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16. Abstract

This report documents the results of a Federal Aviation Administration (FAA) noise measurement flight test program with the Boeing-Vertol CH-47D helicopter. The report contains documentary sections describing the acoustical characteristics of the subject helicopter and provides analyses and discussions addressing topics ranging from acoustical propagation to environmental impact of helicopter noise.

This report is the seventh in a series of seven documenting the FAA helicopter noise measurement program conducted at Dulles International Airport during the summer of 1983. The BV234/CH-47D test program involved the acquisition of detailed acoustical, position and meteorological data.

This test program was designed to address a series of objectives including: 1) acquisition of acoustical data for use in assesing heliport environment impact, 2) documentation of directivity characteristics for static operations of helicopters, 3) establishment of grounf-to-ground and air-to-ground acoustical propagtion relationships for helicopters, 4) determination of noise event duration influences on energy dose acoustical metrics, 5) examination of the differences between noise measured by a surface mounted microphone and a microphone mounted at a height of four feet (1.2 meters), and 6) documentation of noise levels aquired using international helicopter noise certification test procedures.

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BOEING VERTOL 234 / CH-47D HELICOPTER

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GLOSSARY

AGL	- Above ground level
AIR	- Aerospace Information Report
AL	- A-Weighted sound level, expressed in decibels (See L_A)
AL_M	- Maximum A-weighted sound level, expressed in decibels (see L_{AM})
AL_{AM}	- As measured maximum A-weighted Sound Level
ALT	- Aircraft altitude above the microphone location
APP	- Approach operational mode
CLC	- Centerline Center
CPA	- Closest point of approach
d	- Distance
dB	- Decibel
dBA	- A-Weighted sound level expressed in units of decibels (see A_L)
df	- Degree of freedom
Δ	- Delta, or change in value
$\Delta 1$	- Correction term obtained by correcting SPL values for atmospheric absorption and flight track deviations per FAR 36, Amendment 9, Appendix A, Section A36.11, Paragraph d
$\Delta 2$	- Correction term accounting for changes in event duration with deviations from tne reference flight path
DUR(A)	- "10 dB-Down" duration of L_A time history
EPNL	- Effective perceived noise level (symbol is LEPN)

EV	-	Event, test run number
FAA	-	Federal Aviation Administration
FAR	-	Federal Aviation Regulation
FAR-36	-	Federal Aviation Regulation, Part 36
GLR	-	Graphic level recorder
HIGE	-	Hover-in-ground effect
HOGE	-	Hover-out-of-ground effect
IAS	-	Indicated airspeed
ICAO	-	International Civil Aviation Organization
IRIG-B	-	Inter-Range Instrumentation Group B (established technical time code standard)
J	-	The value which determines the radiation pattern
K(DUR)	-	The constant used to correct SEL for distance and velocity duration effects in $\Delta 2$
KIAS	-	Knots Indicated Air Speed
K(P)	-	Propagation constant describing the change in noise level with distance
K(S)	-	Propagation constant describing the change in SEL with distance
Kts	-	Knots
L_A	-	A-Weighted sound level, expressed in decibels
Leq	-	Equivalent sound level
LFO	-	Level Flyover operational mode
M_A	-	Advancing blade tip Mach number
M_R	-	Rotational Mach number
M_T	-	Translational Mach number
N	-	Sample Size
NWS	-	National Weather Service
$OASPL_M$	-	Maximum overall sound pressure level in decibels
PISLM	-	Precision integrating sound level meter

PNL_M	-	Maximum perceived noise level
$PNLT_M$	-	Maximum tone corrected perceived noise level
POP	-	Photo overhead positioning system
Q	-	Time history "shape factor"
RH	-	Relative Humidity in percent
RPM	-	Revolutions per minute
SAE	-	Society of Automotive Engineers
SEL	-	Sound exposure level expressed in decibels. The integration of the AL time history, normalized to one second (symbol is L_{AE})
SEL_{AM}	-	As measured sound exposure level
$SEL-AL_M$	-	Duration correction factor
SHP	-	Shaft horse power
SLR	-	Single lens reflex (35 mm camera)
SPL	-	Sound pressure level
T	-	Ten dB down duration time
TC	-	Tone correction calcualted at $PNLT_M$
T/O	-	Takeoff
TSC	-	Department of Transportation, Transportation Systems Center
V	-	Velocity
VASI	-	Visual Approach Slope Indicator
V_H	-	Maximum speed in level flight with maximum continuous power
V_{NE}	-	Never-exceed speed
Vy	-	Velocity for best rate of climb

1.0 Introduction - This report documents the results of a Federal Aviation Administration (FAA) noise measurement/flight test program involving the Boeing Vertol 234/CH-47D helicopter. The report contains documentary sections describing the acoustical characteristics of the subject helicopter and provides analyses and discussions addressing topics ranging from acoustical propagation to environmental impact of helicopter noise.

This report is the seventh in a series of seven documenting the FAA helicopter noise measurement program conducted at Dulles International Airport during the summer of 1983.

The CH-47D test program was conducted by the FAA in cooperation with Boeing Vertol and a number of supporting Federal agencies. The rigorously controlled tests involved the acquisition of detailed acoustical, position and meteorological data.

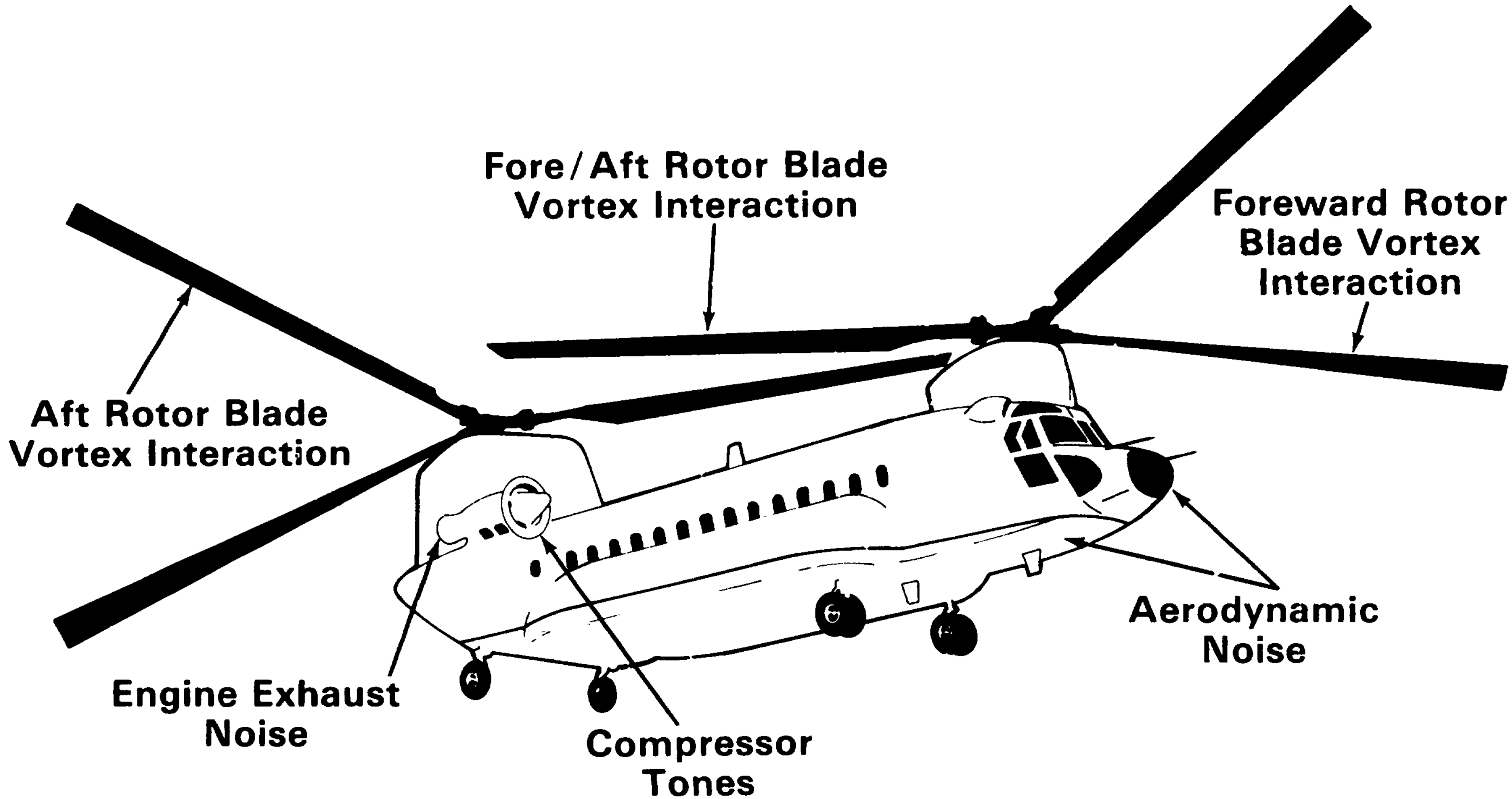
This test program was designed to address a series of objectives including: 1) acquisition of acoustical data for use in heliport environmental impact analyses, 2) documentation of directivity characteristics for static operation of helicopters, (3) establishment of ground-to-ground and air-to-ground acoustical propagation relationships for helicopters, 4) determination of noise event duration influences on energy dose acoustical metrics, 5) examination of the differences between noise measured by a surface mounted microphone and a microphone mounted at a height of four feet (1.2 meters), and 6) documentation of noise levels acquired using international helicopter noise certification test procedures.

The helicopter is a complex aircraft which generates noise from many different sources. Figure 1.1 provides a diagram identifying some of these sources. Two other noise generating mechanisms (both producing impulsive noise) are blade vortex interaction (see Figure 9.12) and high advancing tip Mach Numbers. These figures are provided for the reader's reference, since this report deals with the helicopter's noise in general.

The appendices to this document provide a reference set of acoustical data for the Hughes helicopter operating in a variety of typical flight regimes. The first seven chapters contain the introduction and description of the helicopter, test procedures and test equipment. Chapter 8 describes analyses of flight trajectories and meteorological data and is documentary in nature. Chapter 9 delves into the areas of acoustical propagation, helicopter directivity for static operations, and variability in measured acoustical data over various propagation surfaces. The analyses of Chapter 9 in some cases succeed in establishing relationships characterizing the acoustic nature of the subject helicopter, while in other instances the results are too variant and anomalous to draw any firm conclusions. In any event, all of the analyses provide useful insight to people working in the field of helicopter environmental acoustics, either in providing a tool or by identifying areas which need the illumination of further research efforts.

Figure 1.1

Helicopter Noise Sources



TEST HELICOPTER DESCRIPTION

2.0 Test Helicopter Description - The 234/CH-47D (Chinook) is a helicopter that the manufacturer, Boeing Vertol of Philadelphia, Pennsylvania, currently produces for the U.S. Army. The aircraft was designed to meet the Army's need for an all-weather medium transport helicopter that could operate under severe altitude and temperature conditions. It is equipped to transport two pilots, 33 to 44 troops or 24 litters and two attendants. Other features include a triple external cargo hook system, ferry fuel tanks, and a power-down ramp and water dam so that the ramp may operate on water. Figure 2.1 provides general dimensional figures for the helicopter.

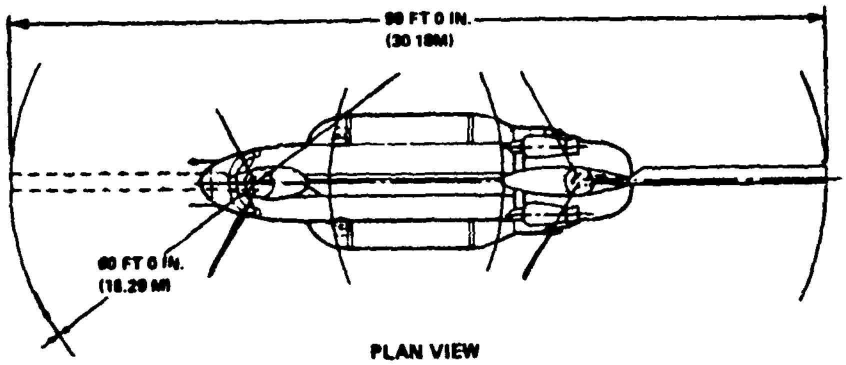
The Boeing Vertol Company originally constructed this helicopter as a military transport under the designation Ch-47D. Later, a civil transport version of the original military helicopter was developed and designated as the BV 234. Acoustically, there are a few prominent differences between the two versions. The basic airframe, power plant and rotor system are identical for the two models with the exception that the Ch-47D has an outside air-scoop in the nose area which is not present on the civilian BV 234 model. The primary acoustical differences, however, occur with operational considerations of rotor RPM and relaive fore/aft rotor tilt. The CH-47D uses a constant rotor speed of 225 RPM while the BV 234 uses a rotor speed of 220 RPM. The CH-47D utilizes a military rotor trim which establishes the minimum distance separation between the lane of the fore rotor and the plane of the aft rotor. The BV 234 uses an alternative civil trim which further separates the fore/aft rotor planes, thus minimizing the degree of vortex interaction between the rotor system.

In the test program, a number of different flight configurations were utilized to employ both military and civilian operational characteristics. Section 7 specifies the operational mode for each test series. Throughout the report, the helicopter is usually referred to by both its names--BV 234/Ch-47D--but within specific analyses utilizing data from a particular test series, only the appropriate civil or military designation is used.

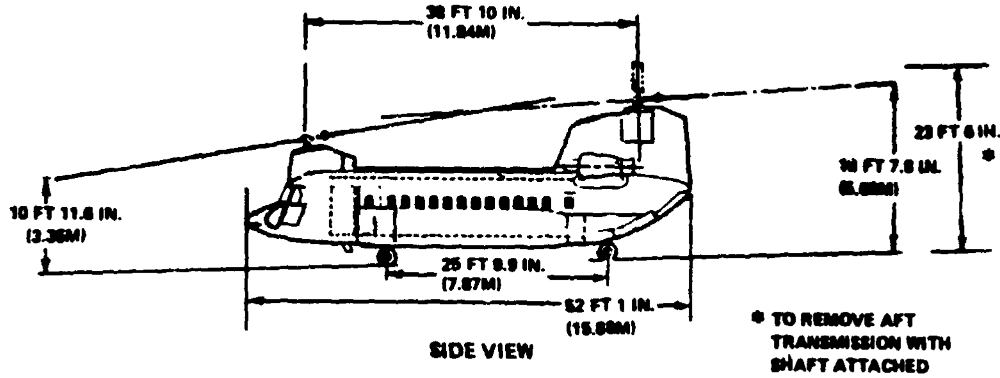
Selected operational characteristics, obtained from the helicopter manufacturer, are presented in Table 2.1. Table 2.2 presents a summary of the flight operational reference parameters determined using the procedures specified in the International Civil Aviation Organization (ICAO) noise certification testing requirements. Presented along with the operational parameters are the altitudes that one would expect the helicopter to attain (referred to the ICAO reference test sites). This information is provided so that the reader may implement an ICAO type data correction using the "As Measured" data contained in this report. This report does not undertake such a correction, leaving it as the topic of a subsequent report.

FIGURE 2.1

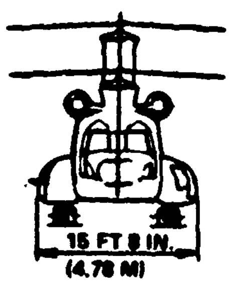
BOEING VERTOL 234/CH-47D GENERAL DIMENSIONS



PLAN VIEW



SIDE VIEW



FRONT VIEW

TABLE 2.1

HELICOPTER CHARACTERISTICS

HELICOPTER MANUFACTURER	: Boeing Vertol
HELICOPTER MODEL	: 234
HELICOPTER TYPE	: Tandem rotor
TEST HELICOPTER N-NUMBER	: N J016
MAXIMUM GROSS TAKEOFF WEIGHT	: 48,500 lbs (21,999 kg)
NUMBER AND TYPE OF ENGINES	: 2 Lycoming T55-L-712
SHAFT HORSE POWER	: 4075 HP
MAXIMUM CONTINUOUS POWER	: 2975 HP
SPECIFIC FUEL CONSUMPTION AT MAXIMUM POWER (LB/HR/HP)	: .533 LB/HR/HP
NEVER EXCEED SPEED (V_{NE})	: 150 KTS
MAX SPEED IN LEVEL FLIGHT WITH MAX CONTINOUS POWER (V_H)	: 145 KTS
SPEED FOR BEST RATE OF CLIMB (V_Y)	: 85 KTS
BEST RATE OF CLIMB	: 1120 FT/MIN

FORWARD AND AFT ROTOR SPECIFICATIONS

ROTOR SPEED	: 225 RPM
DIAMETER	: 60 FT.
CHORD	: 2.67 FT.
NUMBER OF BLADES	: 3
BLADE LOAD	: 101 LBS/FT^2
FUNDAMENTAL BLADE PASSAGE FREQUENCY	: 11 Hz
ROTATIONAL TIP MACH NUMBER (77^oF)	: .6349

TABLE 2.2

ICAO REFERENCE PARAMETERS

	TAKEOFF	APPROACH	LEVEL FLYOVER
AIRSPEED (KTS)	: 85	85	145
RATE OF CLIMB/DESCENT (fpm)	: 1120		NA
CLIMB/DESCENT ANGLE (DEGREES)	: 7.5°	6°	NA
ALTITUDE/CPA (FEET)			
SITE 5	: 217/215	342/340	492
SITE 1	: 281/279	394/392	492
SITE 4	: 346/343	446/443	492
SLANT RANGE (FEET) TO			
SITE 2	: 567	630	696
SITE 3	: 567	630	696

TEST SYNOPSIS

3.0 Test Synopsis - Below is a listing of pertinent details pertaining to the execution of the helicopter tests.

1. Test Sponsor, Program Management, and Data Analysis: Federal Aviation Administration, Office of Environment and Energy, Noise Abatement Division, Noise Technology Branch (AEE-120).

2. Test Helicopter: Ch-47D, provided by Boeing Vertol

3. Test Date: Friday, July 22, 1983

4. Test Location: Dulles International Airport, Runway 30 over-run area.

5. Noise Data Measurement (recording), processing and analysis: Department of Transportation (DOT), Transportation Systems Center (TSC), Noise Measurement and Assessment Facility.

6. Noise Data Measurement (direct-read), processing and analysis: FAA, Noise Technology Branch (AEE-120).

7. Cockpit instrument photo documentation, photo-altitude determination system; documentary photographs: Department of Transportation, Photographic Services Laboratory.

8. Meteorological Data (fifteen minute observations): National Weather Service Office, Dulles International Airport.

9. Meteorological Data (radiosonde/rawinsonde weather balloon launches): National Weather Service Upper Air Station, Sterling Park, Virginia.

10. Meteorological Data (on site observations): DOT-TSC.

11. Flight Path Guidance (portable visual approach slope indicator (VASI) and theodolite/verbal course corrections): FAA Technical Center, ACT-310.

12. Air Traffic Control: Dulles International Airport Air Traffic Control Tower.

FIGURE 3.1

Flight Test and Noise Measurement Personnel In Action

13. Test site preparation; surveying, clearing underbrush, connecting electrical power, providing markers, painting signs, and other physical arrangements: Dulles International Airport Grounds and Maintenance, and Airways Facilities personnel.

Figure 3.1 is a photo collage of flight test and measurement personnel performing their tasks.

3.1 Measurement Facility - The noise measurement testing area was located adjacent to the approach end of Runway 12 at Dulles International Airport. (The approach end of Runway 12 is synonymous with Runway 30 over-run area.) The low ambient noise level, the availability of emergency equipment, and the security of the area all made this location desirable. Figure 3.2 provides a photograph of the Dulles terminal and of the test area.

The test area adjacent to the runway was nominally flat with a ground cover of short, clipped grass, approximately 1800 feet by 2200 feet, and bordered on north, south, and west by woods. There was minimum interference from the commercial and general aviation activity at the airport since Runway 12/30 was closed to normal traffic during the tests. The runways used for normal traffic, 1L and 1R, were approximately 2 and 3 miles east, respectively, of the test site.

The flight track centerline was located parallel to Runway 12/30 centered between the runway and the taxiway. The helicopter hover point for the static operations was located on the southwest corner of the approach end of Runway 12. Eight noise measurement sites were established in the grassy area adjacent to the Runway 12 approach ground track.

Figure 3.2

The Terminal and Air Traffic Control Tower
at Dulles International Airport

Approach to Runway 12 at Dulles Noise
Measurement Site for 1983 Helicopter Tests

3.2 Microphone Locations - There were eight separate microphone sites located within the testing area, making up two measurement arrays. One array was used for the flight operations, the other for the static operations. A schematic of the test area is shown in Figure 3.3.

A. Flight Operations - The microphone array for flight operations consisted of two sideline sites, numbered 2 and 3 in Figure 3.3, and three centerline sites, numbered 5, 1, and 4, located directly below the flight path of the helicopter. Since site number 3, the north sideline site, was located in a lightly wooded area, it was offset 46 feet to the west to provide sufficient clearance from surrounding trees and bushes.

B. Static Operations - The microphone array for static operations consisted of sites 7H, 5H, 1H, 2, and 4H. These sites were situated around the helicopter hover point which was located on the southwest corner of the approach end of Runway 12. These site locations allowed for both hard and soft ground-to-ground propagation paths.

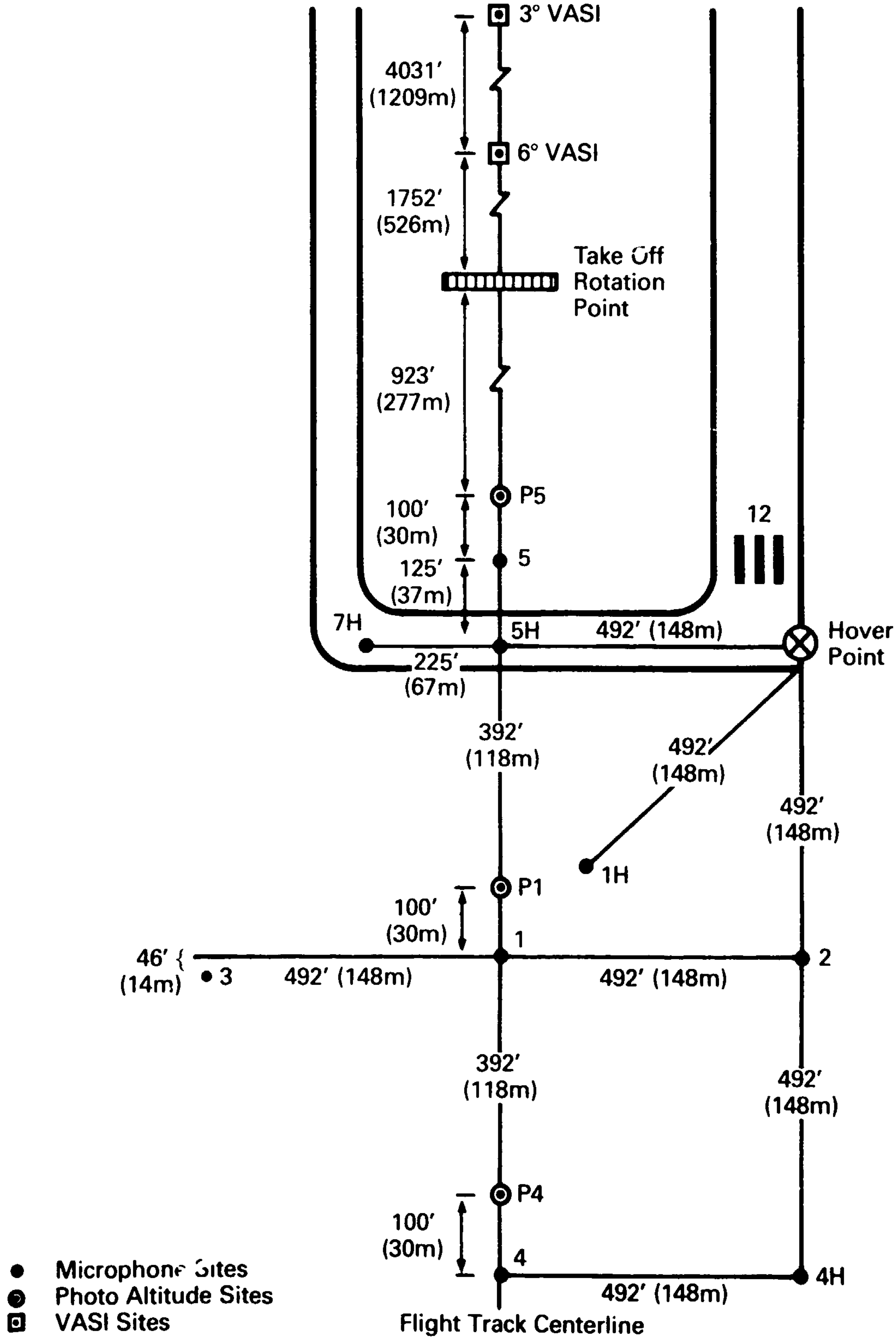
3.3 Flight Path Markers and Guidance System Locations - Visual cues in the form of squares of plywood painted bright yellow with a black "X" in the center were provided to define the takeoff rotation point. This point was located 1640 feet (500 m) from centerline center (CLC) microphone location. Four portable, battery-powered spotlights were deployed at various locations to assist pilots in maintaining the array centerline. To provide visual guidance during the approach portion of the test, a standard visual approach slope indicator (VASI) system was used. In addition to the visual guidance, the VASI crew also provided verbal guidance with the aid of a theodolite. Both methods assisted the helicopter pilot in adhering to the microphone array centerline and in maintaining the proper approach path. The locations of the VASI from CLC are shown in the following table.

Approach Angle (degrees)	Distance from CLC (feet)
12	1830
9	2456
6	3701
3	7423

Each of these locations provided a glidepath which crossed over the centerline center microphone location at an altitude of 394 feet. This test program included approach operations utilizing 6, 9 and 12 degree glide slopes.

FIGURE 3.3

Noise Measurement and Photo Site Schematic



NOTES: Broken Line Indicates not to Scale.
Metric Measurements to
Nearest Meter.

TEST PLANNING AND BACKGROUND

4.0 Test Planning/Background Activities - This section provides a brief discussion of important administrative and test planning activities.

4.1 Test Program Advance Briefings and Coordination - A pre-test briefing was conducted approximately one month prior to the test. The meeting was attended by all pilots participating in the test, along with FAA program managers, manufacturer test coordinators, and other key test participants from the Dulles Airport community. During this meeting, the airspace safety and communications protocol were rigorously defined and at the same time test participants were able to iron out logistical and procedural details. On the morning of the test, a final brief meeting was convened on the flight line to review safety rules and coordinate last-minute changes in the test schedule.

4.2 Communications Network - During the helicopter noise measurement test, an elaborate communications network was utilized to manage the various systems and crews. This network was headed by a central group which coordinated the testing using three two-way radio systems, designated as Radios 1-3.

Radio 1 was a walkie talkie system operating on 169.275 MHz, providing communications between the VASI, National Weather Service, FAA Acoustic Measurement crew, the TSC acoustic team coordinator, and the noise test coordinating team.

Radio 2 was a second walkie talkie system operating on 170.40 MHz, providing communications between the TSC acoustic team coordinator and the TSC acoustic measurement teams.

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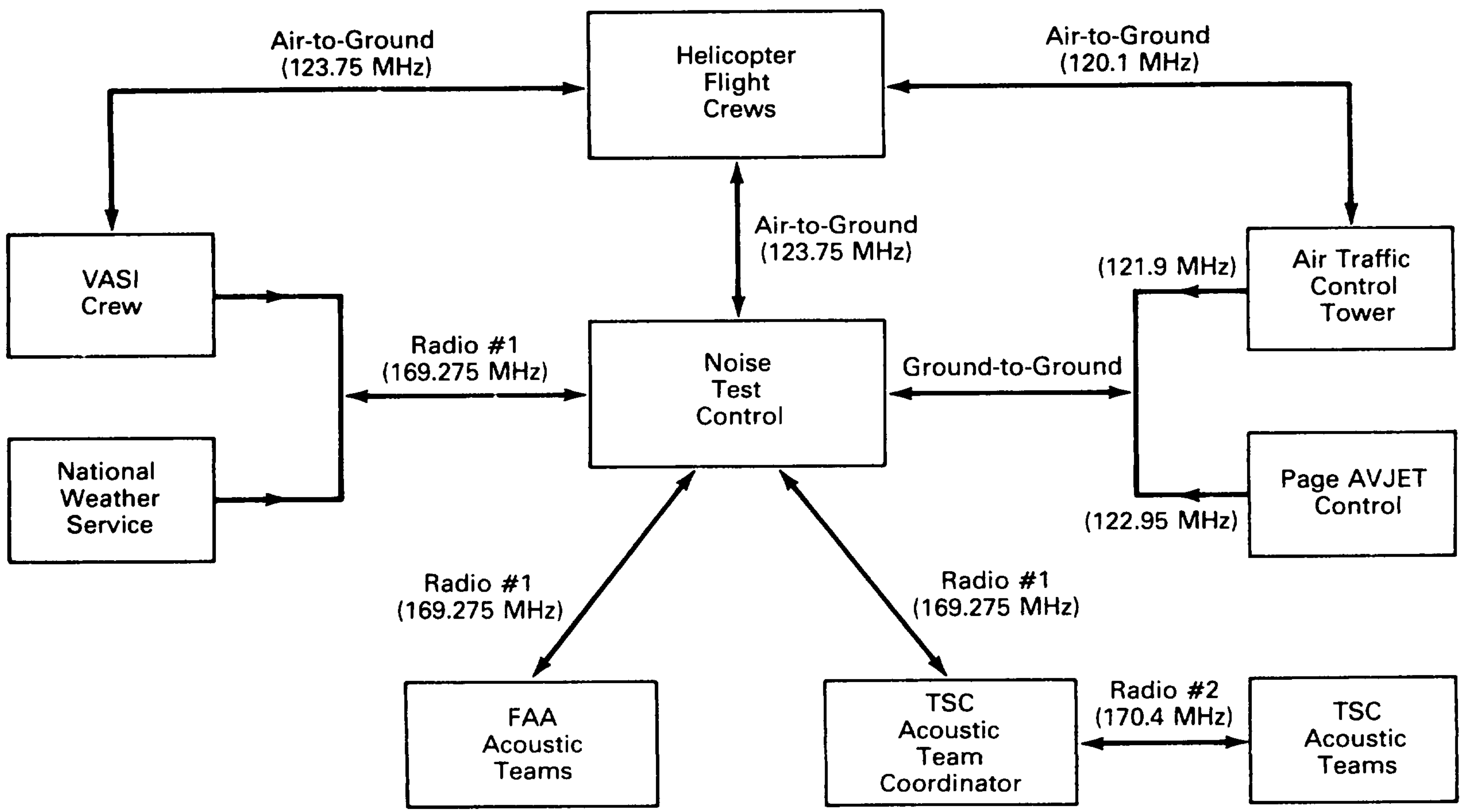
FIGURE 4.1
Helicopter Noise Test Communication Network Schematic



Radio 3, a multi-channel transceiver, was used as both an air-to-ground and ground-to-ground communications system. In air-to-ground mode it provided communications between VASI, helicopter flight crews, and noise test control on 123.175 MHz. In ground-to-ground mode it provided communications between the air traffic control tower (121.9 MHz), Page Avjet (the fuel source; 122.95 MHz), and noise test control.

