 10 | 11 to 20 | 21 to 50 | 51 to 100

More than 100

Please indicate how the sounds from these jets affected you over the past week as you went about your normal activities by rating the overall annoyance of the sounds

Over the past week the sounds were:

0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8

Minimally Slightly Fairly Moderatly Decidedly Highly Extremely

ANNOYING

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APPENDIX 7

Post-Experiment Questionnaire

Post-Experiment Questionnaire

Name: ______________________ Participant #__________

Date: ______________ Time __________

1. The next few questions concern your perceptions about all the low-flying military jet aircraft that you heard during the four weeks of this experiment. They refer to all the low-flying military jets, both real and recorded, that you heard while you were at home inside your house or outside on your property.

   a. On the average, on any given day of the experiment, about how many low-flying military jets did you hear per day in and around your house?

      ____

   b. On the average, about how many low-flying military jets did you hear in and around your house during a typical week of the experiment?

      ____

   c. Overall, about how many low-flying military jets did you hear in and around your house during the entire four weeks of the experiment?

      ____

2. During four weeks of the experiment, how annoyed did the sound from low-flying military jets, both real and recorded, make you feel when you were in and around your house?

THE SOUND WAS:

0	1	2	3	4	5	6	7	8
	Minimally	Slightly	Fairly	Moderately	Decidedly	Highly	Extremely	

ANNOYING.

3. What are the one or two things you like most about this area or community – that is, the things you feel are advantages and make it a good place to live?

   ____

   ____

4. What are the one or two things you may dislike most living around here in the last several years?

   ____

   ____

Participant #________

5. What is your present occupation? ____________________

   Are there any loud noises in your present occupation? Yes ___ No ___

   If yes, what kind of noises? ____________________

   Were there any loud noises in any previous occupation (including the military)?

   Yes ___ No ___

   If yes, what was that occupation? ____________________

   What were the noises? ____________________

6. Do you work outside of your home? Yes ___ No ___
   If yes, about how many miles away from home do you work? ________ Miles

7. Have you ever flown in an airplane? Yes ___ No ___
   If yes, on the average, how often have you flown? Check one:

   a. A few times in your life ______
   b. Once every few years ______
   c. Once a year ______
   d. A few times a year ______
   e. Once a month ______

8. Have you ever lived near an airport or near aircraft operations? Yes ___ No ___

   If yes, have you ever been annoyed by the noise? Yes ___ No ___

   Explain briefly. ____________________

9. Have you ever been exposed to unusually high levels of any of the following noises? Yes ___ No ___ Check all that apply:

   a. Railroad noise ______
   b. Traffic noise ______
   c. Industrial noise ______
   d. Aircraft noise ______
   e. Truck noise ______
   f. Outdoor machinery noise ______
   g. Shipboard noise ______

Participant #________

10. Please indicate whether you have heard noises from the following at home and how much they bothered or annoyed you.

a. Cars on the street or highway: Yes ___ No ___
If yes, how annoyed were you by these noises:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

b. Trucks on the street or highway: Yes ___ No ___
If yes, how annoyed were you by these noises:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

c. Motorcycles: Yes ___ No ___
If yes, how annoyed were you by these noises:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

d. Any other road traffic? Yes ___ No ___
If yes, please describe:

____

If yes, how annoyed were you by these noises:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

e. Trains: Yes ___ No ___
If yes, how annoyed were you by these noises:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

f. Neighbors' tools or yard equipment: Yes ___ No ___
If yes, how annoyed were you by these noises:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

Participant #______

g. Helicopters: Yes ___ No ___
If yes, how annoyed were you by these noises:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

h. Military jets (real, not recorded): Yes ___ No ___
If yes, how annoyed were you by these noises:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

i. Any other airplanes (real, not recorded): Yes ___ No ___
If yes, how annoyed were you by these noises:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

j. Any other noises? Yes ___ No ___
If yes, please describe:

____

If yes, how annoyed were you by these noises:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

Please answer the following questions with regard to both the recorded and the real military jet flyover noises that you heard during the experiment.