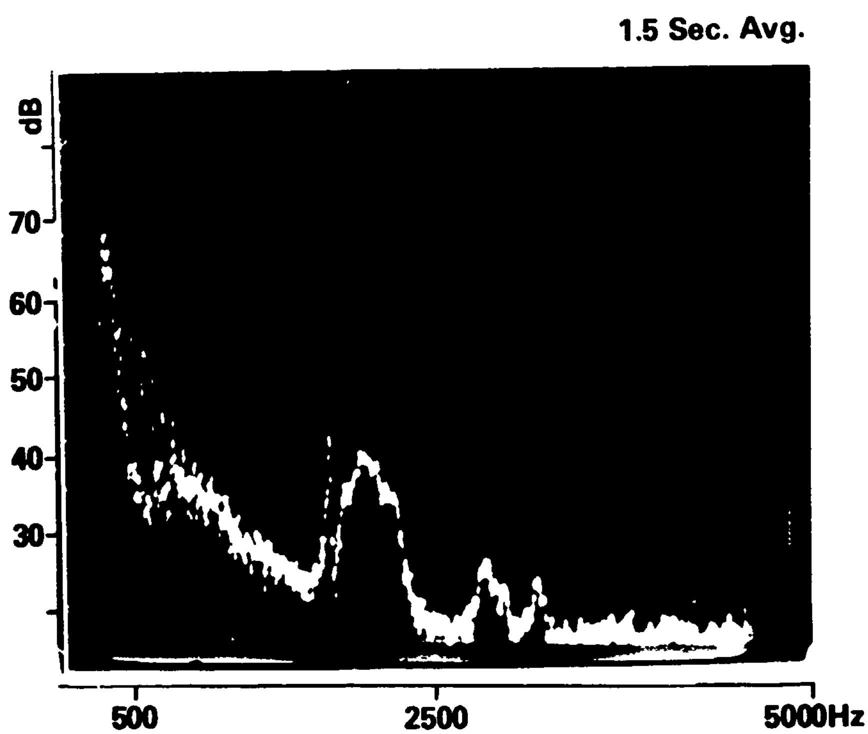
A schematic of this network is shown in Figure 4.1.

4.3 Local Media Notification - Noise test program managers working through the FAA Office of Public Affairs released an article to the local media explaining that helicopter noise tests were to be conducted at Dulles Airport on July 22, the test day commencing around dawn and extending through midday. The article described general test objectives, flight paths, and rationale behind the very early morning start time (low wind requirements). In the case of a farm located very close to the airport, a member of the program management team personally visited the residents and explained what was going to be involved in the test. As a consequence of these efforts (it is assumed), there were very few complaints about the test program.

4.4 Ambient Noise - One of the reasons that the Dulles Runway 30 over-run area was selected as the test site was the low ambient noise level in the area. Typically one observed an A-Weighted LEQ on the order of 45 dB, with dominant transient noise sources primarily from the avian and insect families. The primary offender was the Collinus Virginianus, commonly known as the bobwhite, quail, or partridge. The infrequent intrusive sound pressure levels were on the order of 55 dB centered in the 2000 Hz one-third octave band. A picture of the noisy offender and a narrow band analysis of its song may be found in Figure 4.2

As an additional measure for safety and for lessening ambient noise, a Notice to Airmen or NOTAM was issued advising aircraft of the noise test, and indicating that Runway 12/30 was closed for the duration of the test.

FIGURE 4.2



DATA ACQUISITION AND GUIDANCE SYSTEMS

5.0 Data Acquisition and Guidance Systems - This section provides a detailed description of the test program data acquisition systems, with special attention given to documenting the operational accuracy of each system. In addition, discussion is provided (as needed) of field experiences which might be of help to others engaged in controlled helicopter noise measurements. In each case, the location of a given measurement system is described relative to the helicopter flight path.

5.1 Approach Guidance System - Approach guidance was provided to the pilot by means of a visual approach slope indicator (VASI) and through verbal commands from an observer using a ballon-tracking theodolite. (A picture of the theodolite is included in Figure 3.1, in Section 3.0.) The VASI and theodolite were positioned at the point where the approach path intercepted the ground.

The VASI system used in the test was a 3-light arrangement giving vertical displacement information within ± 0.5 degrees of the reference approach slope. The pilot observed a green light if the helicopter was within 0.5 degrees of the approach slope, red if below the approach slope, white if above. The VASI was adjusted and repositioned to provide a variety of approach angles. A picture of the VASI is included in Figure 3.1.

The theodolite system, used in conjunction with the VASI, also provided accurate approach guidance to the pilot. A brief time lag existed between the instant the theodolite observor perceived deviation, transmitted a command, and the pilot made the correction; however, the theodolite crew was generally able to alert the pilot of approach path deviations (slope and lateral displacement) before the helicopter exceeded the limits of the one degree green light of the VASI. Thus, the helicopter only occasionally and temporarily deviated more than 0.5 degrees from the reference approach path.

Approach paths of 6 and 9 degrees were used during the test program. Table 5.1 summarizes the VASI beam width at each measurement location for a variety of the approach angles used in this test.

TABLE 5.1

REFERENCE HELICOPTER ALTITUDES FOR APPROACH TESTS
(all distances expressed in feet)

	MICROPHONE NO. 4	MICROPHONE NO. 1	MICROPHONE NO. 5
APPROACH ANGLE = 3°	A = 8010 B = 420 C = ±70	A = 7518 B = 394 C = ±66	A = 7026 B = 368 C = ±62
6°	A = 4241 B = 446 C = ±37	A = 3749 B = 394 C = ±33	A = 3257 B = 342 C = ±29
9°	A = 2980 B = 472 C = ±27	A = 2488 B = 394 C = ±22	A = 1362 B = 316 C = ±18

A = distance from VASI to microphone location

B = reference helicopter altitude

C = boundary of the 1 degree VASI glide slope "beam width".

5.2 Photo Altitude Determination Systems - The helicopter altitude over a given microphone was determined by the photographic technique described in the Society of Automotive Engineers report AIR-902 (ref. 1). This technique involves photographing an aircraft during a flyover event and proportionally scaling the resulting image with the known dimensions of the aircraft. The camera is initially calibrated by photographing a test object of known size and distance. Measuring the resulting image enables calculation of the effective focal length from the proportional relationship:

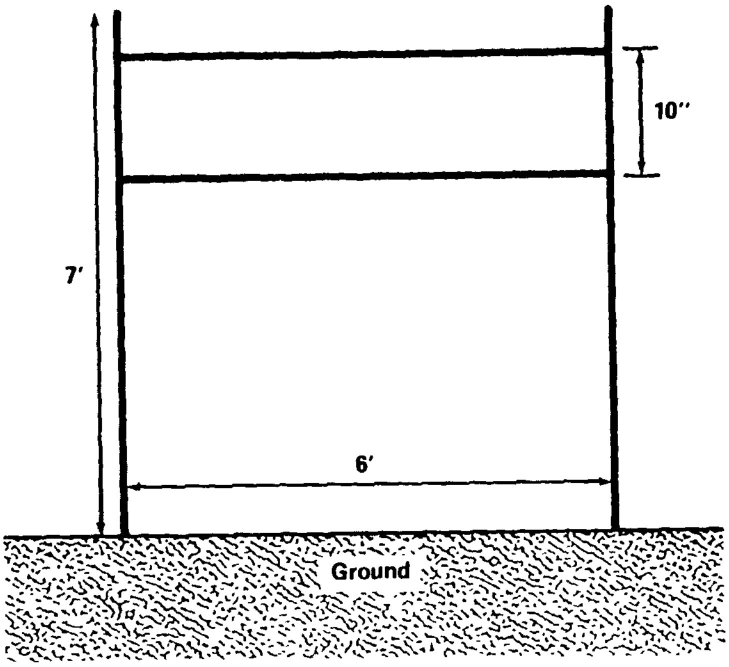
(image length)/(object length) = (effective focal length)/(object distance)

This relationship is used to calculate the slant distance from microphone to aircraft. Effective focal length is determined during camera calibration, object length is determined from the physical dimensions of the aircraft (typically the rotor diameter or fuselage) and the image size is measured on the photograph. These measurements lead to the calculation of object distance, or the slant distance from camera or microphone to aircraft. The concept applies similarly to measuring an image on a print, or measuring a projected image from a slide.

The SAE AIR-902 technique was implemented during the 1983 helicopter tests with three 35mm single lens reflex (SLR) cameras using slide film. A camera was positioned 100 feet from each of the centerline microphone locations. Lenses with different focal lengths, each individually calibrated, were used in photographing helicopters at differing altitudes in order to more fully "fill the frame" and reduce image measurement error.

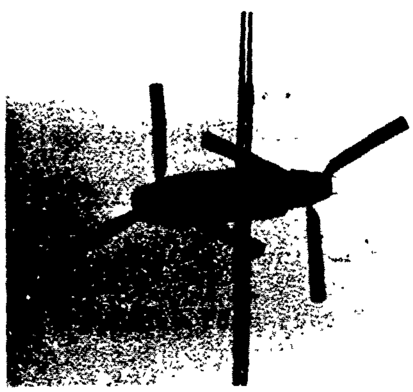
Figure 5.1

Photo Overhead Positioning System (Pop System)



Artist's Drawing of the Photo Overhead Positioning System (Figure is not to scale.)

Photographer using the POP system to photograph the helicopter.



Photographs of the Boeing Vertol 234/Ch-47D, as taken by the photographer using the POP system.

The photoscaling technique assumes the aircraft is photographed directly overhead. Although SAE AIR-902 does present equations to account for deviations caused by photographing too soon or late, or by the aircraft deviating from the centerline, these corrections are not required when deviations are small. Typically, most of the deviations were acoustically insignificant. Consequently, corrections were not required for any of the 1983 test photos.

The photographer was aided in estimating when the helicopter was directly overhead by means of a photo-overhead positioning system (POPS) as illustrated in the figure and pictures in Figure 5.1 The POP system consisted of two parallel (to the ground) wires in a vertical plane orthogonal to the flight path. The photographer, lying beneath the POP system, initially positioned the camera to coincide with the vertical plane of the two guide wires. The photographer tracked the approaching helicopter in the viewfinder and tripped the shutter when the helicopter crossed the superimposed wires. This process of tracking the helicopter also minimized image blurring and the consequent elongation of the image of the fuselage.

A scale graduated in 1/32-inch increments was used to measure the projected image. This scaling resolution translated to an error in altitude of less than one percent. A potential error lies in the scaler's interpretation of the edge of the image. In an effort to quantify this error, a test group of ten individuals measured a selection of the fuzziest photographs from the helciopter tests. The resulting statistics revealed that 2/3 of the participants were within two percent of the mean altitude. SAE AIR-902 indicates that the overall photoscaling technique, under even the most extreme conditions, rarely produces error exceeding 12 percent, which is equivalent to a maximum of 1 dB error in corrected sound level data. Actual accuracy varies from photo to photo; however, by using skilled photographers and exercising reasonable care in the measurements, the accuracy is good enough to ignore the resulting small error in altitude.

Tests were recently conducted in West Germany which compared this camera method with the more elaborate Kinotheodolite tracking method to discover which was best for determining overflight height and overground speed. Both methods were found to be reasonably accurate; thus, the simpler camera method remains appropriate for test purposes (ref. 2).

5.3 Cockpit Photo Data - During each flight operation of the test program, cockpit instrument panel photographs were taken with a 35mm SLR camera, with an 85mm lens, and high speed slide film. These pictures served as verification of the helicopter's speed, altitude, and torque at a particular point during a test event. The photos were intended to be taken when the aircraft was directly over the centerline-center microphone site #1 (see Figure 3.3). Although the photos were not always taken at precisely that point, the pictures do represent a typical moment during the test event. The word typical is important because the snapshot freezes instrument readings at one moment in time, while actually the readings are constantly changing by a small amount because of instrument fluctuation and pilot input. Thus, fluctuations above or below reference conditions are to be anticipated. A reproduction of a typical cockpit photo is shown in Figure 5.2. This data acquisition system was augmented by the presence of an experienced cockpit obersver who provided additional documentation of operational parameters.

For future tests, the use of a video tape system is being considered to acquire a continuous record of cockpit parameters during each data run. Preliminary FAA studies (April 1984) indicate that this technique can be successful using off the shelf equipment. When slides were projected onto a screen, it was possible to read and record the instrument readings with reasonable accuracy.

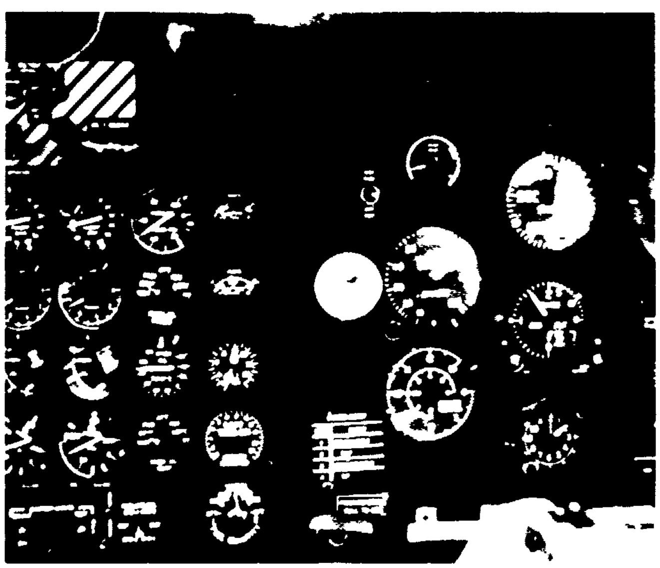


FIGURE 5.2

5.4 Upper Air Meteorological Data Acquisition/NWS: Sterling, VA - The National Weather Service (NWS) at Sterling, Virginia provided upper air meteorological data obtained from balloon-borne radiosondes. These data consisted of pressure, temperature, relative humidity, wind direction, and speed at 100' intervals from ground level through the highest test altitude. The balloons were launched approximately 2 miles north of the measurement array. To slow the ascent rate of the balloon, an inverted parachute was attached to the end of the flight train. The VIZ Accu-Lok (manufacturer) radiosonde employed in these tests consisted of sensors which sampled the ambient temperature, relative humidity, and pressure of the air. Each radiosonde was individually calibrated by the manufacturer.

The sensors were coupled to a radio transmitter which emitted an RF signal of 1680 MHz sequentially pulse-modulated at rates corresponding to the values of sampled meteorological parameters. These signals were received by the ground-based tracking system ana converted into a continuous trace on a strip chart recorder. The levels were then extracted manually and entered into a minicomputer where calculations were performed. Wind speed and direction were determined from changes in position and direction of the "flight train" as detected by the radiosonde tracking system. Figure 5.3 shows technicians preparing to launch a radiosonde.

FIGURE 5.3

The manufacturer's specifications for accuracy are:

Pressure = ± 4 mb up to 250 mb

Temperature = $\pm 0.5°C$, over a range of $+30°C$ to $-30°C$

Humidity = $\pm 5\%$ over a range of $\pm 25°C$ to $5°C$

The National Weather Service has determined the "operational accuracy" of a radiosonde (as documented in an unpublished report entitled "Standard for Weather Bureau Field Programs", 1-1-67) to be as follows:

Pressure = ± 2 mb, over a range of 1050 - 5 mb

Temperature = $\pm 1°C$, over a range of $+50°C$ to $-70°C$

Humidity = $\pm 5\%$ over a range of $+40°C$ to $-40°C$

The temperature and pressure data are considered accurate enough for general documentary purposes. The relative humidity data are the least reliable. The radiosonde reports lower than actual humidities when the air is near saturation. These inaccuracies are attributable to the slow response time of the humidity sensor to sudden changes. (Ref. 3).

For future testing, the use of a SODAR (acoustical sounding) system is being considered. The SODAR is a measurement system capable of defining the micro-wind structure, making the influences of wind speed, direction and gradient easier to identify and to assess in real time (Ref. 4).

5.5 Surface Meteorological Data Acquisition/NWS: Dulles Airport - The National Weather Service Station at Dulles provided temperature, windspeed, and wind direction on the test day. Readings were noted every 15 minutes. These data are presented in Appendix H. The temperature transducers were located approximately 2.5 miles east of the test site at a height of 6 feet (1.8 m) above the ground, the wind instruments were at a height of 30 feet (10 m) above ground level. The dry bulb thermometer and dew point transducer were contained in the Bristol (manufacturer) HO-61 system operating with ± one degree accuracy. The windspeed and direction were measured with the Electric Speed Indicator (manufacturer) F420C System, operating with an accuracy of 1 knot and ±5°.

On-site meterological data were also obtained by TSC personnel using a Climatronics (manufacturer) model EWS weather system. The anemometer and temperature sensor were located 10 feet above ground level at noise site 4. These data are presented in Appendix I. The following table (Table 5.2) identifies the accuracy of the individual components of the EWS system.

TABLE 5.2

Sensor	Accuracy	Range	Time Constant
Windspeed	±.025 mph or 1.5%	0-100 mph	5 sec
Wind Direction	±1.5%	0-360° Mech 0-540° Elect	15 sec
Relative Humidity	±2% 0-100% RH	0-100% RH	10 sec
Temperature	±1.0°F	-40 to +120°F	10 sec

After "detection" (sensing), the meteorological data are recorded on a Rustrak (manufacturer) paperchart recorder. The following table (Table 5.3) identifies the range and resolutions associated with the recording of each parameter.

TABLE 5.3

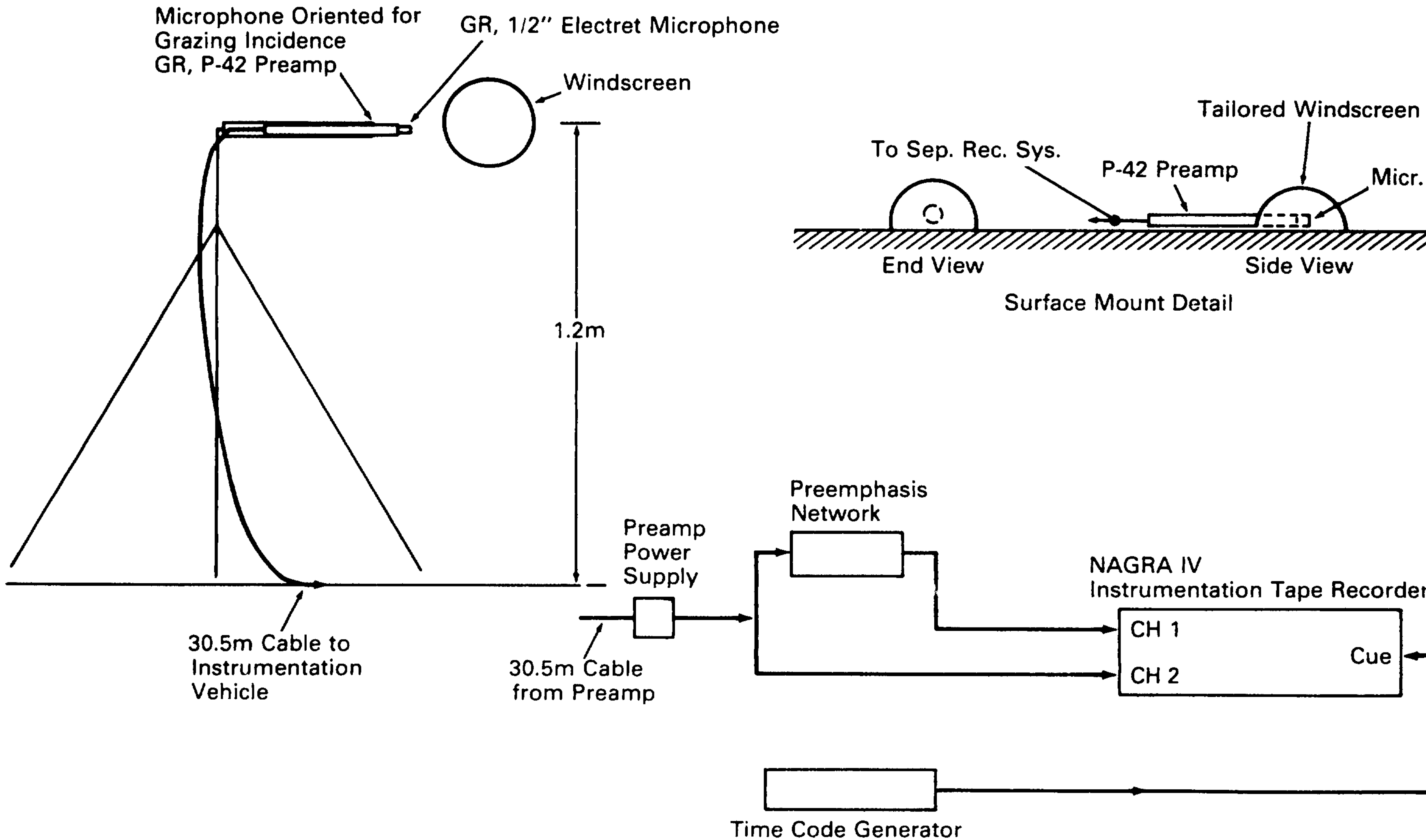
Sensor	Range	Chart Resolution
Windspeed	0-25 TSC mod 0-50 mph	±0.5 mph
Wind Direction	0-540°	±5°
Relative Humidity	0-100% RH	±2% RH
Temperature	-40° to 120°F	±1°F

5.6.0 Noise Data Acquisition Sytems/System Deployment - This section provides a detailed description of the acoustical measurement systems employed in the test program along with the deployment plan utilized in each phase of testing.

5.6.1 Description of TSC Magnetic Recording Systems - TSC personnel deployed Nagra two-channel direct-mode tape recorders. Noise data were recorded with essentially flat frequency response on one channel. The same input data were weighted and amplified using a high frequency pre-emphasis filter and were recorded on the second channel. The pre-emphasis network rolled off those frequencies below 10,000 Hz at 20 dB per decade. The use of pre-emphasis was necessary in order to boost the high frequency portion of the acoustical signal (such as a helicopter spectrum) characterized by large level differences (30 to 60 dB) between

FIGURE 5.4

Acoustical Measurement Instrumentation



the high and low frequencies. Recording gains were adjusted so that the best possible signal-to-noise ratio would be achieved while allowing enough "head room" to comply with applicable distortion avoidance requirements.

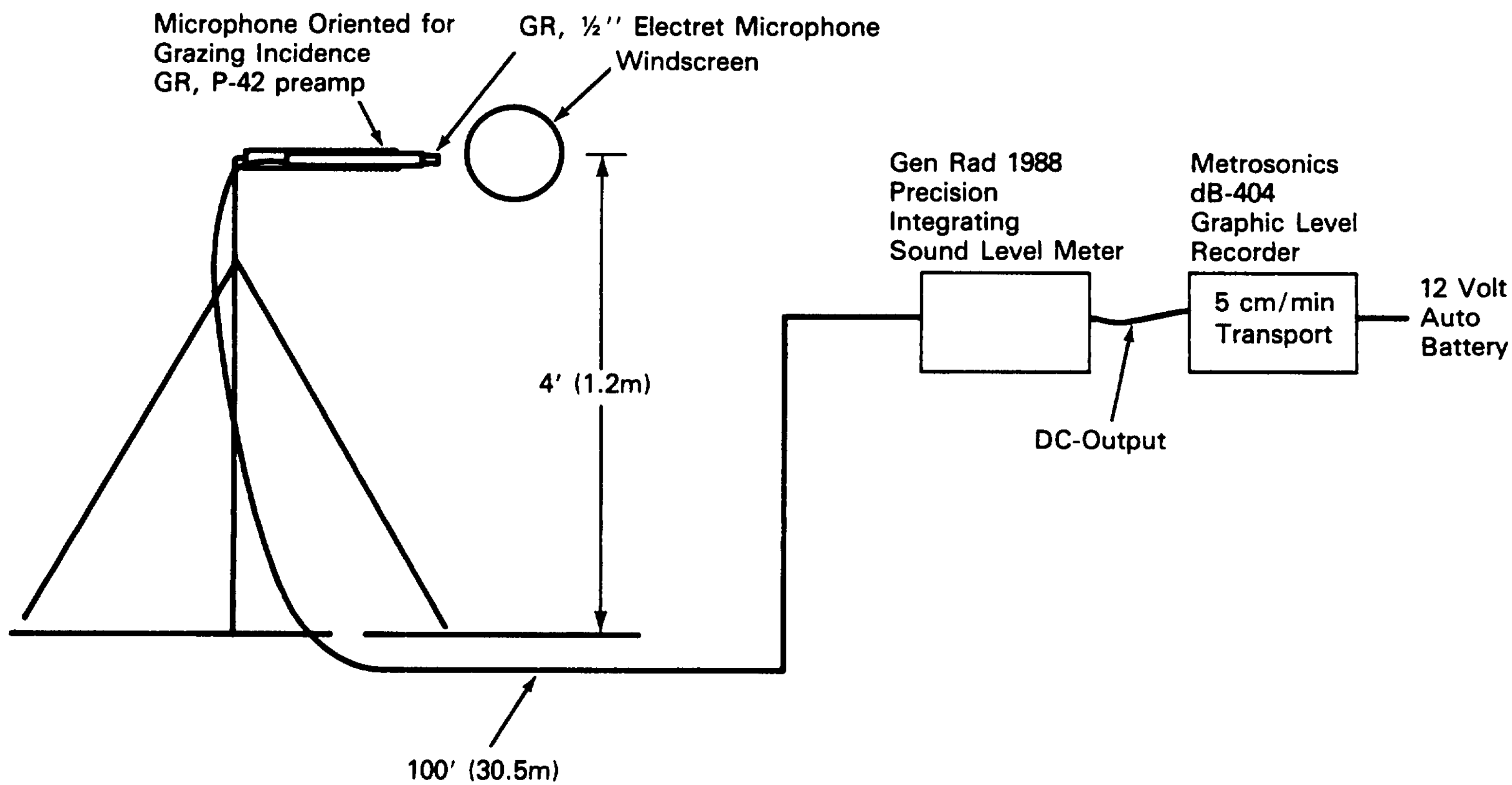
IRIG-B time code synchronized with the tracking time base was recorded on the cue channel of each system. The typical measurement system consisted of a General Radio 1/2 inch electret microphone oriented for grazing incidence driving a General Radio P-42 preamp and mounted at a height of four feet (1.2 meters). A 100-foot (30.5 meters) cable was used between the tripod and the instrumentation vehicle located at the perimeter of the test circle. A schematic of the acoustical instrumentation is shown in Figure 5.4.

Figure 5.4 also shows the cutaway windscreen mounting for the ground microphone. This configuration places the lower edge of the microphone diaphram approximately one-half inch from the plywood (4 ft by 4 ft) surface. The ground microphone was located off center in order to avoid natural mode resonant vibration of the plywood square.

5.6.2 <u>FAA Direct Read Measurement Systems</u> - In addition to the recording systems deployed by TSC, four direct read, Type-1 noise measurement systems were deployed at selected sites. Each noise measurement site consisted of an identical microphone-preamplifier system comprised of a General Radio 1/2-inch electret microphone (1962-9610) driving a General Radio P-42 preamplifier mounted 4 feet (1.2m) above the ground and oriented for grazing incidence. Each microphone was covered with a 3-inch windscreen.

FIGURE 5.5

Acoustical Measurement Instrumentation



Direct Read Noise Measurement System

Three of the direct read systems utilized a 100-foot cable connecting the microphone system with a General Radio 1988 Precision Integrating Sound Level Meter (PISLM). In each case, the slow response A-weighted sound level was output to a graphic level recorder (GLR). The GLRs operated at a paper transport speed of 5 centimeters per minute (300 cm/hr). These systems collected single event data consisting of maximum A-weighted Sound Level (AL), Sound Exposure Level (SEL), integration time (T), and equivalent sound level (LEQ).

The fourth microphone system was connected to a General Radio 1981B Sound Level Meter. This meter, used at site 7H for static operations only, provided A-weighted Sound Level values which were processed using a micro sampling technique to determine LEQ.

All instruments were calibrated at the beginning and end of each test day and approximately every hour in between. A schematic drawing of the basic direct read system is shown in Figure 5.5.

5.6.3 Deployment of Acoustical Measurement Instrumentation - This section describes the deployment of the magnetic tape recording and direct read noise measurement systems.

During the testing, TSC deployed six magnetic tape recording systems. During the flight operations, four of these recording system were located at the three centerline sites: one system at site 4, one at site 5, and two at centerline center with the microphone of one of those systems at 4 feet above ground, the microphone of the other at ground level. The two remaining recording systems were located at the two sidelines sites. The FAA deployed three direct read systems at the three centerline sites during the flight operations. Figure 5.6 provides a schematic drawing of the equipment deployment for the flight operations.

In the case of static operations, only four of the six recorder systems were used. The recorder system with the 4-foot microphone at site 1 moved to site 1H. The recorders at sites 4 and 5 moved to 4H and 5H respectively. The recorder at site 2, the south sideline site, was also used. The three direct read systems were moved from the centerline sites to sites 5H, 2, and 4H. The fourth direct read system was employed at site 7H. Figure 5.7 provides a schematic diagram of the equipment deployment for the static operations.

FIGURE 5.6
Microphone and Acoustical Measurement Instrument Deployment Flight Operations

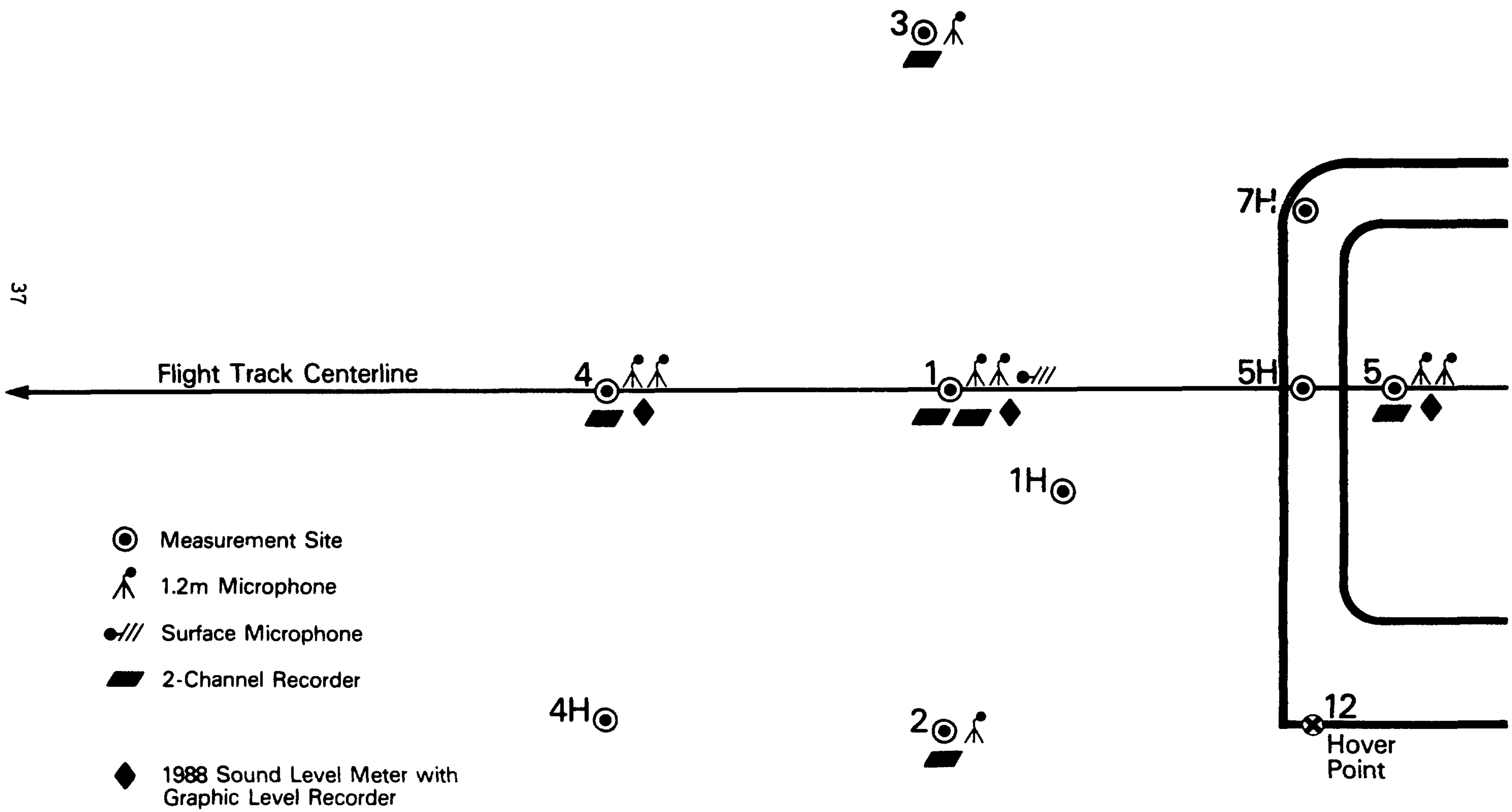
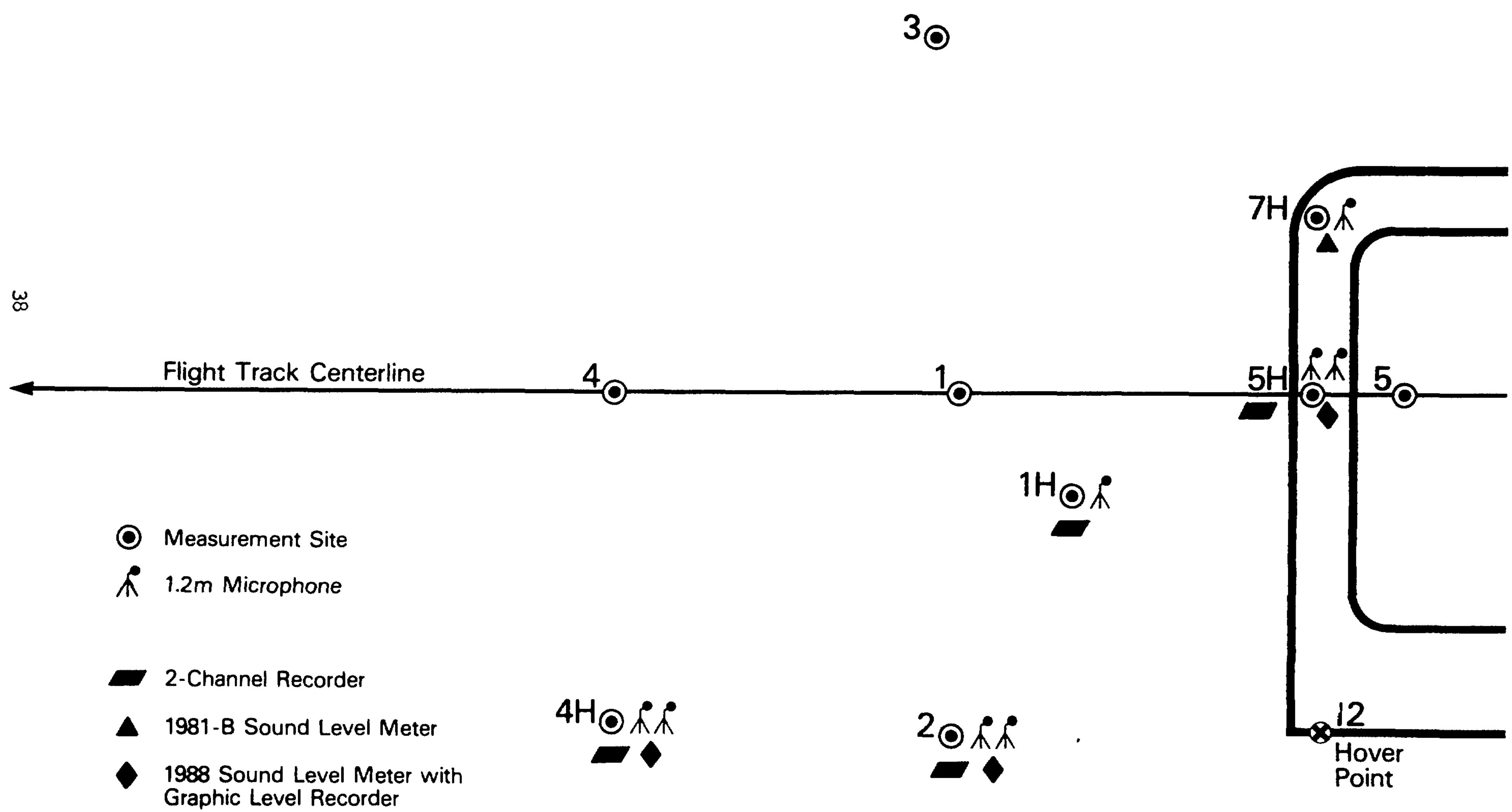


FIGURE 5.7

Microphone and Acoustical Measurement Instrument Deployment Static Operations



ACOUSTICAL DATA REDUCTION

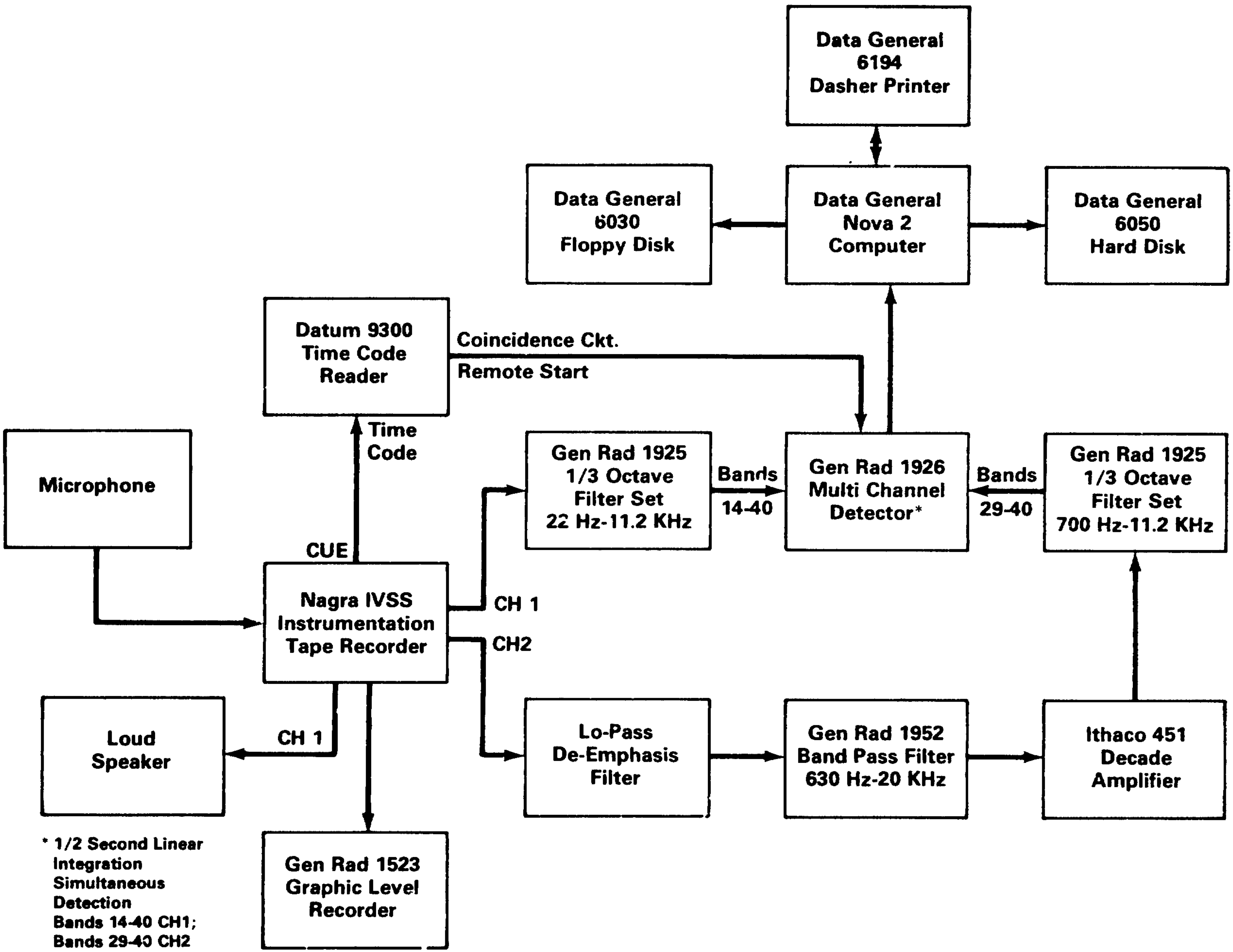
6.0 Acoustical Data Reduction - This section describes the treatment of tape recorded and direct read acoustical data from the point of acquisition to point of entry into the data tables shown in the appendices of this document.

6.1 TSC Magnetic Recording Data Reduction - The analog magnetic tape recordings analyzed at the TSC facility in Cambridge, Massachusetts were fed into magnetic disc storage after filtering and digitizing using the GenRad 1921 one-third octave real-time analyzer. Figure 6.1 is a picture of the TSC facility; Figure 6.2 is a flow chart of the data collection, reduction and output process accomplished by TSC personnel. Recording system frequency response adjustments were applied, assuring overall linearity of the recording and reduction system. The stored 24, one-third octave sound pressure levels (SPLs) for contiguous one-half second integration periods making up each event comprise the base of "raw data." Data reduction followed the basic procedures defined in Federal Aviation Regulation (FAR) Part 36 (Ref. 5). The following sections describe the steps involved in arriving at final sound level values.

FIGURE 6.1

FIGURE 6.2

Acoustical Data Reduction/Instrumentation



* 1/2 Second Linear Integration Simultaneous Detection Bands 14-40 CH1; Bands 29-40 CH2

6.1.1 Ambient Noise - The ambient noise is considered to consist of both the acoustical background noise and the electrical noise of the measurement system. For each event, the ambient level was taken as the five to ten-second time averaged one-third octave band taken immediately prior to the event. The ambient noise was used to correct the measured raw spectral data by subtracting the ambient level from the measured noise levels on an energy basis. This subtraction yielded the corrected noise level of the aircraft. The following execeptions are noted:

1. At one-third octave frequencies of 630 Hz and below, if the measured level was within 3 dB of the ambient level, the measured level was corrected by being set equal to the ambient. If the measured level was less than the ambient level, the measured level was not corrected.

2. At one-third octave frequencies above 630 Hz, if the measured level was within 3 dB or less of the ambient, the level was identified as "masked."

6.1.2 Spectral Shaping - The raw spectral data, corrected for ambient noise, were adjusted by sloping the spectrum shape at -2 dB per one-third octave for those bands (above 1.25 kHz) where the signal to noise ratio was less than 3 dB, i.e., "masked" bands. This procedure was applied in cases involving no more than 9 "masked" one-third octave bands. The shaping of the spectrum over this 9-band range was conducted to minimize EPNL data loss. This spectral shaping methodology deviates from FAR-36 procedures in that the extrapolation includes four more bands than normally allowed.

6.1.3 Analysis System Time Constant/Slow Response - The corrected raw spectral data (contiguous linear 1/2 second records of data) were processed using a sliding window or weighted running logarithmic averaging procedure to achieve the "slow" dynamic response equivalent to the "slow response" characteristic of sound level meters as required under the provisions of FAR-36. The following relationship using four consecutive data records was used:

$$L_i = 10 \text{ Log } [0.13(10.^{0.1L_{i-3}})+0.21(10.^{0.1L_{i-2}})+0.27(10.^{0.1L_{i-1}})+0.39(10.^{0.1L_i})]$$

where L_i is the one-third octave band sound pressure level for the ith one-half second record number.

6.1.4 Bandsharing of Tones - All calculations of PNLTM included testing for the presence of band sharing and adjustment in accordance with the procedures defined in FAR-36, Appendix B, Section B 36.2.3.3, (Ref. 6).

6.1.5 Tone Corrections - Tone corrections were computed using the helicopter acoustical spectrum from 24 Hz to 11,200 Hz, (bands 14 through 40). Tone correction values were computed for bands 17 through 40, the same set of bands used in computing the EPNL and PNLT. The initiation of the tone correction procedure at a lower frequency reflects recognition of the strong low frequency tonal content of helicopter noise. This procedure is in accordance with the requirements of ICAO Annex 16, Appendix 4, paragraph 4.3. (Ref. 7).

6.1.6 Other Metrics - In addition to the EPNL/PNLT family of metrics and the SEL/AL family, the overall sound pressure level and 10-dB down duration times are presented as part of the "As Measured" data set in Appendix A. Two factors relating to the event time history (distance duration and speed corrections, discussed in a later section) are also presented.

6.1.7 Spectral Data/Static Tests - In the case of static operations, thirty-two seconds of corrected raw spectral data (64 contiguous 1/2 second data records) were energy averaged to produce the data tabulated in Appendix C. The spectral data presented is "as measured" at the emission angles shown in Figure 6.3, established relative to each microphone location. Also included in the tables are the 360 degree (eight emission angles) average levels, calculated by both arithmetic and energy averaging.

Note that "masked" levels (see Section 6.1.1) are replaced in the tables of Appendix C with a dash (-). The indexes shown, however, were calculated with a shaped spectra as per Section 6.1.2.

FIGURE 6.3

Acoustical Emission Angle Convention

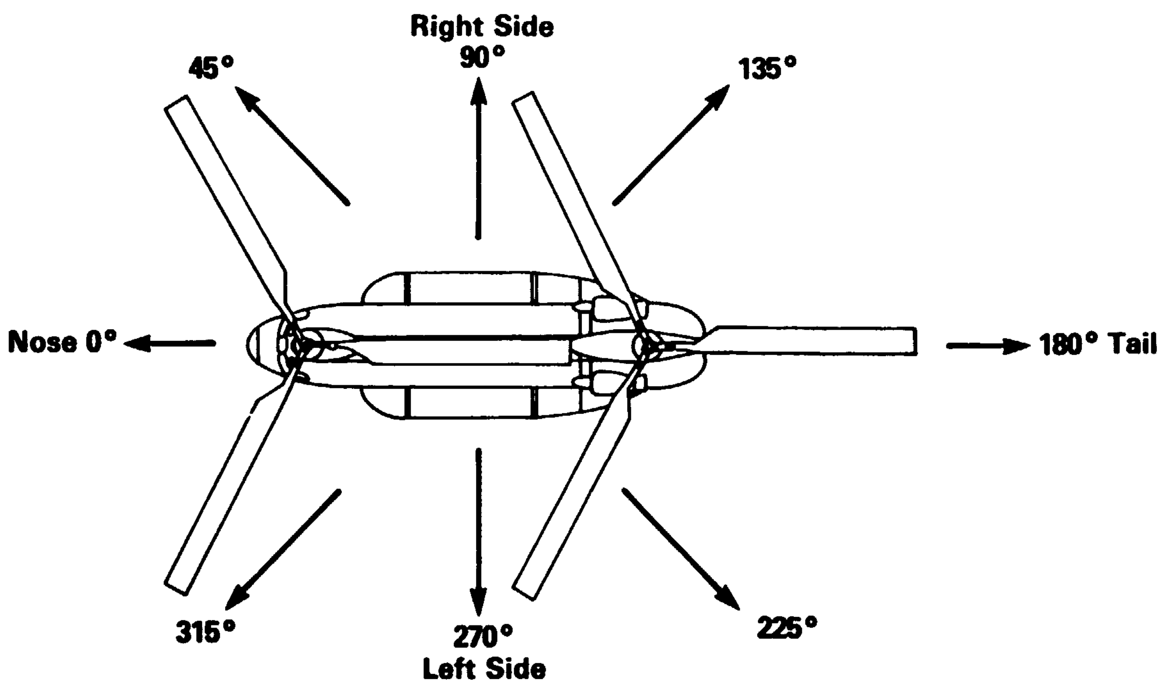
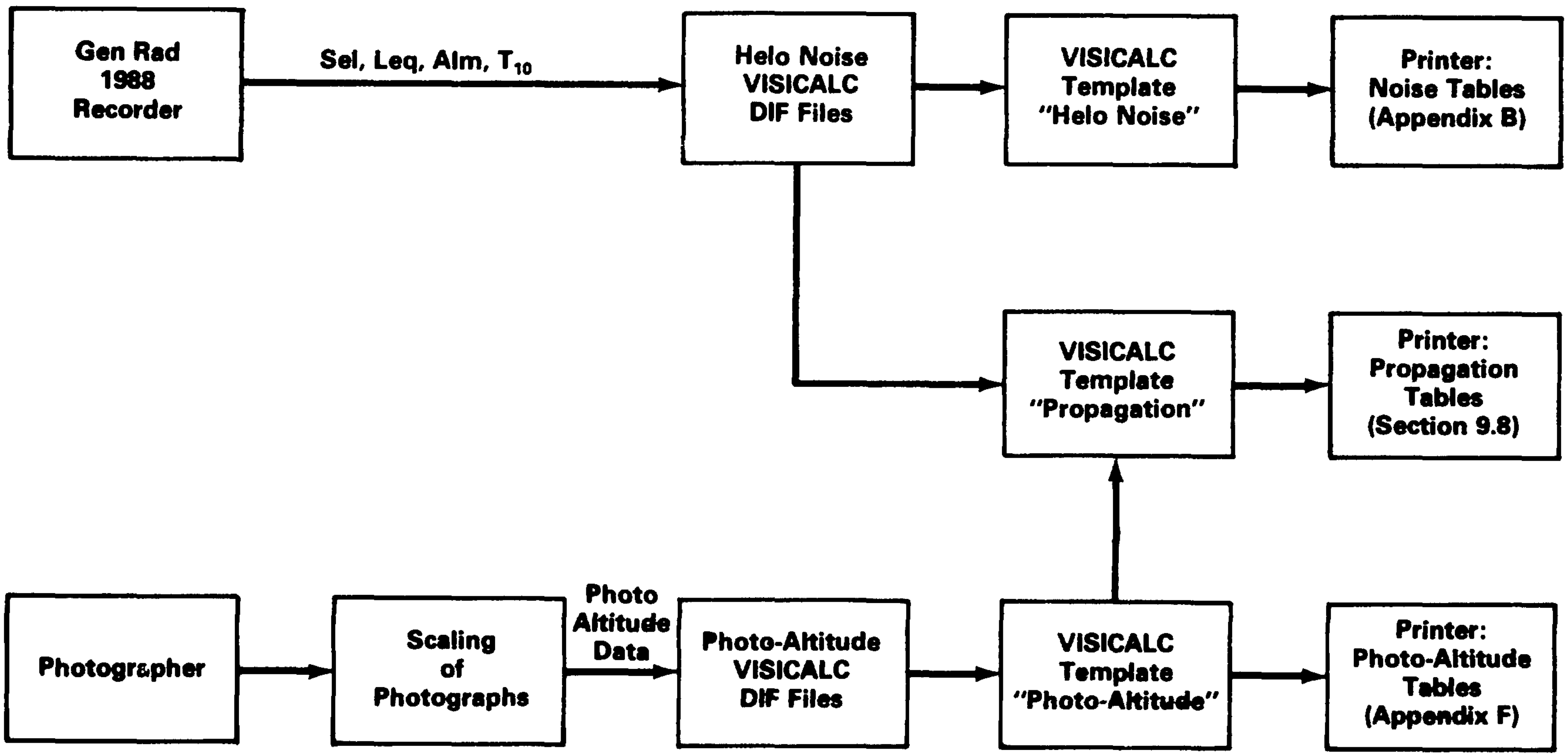


FIGURE 6.4

Direct Read Data Reduction



6.2 FAA Direct Read Data Reduction - Figure 6.4 provides a flow diagram of the data collection, reduction and output process effected by FAA personnel. FAA direct read data was reduced using the Apple IIe microcomputer and the VISICALC® software package. VISICALC® is an electronic worksheet composed of 256 x 256 rows and columns which can support mathematical manipulation of the data placed anywhere on the worksheet. This form of computer software lends itself to a variety of data analyses, by means of constructing templates (worksheets constructed for specific purposes). Data files can be constructed to contain a variety of information such as noise data and position data using a file format called DIF (data interchange format).

Data analysis can be performed by loading DIF files onto analysis templates. The output or results can be displayed in a format suitable for inclusion in reports or presentations. Data tables generated using these techniques are contained in Appendices B and D, and are discussed in Section 9.0.

6.2.1 Aircraft Position and Trajectory - A VISICALC® DIF file was created to contain the photo altitude data for each event of each test series for the test conducted. These data were input into a VISICALC® template designed to perform a 3-point regression through the photo altitude data from which estimates of aircraft altitudes could be determined for each microphone location.

6.2.2 Direct Read Noise Data - Another template was designed to take two VISICALC® DIF files as input. The first contained the "as measured" noise levels SEL and dBA obtained from the FAA direct read systems and the 10-dB duration time obtained from the graphic level recorder strips, for each of the three microphone sites.

The second consisted of the estimates of aircraft altitude over three microphone sites. Calculations using the two input files determined two figures of merit related to the event duration influences on the SEL energy dose metric. This analysis is described in Section 9.4. All of the available template output data are presented in Appendix B.

TEST SERIES DESCRIPTION

7.0 Test Series Description - The noise-flight test operations schedule for the Boeing-Vertol CH-47D consisted of two major parts.

The first part or core test program included the ICAO certification test operations (takeoff, approach, and level flyover) supplemented by level flyovers at various altitudes (at a constant altitude), at various airspeeds (at a constant altitude), at different rotor RPM's and at civilian and military trims. Trim refers to the angle of the aft rotor to the foreward rotor. In addition to the ICAO takeoff operation, a second takeoff flight series was included using the military trim. Alternative approach operations were also included - one utilizing a three degree approach angle, the other a six degree approach angle using military trim - to compare with the six degree ICAO approach data.

The second part of the test program consisted of static operations designed to asses helicopter directivity patterns and examine ground-to-ground propagtion.

The information presented in Table 7.1 describes the Sikorsky S-76 test schedule by test series, each test series representing a group of similar events. Each noise event is identified by a letter prefix, corresponding to the appropriate test series, followed by a number which represents the numerical sequence of event (i.e., A1, A2, A3, A4, B5, B6,...etc.). In some cases the actual order of test series may not follow alphabetically, as a D1, D2, D3, D4, E5, E6, E8, H9, H10, H11,... etc.). In the case of static operations the individual events are reported by the acoustical emission angle referenced to each individual microphone location (i.e., J120, J165, J210, J255, J300, J345, J030, J75). In Table 7.1, the test target operational parameters for each series are specified along with approximate start and stop times. These times can be used to reference corresponding meteorological data in Appendix G. Timing of fuel breaks are also identified so that the reader can estimate changes in helicopter weight with fuel burn-off. Actual operational parameters and position information for specific events are specified in the appendices of this document.

Figures 7.1, 7.2 and 7.3 present the test flight configuration for the takeoff, approach and level flyover operations. A schematic of the actual flight tracks is available in Figure 3.3.

TABLE 7.1

TEST SUMMARY

BOEING-VERTOL CH-47D

TEST SERIES AND RUN NUMBERS	DESCRIPTION OF SERIES	RPM	TRIM	START TIME	FINISH TIME
M	HOVER-IN-GROUND-EFFECT	225	234	6:47 am	6:59 am
N(A)	STATIC/FLIGHT-IDLE RPM	225	234	7:01 am	7:46 am
N(B)	STATIC/GROUND-IDLE RPM	225	234	7:01 am	7:46 am
O	HOVER-OUT-OF-GROUND-EFFECT	225	234	7:50 am	8:04 am
				FUEL BREAK	
A	LFO, 500 ft.	225	234	9:12 am	9:27 am
B	LFO, 500 ft.	225	D	9:31 am	9:38 am
C	LFO, 500 ft.	220	234	9:41 am	9:50 am
D	LFO, 500 ft.	220	234	9:53 am	10:07 am
E	LFO, 500 ft	220	234	10:14 am	
F	LFO, 1000 ft.	220	234	12:22 pm	12:35 pm
H	APPROACH (ICAO), 85 kts.	225	234	12:41 pm	1:04 pm
I	APPROACH (MILITARY), 70 kts.	225	D	1:08 pm	1:28 pm
				FUEL BREAK	
G	TAKEOFF (ICAO), 85 kts.	225	234	2:01 pm	2:28 pm
J	TAKEOFF, 85 kts.	225	234	2:42 pm	2:49 pm
K	APPROACH, 100 kts.	220	234	2:42 pm	2:49 pm
L	TAKEOFF (MILITARY), 70 kts.	225	D	2:53 pm	2:59 pm

Figure 7.1

Helicopter Takeoff Noise Tests

The take-off flight path shall be established as follows:

(a) the helicopter shall be established in level flight at the best rate of climb speed, V_y, ± 3 knots, of the maximum speed of the curve contiguous to the ordinate of the limiting height-speed envelope +3 knots (±3 knots), whichever is greater, and, at a height of 20 m (66 ft) above the ground until a point 500 m (1,640 ft) before the flight path reference point is reached;

(b) upon reaching the point specified in (a) above, the power shall be increased to maximum take-off power and a steady climb initiated and maintained *over the noise measurement time period;*

(c) airspeed established in (a) above shall be maintained throughout the take-off reference procedure;

(d) the steady climb shall be made with the rotor speed stabilized at the maximum rpm for power-on operations

(e) a constant take-off configuration selected by the applicant shall be maintained throughout the take-off reference procedure except that the landing gear may be retracted; and

(f) the weight of the helicopter shall be the maximum take-off weight.

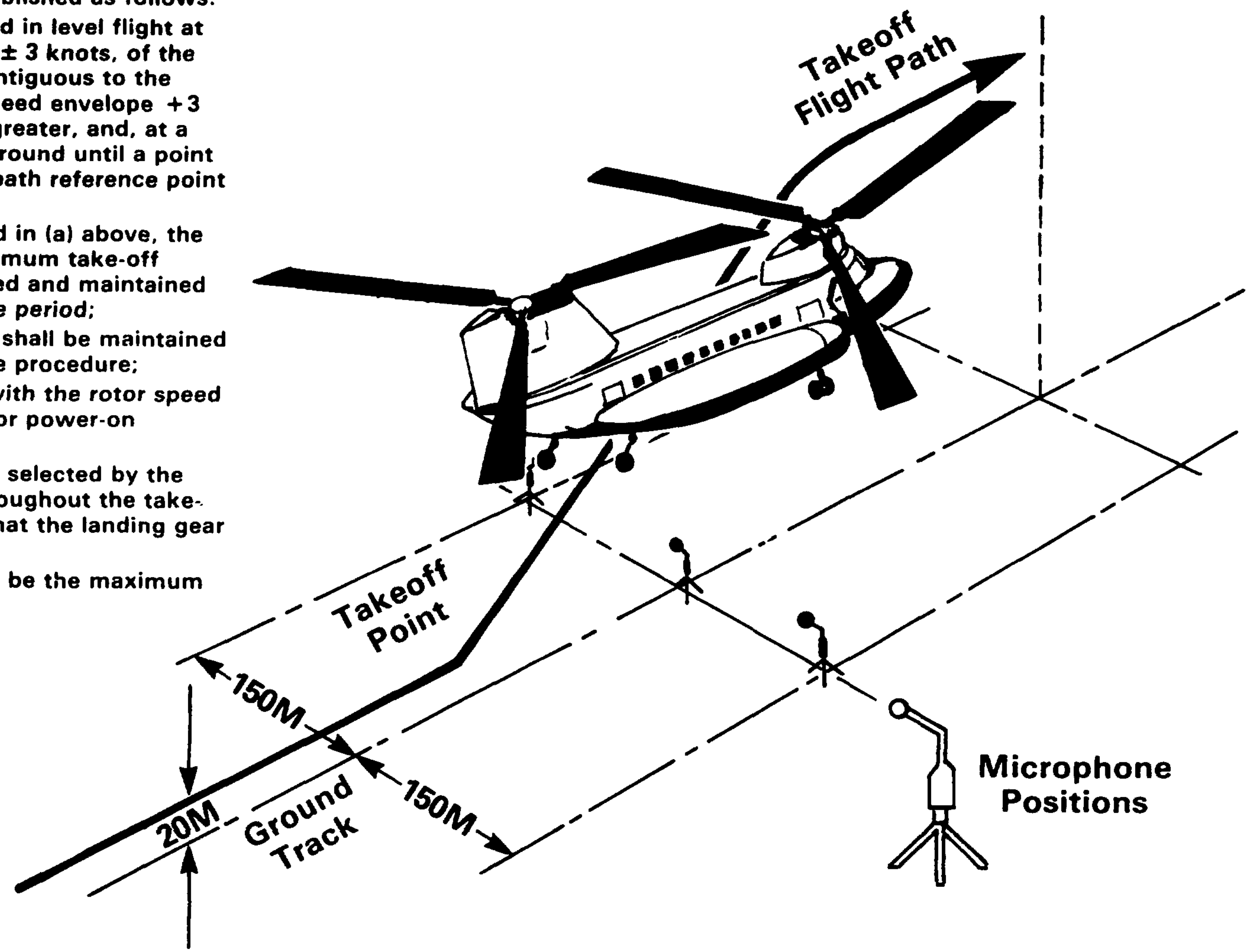


Figure 7.2

Helicopter Approach Noise Tests

The approach procedure shall be established as follows:

(a) the helicopter shall be stabilized and following a 6.0° approach path;

(b) the approach shall be made at a stabilized airspeed equal to the best rate of climb speed V_y, ± 3 knots, or the maximum speed of the curve contiguous to the ordinate of the limiting height-speed envelope +3 knots (±3 knots), whichever is the greater, with power stabilized during the approach and over the flight path reference point, and continued to 50 feet above ground level

(c) the approach shall be made with the rotor speed stabilized at the maximum rpm for power-on operations.