11. Did the military jet flyovers ever startle or surprise you?
Yes ___ No ___ If no, go to question 16. If yes, please describe your reaction and how you felt.

____

12. Did any of the military jet flyover sounds ever startle you so much that you made a jerky movement? Yes ___ No ___
If yes, how often would this happen? Sometimes ___ Almost Always ___

13. Did any of the military jet flyover sounds ever startle you so much that it made your heart beat faster or left you feeling a bit weak?
Yes ___ No ___
If yes, how often would this happen? Sometimes ___ Almost Always ___

Participant #________

14. Did the sounds from the military planes ever:

a. Interfere with your radio or TV enjoyment?
Yes ___ No ___ Don't know ___
If yes, how often?
Very often ______
Fairly often ______
Occasionally ______

Please indicate how bothered or annoyed you were:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

b. Make your house rattle or shake?
Yes ___ No ___ Don't know ___
If yes, how often?
Very often ______
Fairly often ______
Occasionally ______

Please indicate how bothered or annoyed you were:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

c. Interfere with your rest or relaxation?
Yes ___ No ___ Don't know ___
If yes, how often?
Very often ______
Fairly often ______
Occasionally ______

Please indicate how bothered or annoyed you were:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

d. Interfere with your conversation?
Yes ___ No ___ Don't know ___
If yes, how often?
Very often ______
Fairly often ______
Occasionally ______

Please indicate how bothered or annoyed you were:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

Participant #________

e. Interfere with your mealtime?
Yes ___ No ___ Don't know ___
If yes, how often?
Very often ______
Fairly often ______
Occasionally ______

Please indicate how bothered or annoyed you were:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

f. Interfere with your telephone conversation?
Yes ___ No ___ Don't know ___
If yes, how often?
Very often ______
Fairly often ______
Occasionally ______

Please indicate how bothered or annoyed you were:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

15. Do you recall the sounds from the military planes interfering with any other activities not already mentioned? Yes ___ No ___

If yes, please describe. ____

____

How often?
Very often ______
Fairly often ______
Occasionally ______

Please indicate how bothered or annoyed you were:
Very much annoyed ______
Moderately annoyed ______
A little annoyed ______
Not at all annoyed ______

Participant #________

16. Did any of the days have more military flyover sounds than other days?
Yes ___ No ___

a If yes, all other things being equal, which days were <u>more</u> annoying?

1. ______ Those days with more flights.
2. ______ Those days with fewer flights.

b. About how many flyover sounds did you hear on those days with the most flights? ________

Taken as a whole, how annoying were all the flyover sounds on such a day?

THE SOUND WAS:

0	1	2	3	4	5	6	7	8
	Minimally	Slightly	Fairly	Moderately	Decidedly	Highly	Extremely	

ANNOYING.

c. About how many flyover sounds did you hear on those days with the least flights (excluding those days with no flights)? ________

Taken as a whole, how annoying were all the flyover sounds on such a day?

THE SOUND WAS:

0	1	2	3	4	5	6	7	8
	Minimally	Slightly	Fairly	Moderately	Decidedly	Highly	Extremely	

ANNOYING.

d. About how many flyovers did you hear on days with a medium number of flights? ________

Taken as a whole, how annoying were all the flyover sounds on such a day?

THE SOUND WAS:

0	1	2	3	4	5	6	7	8
	Minimally	Slightly	Fairly	Moderately	Decidedly	Highly	Extremely	

ANNOYING.

Participant #________

17. Did the pattern of flyover sounds seem to come at more regular or periodic intervals on some days and at more sporadic or random intervals on other days? Yes ___ No ___

   a. If yes, all other things being equal, which days were <u>more</u> annoying?

      1. ______ Those days with more regular flights.

      2. ______ Those days with more sporadic flights.

   b. On days when the flyover sounds seemed to come at more regular intervals, how would you describe the pattern of sounds:

      Extremely regular ______
      Very regular ______
      Moderately regular ______
      Somewhat regular ______

      Not very regular ______

   c. Was there any average period or interval between the flights on such a regular day? Yes ___ No ___

      If yes, how often do you think the flights came on such a day?