(d) the constant approach configuration used in airworthiness certification tests, with the landing gear extended, shall be maintained throughout the approach reference procedure; and

(e) the weight of the helicopter shall be the maximum landing weight.

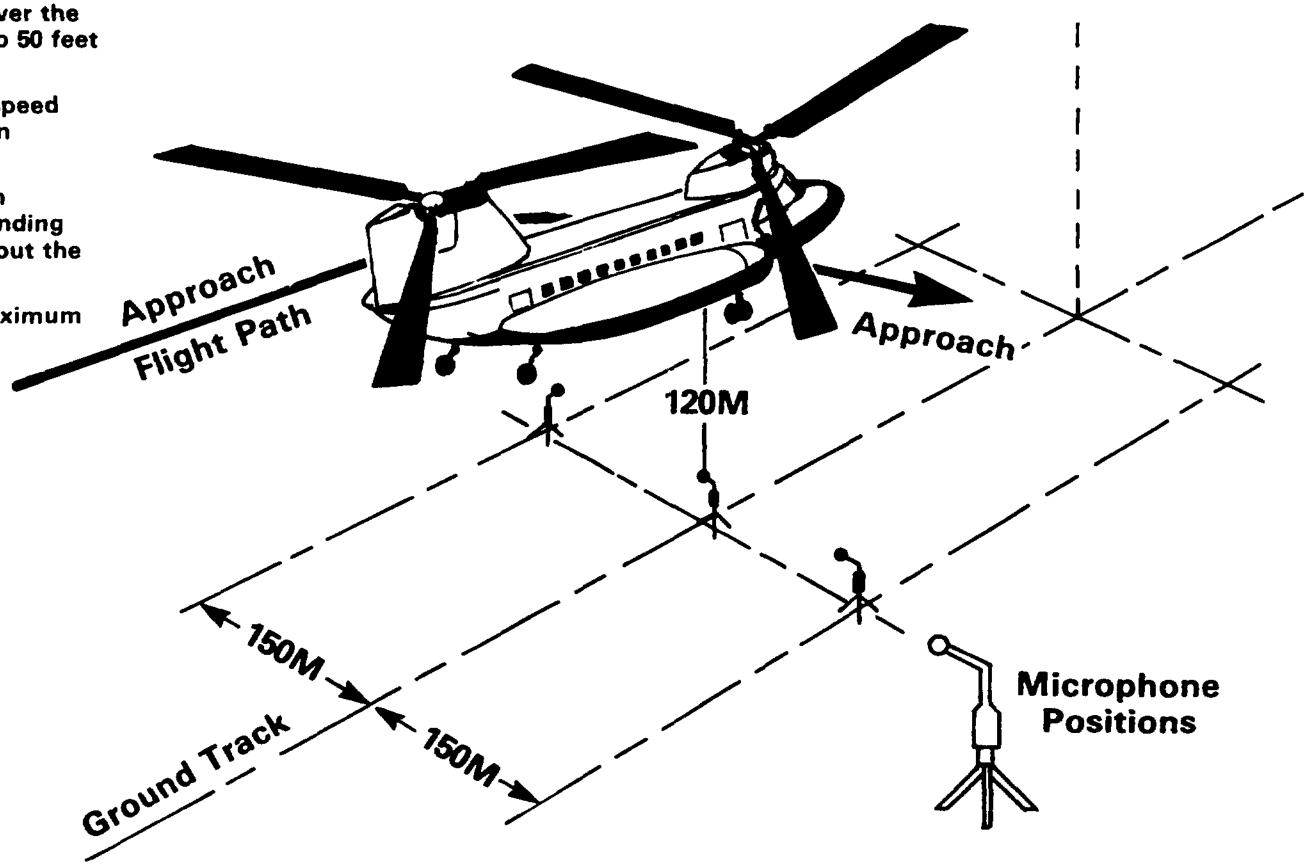


Figure 7.3

Helicopter Flyover Noise Tests

The flyover procedure shall be established as follows:

(a) the helicopter shall be stabilized in level flight overhead the flight path reference point at a height of 150 m (492 ft);

(b) a speed of $0.9V_H$ or $0.9V_{NE}$, whichever is the lesser, shall be maintained throughout the overflight reference procedure;

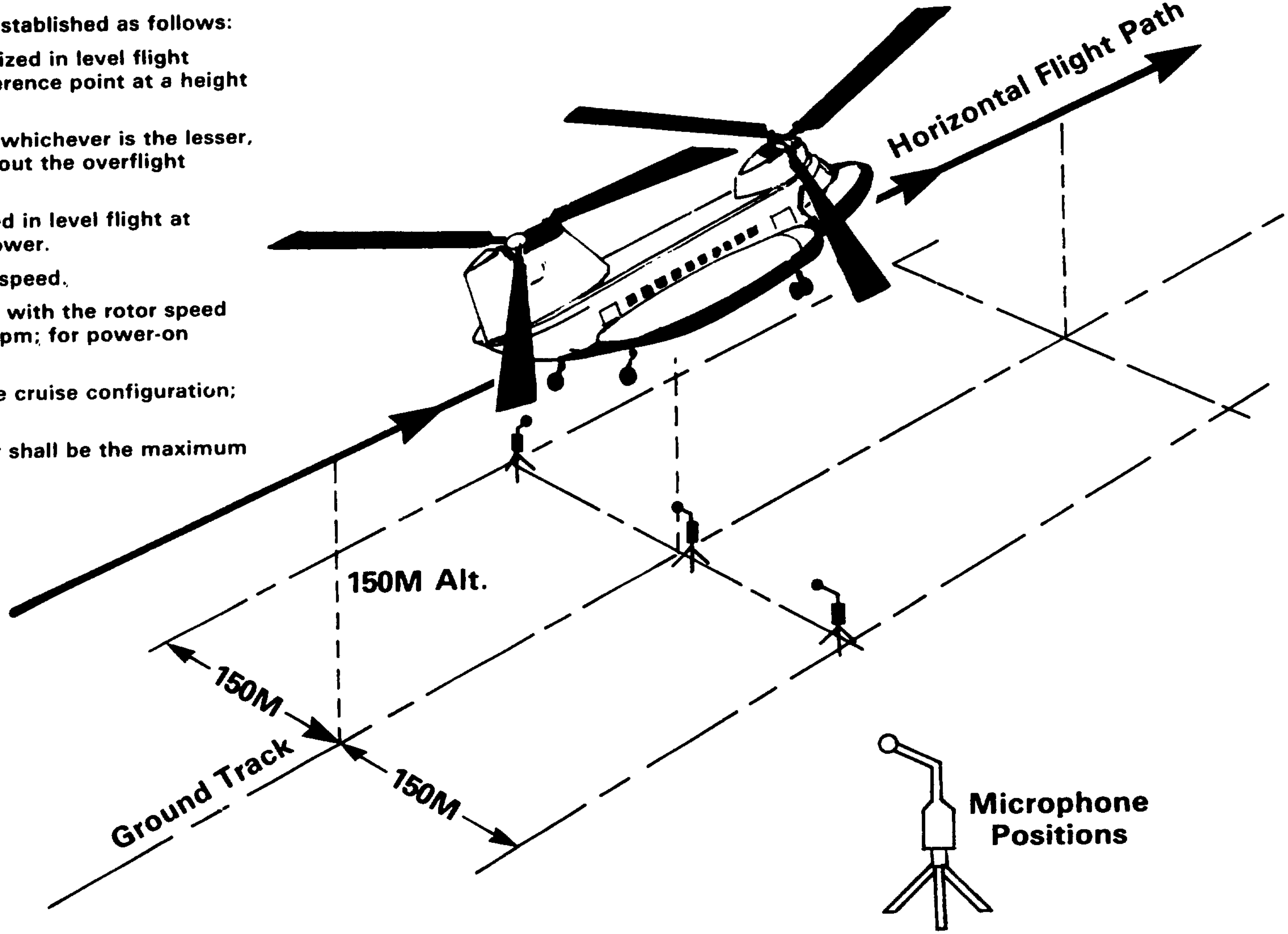
NOTE: V_H is the maximum speed in level flight at maximum continuous power.

V_{NE} is the never exceed speed.

(c) the overflight shall be made with the rotor speed stabilized at the maximum rpm; for power-on operations.

(d) the helicopter shall be in the cruise configuration; and

(e) the weight of the helicopter shall be the maximum take-off weight.



DOCUMENTARY ANALYSES

8.0 Documentary Analyses/Processing of Trajectory and Meteorological Data - This section contains analyses which were performed to document the flight path trajectory and upper air meteorological characteristics during the BV-234/CH-47D test program.

8.1 Photo-Altitude Flight Path Trajectory Analyses - Data acquired from the three centerline photo-altitude sites were processed on an Apple IIe microcomputer using a VISICALC® (manufacturer) electronic spread sheet template developed by the authors for this specific application. The scaled photo-altitudes for each event (from all three photo sites) were entered as a single data set. The template operated on these data, calculating the straight line slope in degrees for the helicopter position between each pair of sites. In addition, a linear regression analysis was performed in order to create a straight line approximation to the actual flight path. This regression line was then used to compute estimated altitudes and CPA's (Closest Point of Approach) referenced to each microphone location (Note: Photo sites were offset from microphone sites by 100 feet). The results of this analysis are contained in the tables of Appendix F.

Discussion - While the photo-altitude data do provide a reasonable description of the helicopter trajectory and provide the means to effect distance corrections to a reference flight path (not implemented in this report), there is the need to exercise caution in interpretation of the data. The following excerpt makes an important point for those trying to relate the descent profiles (in approach test series) to resulting acoustical data.

In our experience, attempts by the pilot to fly down a very narrow VASI beam produce a continuously varying rate of descent. Thus while the mean flight path is maintained within a reasonable degree of test precision, the rate of descent (important parameter connected with blade/vortex interactions) at any instant in time may vary much more than during operational flying. (Ref. 8)

Further, care is necessary when using the regression slope and the regression estimated altitude; one must be sure that the site-to-site slopes are similiar (approximate constant angle) and that they are in agreement with the regression slope. If these slopes are not in agreement, then use photo altitude data along with the site-to-site slopes in calculating altitude over microphone locations.

Also included for reference are the mean values and standard deviations for the data collected at each site, for each series. These data display the variability in helicopter position within a given test series. The difference in the degree of variation from one similar test series to the next may provide an indication of changes in micro-meterological, (winds and turbulence). The differences in the degree of variation from one type of operation to the next type of op eration provides and indication of inherent stability or lackof inherent stability associated with repetition of a nominally identical operation

8.2 Meteorological Data - This section documents the course variation in upper air meteorological parameters as a function of time for the June 8 test program.

The National Weather Service office in Sterling, Virginia provided preliminary data processing resulting in the data tables shown in Appendix H. Supplementary analyses were then under taken to develop time histories of various parameters over the period of testing for selected altitudes. Each time history was constructed using least square linear regression techniques for the five available data points (one for each launch). The plots attempt to represent the gross (macro) meteorological trends over the test period.

Temperature: Figure 8.1 shows the temperature time history for July 12, 1983 at the 500, 1000 and 2000 foot levels. Data recieved from the National Weather Service (NWS) ground station reveals that on July 12 a temperature inversion existed from 6:00 to 9:00am. Static operations were conducted on the BV 234 from 7:00 to 8:00am; level flyover operations were conducted from 9:00am to 12:00pm, followed by takeoff and approaches operations.

Acoustic theory states that during temperature inversions, refraction/reflection of acoustical energy occurs, resulting in meteorlogically influenced noise levels.

Relative Humidity: Figure 8.2 shows the time history of relative humidity for July 12, 1983 at the 500, 1000 and 2000 foot levels. Data recieved from the National Weather Service (Dulles) ground station fills in the

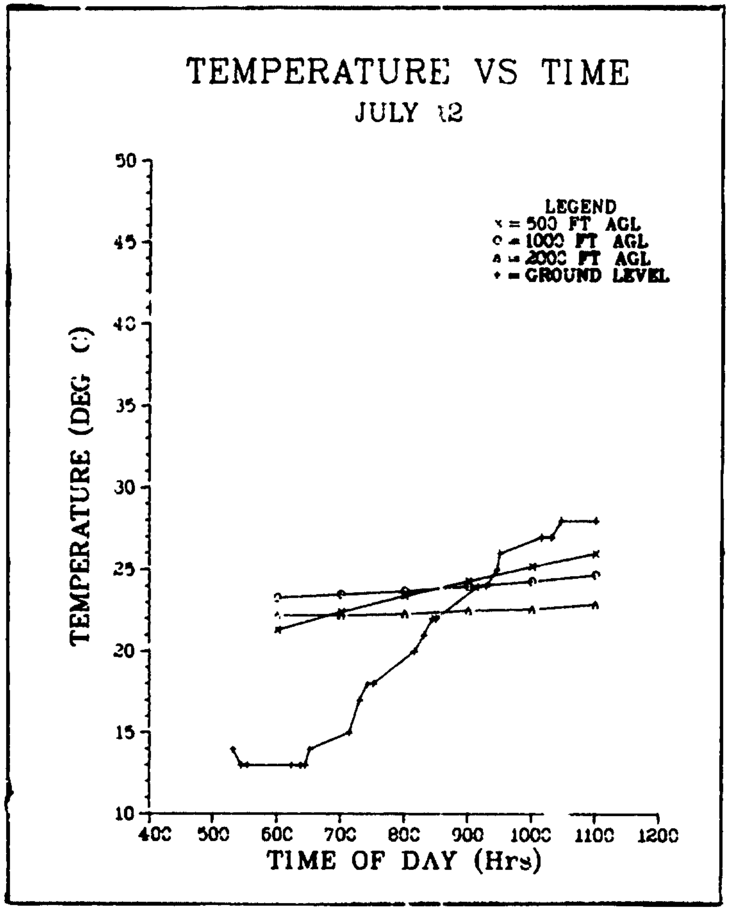


FIGURE 8.1

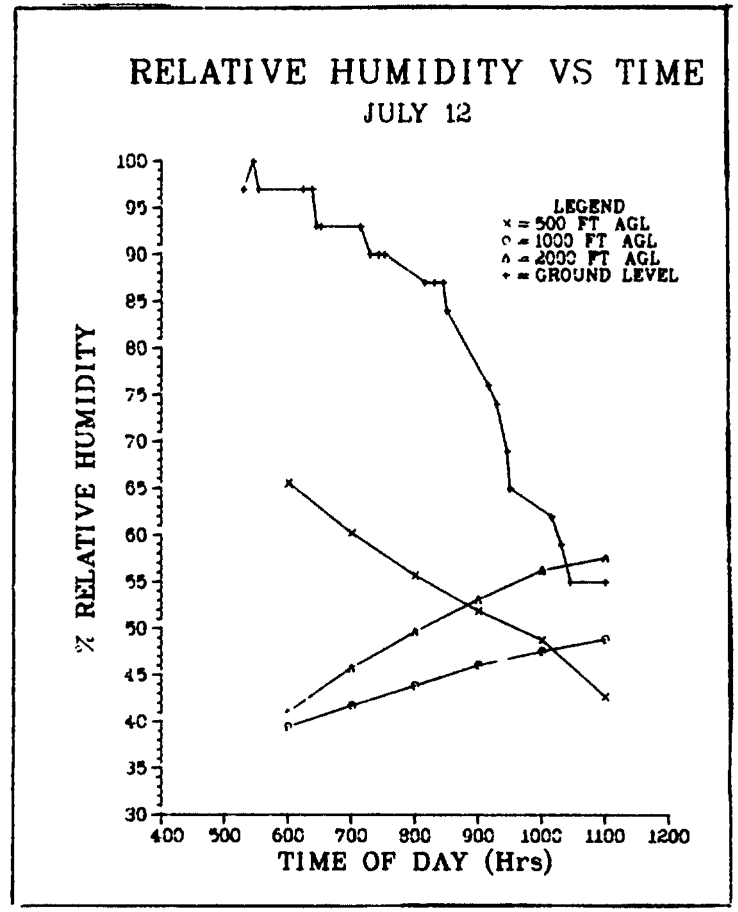
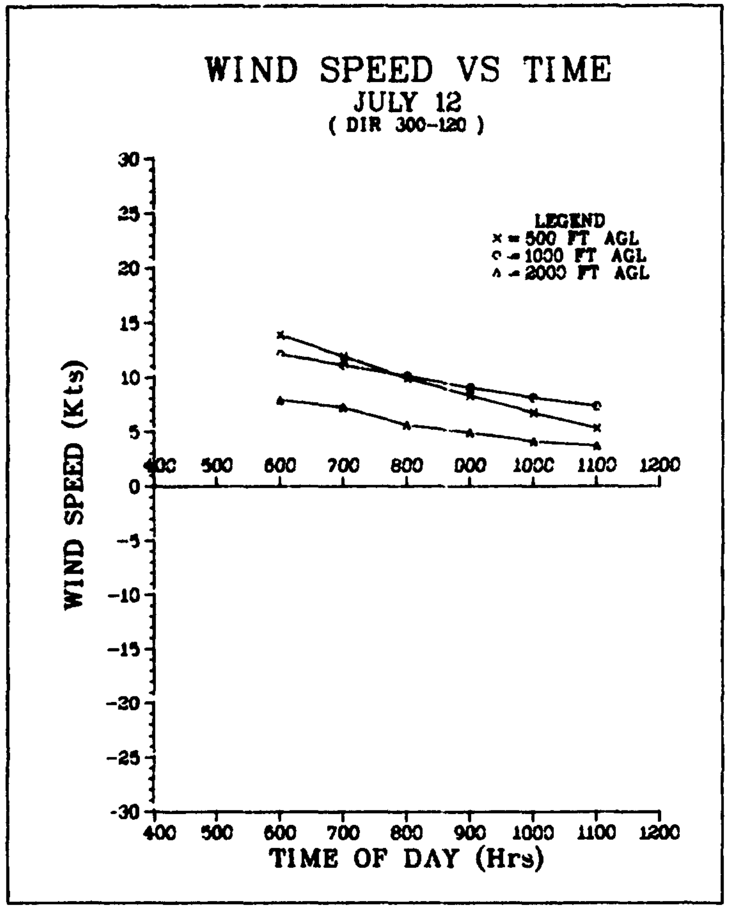


FIGURE 8.2

picture of relative humidity as a function of time from the surface to the 2000 foot level. With this data it can be seen that surface R/H was 93% at 6:00am and finially decreased to 43% at 12:00pm in accordance with the burn off of surface moisture due to solar heating.

Wind Data: Figures 8.3 and 8.4 show the time histories of head/tail and cross wind components for July 12, 1983. From Figure 8.3 it is seen that there existed a head wind of 14 knots at 6:00am, which decreased to about 7 knots at 11:00am. Static operations were conducted from 6:47am to 8:05am followed by level flyovers and then takeoff and approach operations. In a similar manner Figure 8.4 shows a cross wind magnitude of 2 to 3 knots consistently from 6:00 to 11:00am. The reader should note that whether a head/tail wind was experienced during a flight depends on the direction of flight, and in a similar manner the same can be said for the cross wind component.

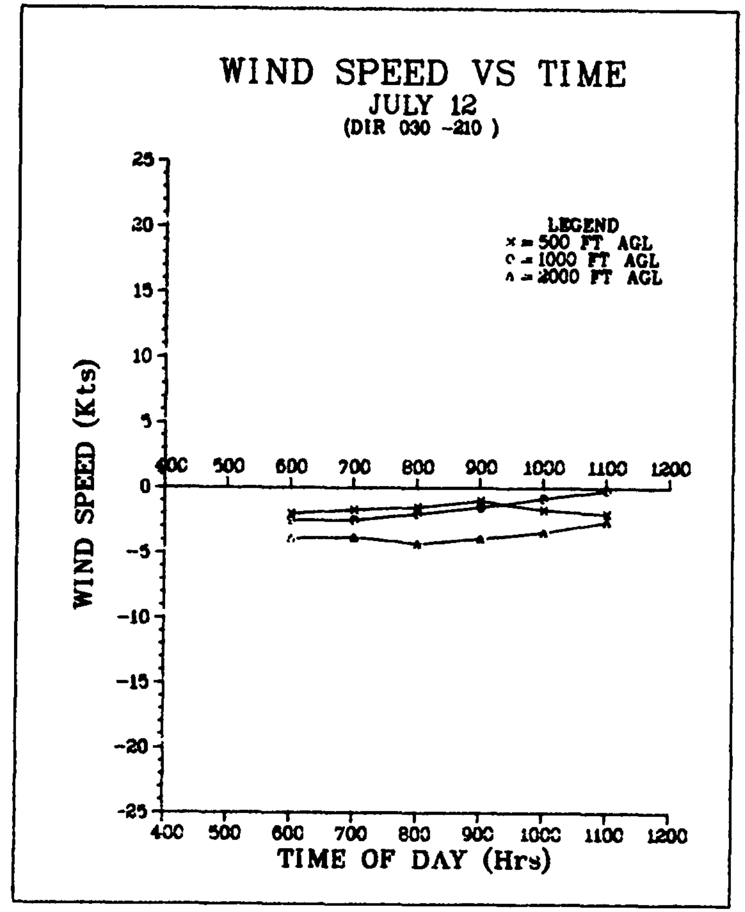
FIGURE 8.3



HEAD/TAIL WIND

This plot indicates a headwind for operations in the 300 degree magnetic direction.

FIGURE 8.4



CROSS WIND

This plot indicates a right side crosswind for operations in the 120 degree magnetic direction.

EXPLORATORY ANALYSES AND DISCUSSIONS

9.0 Exploratory Analyses and Discussion - This section is comprised of a series of distinct and separate analyses of the data acquired during Boeing Vertol 234/CH-47D noise measurement program. In each analysis section an introductory discussion is provided describing pre-processing of data (beyond the basic reduction previously described), followed by presentation of either a data table, graph(s), or reference to appropriate appendices. Each section concludes with a discussion of salient results and presentation of conclusions.

The following list identifies the analyses which are contained in this section.

9.1 Variation in noise levels with airspeed for level flyover operations

9.2 Static data analysis: source directivity and hard vs. soft propagation characteristics

9.3 Comparison of noise data: 4-foot vs. ground microphones

9.4 Duration effect analysis

9.5 Analysis of variability in noise levels for two sites equidistant over similar propagation paths

9.6 Variation in noise levels with airspeed and rate of descent for approach operations

9.7 Analysis of ground-to-ground acoustical propagation for a nominally soft propagation path

9.8 Air-to-ground acoustical propagation analysis

9.1 Variation in Noise levels for Level Flyover Operations - This section analyzes the variation in noise levels for level flyover operations under various conditions.

9.1.1 Variation in Noise Levels with Different Airspeeds - This section analyzes the variation in noise levels for level flyover operations as a function of airspeed. Data acquired from the centerline-center location (site 1) magnetic recording system (see Appendix A) have been utilized in this analysis. All data are "as measured", uncorrected for the minor variations in altitude from event to event.

Discussion - It has been observed that as a helicopter increases its airspeed, two acoustically related events take place. First, the noise event duration is decreased as the helicopter passes more quickly. Second, the source acoustical emission characteristics change. These changes reflect the aerodynamic effects which accompany an increase in speed. At speeds higher than the speed for minimum power, the power required (torque) increases with an increase in airspeed. These influences lead to a noise intensity versus airspeed relationship generally approximated by a parabolic curve. At first, noise levels decrease with airspeed, reaching a minimum at the speed for minimum power; then an upturn occurs as a consequence of increasing advancing blade tip Mach number effects, which in turn generate impulsive noise.

The noise versus airspeed plots for the BV 234/CH-47D are shown for various acoustical metrics in Figures 9.1 througl 9.4, for the test series conducted with BV 234 trim and an RPM of 220. These plots are consistent with the expected parabolic nature of the noise versus airspeed

BOEING VERTOL 234/CH-47D LEVEL FLYOVER PLOTS

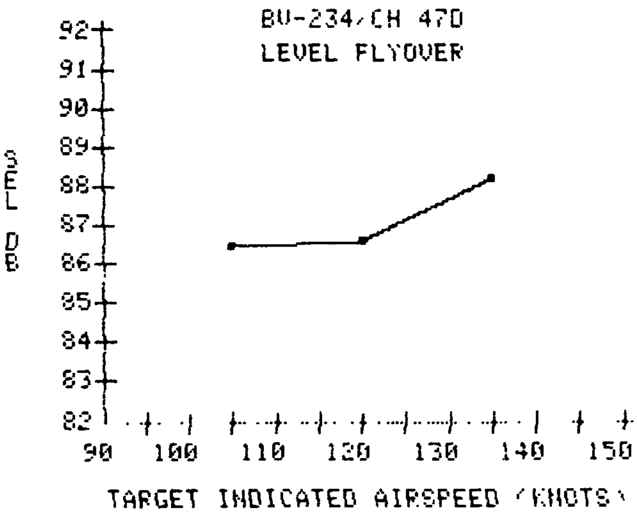


FIGURE 9.1

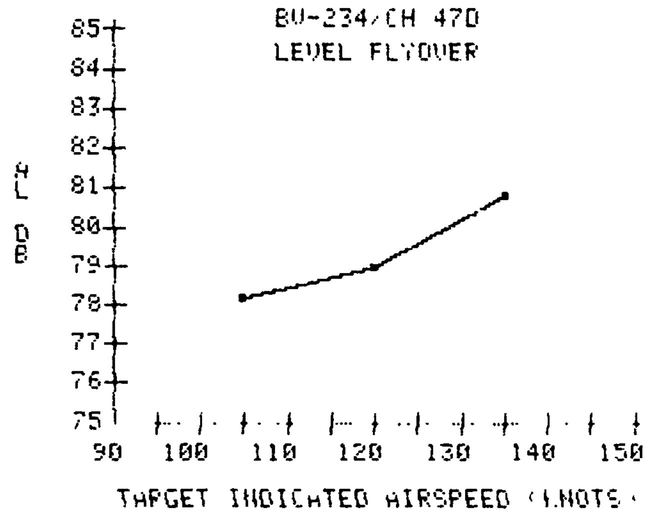


FIGURE 9.2

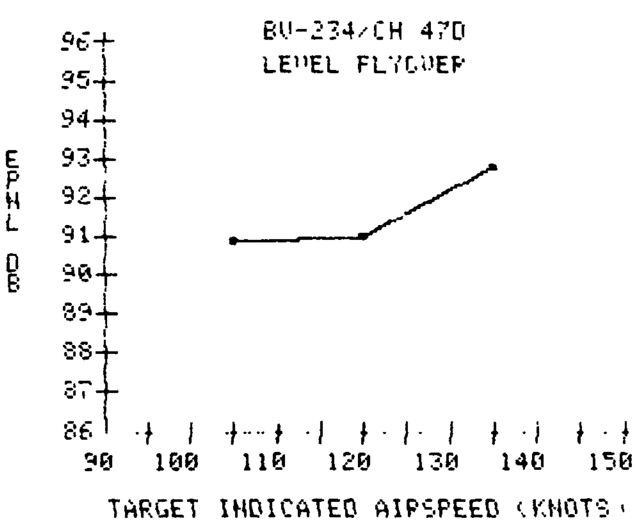


FIGURE 9.3

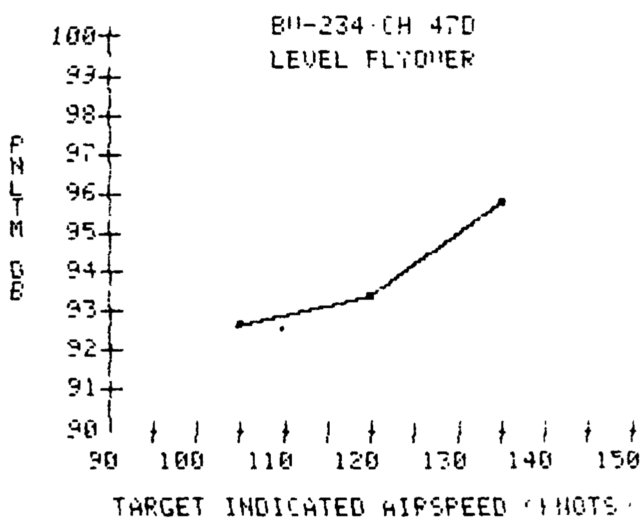


FIGURE 9.4

relationship described above, although displaying only the minimal increasing portion of the curve. Each plotted point represents a test series average noise level and the corresponding target indicated airspeed.

For other helicopters, it has been observed that noise increases most rapidly when the Mach number advances beyond a value of about 0.80. Table 9.1 shows the relationship between indicated airspeed and advancing blade tip Mach number for the BV 234/CH-47D at the two operational rotor speeds. Because this helicopter has a tandem main rotor system, one rotor rotating clockwise while the other rotates counterclockwise, there is an advancing (and a retreating) blade on either side of the helicopter at all times. This circumstance would tend to minimize left-side, right-side differential noise directivity associated with the advancing blade (usually observed for single main rotor helicopters).

TABLE 9.1

IAS (KTS)	M_A (220 RPM)	M_A (225 RPM)
100	.76	.77
110	.77	.79
120	.79	.80
130	.80	.82
140	.82	.83
150	.83	.85

9.1.2 Variation in Noise Level (for a Constant Airspeed) with Variation in Trim and Rotor Speed - This section provides a glimpse at the variation in noise level with change in trim and rotor speed for a nominally constant target airspeed. While a more extensive matrix of test conditions would be required to establish generalized noise level/trim and noise level/RPM relationships, the results shown below in Table 9.2 do provide a starting point.

TABLE 9.2

				SITE #1	
TEST SERIES	IAS	RPM	TRIM	AVG SEL	AVG DBA
A LFO (ICAO)	135	225	234	87.1	79.2
B Military LFO	135	225	CH-47D	89.2	82.0
C LFO	135	220	234	88.2	80.8

The test series done with 225 RPM and 234 trim (Series A) displays lower levels than the corresponding series with CH-47D trim. These results are as expected, since the 234 trim is the Fly Neighborly configuration. What is surprising, however, is the lower levels for series A compared with the lower RPM series C.

9.2 Static Operations: Analysis of Source Directivity and Hard vs. Soft Path Propagation Characteristics - This analysis is comprised of two principal components. First, the plots shown in Figures 9.5 through 9.8 depict the time averaged directivity patterns for various static operations for measurement sites located equidistant from the hover point. The second component involves the fact that one of the two sites lies separated from the hover point by a hard concrete surface, while the other site is separated from the hover point by a soft grassy surface. The difference in the propagation of sound over the two disparate surfaces is reflected in the difference between the upper and lower curves in each plot. Figure 9.9 depicts the microphone positions and hard and soft paths in relation to the helicopter movement.

Time averaged (approximately 60 seconds) data are shown for acoustical emission directivity angles (see Figure 6.3) established every 45 degrees from the nose of the helicopter (zero degrees), in a clockwise fashion. Magnetic recording data plotted in these figures can be found in Appendix C for microphones 5H and 2.

Discussion - The following paragraphs highlight salient features observed in the static test data.

HIGE - Figure 9.5 shows the noise emission pattern for the BV 234/CH-47D in the hover-in-ground effect (HIGE) configuration (approximately feet above the ground). This figure shows dramatically an assymetrical radiation pattern in which we see the maximum noise occurring at the 45° emission angle, while the minimum noise is directed from the 270° emission angle. This asymetrical pattern may be associated with forward/aft rotor vortex interaction. The maximum difference in noise levels due to surface characteristics is observed at the 270° emission angle to be 6 dB.A final point of interest in the HIGE plot is the generally small difference observed between the hard and soft propagation paths.

HOGE - Figure 9.6 shows the noise emission pattern for the BV 234/CH-47D in the hover-out-of-ground effect (HOGE) configuration (approximately feet off the ground). As seen from the figure, the BV 234/CH-47D displays a noise emission pattern which appears to be dominant in the right fore-quadrant corresponding to an acoustic emission angle of 45°. The discontinuity in the top curve at the 270° emission angle is associated with an instrumentation problem. The maximum difference in noise levels between the hard and soft paths is seen to occur at the 180° emission angle, and is about 4 dB, clearly demonstrating the potential reduction in noise levels associated with soft surface characteristics.

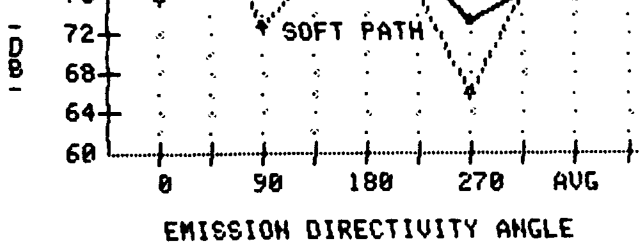


FIGURE 9.5

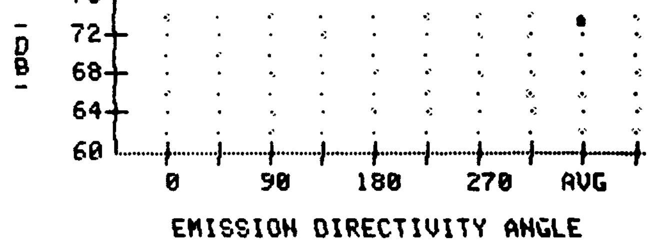


FIGURE 9.6

Ground Idle - Figure 9.7 shows the acoustic emission pattern for the BV 234/CH-47D in the ground idle (GI) configuration. In this figure, the left side of the helicopter is seen to be noisier than the right. This result is most likely associated with changes in the acoustical spectrum which occur with the lower rotor RPM utilized in this configuration. The maximum noise level is seen to occur at the 225° emission angle. The maximum difference noise levels due to surface characteristics is about 8 dB occurring to either side of the tail, at the 135° and 225° emission angles.

Flight Idle - Figure 9.8 shows the acoustic emission pattern for the BV 234/CH-47D in the flight idle (FI) configuration. This figure shows a nearly omni-directional radiation pattern as observed for the soft site. In the hard path scenario, one observes a maximum occurring on either side of the tail in an almost symmetrical manner. The maximum difference in noise levels between hard and soft paths is 6 to 8 dB, occurring at the 135° emission angle.

FIGURE 9.7

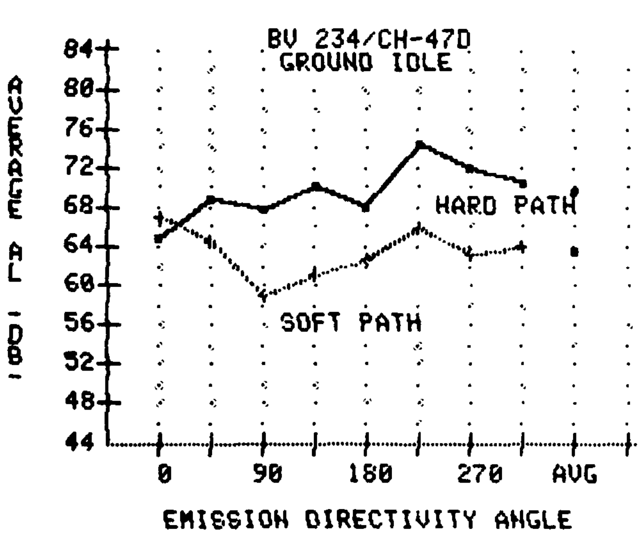
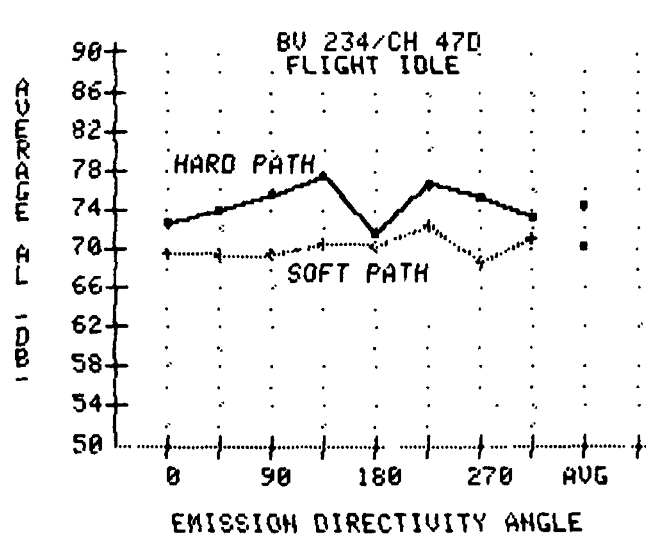


FIGURE 9.8



Environmental Impact - Table 9.3, shown below, presents observations concerning noise impact and acceptability and are based on consideration of typical urban/community ambient noise levels and the levels of urban transportation noise sources. Interpretations assume that event durations reflect static operational scenarios (usually 1 minute to 15 minutes). In general, the interpretation of environmental impact requires careful consideration of the ambient sound levels in the vicinity of the specific heliport under consideration. A useful document for further interpretation is Reference 9.

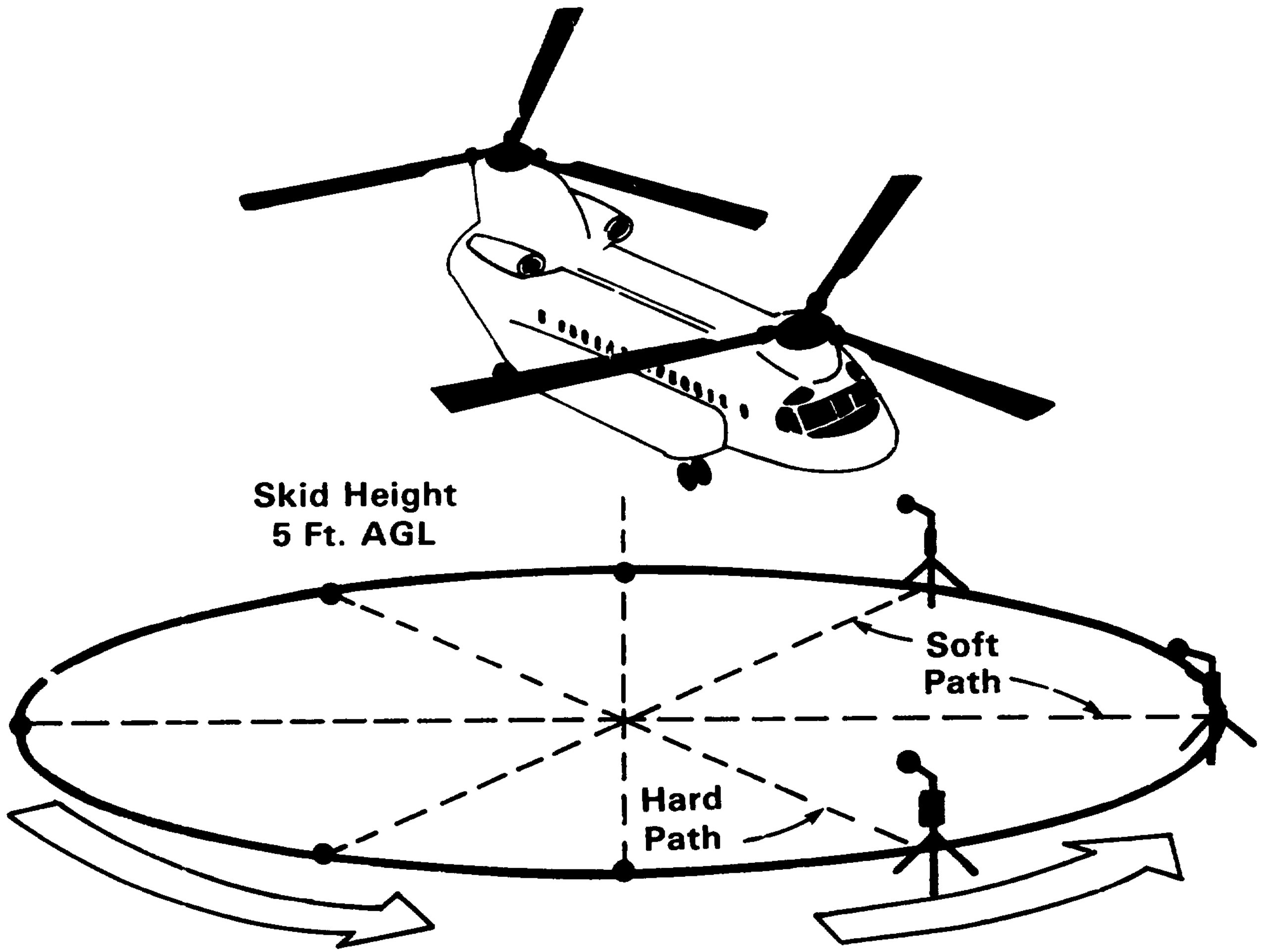
Table 9.3

A-Weighted Noise Level Ranges

60 dB	-	Urban ambient noise level
Mid 60's	-	Urban ambient noise level
70 dB	-	Noise level of minor concern
Mid 70's	-	Moderately intrusive noise level
80 dB	-	Clearly intrusive noise level
Mid 80's	-	Potential Problems due to noise
90 dB	-	Noise level to be avoided for any length of time.

FIGURE 9.9

Helicopter Hover Noise Test



Helicopter Rotates in 45° Steps
8 Microphone Positions

9.3 Comparison of Measured Sound Levels: 4 Foot vs. Ground Microphones - This analysis addresses the comparability of noise levels measured at ground level and at 4 feet above the ground. The topic is discussed in the context of noise certification testing requirements. The analysis involves examination of differences between noise levels acquired for ground mounted and 4-ft mounted microphone systems. The objectives of this analysis are: 1) observe the value and variability of ground/4-ft microphone differences and identify the degree of phase coherence and 2) examine the variation with operational configuration.

The data employed in this analysis are from the microphone site #1 magnetic recording system (Appendix A). The mean differences between the ground and four foot microphones are shown in Table 9.4 for twelve different test series.

In conducting this analysis, our initial assumption was that the ground-mounted microphone experiences phase coherent pressure doubling (a reasonable assumption at the frequencies of interest). At the 4-foot microphone one would expect to see a lower value, somewhere within the range of 0 to 3 dB, depending on the degree of random verses coherent phase between incident and reflected sound waves. It is also possible to experience phase cancellation between the two sound paths. If cancellation occurs at dominant frequencies, then one is likely to observe noise levels at the 4-foot microphone more than 3 dB below the ground microphone values. In fact, significant cancellation is observed with instances of 5.2 dB (weighted metric) lower levels at the 4-foot microphone. Figure 9.10 provides a schematic of the various "difference regions" associated with different relationships between incident and reflected sound waves.

Discussion - It is argued that acquisition of data from ground-mounted microphones provides a cleaner spectrum, closer to the spectrum actually emitted by the helicopter--that is, not influened by a mixture of constructive and destructive ground reflections. Theoretically, one would be interested in correcting ground-based data to levels expected at 4 feet or vice versa in order to maintain equally stringent regulato policy. In other words, to change a certification limit at a 4-ft microphone to fit a ground-based microphone test, one theoretically would have to increase the limit by an amount necessary to maintain equal stringency. Examination of the results in Table 9.4 show that most differences do fall between 3 and 5 dB. These results are consistent with theory and suggest that a degree of cancellation typiclly accompanies the 3 dB difference one would expect for random versus coherent phase relationships.

The variability in test results between operations modes displays no clear pattern. The variation in difference in values can be considered to reflect differences in the "acoustical angle" or the angle of incidence at the time of the maximum noise. These geometrical factors are also joined by differences in spectral content in influencing resulting sound level values.

FIGURE 9.10

RELATIONSHIP BETWEEN INCIDENT AND REFLECTED SOUND WAVES

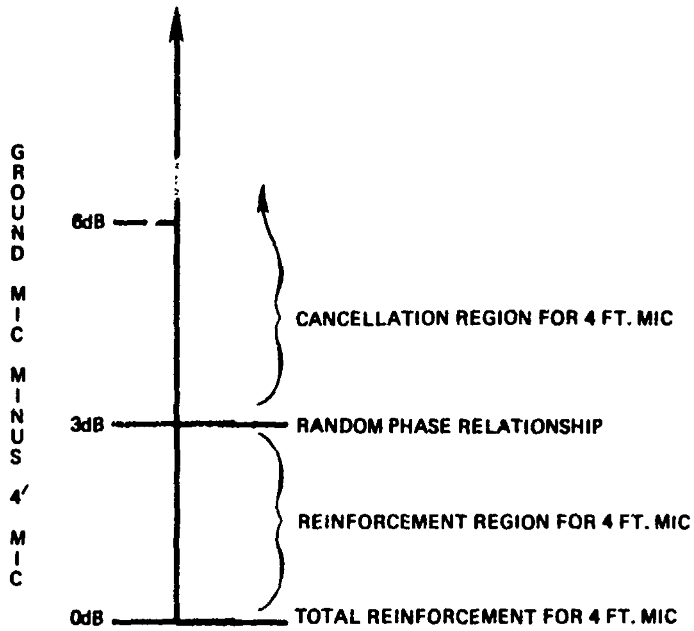


TABLE 9.4

COMPARISON OF

GROUND AND 4 FT. (1.2 M) MICROPHONE DATA

TEST SERIES	OPERATION	SAMPLE SIZE	TARGET IAS (KTS)	DELTA dB = (GND MIC.) minus (4 FT. MIC.) SEL	AL	EPNL	PNLTM
A	500'LFO	6	135	4.4	4.1	5	5.1
B	500'LFO	4	135	4.2	4	4.8	4.7
C	500'LFO	4	135	4.1	3.9	4.5	4.7
D	500'LFO	5	120	4.3	4.2	4.9	4.6
E	500'LFO	6	105	4.2	4	4.4	4.3
F	1000'LFO	4	135	3.9	3.5	4.9	4.4
G	ICAO T/O	6	85	3.8	3.5	3.7	3.6
H	ICAO APP	6	85	3.8	4.1	3.7	3.8
I	MIL.APP	4	70	3.8	4.5	3.7	4.4
J	TAKEOFF	3	85	4.4	4.5	4.9	4.7
K	APP	4	100	3.8	4	3.7	3.9
L	MIL. T/O	3	70	4.8	4.9	5.2	4.8
		WEIGHTED AVERAGE		4.1	4.05	4.4	4.38

9.4 Analysis of Duration Effects - This section consists of three parts, each developing relationships and insights useful in adjusting from one acoustical metric to another (typically from a maximum level to an energy dose). Each section quantitatively addresses the influence of the event duration.

9.4.1 Relationships Between SEL, AL and T-10 - This analysis explores the relationship between the helicopter noise event (intensity) time-history, the maximum intensity, and the total acoustical energy of the event. Our interests in this endeavor include the following:

1) It is often necessary to estimate an acoustical metric given only part of the information required.

2) The time history duration is related to the ground speed and altitude of a helicopter. Thus any data adjustments for different altitudes and speeds will affect duration time and consequently the SEL (energy metric). The requirement to adjust data for these effects often arises in environmental impact analyses around heliports. In addition, the need to implement data corrections in helicopter noise certification tests further warrants the study of duration effects.

Two different approaches have been utilized in analyzing the effect of event 10-dB-down duration (DURATION or T_{10}) on the accumulated energy dose (Sound Exposure Level).

Both techniques are empirical, each employing the same input data but using a different theoretical approach to describe duration influences.

The fundamental question one may ask is "If we know the maximum A-weighted sound level and we know the 10-dB-down duration time, can we with confidence estimate the acoustical energy dose, the Sound Exposure Level?" A rephrasing of this question might be: If we know the SEL, the AL, and the 10-dB-down duration time (DURATION), can we construct a universal relationship linking all three?

Both attempts to establish relationships involve taking the difference between the SEL and AL (delta), placing the delta on the left side of the equation and solving as a function of duration. The form which this function takes represents the differences in approach.

In the first case, one assumes that delta equals some constant K(DUR) multiplied by the base 10 logarithm of DURATION, i.e.,

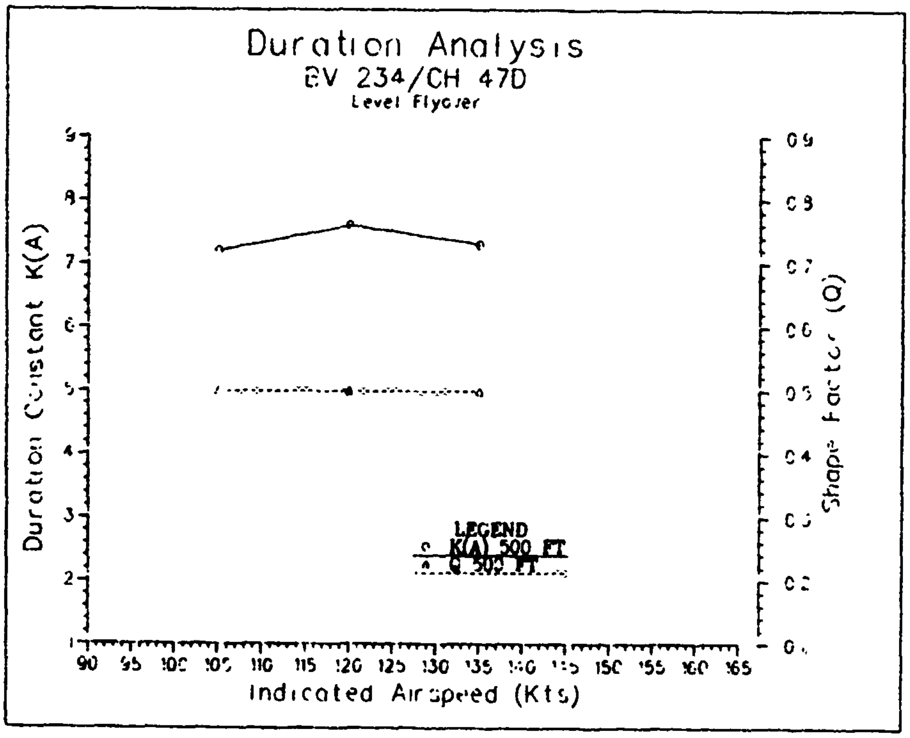
$$SEL - AL = K(DUR) \times LOG(DURATION)$$

In the second case, we retain the 10 x LOG dependency, consistent with theory, while achieving the equality through the shape factor, Q, which is some value less than unity i.e., $SEL-AL = 10 \times LOG(Q \times DURATION)$. In a situation where the flyover noise event time history was represented by a step function or square wave shape, we would expect to see a value of Q equaling precisely one. However, we know that the time history for typical non-impulsive events is much closer in shape to an isosceles triangle and consequently likely to have a Q much closer to 0.5.

Another possible use of this analytical approach for the assessment of duration effects is in correcting noise certification test data which were acquired under conditions of nonstandard ground speed and/or distance.

Discussion - Each of the noise template data tables lists both of the duration related figures of merit for each individual event (see Appendix B). One immediate observation is the apparent insensitivity of the metrics to changes in operation, and the extremely small variation in the range of metric values, nearly a constant Q = 0.5 and a stable K(A) value of approximately 7.0. Data have been plotted in Figure 9.11 which show the minor variation of both metrics with airspeed for level flyover operations recorded at microphone site 1 direct read system. The lack of variation in the parameters, suggests that a simple and nearly constant dependency exists between SEL, AL, and log DURATION, relatively unaffected by changes in airspeed, in turn suggesting a consistent time history shape for the range of airspeeds evaluated in this test. As SEL increases with airspeed, the increase appears to be related to increase in AL_M but mitigated in part by reduced duration time (and a nearly constant K(A)=7).

FIGURE 9.11



It is interesting to note that similar results were found for other helicopters (Ref. 10, 11, 12, 13, 14, 15), suggesting that different helicopter models will have similar values for K and Q. This implies that it would not be necessary to develop unique constants for different helicopter models for use in implementing duration corrections. Notwithstanding, caution is raised to avoid drawing any firm conclusions. The possibility exists that this particular analytical technique lacks the sensitivity necessary to detect distance and speed functionality.

9.4.2 <u>Estimation of 10 dB Down Duration Time</u> - In some cases, one does not have access to 10 dB down duration time (DURATION) information. A moderate to highly reliable technique for estimating DURATION for the BV 234/CH-47D is developed empirically in this section.

The distance from the helicopter to the observer at the closest point of approach (expressed in feet) divided by the airspeed (expressed in knots) yields a ratio, hereafter referred to as (D/V). This ratio has been compiled for various test series for microphone sites 1, 2 and 3 and has been presented in Table 9.5 along with the average DURATION expressed in seconds. A linear regression was performed on each data set in Table 9.5 and those results are also displayed in Table 9.5. Here one observes generally high correlation coefficients, in the range of 0.67 to 0.94. The regression equations relating DURATION with D/V are given as

Centerline center, Microphone Site 1:

$$T_{10} = [1.75 \times (D/V)] + 4.0$$

Sideline South, Microphone Site 2:

$$T_{10} = [1.84 \times (D/V)] + 4.0$$

Sideline North, Microphone Site 3:

$$T_{10} = [0.95 \times (D/V)] + 7.7$$

Because the regression analyses were conducted for a population consisting of all test series using trim and 220 RPM (which involved the operations

TABLE 9.5

HELICOPTER: BOEING-VERTOL CH-47D

DURATION (T-10) REGRESSION ON D/V

SITE 1

TEST SERIES	COCKPIT PHOTO DATA V AVG	AVG DUR(A)	AVG EST ALT	D/V	LINEAR REGRESSION	
C	135	10.1	509.7	3.8	SLOPE	1.75
D	121.25	11.5	487.2	4	INTERCEPT	4.01
E	103.6	14.7	507.3	4.9	R SQ.	.67
F	134.25	16.1	930.6	6.9	R	.82
K	90.5	10.7	456.7	5	SAMPLE	5

SITE 2

C	135	12.7	708.5	5.2	SLOPE	1.84
D	121.25	15.2	692.5	5.7	INTERCEPT	4
E	103.6	17.4	707.3	6.8	R SQ.	.88
F	134.25	18	1052.7	7.8	R	.94
K	90.5	17.2	671.3	7.4	SAMPLE	5

SITE 3

C	135	12	710.5	5.3	SLOPE	.96
D	121.25	13.4	692.5	5.7	INTERCEPT	7.69
E	103.6	16	707	6.8	R SQ.	.44
F	134.25	15	1052.3	7.8	R	.67
K	90.5	13.6	667.7	7.4	SAMPLE	5

in both directions--test series C, D, E, F and K), it is not possible to comment on left-right side acoustical directivity of the helicopter.

Synthesis of Results - It is now possible to merge the results of Section 9.4.1 with the finding above in establishing a relationship between (D/V) and SEL and AL. Given the approximation

$$SEL = AL + (10 \times LOG(0.50 \times DURATION))$$

It is possible to insert the computer value for $^{T}10$ (DURATION) into the equation and arrive at the desired relationship.

9.4.3 Relationship Between SEL Minus AL and the Ratio D/V - The difference between SEL and AL_M or conversely, EPNL and $PNLT_M$ (in a certification context) is referred to as the DURATION CORRECTION. This difference is clearly controlled by the event $^{T}10$ (10 dB down duration time) and the acoustical energy contained within those bounds. As discussed in previous sections, the $^{T}10$ is highly correlated with the ratio D/V. This analysis establishes a direct link between D/V and the DURATION CORRECTION in a manner similar to that employed in Section 9.4.2. Table 9.6 provides a summary of data used in regression analyses for microphones 1, 2 and 3 along with the slope, intercept, correlation coefficient and other statistical information.

One observes a very strong correlation at one sideline site (R=0.89) and a virtually nonexistent value (R=0.18) at the other site. Meanwhile the centerline site also displays a low correlation coefficient, R-0.56. As mentioned in Section 9.4.2, it is difficult to comment explicitly on source directivity because operations were conducted in both directions. Regardless, one can see that centerline/sideline differences do exist.

The reader is cautioned not to expect these relatinships to necessarily hold for D/V ratios beyond the range explored in these analyses.

TABLE 9.6

HELICOPTER: BOEING-VERTOL CH-47D

SEL-ALm REGRESSION ON D/V

SITE 1

TEST SERIES	COCKPIT PHOTO DATA V AVG	AVG SEL-ALm	AVG EST ALT	D/V
C	135	7.3	509.7	3.8
D	121.25	7.6	487.2	4
E	103.6	8.4	507.3	4.9
F	134.25	8.8	930.6	6.9
K	90.5	6.4	456.7	5

LINEAR REGRESSION	
SLOPE	.43
INTERCEPT	5.58
R SQ.	.32
R	.56
SAMPLE	5

SITE 2

TEST SERIES	COCKPIT PHOTO DATA V AVG	AVG SEL-ALm	AVG EST ALT	D/V
C	135	7.9	/08.5	5.2
D	121.25	8.7	692.5	5.7
E	103.6	9.3	707.3	6.8
F	134.25	9.3	1052.7	7.8
K	90.5	9.2	671.3	7.4

LINEAR REGRESSION	
SLOPE	.49
INTERCEPT	5.68
R SQ.	.8
R	.89
SAMPLE	5

SITE 3

TEST SERIES	COCKPIT PHOTO DATA V AVG	AVG SEL-ALm	AVG EST ALT	D/V
C	135	7.7	710.5	5.2
D	121.25	8.2	692.5	5.7
E	103.6	8.7	707	6.8
F	134.25	8.1	1052.3	7.8
K	90.5	7.8	667.7	7.4

LINEAR REGRESSION	
SLOPE	.07
INTERCEPT	7.66
R SQ.	.03
R	.18
SAMPLE	5

9.5 Analysis of Variability in Noise Levels for Two Sites Over Similiar Propagation Paths - This analysis examines the differences in noise levels observed for two sites each located 500 feet away from the hover point over similar terrain. The objective of the analysis was to examine variability in noise levels associated with ground-to-ground propagation over nominally similar propagation paths. The key word in the last sentence was nominally,...in fact the only difference in the propagation paths is that microphone 1H was located in a slight depression, (elevation is minus 2.5 feet relative to the hover point), while site 2 has an elevation of plus 0.2 feet relative to the hover point. This is a net difference of 2.7 feet over a distance of 500 feet. This configuration serves to demonstrate the sensitivity of ground-to-ground sound propagation over minor terrain variations.

Discussion - The results presented in Tables 9.7, 9.8, 9.9 and 9.10 show the observed differences in time averaged noise levels for each of four static operations. In each table, data are shown for eight directivity angles and the spacial average. In each case, magnetic recording data (Appendix C) have been used in the analyses. It is observed that only minor differences in noise level occur during all operational scenarios (1 to 1.5 dB) with the exception of ground idle, where differences of 2 to 4 dB are observed.

The most remarkable aspect of these results is the small difference in noise levels for 3 out of 4 static operations. In every other report in this series (six other helicopters), very large differences have been observed (4 to 10 dB). The results for ground idle for the BV 234/CH-47D actually reflect the type of differences previously seen. It is worth noting here that the reduced rotor RPM associated with ground idle operations allows more engine noise (higher frequency sound) to dominate resulting A-weighted spectra.

First, let us consider why such relatively small differences are observed here. The BV 234/CH-47D rear tandem rotor lies in a plane approximately 18 feet off the ground, thus establishing a higher angle of incidence for projected acoustical energy. Other helicopters in this test program have rotors 7 to 9 feet off the ground. Additional reasons for the good agreement could include the dominant influence of low frequency energy and the lesser sensitivity to meteorological effects.

Reasons for differences in sound levels are somewhat easier to propose. It is speculated that very minor variations in site elevation (and resulting microphone placement) lead to site-to-site differences in the measured noise levels for static operations. Differences in microphone height result in different positions within the interference pattern of incident and reflected sound waves. It is also appropriate to consider whether variation in the acoustical source characteristics with time may contribute to noise level differences. In this analysis, magnetic recording data from microphone site 2 are compared with data recorded at site 1H approximately one minute later. That is, the helicopter rotated 45 degrees every sixty seconds, in order to project each directivity angle (there is a 45 degree separation between the two sites). In addition to source variation, it is also possible that the helicopter heading, based on magnetic compass readings may have been slightly different in each case, resulting in the projection of different intensities and accounting for the observed differences. A final item of consideration is the possibility of refraction of sound waves (due to thermal or wind gradients) resulting in shadow regions.