      Every ________ { minutes / hours } (fill in and circle)

   d. Taken as a whole, how annoying were all the flyover sounds on such a day?

THE SOUND WAS:

0	1	2	3	4	5	6	7	8
	Minimally	Slightly	Fairly	Moderately	Decidedly	Highly	Extremely	

ANNOYING.

   e. On days when the flyover sounds seemed to come at more sporadic intervals, how would you describe the pattern of sounds:

      Extremely sporadic ______
      Very sporadic ______
      Moderately sporadic ______
      Somewhat sporadic ______

      Not very sporadic ______

Participant #________

f. Taken as a whole, how annoying were all the flyover sounds on such a day?

THE SOUND WAS:

0	1	2	3	4	5	6	7	8
	Minimally	Slightly	Fairly	Moderately	Decidedly	Highly	Extremely	

ANNOYING.

18. Did any of the types of individual airplane flyover sounds stand out as being particularly less annoying than the others? Yes ___ No ___
If yes, which ones? Describe in words.

____

Please describe why you thought they were less annoying:

____

19. Did any of the types of individual airplane flyover sounds stand out as being particularly more annoying than the others? Yes ___ No ___
If yes, which ones? Describe in words.

____

Please describe why you thought they were more annoying:

____

20. Did any of the days stand out as being particularly less annoying than the others? Yes ___ No ___ If yes, which days? Describe in words.

____

Please describe why you thought they were less annoying:

____

21. Did any of the days stand out as being particularly more annoying than the others? Yes ___ No ___ If yes, which days? Describe in words.

____

Please describe why you thought they were more annoying:

____

Participant #________

22. Please rank-order the following qualities of the airplane sounds that you have heard over the past week as to their importance in contributing to your annoyance judgments. Put a number "1" after the quality that annoyed you the most. Put a number "2" after the next most annoying quality. By a process of elimination, put a "3" next to the third most annoying quality. Finally, put a "4" next to the remaining item indicating this quality as the least annoying. Make sure all blanks are filled in; use each number only once, but use all 4 numbers.

Quality	Rank
How long the sounds lasts (duration)	______
How strong the sound peak is (intensity)	______
How fast the sound comes on (onset rate)	______
How slow the sound fades away (decay rate)	______

23. Please rank-order the following qualities of the daily patterns of military airplane sounds that you heard over the past week as to their importance in contributing to your annoyance judgments. Use the same ranking procedure as you used for the previous question. Put a number "1" after the quality that annoyed you the most, and so on, until you have used all 4 numbers.

Quality	Rank
Days with few (infrequent) flights	______
Days with random (sporadic) flights	______
Days with many (frequent) flights	______
Days with periodic (regular) flights	______

24. Did you ever think that there was a danger of one of the real military planes crashing in your neighborhood? Yes ___ No ___

If yes, would you say that you felt this:
Very often ______
Moderately often ______
Only occasionally ______

25. Do you have any animals or livestock or any types of pets? Yes ___ No ___

If yes, what numbers and types of animals do you have?

____

Were the animals or livestock ever disturbed by military flyover noise?
Yes ___ No ___
If yes, were the sounds real ___ , or recorded ___ , or both ___ ?

Participant #________

What did you notice about the animals or livestock when they were disturbed?

____

Have you ever lost any money or had to spend any money because the animals or livestock were disturbed by military flyover noise? Yes ___ No ___

If yes, please explain. ____

____

26. Do you hear the noise from real military jets on a regular basis when you are away from your home? Yes ___ No ___

    If yes, where? ____

    About how many flyovers per week? ____

27. Have you ever done anything about real military flyovers like writing, visiting, or telephoning an official or someone else to complain about them?

    Yes ___ No ___ If yes, please explain. ____

    ____

28. Do you think people around here should complain about military flyovers if they are annoyed by them? Yes ___ No ___ Don't know ___

    Please explain your answer. ____

    ____

29. How would you rate the overall experiment? ____

    ____

    ____

30. How might the experiment be improved? ____

    ____

    ____

31. Do you have any other comments? ____

    ____

    ____

32. If there are any other things that come up that we need to ask you about, would it be all right to give you a call? Yes ___ No ___