TABLE 9.7

COMPARISON OF
NOISE VERSUS DIRECTIVITY ANGLES
FOR
TWO SOFT SURFACES

HELICOPTER: BOEING-VERTOL CH-47D

OPERATION: HOVER-IN-GROUND-EFFECT

	DIRECTIVITY ANGLES (DEGREES)								Lav(360 DEGREE)	
SITE	0	45	90	135	180	225	270	315	ENERGY	ARITH.
	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ
SOFT 1H	75.2	81.4	74.2	77.8	75.7	76	68.7	74.4	76.6	75.4
SOFT 2	75.6	83.5	72.8	79	76 5	76.3	66	75.9	77.8	75.7
DELTA dB	.4	2.1	1.4	1.2	.8	.3	2.7	1.5	1.2	.3

TABLE 9.8

COMPARISON OF
NOISE VERSUS DIRECTIVITY ANGLES
FOR
TWO SOFT SURFACES

HELICOPTER: BOEING-VERTOL CH-47D

OPERATION: HOVER-OUT-OF-GROUND-EFFECT

	DIRECTIVITY ANGLES (DEGREES)								Lav(360 DEGREE)	
SITE	0	45	90	135	180	225	270	315	ENERGY	ARITH.
	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ
SOFT 1H	79.6	84.3	83.8	84.4	NA	81.4	82.7	81.4	82.8	82.5
SOFT 2	79.6	86.2	85.4	85.5	82.2	83.9	82.3	82.4	83.9	83.4
DELTA dB	0	1.9	1.6	1.1	NA	2.5	.4	1	1.1	.9

TABLE 9.9

COMPARISON OF
NOISE VERSUS DIRECTIVITY ANGLES
FOR
TWO SOFT SURFACES

HELICOPTER: BOEING-VERTOL CH-47D

OPERATION: FLIGHT IDLE

	DIRECTIVITY ANGLES (DEGREES)								Lav(360 DEGREE)	
SITE	0	45	90	135	180	225	270	315	ENERGY	ARITH.
	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ
SOFT 1H	68.5	72.3	70.5	69.8	66.7	68.2	66	69.9	69.4	69
SOFT 2	69.4	69.3	69.6	70.6	70.3	72.3	68.8	71.1	70.3	70.2
DELTA dB	.9	3	.9	.8	3.6	4.1	2.8	1.2	.9	1.2

TABLE 9.10

COMPARISON OF
NOISE VERSUS DIRECTIVITY ANGLES
FOR
TWO SOFT SURFACES

HELICOPTER: BOEING-VERTOL CH-47D

OPERATION: GROUND IDLE

	DIRECTIVITY ANGLES (DEGREES)								Lav(360 DEGREE)	
SITE	0	45	90	135	180	225	270	315	ENERGY	ARITH.
	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ	LEQ
SOFT 1H	62.8	63.2	56.3	59	59.1	63.2	61.8	60.2	61.2	60.7
SOFT 2	66.9	64.5	58.9	61	62.8	65.9	63.2	64.1	64	63.4
DELTA dB	4.1	1.3	2.6	2	3.7	2.7	1.4	3.9	2.8	2.7

9.6 Variation in Noise Levels with Airspeed for Approach Operations - This section examines the change in noise levels with variation in appproach angle, RPM, and trim configuration for the BV 234/CH-47D in the approach mode.

Data shown in Table 9.11 have been corrected for altitude deviations from the reference ICAO approach (test series H) for each microphone site. Each of these three test series represents a unique mixture of RPM, airspeed and trim configuration. While this analysis represents only three points within the 5-dimensional space defined by (1) noise level, (2) trim, (3) rotor RPM, (4) rate of descent and (5) airspeed, the results do provide a starting point for mapping generalized relationships.

One of the physical phenomena governing noise levels in the approach operation is the collision of vortices from the forward rotor with the aft rotor blade as shown in Figure 9.12. As one might expect, changing the relative tilt (or trim) of the respective rotors will influence the degree of vortex-blade interaction.

Significant findings include the apparent (relative) lower levels for test series H as opposed to series I and K. The site 1 differential in SEL between series H and I is more than 5 dB. While further work would be required to establish the optimal "Fly Neighborly" approach operational regime, one can clearly identify series H as a relatively less noisy configuration for some on track noise sites. It is interesting to note that noise levels observed at other centerline sites did not display the sensitivity to operational modes as did the levels observed at site 1.

TABLE 9.11

BV 234/CH-47D APPROACH DATA

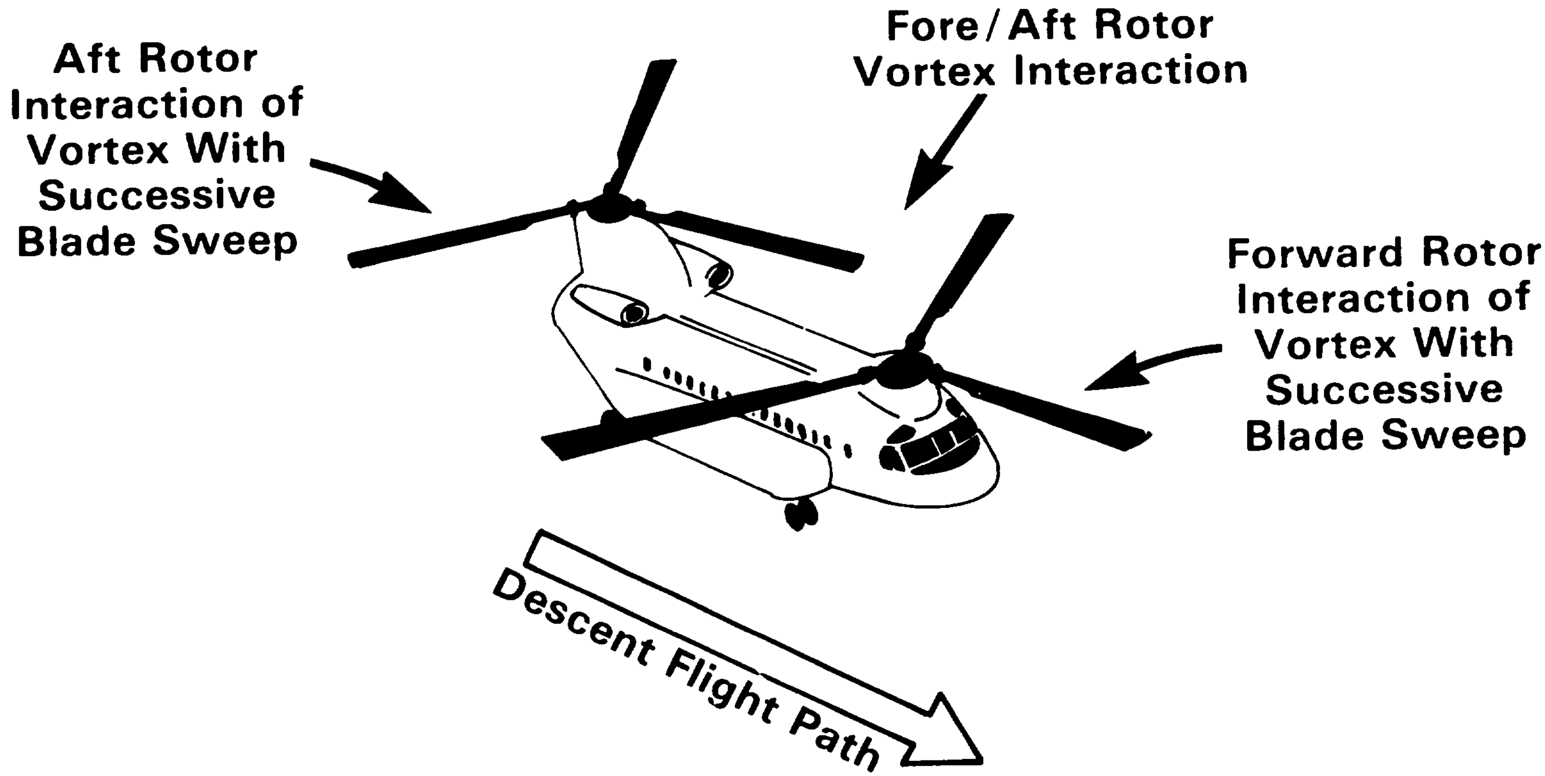
TEST	DESCRIPTION				SITE 5		SITE 1		SITE 4	
SERIES	RPM	IAS	TRIM	APP ANG	SEL	DBA	SEL	DBA	SEL	DBA
H	225	85	234	6°	98.6	91.9	97.9	90.9	96.8	89.0
I	225	70	CH-47D	6°	99.8	93.1	103	96.2	97.7	89.8
K	220	100	234	3°	98.3	92.4	101.5	95.3	95.9	89.2

In the context of the "Fly Neighborly" program, it is worth acknowledging the potential tradeoff (and classic problem) of diminishing noise levels at one location while increasing or not affecting noise levels at another. A recent study conducted in France (ref. 16) included a matrix of 24 microphones. While cost and logistical constraints make this unrealistic for evaluation of each civil transport helicopter, one would be prudent to evaluate several centerline and sideline microphone locations in any in-depth "Fly Neighborly" flight test.

Two final points of concern in developing "Fly Neighborly" procedures are safety and passenger comfort. Rates of descent, airspeed, initial apprach altitude and "engine-out" performance are all factors requiring careful consideration in establishing a noise abatement approach. Finally, while certain operational modes may significantly reduce noise levels, there may be an unacceptable acceleration/deceleration or rate of descent imposed on passengers. This matter is clearly an important concern in commercial air shuttle operations.

FIGURE 9.12

Tip Vortex Interaction



9.7 Analysis of Ground-to-Ground Acoustical Propagation

9.7.1 Soft Propagation Path - This analysis involves the empirical derivation of propagation constants for a nominally level, "soft" path, a ground surface composed of mixed grasses. As discussed in previous analyses, there are several physical phenomena that influence the diminution of sound over distance. Among these phenomena, spreading loss, ground-to-ground attenuation and refraction are considered dominant in controlling the observed propagation constants.

A-weighted L_{eq} data for the four static operational modes- HIGE, HOGE, Flight Idle, and Ground Idle- have been analyzed in each case for eight different directivity angles. Direct read acoustical data from sites 2 and 4H have been used to calculate the propagation constants (K) as follows:

$$K = (Leq(site\ 2) - Leq(site\ 4))/Log\ (2/1)$$

where the Log (2/1) factor represents the doubling of distance dependency (Site 2 is 492 feet and site 4H is 984 feet from the hover point).

For each mode of operation, the average (over various directivity angles) propagation constant has also been computed. The data used in this analysis (derived from Appendix C) are displayed in Table 9.12 and the results are summarized in Table 9.13.

Discussion - The results shown in Table 9.13 exhibit extreme variation from one operational mode to the next. The higher angle operations HIGE and HOGE display propagation constants one would expect for a low-frequency-dominated spherical spreading (air to ground propagation) scenario.

For these operational modes, the general relationship ΔdB = 21 log (dl/d2) provides a working approximation for calculating ground-to-ground diminution of A-weighted sound levels over nominally soft paths out to a distance of 1000 feet. In the case of the low angle (wheels on the ground) propagation scenarios where rotor noise is diminished and turbine engine noise is more dominant, one observes very high rates of attenuation undoubtedly associated with absorption of high frequency energy.

9.7.2 Hard Path Propagation - This part of the analyses involves the empirical derivation of constants for sound propagation over a "hard" propagation path, a concrete, composite taxi-way surface. The analytical methods described above (Section 9.7.1) are applicable using data from sites 5H and 7H, respectively 492 and 717 feet from the hover site. The data used in this analyses (derived from Appendix D) are shown in Table 9.14 and the results are summarized in Table 9.15. The salient feature of this scenario is the presence of a ground surface which is highly reflective and uniform in composition.

TABLE 9.12

DATA UTILIZED IN COMPUTING EMPIRICAL
PROPAGATION CONSTANTS (K)
FOR SOFT SITES
4H & 2

BOEING-VERTOL CH-47D

7-12-83

SITE 4H

HIGE		FLT.IDLE		GRN.IDLE		HOGE	
M-90	75.90	N-90A	58.80	N-90B	51.00	0-90	73.20
M-45	76.50	N-45A	53.90	N-45B	47.70	0-45	75.90
M-0	62.00	N-0A	56.00	N-0B	48.10	0-0	76.70
M-315	69.20	N-315A	56.30	N-315B	52.00	0-315	78.00
M-270	74.50	N-270A	56.60	N-270B	49.40	0-270	76.00
M-225	77.30	N-225A	56.80	N-225B	49.30	0-225	79.00
M-180	68.50	N-180A	57.20	N-180B	49.40	0-180	79.00
M-135	75.30	N-135A	55.50	N-135B	48.50	0-135	78.70

SITE 2

HIGE		FLT.IDLE		GND.IDLE		HOGE	
M-90	76.60	N-90A	70.80	N-90B	64.60	0-90	80.20
M-45	77.50	N-45A	72.80	N-45B	65.60	0-45	82.50
M-0	67.20	N-0A	69.90	N-0B	64.60	0-0	82.80
M-315	77.60	N-315A	73.40	N-315B	66.60	0-315	84.20
M-270	77.70	N-270A	71.10	N-270B	64.10	0-270	82.70
M-225	80.80	N-225A	70.80	N-225B	61.20	0-225	86.20
M-180	73.90	N-180A	70.50	N-180B	58.70	0-180	86.10
M-135	84.80	N-135A	70.20	N-135B	66.20	0-135	86.40

TABLE 9.13

BOEING-VERTOL

EMPIRICAL PROPOGATION CONSTANTS (K)
FOR SOFT SITES (4M+2)

EMISSION ANGLE	HIGE K	FLT.IDLE K	GND.IDLE K	HOGE K
90	2.33	40.00	45.33	23.33
45	3.33	63.00	59.67	22.00
0	17.33	46.33	55.00	20.33
315	28.00	57.00	48.67	20.67
270	10.67	48.33	49.00	22.33
225	11.67	46.67	39.67	24.00
180	18.00	44.33	31.00	23.67
135	31.67	49.00	59.00	25.67
AVERAGE	15.37	49.33	48.42	22.75

TABLE 9.14

DATA UTILIZED IN COMPUTING EMPIRICAL
PROPAGATION CONSTANTS (K)
FOR HARD SITES
7H & 5H

BOEING-VERTOL CH-47D

7-12-83

SITE 7H

HIGE		FLT.IDLE		GND.IDLE		HOGE	
M-90	72.49	N-90A	72.85	N-90B	62.38	0-90	86.82
M-45	83.64	N-45A	71.07	N-45B	64.18	0-45	88.43
M-0	75.52	N-0A	69.28	N-0B	59.11	0-0	82.76
M-315	72.17	N-315A	69.00	N-315B	65.93	0-315	83.86
M-270	71.48	N-270A	70.72	N-270B	66.02	0-270	82.25
M-225	75.76	N-225A	72.02	N-225B	65.87	0-225	80.92
M-180	72.68	N-180A	66.68	N-180B	61.21	0-180	83.95
M-135	75.69	N-135A	74.60	N-135B	62.27	0-135	85.80

SITE 5H

HIGE		FLT.IDLE		GND.IDLE		HOGE	
M-90	NA	N-90A	76.30	N-90B	68.10	0-90	89.10
M-45	85.10	N-45A	75.50	N-45B	69.60	0-45	91.00
M-0	78.00	N-0A	78.60	N-0B	65.60	0-0	84.80
M-315	77.70	N-315A	74.30	N-315B	69.70	0-315	87.40
M-270	75.10	N-270A	75.00	N-270B	70.90	0-270	86.30
M-225	79.80	N-225A	77.10	N-225B	74.10	0-225	85.90
M-180	76.40	N-180A	72.00	N-180B	67.20	0-180	88.80
M-135	80.20	N-135A	78.30	N-135B	69.90	0-135	90.60

TABLE 9.15

BOEING-VERTOL

EMPIRICAL PROPOGATION CONSTANTS (K)
FOR HARD SITES (7H & 5H)

EMISSION ANGLE	HIGE K	FLT.IDLE K	GND.IDLE K	HOGE K
90		21.56	35.75	14.25
45	9.13	27.69	33.88	16.06
0	15.50	58.25	40.56	12.75
315	34.56	33.13	23.56	22.13
270	22.63	26.75	30.50	25.31
225	25.25	31.75	51.44	31.13
180	23.25	33.25	37.44	30.31
135	28.19	23.13	47.69	30.00
AVERAGE	22.64	31.94	37.60	22.74

9.8 <u>Air-to-Ground Acoustical Propagation Analysis</u> - The approach and takeoff operations provided the opportunity to assess empirically the influences of spherical spreading and atmospheric absorption. Through utilization of both noise and position data at each of the three flight track centerline locations (microphones 5, 1, and 4), it was possible to determine air-to-ground propagation constants.

One would expect the propagation constants to reflect the aggregate influences of spherical spreading and atmospheric absorption. It is assumed that the acoustical source characteristics remain constant as the helicopter passes over the measurement array. In past studies (Ref. 10 - 15), it has been observed that this assumption is reasonably valid for takeoff and level flyover operations. In the case of approach, however, significant variation has been evident. Because of the spacial/temporal variability in approach sound radiation along the (1000 feet) segment of interest, approach data have not been utilized in estimating propagation constants. As a final background note relating to the assumption of source stability, a helicopter would require approximately 10 seconds, travelling at 60 knots, to travel the distance between measurement sites 4 and 5.

In both the case of the single event intensity metric, AL, and the single event energy metric, SEL, the difference between SEL and AL is determined for each pair of centerline sites. The delta in each case is then equated with the base ten logarithm of the respective altitude ratio multiplied by the propagation constant (either KA(AL) or KA(SEL)), the values to be determined.

Data have also been analyzed from the 500 and 1000 foot level flyover operations and the KP(AL) has been computed. In this case, data were pooled for all centerline sites (5, 1, and 4) in the process of arriving at the propagation constant.

The takeoff analyses are shown in Table 9.16, 9.17 and 9.18 and are summarized in Table 9.19. Results of the level flyover calculations are presented in Table 9.21. The level flyover and takeoff analyses are also accompanied by a tabulation of results from five previous reports (Tables 9.20 and 9.22).

Discussion - In the case of takeoff data (Table 9.19) one observes a propagation constant of about 22.3, a value in good agreement with previous results shown in Table 9.20. This value suggests that either little absorption takes place over the propagation path or that the source frequency content is dominated by low frequency components, (relatively unaffected by absorption).

In the case of level flyover data (Table 9.21), one observes a value of less than 20. This propagation constant is similar to values observed for the Aerospatiale TwinStar and AStar, but significantly less than values seen for the Bell 222 and the Sikorsky S-76A.

Table 9.23 provides a brief examination of propagation constants for the EPNL acoustical metric, used in noise certification. Calculations show a constant of approximately 19. This propagation constant is very close to the mean value observed for helicopters analyzed in other reports (refs. 10 - 15) and summarized in Table 9.24. It is interesting to note that the theoretical value for the EPNL propagation constant is 10. The reader may consider computing propagation constants for other acoustical metrics as the need arises.

TABLE 9.16

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-13-83

OPERATION: ICAO TAKEOFF
TARGET IAS=85 KTS

MIC. 5-4

EVENT NO.	KP(AL)	KP(SEL)
630	17.5	15.3
631	20.6	15.7
632	19.9	14
633	20.6	13.5
634	22.4	16.9
63	19.9	16.1
AVERAGE	20.2	15.3
STD. DEV	1.59	1.29
90% C.I.	1.31	1.06

TABLE 9.17

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-13-83

OPERATION: TAKEOFF
TARGET IAS=85 KTS

MIC. 5-4

EVENT NO.	KP(AL)	KP(SEL)
J47	22	-5.8
J49	17.3	10.6
J51	20.6	10.3
AVERAGE	20	5
STD. DEV	2.43	9.44
90% C.I.	4.09	15.91

TABLE 9.18

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-13-83

OPERATION: MILITARY TAKEOFF
TARGET IAS=70 KTS

MIC. 5-4

EVENT NO.	KP(AL)	KP(SEL)
L53	29	15.8
L54	23.1	13.4
L55	27.6	15.6
AVERAGE	26.6	14.9
STD. DEV	3.10	1.35
90% C.I.	5.23	2.28

TABLE 9.19

Summary of Propagation Constants for Three Takeoff Operations

Operation	Propagation Constant (K)
ICAO Takeoff	20.2
Takeoff	20
Military Takeoff	26.6
Average	22.27

TABLE 9.20

Summary for Takeoff Operation--AL Metric

Helicopter	Propagation Constant (K)
Bell 222	NA
Dauphin	20.67
Hughes	21.15
TwinStar	24.4
AStar	21.9
S-76	15.5
CH-47D	22.27
Average	20.98

TABLE 9.21

BOEING-VERTOL CH-47D

LEVEL FLYOVER PROPAGATION--AL

OPERATION		MIC 5	MIC 1	MIC 4	AL WEIGHTED AVERAGE
	N=	4	4	4	
500' (0.9Vh)	AVG AL=	79.7	80.8	80	80.17
	STD DEV=	1	.8	.6	
	N=	4	4	4	
1000' (0.9Vh)	AVG AL=	74.6	74.4	73.8	74.27
	STD DEV=	1.1	.7	.6	

K= ΔdB / LOG(934.37 / 531.63) ΔdB= 5.90

K= 5.90 /.2449094

K= 24.09

TABLE 9.22

SUMMARY FOR LEVEL FLYOVER OPERATION

AL METRIC

HELICOPTER	PROPAGATION CONSTANT (K)
BELL 222	21.08
AEROSPATIALE DAUPHIN 2	21.40
HUGHES 500D	20.81
AEROSPATIALE TWINSTAR	20.19
AEROSPATIALE ASTAR	19.77
SIKORSKY S-76A	25.36
BOEING-VERTOL CH-47D	24.09

AVERAGE = 21.67

TABLE 9.23

BOEING-VERTOL CH-47D

LEVEL FLYOVER PROPAGATION--EPNL

OPERATION		MIC 5	MIC 1	MIC 4	EPNL WEIGHTED AVERAGE
	N=	4	4	4	
500' (0.9Vh)	AVG EPNL=	92.1	92.8	91.9	92.27
	STD DEV=	.5	.7	1	
	N=	4	4	4	
1000' (0.9Vh)	AVG EPNL=	86.9	87.1	86.7	86.90
	STD DEV=	.7	.6	.6	

K= ΔdB / LOG(934.37 / 531.63) ΔdB= 5.37

K= 5.37 / .2449094

k= 21.91

TABLE 9.24

SUMMARY TABLE FOR EPNL

HELICOPTER	PROPAGATION CONSTANT (K)
BELL 222	14.33
AEROSPATIALE DAUPHIN 2	18.67
HUGHES 500D	14.80
AEROSPATIALE TWINSTAR	13.84
AEROSPATIALE ASTAR	13.14
SIKORSKY S-76A	17.91
BOEING-VERTOL CH-47D	21.91

AVERAGE = 16.37

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APPENDIX A

Magnetic Recording Acoustical Data and Duration Factors for Flight Operations

This appendix contains magnetic recording acoustical data acquired during flight operations. A detailed discussion is provided in Section 6.1 which describes the data reduction and processing procedures. Helpful cross references include measurement location layout, Figure 3.3; measurement equipment schematic, Figure 5.4; and measurement deployment plan, Figure 5.7. Tables A.a and A.b which follow below provide the reader with a guide to the structure of the appendix and the definition of terms used herein.

TABLE A.a

The key to the table numbering system is as follows:

Table No. A. 1-1. 1

Appendix No. — A.

Helicopter No. & Microphone Location — 1-1.

Page No. of Group — 1

Microphone No.	1	centerline-center
	1G	centerline-center(flush)
	2	sideline 492 feet (150m) south
	3	sideline 492 feet (150m) north
	4	centerline 492 feet (150m) west
	5	centerline 617 feet (188m) east

TABLE A.b

Definitions

A brief synopsis of Appendix A data column headings is presented.

EV	Event Number
SEL	Sound Exposure Level, the total sound energy measured within the period determined by the 10 dB down duration of the A-weighted time history. Reference duration, 1-second.
ALm	A-weighted Sound Level(maximum)
SEL-ALm	Duration Correction Factor
K(A)	A-weighted duration constant where:
	K(A) = (SEL-ALm) / (Log DUR(A))
Q	Time History Shape Factor, where:
	$Q = (10^{0.1(SEL-ALm)} / (DUR(A))$
EPNL	Effective Perceived Noise Level
PNLm	Perceived Noise Level(maximum)
PNLTm	Tone Corrected Perceived Noise Level(maximum)
K(P)	Constant used to obtain the Duration Correction for EPNL, where:
	K(P) = (EPNL-PNLTm + 10) / (Log DUR(P))
OASPLm	Overall Sound Pressure Level(maximum)
DUR(A)	The 10 dB down Duration Time for the A-weighted time history
DUR(P)	The 10 dB down Duration Time for the PNLT time history
TC	Tone Correction calculated at PNLTm

Each set of data is headed by the site number, microphone location and test date. The target reference condtions are specified above each data subset.

TABLE NO. A.7-1.1

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/13/84

SUMMARY NOISE LEVEL DATA

AS MEASURED *

SITE: 1 CENTERLINE - CENTER JULY 12,1983

EV	SEL	AL*	SEL-AL*	K(A)	Q	EPNL	PNL*	PNLT*	K(P)	OASPL*	DUR(A)	DUR(P)	TC
TAKEOFF -- TARGET IAS 85 KTS													
J47	85.8	77.2	8.6	7.1	0.4	90.0	89.6	90.5	7.4	92.8	16.5	19.5	0.9
J49	86.2	78.5	7.8	6.7	0.4	90.3	90.9	91.9	7.1	92.2	14.5	15.5	0.9
J51	87.3	79.0	8.3	7.1	0.5	91.5	92.2	92.7	7.4	95.7	14.5	15.5	1.0
Avg.	86.5	78.2	8.2	7.0	0.4	90.6	90.9	91.7	7.3	93.6	15.2	16.8	0.9
Std Dv	0.7	0.9	0.4	0.2	0.0	0.8	1.3	1.1	0.2	1.9	1.2	2.3	0.0
90% CI	1.3	1.6	0.7	0.4	0.0	1.3	2.2	1.8	0.3	3.2	1.9	3.9	0.0
TAKEOFF -- TARGET IAS 70 KTS (MILITARY)													
L53	89.8	83.1	6.7	6.7	0.5	-	96.5	97.4	-	97.9	10.0	-	0.9
L54	90.2	83.0	7.3	7.0	0.5	95.4	96.7	97.7	7.3	99.4	11.0	11.5	1.0
L55	90.2	83.2	7.1	6.7	0.4	95.1	96.3	96.8	7.5	98.3	11.5	13.0	0.4
Avg.	90.1	83.1	7.0	6.8	0.5	95.3	96.5	97.3	7.4	98.6	10.8	12.2	0.8
Std Dv	0.2	0.1	0.3	0.2	0.0	0.2	0.2	0.5	0.2	0.8	0.8	1.1	0.3
90% CI	0.4	0.2	0.5	0.3	0.0	0.8	0.3	0.8	0.7	1.3	1.3	4.7	0.5
APPROACH -- TARGET IAS 100 KTS													
K46	97.8	90.7	7.1	6.6	0.4	102.1	104.4	105.0	6.6	102.4	12.0	12.0	0.7
K48	96.6	89.9	6.6	6.0	0.4	100.6	103.6	104.1	6.9	101.5	13.0	9.0	0.5
K50	96.6	90.5	6.1	6.1	0.4	100.7	103.9	104.8	6.0	100.4	10.0	9.5	0.8
K52	96.9	91.0	5.9	6.5	0.5	100.9	104.7	105.4	6.1	101.8	8.0	8.0	0.7
Avg.	97.0	90.6	6.4	6.3	0.4	101.1	104.1	104.8	6.4	101.5	10.7	9.6	0.7
Std Dv	0.6	0.5	0.5	0.3	0.1	0.7	0.5	0.6	0.4	0.8	2.2	1.7	0.2
90% CI	0.7	0.5	0.6	0.4	0.1	0.8	0.6	0.7	0.5	1.0	2.6	2.0	0.2
APPROACH -- TARGET IAS 70 KTS (MILITARY)													
I36	99.3	92.4	6.9	6.7	0.4	103.2	104.5	105.0	7.3	103.2	11.0	13.0	0.5
I37	97.6	89.6	8.0	7.0	0.5	101.6	102.9	103.7	6.8	101.6	14.0	14.5	0.7
I38	99.4	91.8	7.7	7.1	0.5	103.7	105.3	106.2	7.2	102.9	12.0	11.0	1.0
I39	98.6	90.3	8.3	7.7	0.6	102.6	103.9	104.5	7.4	101.9	12.0	12.5	0.7
Avg.	98.7	91.0	7.7	7.1	0.5	102.8	104.1	104.9	7.2	102.4	12.2	12.7	0.7
Std Dv	0.8	1.3	0.6	0.4	0.1	0.9	1.0	1.1	0.3	0.8	1.3	1.4	0.2
90% CI	1.0	1.5	0.7	0.5	0.1	1.1	1.2	1.3	0.3	0.9	1.5	1.7	0.2

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED
FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-1.2

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/13/84

SUMMARY NOISE LEVEL DATA

AS MEASURED *

SITE: 1 CENTERLINE - CENTER JULY 12,1983

EV	SEL	AL*	SEL-AL*	K(A)	Q	EPNL	PNL*	PNLT*	K(P)	OASPL*	DUR(A)	DUR(P)	TC
500 FT. FLYOVER -- TARGET IAS 135 KTS													
C11	87.3	80.3	7.0	7.4	0.6	91.9	94.8	94.9	7.3	97.6	9.0	9.0	0.3
C12	88.9	82.0	6.9	6.9	0.5	93.5	96.4	97.0	6.6	98.7	10.0	9.5	0.7
C13	88.5	80.3	8.3	8.1	0.6	93.3	94.9	95.1	8.1	97.3	10.5	10.0	0.4
C14	88.0	80.9	7.1	6.9	0.5	92.7	95.2	95.9	6.6	96.7	11.0	11.0	0.6
Avg.	88.2	80.8	7.3	7.3	0.5	92.8	95.3	95.8	7.1	97.6	10.1	9.9	0.5
Std Dv	0.7	0.8	0.6	0.6	0.1	0.7	0.7	0.9	0.7	0.8	0.9	0.9	0.2
90% CI	0.8	0.9	0.7	0.7	0.1	0.8	0.8	1.1	0.9	1.0	1.0	1.0	0.2
500 FT. FLYOVER -- TARGET IAS 135 KTS (ICAO)													
A1	86.8	80.0	6.8	6.9	0.5	91.6	94.9	95.6	6.3	95.4	9.5	9.0	0.6
A2	87.0	79.6	7.4	6.8	0.5	92.1	94.7	95.0	6.1	95.2	12.0	14.5	0.4
A3	87.3	78.6	8.7	7.6	0.5	92.6	93.5	93.9	7.0	95.6	14.0	17.5	0.4
A4	87.8	79.8	8.0	6.8	0.4	93.0	94.9	95.2	6.6	95.8	15.0	15.0	0.3
A5	86.5	78.5	8.0	7.0	0.5	91.9	93.6	94.0	6.9	95.2	14.0	14.0	0.4
A6	87.0	78.4	8.5	7.0	0.4	91.8	93.6	94.1	6.5	95.0	16.5	15.5	0.5
Avg.	87.1	79.2	7.9	7.0	0.5	92.2	94.2	94.6	6.6	95.4	13.5	14.2	0.4
Std Dv	0.4	0.7	0.7	0.3	0.0	0.5	0.7	0.7	0.3	0.3	2.4	2.8	0.1
90% CI	0.4	0.6	0.6	0.2	0.0	0.4	0.6	0.6	0.3	0.3	2.0	2.3	0.1
500 FT. FLYOVER -- TARGET IAS 135 KTS (MILITARY)													
B7	88.9	81.0	7.9	6.8	0.4	94.2	96.9	97.2	6.2	95.8	14.5	13.5	0.4
B8	89.5	82.1	7.5	6.9	0.5	95.4	97.9	98.3	6.6	97.1	12.0	12.0	0.4
B9	89.5	84.1	5.4	6.0	0.4	95.2	99.7	100.1	5.9	98.3	8.0	7.5	0.4
B10	88.8	81.1	7.7	6.4	0.4	94.3	96.6	96.9	6.7	97.5	16.0	13.0	0.2
Avg.	89.2	82.0	7.1	6.5	0.4	94.8	97.8	98.1	6.3	97.2	12.6	11.5	0.3
Std Dv	0.4	1.4	1.2	0.4	0.0	0.6	1.4	1.4	0.4	1.0	3.5	2.7	0.1
90% CI	0.5	1.7	1.4	0.5	0.0	0.7	1.6	1.7	0.4	1.2	4.1	3.2	0.1
500 FT. FLYOVER -- TARGET IAS 120 KTS													
D15	86.3	79.6	6.7	6.7	0.5	90.9	93.2	93.6	6.9	96.0	10.0	11.5	0.4
D16	87.2	79.0	8.2	7.4	0.5	91.8	92.6	94.1	6.9	95.0	13.0	13.0	1.5
D17	86.0	78.2	7.8	7.2	0.5	90.6	92.1	92.4	7.5	95.3	12.5	12.5	0.2
D18	87.0	79.4	7.5	7.1	0.5	91.5	93.3	93.7	7.3	95.4	11.5	12.0	0.4
D19	86.3	78.8	7.5	7.3	0.5	90.4	93.0	93.3	7.1	94.0	10.5	10.0	0.3
Avg.	86.6	79.0	7.6	7.1	0.5	91.0	92.8	93.4	7.1	95.1	11.5	11.8	0.6
Std Dv	0.5	0.6	0.6	0.3	0.0	0.6	0.5	0.7	0.3	0.7	1.3	1.2	0.5
90% CI	0.5	0.5	0.5	0.3	0.0	0.6	0.5	0.6	0.2	0.7	1.2	1.1	0.5

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED
FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-1.3

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/13/84

SUMMARY NOISE LEVEL DATA

AS MEASURED *

SITE: 1 CENTERLINE - CENTER JULY 12,1983

EV	SEL	AL*	SEL-AL*	K(A)	Q	EPNL	PNL*	PNLT*	K(P)	OASPL*	DUR(A)	DUR(P)	TC
500 FT. FLYOVER -- TARGET IAS 105 KTS													
E20	89.2	81.3	7.8	7.2	0.5	93.6	95.0	95.5	7.4	95.5	12.5	12.5	0.5
E21	85.8	77.8	8.0	7.6	0.6	90.2	92.1	92.6	7.3	92.8	11.5	11.5	0.5
E22	86.6	77.5	9.1	7.2	0.4	90.8	91.1	91.7	7.3	91.7	18.5	17.5	0.6
E23	85.7	77.5	8.2	7.1	0.5	90.1	91.4	91.9	7.1	91.8	14.5	14.5	0.4
E24	86.3	77.4	8.9	7.1	0.4	90.9	91.1	92.3	7.0	91.1	18.0	16.5	1.2
E25	85.6	77.5	8.1	7.3	0.5	90.0	91.5	92.1	7.2	93.8	13.0	12.5	0.6
Avg.	86.5	78.2	8.4	7.2	0.5	90.9	92.0	92.7	7.2	92.8	14.7	14.2	0.6
Std Dv	1.4	1.6	0.5	0.2	0.0	1.3	1.5	1.4	0.1	1.6	2.9	2.4	0.3
90% CI	1.1	1.3	0.4	0.2	0.0	1.1	1.2	1.2	0.1	1.3	2.4	2.0	0.2
1000 FT. FLYOVER -- TARGET IAS 135 KTS													
F26	83.9	73.9	10.0	8.0	0.6	87.6	87.8	88.4	7.8	89.5	17.5	15.0	0.7
F27	83.4	75.4	8.0	6.9	0.4	87.4	89.3	89.7	6.8	89.9	14.5	13.5	0.4
F28	82.8	73.9	8.8	7.4	0.5	86.5	88.1	88.6	6.7	88.3	15.5	15.0	0.6
F29	83.0	74.5	8.5	6.9	0.4	86.7	88.2	88.6	6.6	88.6	17.0	16.5	0.4
Avg.	83.3	74.4	8.8	7.3	0.5	87.1	88.3	88.8	7.0	89.1	16.1	15.0	0.5
Std Dv	0.5	0.7	0.9	0.5	0.1	0.6	0.7	0.6	0.6	0.8	1.4	1.2	0.1
90% CI	0.6	0.8	1.0	0.6	0.1	0.7	0.8	0.7	0.7	0.9	1.6	1.4	0.1
TAKEOFF -- TARGET IAS 85 KTS (ICAO)													
G40	90.1	83.6	6.4	6.3	0.4	-	96.8	97.2	-	98.6	10.5	-	0.4
G41	90.0	83.6	6.4	6.3	0.4	94.6	96.5	97.1	6.7	97.9	10.5	13.0	0.6
G42	90.5	83.9	6.6	6.7	0.5	95.1	97.2	97.7	7.0	99.0	9.5	11.5	0.5
G43	90.0	83.0	7.0	6.8	0.5	-	96.4	96.9	-	98.6	11.0	-	0.5
G44	91.3	85.8	5.4	6.2	0.5	95.9	99.3	100.0	6.4	100.3	7.5	8.5	0.6
G45	91.4	85.8	5.6	6.4	0.5	96.2	99.3	99.7	6.9	100.5	7.5	9.0	0.4
Avg.	90.5	84.3	6.2	6.4	0.5	95.5	97.6	98.1	6.7	99.2	9.4	10.5	0.5
Std Dv	0.7	1.2	0.6	0.2	0.0	0.8	1.4	1.4	0.2	1.0	1.6	2.1	0.1
90% CI	0.5	1.0	0.5	0.2	0.0	0.9	1.1	1.1	0.3	0.8	1.3	2.5	0.1
APPROACH -- TARGET IAS 85 KTS (ICAO)													
H30	97.6	90.8	6.8	6.6	0.4	101.9	104.1	104.9	6.7	102.1	11.0	11.0	0.9
H31	97.3	90.0	7.3	6.5	0.4	101.3	103.8	104.4	6.5	102.5	13.5	11.5	0.6
H32	98.1	91.1	7.0	6.8	0.5	102.4	104.9	105.5	6.7	102.9	10.5	10.5	0.6
H33	98.7	91.2	7.5	7.0	0.5	103.0	105.0	105.5	7.2	103.2	12.0	11.0	0.5
H34	98.4	91.3	7.2	7.2	0.5	102.8	104.7	105.5	7.3	102.9	10.0	10.0	0.7
H35	97.3	91.0	6.4	5.7	0.3	101.2	104.5	105.0	6.5	102.5	13.0	9.0	0.6
Avg.	97.9	90.9	7.0	6.6	0.4	102.1	104.5	105.1	6.8	102.7	11.7	10.5	0.6
Std Dv	0.6	0.5	0.4	0.5	0.1	0.8	0.5	0.4	0.4	0.4	1.4	0.9	0.2
90% CI	0.5	0.4	0.3	0.4	0.1	0.6	0.4	0.4	0.3	0.3	1.2	0.7	0.1

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED
FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-1G.1

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/13/84

SUMMARY NOISE LEVEL DATA

AS MEASURED *

SITE: 1G CENTERLINE-CENTER (FLUSH) JULY 12,1983

EV	SEL	AL■	SEL-AL■	K(A)	Q	EPNL	PNL■	PNLT■	K(P)	OASPL■	DUR(A)	DUR(P)	TC
TAKEOFF -- TARGET IAS 85 KTS													
J47	90.7	81.9	8.8	6.9	0.4	95.4	94.9	95.7	7.4	99.2	18.5	20.5	0.8
J49	90.4	82.4	8.0	6.7	0.4	94.9	94.3	95.2	7.9	98.2	16.0	17.0	0.9
J51	91.6	83.9	7.8	7.0	0.5	96.2	97.4	98.2	7.0	101.8	13.0	14.0	0.9
Avg.	90.9	82.7	8.2	6.8	0.4	95.5	95.5	96.4	7.5	99.7	15.8	17.2	0.9
Std Dv	0.6	1.0	0.5	0.2	0.0	0.7	1.6	1.6	0.4	1.8	2.8	3.3	0.1
90% CI	1.1	1.7	0.9	0.3	0.1	1.1	2.7	2.7	0.7	3.1	4.6	5.5	0.1
TAKEOFF -- TARGET IAS 70 KTS (MILITARY)													
L53	94.2	87.6	6.6	6.7	0.5	-	100.4	101.1	-	103.0	9.5	-	0.7
L54	95.1	88.1	6.9	6.7	0.4	100.4	101.4	103.0	7.3	105.0	11.0	10.5	1.6
L55	95.5	88.4	7.1	6.7	0.4	100.5	101.0	102.2	7.5	104.0	11.5	12.5	1.6
Avg.	94.9	88.0	6.9	6.7	0.5	100.5	100.9	102.1	7.4	104.0	10.7	11.5	1.3
Std Dv	0.7	0.4	0.3	0.0	0.0	0.1	0.5	1.0	0.2	1.0	1.0	1.4	0.5
90% CI	1.1	0.7	0.5	0.0	0.0	0.3	0.9	1.6	0.9	1.7	1.8	6.3	0.9
APPROACH -- TARGET IAS 100 KTS													
K46	101.6	94.8	6.8	6.6	0.4	105.5	107.9	108.6	6.4	106.5	11.0	12.0	0.7
K48	99.6	93.4	6.2	6.5	0.5	103.7	106.9	107.5	6.4	105.4	9.0	9.5	0.6
K50	100.5	94.5	6.0	6.2	0.4	104.4	108.0	108.9	5.8	105.2	9.0	9.0	0.9
K52	101.4	95.6	5.8	6.4	0.5	105.5	109.0	110.0	6.1	107.0	8.0	8.0	1.1
Avg.	100.8	94.6	6.2	6.4	0.5	104.8	107.9	108.7	6.2	106.0	9.2	9.6	0.8
Std Dv	0.9	0.9	0.5	0.1	0.0	0.9	0.9	1.1	0.3	0.8	1.3	1.7	0.2
90% CI	1.1	1.1	0.5	0.2	0.0	1.1	1.0	1.2	0.3	1.0	1.5	2.0	0.2
APPROACH -- TARGET IAS 70 KTS (MILITARY)													
I36	102.1	95.8	6.3	6.2	0.4	106.2	108.9	109.9	6.1	107.4	10.5	11.0	1.0
I37	101.9	93.8	8.2	7.0	0.5	105.9	106.9	107.7	6.9	106.0	14.5	15.5	0.8
I38	103.3	96.7	6.5	6.2	0.4	107.2	109.7	110.4	6.3	107.9	11.5	12.0	0.6
I39	102.7	95.8	6.9	6.6	0.4	106.7	108.8	109.4	6.9	106.5	11.0	11.5	0.6
Avg.	102.5	95.5	7.0	6.5	0.4	106.5	108.6	109.3	6.5	106.9	11.9	12.5	0.7
Std Dv	0.6	1.3	0.8	0.4	0.0	0.6	1.2	1.2	0.4	0.8	1.8	2.0	0.2
90% CI	0.7	1.5	1.0	0.5	0.0	0.7	1.4	1.4	0.5	1.0	2.1	2.4	0.2

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-1G.2

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/13/84

SUMMARY NOISE LEVEL DATA

AS MEASURED *

SITE: 1G CENTERLINE-CENTER (FLUSH) JULY 12,1983

EV	SEL	ALm	SEL-ALm	K(A)	Q	EPNL	PNLm	PNLTm	K(P)	DASPLm	DUR(A)	DUR(P)	TC
500 FT. FLYOVER -- TARGET IAS 135 KTS													
C11	91.3	84.0	7.3	7.3	0.5	96.3	99.4	99.7	6.7	101.1	10.0	9.5	0.3
C12	93.5	85.9	7.5	7.4	0.5	98.1	101.3	101.5	6.8	103.3	10.5	9.5	0.2
C13	92.5	84.2	8.3	7.8	0.6	97.6	99.9	100.4	7.2	101.0	11.5	10.0	0.6
C14	92.0	84.9	7.2	6.8	0.5	97.2	100.0	100.2	6.9	101.9	[illegible]	10.5	0.3
Avg.	92.3	84.7	7.6	7.3	0.5	97.3	100.1	100.5	6.9	101.8	10.9	9.9	0.3
Std Dv	0.9	0.9	0.5	0.4	0.1	0.8	0.8	0.7	0.2	1.0	0.7	0.5	0.2
90% CI	1.1	1.0	0.6	0.5	0.1	0.9	1.0	0.9	0.2	1.2	0.9	0.6	0.2
500 FT. FLYOVER -- TARGET IAS 135 KTS (ICAO)													
A1	90.7	83.9	6.8	6.7	0.5	96.4	98.9	99.2	6.0	100.1	10.5	15.5	0.3
A2	91.6	83.2	8.4	7.6	0.5	97.3	98.9	99.5	7.2	100.0	13.0	12.0	0.6
A3	91.8	83.1	8.7	7.4	0.5	97.4	99.4	99.8	6.7	100.2	15.0	13.5	0.4
A4	92.7	84.3	8.3	7.2	0.5	98.6	101.0	101.3	6.5	102.1	14.5	13.0	0.3
A5	90.8	82.8	8.0	7.1	0.5	96.6	98.7	99.0	6.6	99.5	13.5	14.0	0.4
A6	[illegible]	82.7	8.6	7.4	0.5	96.9	99.2	99.5	6.8	101.1	14.5	12.5	0.3
Avg.	91.5	83.3	8.2	7.2	0.5	97.2	99.4	99.7	6.7	100.5	13.5	13.4	0.3
Std Dv	0.7	0.7	0.7	0.3	0.0	0.8	0.8	0.8	0.4	0.9	1.6	1.2	0.1
90% CI	0.6	0.5	0.6	0.3	0.0	0.6	0.7	0.7	0.3	0.8	1.4	1.0	0.1
500 FT. FLYOVER -- TARGET IAS 135 KTS (MILITARY)													
B7	93.1	84.7	8.4	7.1	0.5	98.8	100.9	101.2	6.7	102.0	15.5	13.5	0.4
B8	94.0	86.4	7.6	6.9	0.5	100.6	103.3	103.9	6.3	102.9	12.5	11.5	0.6
B9	93.3	87.3	6.0	6.1	0.4	99.6	103.0	103.4	6.5	103.0	9.5	9.0	0.5
B10	93.4	85.4	8.0	7.5	0.5	99.6	102.3	102.8	6.6	102.4	11.5	10.5	0.6
Avg.	93.4	86.0	7.5	6.9	0.5	99.6	102.4	102.8	6.5	102.6	12.2	11.1	0.5
Std Dv	0.4	1.2	1.1	0.6	0.1	0.7	1.1	1.2	0.2	0.5	2.5	1.9	0.1
90% CI	0.4	1.4	1.2	0.7	0.1	0.9	1.3	1.4	0.2	0.5	2.9	2.2	0.1
500 FT. FLYOVER -- TARGET IAS 120 KTS													
D15	90.7	83.9	6.8	6.4	0.4	95.6	97.9	98.2	6.8	100.0	11.5	12.0	0.2
D16	91.4	83.2	8.3	7.4	0.5	96.5	97.1	97.9	7.5	99.4	13.0	14.0	1.2
D17	90.1	82.0	8.0	7.6	0.6	95.2	97.5	97.7	7.1	100.2	11.5	11.5	0.3
D18	91.8	84.0	7.8	7.4	0.5	97.0	98.8	99.0	7.8	101.4	11.5	10.5	0.3
D19	90.6	82.7	7.9	7.6	0.6	95.1	97.1	97.3	7.5	98.4	11.0	11.0	0.2
Avg.	90.9	83.2	7.8	7.3	0.5	95.9	97.7	98.0	7.3	99.9	11.7	11.8	0.4
Std Dv	0.7	0.8	0.6	0.5	0.1	0.8	0.7	0.6	0.4	1.1	0.8	1.4	0.4
90% CI	0.7	0.8	0.5	0.5	0.1	0.8	0.7	0.6	0.4	1.1	0.7	1.3	0.4

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED
FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-1G.3

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

SUMMARY NOISE LEVEL DATA

AS MEASURED *

DOT/TSC
6/13/84

SITE: 1G   CENTERLINE-CENTER (FLUSH)   JULY 12,1983

EV	SEL	ALm	SEL-ALm	K(A)	Q	EPNL	PNLm	PNLTm	K(P)	OASPLm	DUR(A)	DUR(P)	TC
500 FT. FLYOVER -- TARGET IAS 105 KTS													
E20	93.4	85.5	8.0	7.0	0.5	98.0	99.1	99.8	7.2	101.5	13.5	13.5	0.6
E21	90.2	82.2	7.9	7.2	0.5	95.0	97.1	97.5	6.9	98.1	12.5	12.0	0.5
E22	91.1	81.6	9.5	7.0	0.4	95.5	95.7	96.5	7.2	97.3	22.0	18.0	0.8
E23	89.3	81.3	8.0	7.2	0.5	93.9	95.9	96.4	6.9	96.6	13.0	12.0	0.5
E24	90.7	81.3	9.4	7.6	0.5	95.3	94.8	95.7	7.8	96.8	17.5	17.0	0.9
E25	89.5	81.0	8.4	7.4	0.5	94.0	95.9	96.3	6.7	98.0	14.0	14.0	0.4
Avg.	90.7	82.2	8.5	7.2	0.5	95.3	96.4	97.0	7.1	98.0	15.4	14.4	0.6
Std Dv	1.5	1.7	0.7	0.2	0.0	1.5	1.5	1.5	0.4	1.8	3.7	2.5	0.2
90% CI	1.2	1.4	0.6	0.2	0.0	1.2	1.2	1.2	0.3	1.5	3.0	2.1	0.1
1000 FT. FLYOVER -- TARGET IAS 135 KTS													
F26	87.5	77.7	9.8	7.9	0.5	92.4	92.9	93.5	7.6	95.6	17.5	15.5	0.5
F27	87.6	78.3	9.3	7.6	0.5	92.4	92.3	93.3	7.5	94.4	17.0	16.5	1.0
F28	86.7	77.7	9.0	7.3	0.5	91.4	92.2	93.1	6.9	94.3	17.0	16.0	0.9
F29	87.0	77.7	9.3	7.3	0.5	91.7	92.2	92.8	7.5	94.9	18.5	15.5	0.7
Avg.	87.2	77.9	9.3	7.5	0.5	92.0	92.4	93.2	7.4	94.8	17.5	15.9	0.8
Std Dv	0.4	0.3	0.3	0.3	0.0	0.5	0.3	0.3	0.3	0.6	0.7	0.5	0.2
90% CI	0.5	0.3	0.4	0.3	0.0	0.6	0.4	0.3	0.4	0.7	0.8	0.6	0.2
TAKEOFF -- TARGET IAS 85 KTS (ICAO)													
G40	93.6	86.7	6.9	6.6	0.4	98.6	99.8	101.0	7.1	102.9	11.0	11.5	1.2
G41	93.2	86.5	6.7	6.6	0.4	97.8	99.2	99.9	7.3	102.4	10.5	12.0	0.7
G42	94.6	88.1	6.5	6.6	0.5	99.2	100.9	101.5	7.7	103.8	9.5	10.0	0.6
G43	93.5	86.4	7.1	6.7	0.4	-	100.0	100.6	-	103.4	11.5	-	0.5
G44	94.9	89.3	5.6	6.2	0.5	99.7	102.5	103.2	6.9	105.3	8.0	9.0	0.6
G45	95.7	89.6	6.1	6.6	0.5	100.6	103.0	104.0	7.2	105.9	8.5	8.5	1.0
Avg.	94.3	87.8	6.5	6.6	0.5	99.2	100.9	101.7	7.2	103.9	9.8	10.2	0.8
Std Dv	1.0	1.4	0.5	0.2	0.0	1.1	1.6	1.6	0.3	1.3	1.4	1.5	0.3
90% CI	0.8	1.2	0.4	0.1	0.0	1.0	1.3	1.3	0.3	1.1	1.2	1.5	0.2
APPROACH -- TARGET IAS 85 KTS (ICAO)													
H30	101.6	94.2	7.3	7.0	0.5	105.7	107.3	108.4	6.9	107.4	11.0	11.0	1.1
H31	101.0	94.1	6.9	6.5	0.4	105.3	107.2	108.2	6.6	107.5	11.5	12.0	0.9
H32	102.1	95.8	6.3	6.2	0.4	106.4	109.0	109.8	6.3	108.7	10.5	11.0	0.8
H33	102.2	95.7	6.5	6.3	0.4	106.2	108.9	109.4	6.6	108.4	10.5	10.5	0.5
H34	102.2	95.9	6.3	6.4	0.4	106.1	109.0	109.6	6.5	107.4	9.5	10.0	0.6
H35	100.9	94.0	6.9	7.2	0.5	104.9	107.2	108.1	7.2	105.9	9.0	9.0	0.9
Avg.	101.7	95.0	6.7	6.6	0.5	105.8	108.1	108.9	6.7	107.5	10.3	10.6	0.8
Std Dv	0.6	0.9	0.4	0.4	0.0	0.6	0.9	0.8	0.3	1.0	0.9	1.0	0.2
90% CI	0.5	0.8	0.3	0.3	0.0	0.5	0.8	0.6	0.3	0.8	0.8	0.8	0.2

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED
FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-2.1

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

SUMMARY NOISE LEVEL DATA

AS MEASURED *

DOT/TSC
6/13/84

SITE: 2 SIDELINE - 150 M. SOUTH JULY 12,1983

EV	SEL	AL*	SEL-AL*	K(A)	Q	EPNL	PNL*	PNLT*	K(P)	OASPL*	DUR(A)	DUR(P)	TC
TAKEOFF -- TARGET IAS 85 KTS													
J47	86.8	77.2	9.5	7.5	0.5	91.1	90.1	91.1	7.7	97.3	18.5	20.5	1.0
J49	86.6	76.6	10.0	7.5	0.5	90.9	89.2	91.2	7.3	97.7	22.0	21.0	2.0
J51	86.6	76.6	10.0	7.9	0.5	90.9	90.5	91.7	7.4	98.9	18.5	17.5	1.2
Avg.	86.6	76.8	9.9	7.6	0.5	91.0	89.9	91.3	7.5	98.0	19.7	19.7	1.4
Std Dv	0.1	0.4	0.3	0.2	0.0	0.1	0.6	0.3	0.2	0.9	2.0	1.9	0.6
90% CI	0.2	0.6	0.5	0.4	0.1	0.2	1.1	0.6	0.3	1.4	3.4	3.2	0.9
TAKEOFF -- TARGET IAS 70 KTS (MILITARY)													
L53	87.5	77.8	9.6	8.2	0.6	92.2	91.8	93.2	7.7	98.2	15.0	14.5	1.4
L54	87.5	77.6	9.9	8.0	0.6	92.4	91.8	93.4	7.5	98.8	17.5	16.0	1.6
L55	87.9	77.9	10.0	7.9	0.6	92.8	91.8	93.5	7.5	98.1	18.0	17.0	1.7
Avg.	87.6	77.8	9.8	8.0	0.6	92.4	91.8	93.4	7.6	98.4	16.8	15.8	1.6
Std Dv	0.2	0.2	0.2	0.1	0.0	0.3	0.0	0.1	0.1	0.4	1.6	1.3	0.1
90% CI	0.4	0.3	0.3	0.2	0.1	0.5	0.1	0.2	0.2	0.6	2.7	2.1	0.2
APPROACH -- TARGET IAS 100 KTS													
K46	91.1	80.8	10.2	7.6	0.5	95.5	94.9	96.8	7.3	98.2	22.5	16.0	1.9
K48	90.4	81.7	8.8	7.1	0.4	95.5	95.3	96.9	7.2	99.8	17.0	15.5	1.6
K50	91.0	82.2	8.8	7.5	0.5	96.0	95.7	97.4	7.5	100.4	15.0	14.0	1.7
K52	90.5	81.5	9.0	7.7	0.5	95.4	95.7	97.5	7.1	99.9	14.5	13.0	1.9
Avg.	90.8	81.6	9.2	7.5	0.5	95.6	95.4	97.2	7.3	99.6	17.2	14.6	1.8
Std Dv	0.3	0.6	0.7	0.3	0.0	0.2	0.4	0.4	0.1	1.0	3.7	1.4	0.1
90% CI	0.4	0.7	0.8	0.3	0.1	0.3	0.4	0.4	0.2	1.1	4.3	1.6	0.2
APPROACH -- TARGET IAS 70 KTS (MILITARY)													
I36	92.2	83.9	8.3	6.2	0.3	96.4	96.9	98.4	6.1	98.3	21.0	20.5	1.4
I37	90.9	79.9	11.0	7.3	0.4	95.0	93.2	94.9	7.4	97.5	31.0	22.5	1.7
I38	93.3	83.7	9.6	7.6	0.5	98.3	98.0	99.4	7.4	98.3	18.0	16.0	2.0
I39	93.5	83.1	10.4	7.6	0.5	98.5	97.7	99.3	7.0	97.9	23.0	20.5	1.6
Avg.	92.5	82.7	9.8	7.2	0.4	97.0	96.4	98.0	7.0	98.0	23.2	19.9	1.7
Std Dv	1.2	1.9	1.2	0.7	0.1	1.7	2.2	2.1	0.6	0.4	5.6	2.7	0.2
90% CI	1.4	2.2	1.4	0.8	0.1	2.0	2.6	2.5	0.7	0.5	6.5	3.2	0.3

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-2.2

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/13/84

SUMMARY NOISE LEVEL DATA

AS MEASURED *

SITE: 2 SIDELINE - 150 M. SOUTH JULY 12,1983

EV	SEL	ALm	SEL-ALm	K(A)	Q	EPNL	PNLm	PNLTm	K(P)	OASPLm	DUR(A)	DUR(P)	TC
500 FT. FLYOVER -- TARGET IAS 135 KTS													
C11	85.4	77.3	8.0	7.2	0.5	90.3	91.7	92.8	6.8	100.1	13.0	12.5	1.1
C12	87.9	80.9	7.1	6.8	0.5	93.0	95.1	96.1	6.5	102.0	11.0	11.5	0.9
C13	86.2	77.8	8.4	7.6	0.6	90.8	92.2	93.1	7.2	99.9	12.5	12.0	1.0
C14	87.1	79.0	8.1	7.0	0.4	91.5	93.0	93.9	6.7	100.2	14.5	13.5	1.0
Avg.	86.7	78.7	7.9	7.2	0.5	91.4	93.0	94.0	6.8	100.6	12.7	12.4	1.0
Std Dv	1.1	1.6	0.6	0.4	0.0	1.2	1.5	1.5	0.3	1.0	1.4	0.9	0.1
90% CI	1.3	1.8	0.7	0.4	0.1	1.4	1.8	1.7	0.3	1.1	1.7	1.0	0.1
500 FT. FLYOVER -- TARGET IAS 135 KTS (ICAO)													
A1	86.6	77.9	8.7	6.8	0.4	92.2	93.2	94.4	6.1	98.6	19.0	19.0	1.2
A2	86.4	77.5	8.9	7.2	0.4	91.9	91.7	93.0	7.1	99.3	17.5	17.5	1.3
A3	86.7	77.1	9.6	7.4	0.5	92.2	92.4	93.1	7.2	98.3	19.5	18.0	0.7
A4	86.6	78.0	8.6	7.1	0.4	92.4	92.0	93.4	7.2	100.2	16.5	18.0	1.7
A5	86.4	77.1	9.3	7.4	0.5	92.2	92.9	94.1	6.6	98.3	18.0	17.0	1.4
A6	86.4	77.4	9.0	7.5	0.5	91.7	92.2	93.6	7.1	97.2	16.0	17.0	0.9
Avg.	86.5	77.5	9.0	7.2	0.5	92.1	92.4	93.5	6.9	98.7	17.7	17.7	1.2
Std Dv	0.1	0.4	0.4	0.3	0.0	0.3	0.6	0.6	0.4	1.0	1.4	0.8	0.4
90% CI	0.1	0.3	0.3	0.2	0.0	0.2	0.5	0.5	0.4	0.9	1.1	0.6	0.3
500 FT. FLYOVER -- TARGET IAS 135 KTS (MILITARY)													
B7	87.5	78.9	8.5	7.2	0.5	93.0	94.6	95.4	6.9	98.9	15.5	12.5	0.9
B8	87.6	79.5	8.1	6.9	0.4	93.8	94.8	95.9	6.4	100.6	14.5	17.0	1.1
B9	87.9	80.5	7.4	7.1	0.5	94.0	95.7	96.9	6.8	99.6	11.0	11.0	1.1
B10	87.5	78.6	8.9	6.9	0.4	92.9	93.5	94.9	6.5	99.4	19.5	17.5	1.4
Avg.	87.6	79.4	8.2	7.0	0.4	93.4	94.7	95.8	6.7	99.6	15.1	14.5	1.1
Std Dv	0.2	0.8	0.6	0.1	0.0	0.5	0.9	0.8	0.3	0.7	3.5	3.2	0.2
90% CI	0.2	0.9	0.7	0.2	0.1	0.6	1.1	1.0	0.3	0.8	4.1	3.8	0.2
500 FT. FLYOVER -- TARGET IAS 120 KTS													
D15	85.5	77.0	8.4	7.0	0.4	90.3	90.4	91.3	7.6	99.0	16.0	15.5	0.9
D16	86.2	76.9	9.4	7.3	0.5	90.2	90.0	90.9	7.6	99.0	19.0	17.0	0.9
D17	84.7	76.3	8.4	7.4	0.5	89.6	89.9	90.9	7.3	98.8	14.0	15.5	0.9
D18	86.5	77.7	8.9	7.2	0.5	90.7	91.1	92.3	7.0	99.1	17.0	16.0	1.2
D19	85.0	76.9	8.2	8.2	0.7	-	90.9	91.8	-	99.6	10.0	-	0.9
Avg.	85.6	76.9	8.7	7.4	0.5	90.2	90.5	91.4	7.4	99.1	15.2	16.0	1.0
Std Dv	0.8	0.5	0.5	0.4	0.1	0.5	0.5	0.6	0.3	0.3	3.4	0.7	0.2
90% CI	0.7	0.5	0.5	0.4	0.1	0.5	0.5	0.6	0.3	0.3	3.3	0.8	0.2

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED
FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-2.3

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/13/84

SUMMARY NOISE LEVEL DATA

AS MEASURED *

SITE: 2 SIDELINE - 150 M. SOUTH JULY 12,1983

EV	SEL	AL■	SEL-AL■	K(A)	Q	EPNL	PNL■	PNLT■	K(P)	OASPL■	DUR(A)	DUR(P)	TC
500 FT. FLYOVER -- TARGET IAS 105 KTS													
E20	86.7	77.6	9.1	7.0	0.4	90.9	90.9	92.2	6.8	97.8	19.5	18.5	1.3
E21	84.2	74.9	9.3	8.1	0.6	-	88.8	90.3	-	97.0	14.0	-	1.5
E22	85.4	75.9	9.4	7.3	0.4	89.4	89.1	90.6	7.0	96.9	19.5	18.0	1.5
E23	83.9	75.2	8.7	7.4	0.5	88.6	89.5	90.6	7.1	96.7	15.0	13.5	1.1
E24	85.4	.0	9.4	7.5	0.5	89.5	88.9	87.8	7.7	96.7	18.0	18.0	1.2
E25	85.0	75.3	9.7	7.6	0.5	89.5	88.9	90.2	7.4	97.9	18.5	18.0	1.4
Avg.	85.1	75.8	9.3	7.5	0.5	89.6	89.3	90.6	7.2	97.2	17.4	17.2	1.3
Std Dv	1.0	1.0	0.3	0.4	0.1	0.8	0.8	0.8	0.4	0.5	2.4	2.1	0.2
90% CI	0.8	0.8	0.3	0.3	0.1	0.8	0.7	0.7	0.3	0.4	1.9	2.0	0.1
1000 FT. FLYOVER -- TARGET IAS 135 KTS													
F26	84.0	74.6	9.3	7.4	0.5	88.2	88.8	89.6	7.0	96.5	18.5	16.5	0.8
F27	94.7	75.6	9.1	7.3	0.5	88.5	87.9	89.1	7.8	95.5	17.5	16.0	1.3
F28	84.4	75.2	9.2	7.2	0.4	88.4	88.2	89.1	7.4	94.6	18.5	18.0	0.9
F29	83.9	74.2	9.7	7.8	0.5	88.2	88.4	89.0	7.8	94.9	17.5	15.0	0.5
Avg.	84.2	74.9	9.3	7.4	0.5	88.3	88.3	89.2	7.5	95.4	18.0	16.4	0.9
Std Dv	0.4	0.6	0.3	0.3	0.0	0.1	0.4	0.3	0.4	0.8	0.6	1.2	0.3
90% CI	0.4	0.7	0.3	0.3	0.0	0.2	0.5	0.3	0.4	1.0	0.7	1.5	0.4
TAKEOFF -- TARGET IAS 85 KTS (ICAO)													
G40	88.2	78.9	9.3	7.5	0.5	92.4	91.8	93.4	7.6	98.8	17.0	15.5	1.6
G41	88.3	78.9	9.5	8.1	0.6	92.7	92.6	93.7	7.4	99.0	15.0	16.5	1.1
G42	87.6	78.5	9.0	7.9	0.6	91.6	92.5	93.6	7.2	99.3	14.0	13.0	1.1
G43	88.2	79.0	9.2	8.1	0.6	92.6	93.2	94.2	7.6	99.1	13.5	12.5	1.1
G44	88.1	78.6	9.6	7.9	0.6	92.8	93.0	94.1	7.3	98.3	16.0	15.0	1.2
G45	87.7	78.4	9.3	7.1	0.4	92.1	92.5	93.5	6.8	99.1	20.0	18.5	1.0
Avg.	88.0	78.7	9.3	7.8	0.5	92.4	92.6	93.8	7.3	98.9	15.9	15.2	1.2
Std Dv	0.3	0.3	0.2	0.4	0.1	0.4	0.5	0.3	0.3	0.3	2.4	2.2	0.2
90% CI	0.3	0.2	0.2	0.3	0.1	0.4	0.4	0.3	0.3	0.3	2.0	1.8	0.2
APPROACH -- TARGET IAS 85 KTS (ICAO)													
H30	91.7	82.7	9.0	7.2	0.5	96.7	97.1	99.0	6.6	100.7	17.5	15.0	1.9
H31	90.6	80.6	10.0	7.7	0.5	95.4	94.6	96.3	7.4	100.6	20.0	17.0	1.6
H32	91.4	81.9	9.5	7.6	0.5	96.4	95.9	97.7	7.6	100.3	17.5	14.0	1.8
H33	92.6	84.2	8.4	6.6	0.4	97.4	98.2	99.9	6.5	100.2	18.5	14.5	1.7
H34	91.3	82.7	8.6	6.9	0.4	96.2	96.9	98.9	6.5	99.3	17.5	13.0	2.1
H35	91.2	82.0	9.2	7.4	0.5	95.8	96.2	98.1	6.5	100.7	18.0	15.5	1.9
Avg.	91.5	82.4	9.1	7.2	0.5	96.3	96.5	98.3	6.8	100.3	18.2	14.8	1.8
Std Dv	0.7	1.2	0.6	0.4	0.1	0.7	1.2	1.2	0.5	0.5	1.0	1.4	0.2
90% CI	0.5	1.0	0.5	0.3	0.0	0.6	1.0	1.0	0.4	0.4	0.8	1.1	0.1

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED
FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-3.1

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/13/84

SUMMARY NOISE LEVEL DATA

AS MEASURED *

SITE: 3 SIDELINE - 150 M. NORTH JULY 12,1983

EV	SEL	AL*	SEL-AL*	K(A)	Q	EPNL	PNL*	PNLT*	K(P)	OASPL*	DUR(A)	DUR(P)	TC
TAKEOFF -- TARGET IAS 85 KTS													
J47	84.8	75.9	8.9	6.9	0.4	-	87.5	88.2	-	91.4	19.5	-	0.8
J49	85.8	77.1	8.7	7.1	0.4	90.4	89.4	90.8	7.3	96.2	16.5	20.5	1.4
J51	85.5	76.7	8.9	7.2	0.5	90.2	89.7	90.8	7.6	96.9	17.0	17.5	1.3
Avg.	85.4	76.6	8.8	7.1	0.4	90.3	88.9	89.9	7.4	94.8	17.7	19.0	1.2
Std Dv	0.5	0.6	0.1	0.2	0.0	0.1	1.2	1.5	0.2	3.0	1.6	2.1	0.3
90% CI	0.8	1.0	0.2	0.3	0.1	0.6	2.1	2.5	0.7	5.1	2.7	9.5	0.6
TAKEOFF -- TARGET IAS 70 KTS (MILITARY)													
L53	86.4	78.6	7.7	6.9	0.5	91.6	92.1	93.5	7.2	97.5	13.0	13.0	1.5
L54	86.4	77.7	8.7	7.2	0.5	91.6	92.2	93.4	7.0	97.6	16.0	15.0	1.2
L55	87.2	78.7	8.5	6.8	0.4	92.2	91.8	93.4	7.3	96.8	17.5	16.5	2.4
Avg.	86.6	78.4	8.3	7.0	0.4	91.8	92.0	93.4	7.2	97.3	15.5	14.8	1.7
Std Dv	0.4	0.5	0.5	0.2	0.0	0.4	0.2	0.1	0.1	0.4	2.3	1.8	0.6
90% CI	0.7	0.9	0.8	0.3	0.1	0.6	0.4	0.2	0.2	0.7	3.9	3.0	1.0
APPROACH -- TARGET IAS 100 KTS													
K46	93.5	86.1	7.5	6.8	0.4	97.9	98.9	100.5	6.9	100.2	12.5	12.0	1.6
K48	92.4	84.5	7.9	6.5	0.4	96.4	97.4	99.1	6.2	98.5	16.0	14.5	1.7
K50	92.4	84.8	7.6	6.8	0.4	96.2	96.7	98.3	7.1	98.1	13.0	13.0	1.6
K52	92.9	84.8	8.1	7.2	0.5	96.8	97.0	98.8	7.2	98.1	13.0	13.0	1.8
Avg.	92.8	85.0	7.8	6.9	0.4	96.8	97.5	99.2	6.8	98.7	13.6	13.1	1.7
Std Dv	0.5	0.7	0.3	0.3	0.0	0.8	1.0	1.0	0.4	1.0	1.6	1.0	0.1
90% CI	0.6	0.8	0.3	0.3	0.1	0.9	1.2	1.1	0.5	1.2	1.9	1.2	0.1
APPROACH -- TARGET IAS 70 KTS (MILITARY)													
I36	94.7	87.2	7.5	6.7	0.4	99.3	100.2	101.8	6.8	100.4	13.5	13.0	1.5
I37	95.2	87.1	8.1	6.5	0.4	99.4	99.5	101.5	6.5	100.6	17.5	17.0	1.9
I38	95.3	86.8	8.5	6.7	0.4	99.6	100.1	101.9	6.6	100.2	18.5	14.5	1.8
I39	93.4	84.3	9.1	7.1	0.4	-	98.0	99.8	-	99.7	19.0	-	1.8
Avg.	94.7	86.4	8.3	6.7	0.4	99.4	99.5	101.2	6.6	100.2	17.1	14.8	1.8
Std Dv	0.9	1.4	0.7	0.3	0.0	0.2	1.0	1.0	0.1	0.4	2.5	2.0	0.2
90% CI	1.0	1.7	0.8	0.3	0.0	0.3	1.2	1.1	0.2	0.5	2.9	3.4	0.2

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED
FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-3.2

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/13/84

SUMMARY NOISE LEVEL DATA

AS MEASURED *

SITE: 3 SIDELINE - 150 M. NORTH JULY 12,1983

EV	SEL	AL*	SEL-AL*	K(A)	Q	EPNL	PNL*	PNLT*	K(P)	OASPL*	DUR(A)	DUR(P)	TC
500 FT. FLYOVER -- TARGET IAS 135 KTS													
C11	86.6	79.1	7.4	6.9	0.5	91.0	93.4	94.2	6.5	99.3	12.0	11.0	0.9
C12	86.5	78.5	8.0	7.3	0.5	91.0	92.8	93.7	6.6	100.3	12.5	12.5	0.9
C13	86.8	79.0	7.8	7.5	0.6	91.7	93.1	94.2	7.5	99.5	11.0	10.0	1.1
C14	87.2	79.4	7.8	7.1	0.5	91.8	92.9	94.1	6.8	100.1	12.5	14.0	1.2
Avg.	86.8	79.0	7.7	7.2	0.5	91.4	93.1	94.1	6.9	99.8	12.0	11.9	1.0
Std Dv	0.3	0.4	0.2	0.3	0.0	0.4	0.3	0.2	0.5	0.5	0.7	1.7	0.1
90% CI	0.4	0.4	0.3	0.3	0.0	0.5	0.3	0.3	0.5	0.6	0.8	2.1	0.2
500 FT. FLYOVER -- TARGET IAS 135 KTS (ICAO)													
A1	86.0	78.0	8.0	7.2	0.5	90.9	91.5	92.7	7.0	98.8	13.0	14.5	1.2
A2	87.1	78.4	8.7	7.4	0.5	92.4	92.5	93.7	7.3	98.8	15.0	15.5	1.2
A3	87.6	78.7	8.9	7.2	0.4	92.6	92.6	93.5	7.3	100.0	17.5	17.0	0.9
A4	87.1	77.9	9.2	7.3	0.5	92.5	92.6	93.6	7.2	99.0	18.0	17.5	1.0
A5	86.5	77.8	8.7	7.2	0.5	91.6	91.7	92.5	7.5	97.9	16.5	16.5	1.3
A6	86.4	77.1	9.4	7.5	0.5	91.4	91.3	92.1	7.7	98.8	17.5	16.0	1.0
Avg.	86.8	78.0	8.8	7.3	0.5	91.9	92.0	93.0	7.3	98.9	16.2	16.2	1.1
Std Dv	0.6	0.6	0.5	0.2	0.0	0.7	0.6	0.7	0.2	0.7	1.9	1.1	0.1
90% CI	0.5	0.5	0.4	0.1	0.0	0.6	0.5	0.5	0.2	0.6	1.6	0.9	0.1
500 FT. FLYOVER -- TARGET IAS 135 KTS (MILITARY)													
B7	87.4	78.9	8.5	7.2	0.5	92.1	92.9	94.3	6.8	98.7	15.0	14.0	1.3
B8	89.8	81.2	8.6	7.5	0.5	95.6	96.5	97.6	7.1	99.4	14.0	13.5	1.1
B9	68.0	81.2	6.8	6.8	0.5	93.9	95.9	97.1	6.5	100.3	10.0	11.0	1.2
B10	88.8	80.0	8.8	7.1	0.4	93.9	94.6	95.0	7.2	99.4	17.0	17.5	0.7
Avg.	88.5	80.4	8.2	7.2	0.5	93.9	95.0	96.0	6.9	99.4	14.0	14.0	1.1
Std Dv	1.0	1.1	0.9	0.3	0.0	1.4	1.6	1.6	0.3	0.7	2.9	2.7	0.3
90% CI	1.2	1.3	1.1	0.3	0.0	1.7	1.9	1.9	0.4	0.8	3.5	3.1	0.3
500 FT. FLYOVER -- TARGET IAS 120 KTS													
D15	84.9	76.7	8.1	7.2	0.5	89.0	89.9	91.2	7.0	97.3	13.5	13.5	1.3
D16	86.3	77.9	8.3	7.1	0.5	90.9	90.9	92.3	7.2	98.6	15.0	15.5	1.4
D17	85.3	76.8	8.6	7.5	0.5	89.4	90.3	91.5	7.0	97.5	14.0	13.5	1.1
D18	85.6	77.2	8.4	7.4	0.5	89.9	90.9	92.3	6.9	98.8	13.5	12.5	1.5
D19	85.6	78.1	7.5	7.2	0.5	89.8	91.6	92.9	7.0	98.5	11.0	10.0	1.3
Avg.	85.5	77.4	8.2	7.3	0.5	89.8	90.7	92.0	7.0	98.1	13.4	13.0	1.3
Std Dv	0.5	0.7	0.4	0.2	0.0	0.7	0.6	0.7	0.1	0.7	1.5	2.0	0.1
90% CI	0.5	0.6	0.4	0.2	0.0	0.7	0.6	0.6	0.1	0.7	1.4	1.9	0.1

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED
FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-3.3

BOEING VERTOL CH-47D HELICOPTER (CHINOOK) DOT/TSC 6/13/84

SUMMARY NOISE LEVEL DATA

AS MEASURED *

SITE: 3 SIDELINE - 150 M. NORTH JULY 12,1983

EV	SEL	ALm	SEL-ALm	K(A)	Q	EPNL	PNLm	PNLTm	K(P)	OASPLm	DUR(A)	DUR(P)	TC
500 FT. FLYOVER -- TARGET IAS 105 KTS													
E20	86.4	77.1	9.3	7.2	0.4	90.7	91.1	92.6	6.6	98.0	19.5	16.5	1.5
E21	85.5	77.1	8.5	7.2	0.5	89.7	90.9	92.3	6.5	96.0	15.0	13.5	1.4
E22	85.2	75.9	9.2	7.2	0.4	89.4	89.1	90.6	7.2	96.1	19.0	16.5	1.5
E23	85.0	76.7	8.3	7.4	0.5	89.2	90.2	91.6	7.1	95.6	13.5	12.0	1.4
E24	85.1	76.4	8.7	7.1	0.4	89.3	90.2	91.4	6.6	95.6	17.0	16.0	1.2
E25	85.3	77.1	8.1	7.5	0.5	89.4	90.3	91.8	7.0	96.5	12.0	12.0	1.5
Avg.	85.4	76.7	8.7	7.3	0.5	89.6	90.3	91.7	6.9	96.3	16.0	14.4	1.4
Std Dv	0.5	0.5	0.5	0.2	0.0	0.5	0.7	0.7	0.3	0.9	3.0	2.2	0.1
90% CI	0.4	0.4	0.4	0.1	0.0	0.4	0.6	0.6	0.2	0.7	2.5	1.8	0.1
1000 FT. FLYOVER -- TARGET IAS 135 KTS													
F26	85.8	77.6	8.2	7.0	0.4	90.0	91.7	92.2	6.8	95.6	15.0	14.0	0.5
F27	85.8	78.5	7.3	6.2	0.4	89.8	92.4	93.2	6.0	95.1	15.0	12.5	0.8
F28	85.2	77.1	8.1	7.3	0.5	89.4	91.3	92.0	6.9	95.0	13.0	12.0	0.7
F29	84.5	75.7	8.8	7.2	0.4	88.4	89.9	90.5	6.6	94.5	17.0	16.0	0.6
Avg.	85.3	77.2	8.1	6.9	0.4	89.4	91.3	92.0	6.6	95.0	15.0	13.6	0.7
Std Dv	0.6	1.2	0.6	0.5	0.1	0.7	1.0	1.1	0.4	0.4	1.6	1.8	0.1
90% CI	0.7	1.4	0.7	0.6	0.1	0.8	1.2	1.3	0.4	0.5	1.9	2.1	0.2
TAKEOFF -- TARGET IAS 85 KTS (ICAO)													
G40	86.8	78.4	8.4	7.3	0.5	-	91.6	92.6	-	98.3	14.5	-	1.1
G41	86.8	78.8	8.0	7.1	0.5	91.9	92.4	93.5	7.3	99.1	13.5	14.0	1.3
G42	87.6	79.9	7.7	7.1	0.5	92.7	93.4	95.1	7.2	99.3	12.5	11.5	1.8
G43	86.6	78.5	8.1	7.3	0.5	91.8	92.9	93.8	7.2	99.8	13.0	12.5	0.9
G44	87.8	79.7	8.1	7.6	0.6	92.6	93.1	94.7	7.5	99.5	11.5	11.5	1.6
G45	87.3	78.9	8.4	7.7	0.6	92.1	93.2	94.1	7.4	99.7	12.5	12.0	0.9
Avg.	87.2	79.0	8.1	7.3	0.5	92.2	92.8	94.0	7.3	99.3	12.9	12.3	1.3
Std Dv	0.5	0.6	0.3	0.3	0.0	0.4	0.7	0.9	0.1	0.5	1.0	1.0	0.4
90% CI	0.4	0.5	0.2	0.2	0.0	0.4	0.7	0.7	0.1	0.5	0.8	1.0	0.3
APPROACH -- TARGET IAS 85 KTS (ICAO)													
H30	95.1	86.7	8.4	6.8	0.4	99.2	100.1	101.6	6.3	99.9	17.5	16.5	1.5
H31	95.0	86.2	8.7	7.6	0.5	99.4	99.2	101.1	7.4	100.0	14.0	13.5	1.9
H32	94.1	87.7	6.4	6.3	0.4	98.7	100.3	101.9	6.8	99.3	10.5	10.0	1.6
H33	94.7	87.8	7.0	6.3	0.4	99.1	101.4	102.6	6.1	100.5	12.5	11.5	1.3
H34	94.2	86.1	8.1	6.6	0.4	98.8	99.6	101.3	6.9	100.4	17.0	12.5	1.7
H35	95.0	88.3	6.7	6.2	0.4	99.4	101.2	103.2	5.9	101.1	12.0	11.0	2.0
Avg.	94.7	87.2	7.6	6.6	0.4	99.1	100.3	101.9	6.6	100.2	13.9	12.5	1.7
Std Dv	0.4	0.9	1.0	0.5	0.1	0.3	0.9	0.8	0.6	0.6	2.8	2.3	0.3
90% CI	0.3	0.8	0.8	0.4	0.0	0.2	0.7	0.7	0.5	0.5	2.3	1.9	0.2

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-4.1

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/13/84

SUMMARY NOISE LEVEL DATA

AS MEASURED *

SITE: 4 CENTERLINE - 150 M. WEST JULY 12,1983

EV	SEL	AL*	SEL-AL*	K(A)	Q	EPNL	PNL*	PNLT*	K(P)	OASPL*	DUR(A)	DUR(P)	TC
TAKEOFF -- TARGET IAS 85 KTS													
J47	85.0	76.8	8.2	6.7	0.4	-	88.7	89.4	-	90.6	17.0	-	0.6
J49	85.0	76.8	8.2	7.1	0.5	88.9	88.9	89.8	7.3	91.5	14.5	17.5	0.9
J51	85.4	76.9	8.5	7.2	0.5	89.6	89.6	90.5	7.5	92.2	15.5	16.5	0.9
Avg.	85.1	76.8	8.3	7.0	0.4	89.2	89.1	89.9	7.4	91.4	15.7	17.0	0.8
Std Dv	0.3	0.1	0.2	0.3	0.0	0.5	0.5	0.6	0.1	0.8	1.3	0.7	0.1
90% CI	0.4	0.1	0.3	0.4	0.1	2.3	0.8	0.9	0.5	1.4	2.1	3.2	0.2
TAKEOFF -- TARGET IAS 70 KTS (MILITARY)													
L53	88.3	80.1	8.3	7.3	0.5	93.4	94.5	95.1	7.1	97.7	13.5	14.5	0.6
L54	87.8	81.0	6.8	6.3	0.4	92.6	93.7	94.7	7.0	95.4	12.0	13.5	1.0
L55	89.4	82.2	7.2	6.7	0.4	94.3	95.5	96.3	6.8	97.5	12.0	15.0	0.9
Avg.	88.5	81.1	7.4	6.8	0.4	93.4	94.5	95.4	7.0	96.9	12.5	14.3	0.8
Std Dv	0.8	1.1	0.7	0.5	0.0	0.9	0.9	0.9	0.2	1.2	0.9	0.8	0.2
90% CI	1.3	1.8	1.3	0.8	0.1	1.4	1.5	1.4	0.3	2.1	1.5	1.3	0.3
APPROACH -- TARGET IAS 100 KTS													
K46	96.9	89.7	7.2	6.2	0.4	100.7	102.8	103.5	6.7	100.9	14.5	12.0	0.6
K48	95.2	88.8	6.4	6.2	0.4	99.2	102.4	103.1	6.1	100.3	10.5	10.0	0.9
K50	95.6	89.3	6.3	6.6	0.5	99.4	102.4	103.0	6.6	99.7	9.0	9.5	0.6
K52	95.7	89.0	6.8	6.8	0.5	99.6	102.3	102.9	6.7	100.2	10.0	10.0	0.7
Avg.	95.9	89.2	6.6	6.4	0.4	99.7	102.5	103.1	6.5	100.3	11.0	10.4	0.7
Std Dv	0.7	0.4	0.4	0.3	0.1	0.7	0.2	0.2	0.3	0.5	2.4	1.1	0.1
90% CI	0.9	0.5	0.5	0.3	0.1	0.8	0.3	0.3	0.4	0.6	2.8	1.3	0.2
APPROACH -- TARGET IAS 70 KTS (MILITARY)													
I36	97.0	89.0	8.0	6.8	0.4	100.7	102.1	103.0	7.0	100.3	15.0	13.0	0.9
I37	96.9	88.4	8.6	7.2	0.5	100.7	101.2	102.2	7.3	100.5	15.5	15.0	0.9
I38	97.8	90.4	7.4	6.8	0.4	101.9	103.2	104.1	7.0	101.5	12.5	13.0	0.9
I39	97.6	89.6	8.0	6.8	0.4	101.8	102.6	103.5	7.0	101.1	15.5	15.0	0.8
Avg.	97.3	89.3	8.0	6.9	0.4	101.3	102.3	103.2	7.1	100.9	14.6	14.0	0.9
Std Dv	0.4	0.9	0.5	0.2	0.0	0.6	0.8	0.8	0.1	0.6	1.4	1.2	0.0
90% CI	0.5	1.0	0.6	0.3	0.0	0.8	1.0	1.0	0.2	0.7	1.7	1.4	0.1

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-4.2

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

SUMMARY NOISE LEVEL DATA

AS MEASURED *

DOT/TSC
6/13/84

SITE: 4 CENTERLINE - 150 M. WEST JULY 12,1983

EV	SEL	AL*	SEL-AL*	K(A)	Q	EPNL	PNL*	PNLT*	K(P)	OASPL*	DUR(A)	DUR(P)	TC
500 FT. FLYOVER -- TARGET IAS 135 KTS													
C11	86.5	79.4	7.1	6.5	0.4	90.6	93.1	93.4	6.5	93.4	12.5	12.5	0.4
C12	88.7	80.6	8.2	7.9	0.6	93.1	95.1	95.6	7.3	96.2	11.0	10.5	0.5
C13	87.4	80.5	6.9	7.1	0.5	91.8	95.4	95.6	6.6	96.5	9.5	8.5	0.2
C14	87.6	79.5	8.1	7.6	0.6	92.1	94.2	94.6	7.1	94.4	11.5	11.5	0.3
Avg.	87.6	80.0	7.6	7.3	0.5	91.9	94.5	94.8	6.9	95.1	11.1	10.7	0.4
Std Dv	0.9	0.6	0.6	0.6	0.1	1.0	1.0	1.0	0.4	1.5	1.2	1.7	0.1
90% CI	1.1	0.7	0.8	0.7	0.1	1.2	1.2	1.2	0.4	1.8	1.5	2.0	0.1
500 FT. FLYOVER -- TARGET IAS 135 KTS (ICAO)													
A1	87.1	79.4	7.7	6.5	0.4	92.1	94.9	95.3	6.0	95.7	15.0	14.0	0.4
A2	87.0	79.1	7.9	7.1	0.5	92.2	94.0	94.4	6.4	94.7	13.0	16.0	0.4
A3	88.4	79.9	8.5	6.9	0.4	93.6	94.2	95.1	7.0	96.1	16.5	16.5	0.9
A4	87.9	79.5	8.4	6.8	0.4	93.2	94.5	95.1	6.5	95.7	17.5	17.5	0.6
A5	86.8	78.8	8.0	7.1	0.5	92.2	93.4	93.9	6.6	95.3	13.5	18.0	0.5
A6	86.9	78.3	8.6	7.3	0.5	91.8	93.5	94.1	6.6	95.1	15.0	14.5	0.6
Avg.	87.3	79.2	8.2	7.0	0.4	92.5	94.1	94.6	6.5	95.4	15.1	16.1	0.6
Std Dv	0.7	0.6	0.4	0.3	0.0	0.7	0.6	0.6	0.3	0.5	1.7	1.6	0.2
90% CI	0.5	0.5	0.3	0.2	0.0	0.6	0.5	0.5	0.3	0.4	1.4	1.3	0.1
500 FT. FLYOVER -- TARGET IAS 135 KTS (MILITARY)													
B7	90.1	81.4	8.7	7.7	0.5	95.1	96.3	96.9	7.5	96.4	13.5	12.5	0.9
B8	90.3	82.8	7.4	6.9	0.5	96.1	98.4	98.9	6.7	97.1	12.0	12.0	0.5
B9	89.2	83.0	6.2	6.6	0.5	95.2	98.8	99.2	6.1	97.7	8.5	9.5	0.4
B10	88.6	80.3	8.3	6.8	0.4	94.5	96.1	96.5	6.5	96.8	16.5	17.0	0.4
Avg.	89.5	81.9	7.7	7.0	0.5	95.3	97.4	97.9	6.7	97.0	12.6	12.7	0.6
Std Dv	0.8	1.3	1.1	0.5	0.1	0.7	1.4	1.4	0.6	0.5	3.3	3.1	0.2
90% CI	0.9	1.5	1.3	0.6	0.1	0.8	1.6	1.6	0.7	0.6	3.9	3.7	0.3
500 FT. FLYOVER -- TARGET IAS 120 KTS													
D15	85.6	78.0	7.5	7.0	0.5	90.1	91.3	91.9	7.3	93.5	12.0	13.0	0.6
D16	86.3	78.8	7.5	7.0	0.5	90.7	91.9	92.5	7.4	93.9	12.[illegible]	13.0	0.6
D17	85.2	77.9	7.3	6.5	0.4	89.3	91.5	91.9	6.5	93.0	13.0	13.5	0.5
D18	86.3	77.9	8.4	7.7	0.6	90.7	91.7	92.1	7.9	94.5	12.5	12.5	0.4
D19	86.1	78.2	7.8	7.1	0.5	89.9	91.9	92.4	7.3	93.8	12.5	10.5	0.5
Avg.	85.9	78.2	7.7	7.1	0.5	90.1	91.7	92.2	7.3	93.7	12.4	12.5	0.5
Std Dv	0.5	0.4	0.4	0.4	0.1	0.6	0.3	0.3	0.5	0.6	0.4	1.2	0.1
90% CI	0.5	0.4	0.4	0.4	0.1	0.6	0.3	0.3	0.5	0.5	0.4	1.1	0.1

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED
FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-4.3

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/13/84

SUMMARY NOISE LEVEL DATA

AS MEASURED *

SITE: 4 CENTERLINE - 150 M. WEST JULY 12,1983

EV	SEL	AL*	SEL-AL*	K(A)	Q	EPNL	PNL*	PNLT*	K(P)	OASPL*	DUR(A)	DUR(P)	TC
500 FT. FLYOVER -- TARGET IAS 105 KTS													
E20	87.8	78.8	9.0	7.4	0.5	92.2	93.4	93.8	7.1	93.9	16.5	15.0	0.4
E21	85.9	77.6	8.3	7.1	0.5	90.0	90.6	91.1	7.8	91.4	14.5	14.0	0.6
E22	86.2	77.3	8.9	7.2	0.4	90.4	91.7	92.7	6.8	91.0	17.5	13.5	1.0
E23	85.3	77.4	7.9	6.7	0.4	89.5	90.5	91.4	7.3	91.0	15.0	12.5	1.1
E24	86.0	77.4	8.6	7.1	0.4	-	90.8	91.5	-	92.3	16.5	-	0.6
E25	85.8	78.3	7.5	6.5	0.4	89.8	91.8	92.4	6.3	92.8	14.5	15.0	0.6
Avg.	86.2	77.8	8.4	7.0	0.4	90.4	91.5	92.2	7.1	92.1	15.7	14.0	0.7
Std Dv	0.9	0.6	0.6	0.3	0.0	1.1	1.1	1.0	0.6	1.2	1.3	1.1	0.2
90% CI	0.7	0.5	0.5	0.3	0.0	1.0	0.9	0.8	0.5	0.9	1.0	1.0	0.2
1000 FT. FLYOVER -- TARGET IAS 135 KTS													
F26	83.4	73.7	9.7	7.4	0.5	86.8	87.2	87.6	7.3	88.4	20.0	18.0	0.5
F27	83.6	74.7	8.8	7.3	0.5	87.4	88.1	88.5	6.5	88.2	16.5	23.5	0.4
F28	82.6	73.3	9.3	7.6	0.5	86.0	86.3	87.0	7.4	86.9	16.5	16.5	0.9
F29	83.2	73.6	9.7	7.6	0.5	86.7	86.0	86.6	7.9	88.8	19.0	19.5	0.6
Avg.	83.2	73.8	9.4	7.5	0.5	86.7	86.9	87.4	7.2	88.1	18.0	19.4	0.6
Std Dv	0.4	0.6	0.4	0.2	0.0	0.6	1.0	0.8	0.6	0.8	1.8	3.0	0.2
90% CI	0.5	0.7	0.5	0.2	0.0	0.7	1.2	1.0	0.7	1.0	2.1	3.5	0.3
TAKEOFF -- TARGET IAS 85 KTS (ICAO)													
G40	88.6	81.9	6.7	6.4	0.4	93.1	94.6	95.0	6.8	96.9	11.0	15.0	0.4
G41	87.9	80.8	7.2	6.5	0.4	92.2	93.4	93.9	7.3	96.6	12.5	13.5	0.7
G42	88.7	82.0	6.7	6.4	0.4	93.0	94.4	95.0	6.9	96.6	11.0	14.0	0.6
G43	88.4	81.2	7.1	6.7	0.4	-	93.5	94.1	-	95.2	11.5	-	0.7
G44	89.5	83.1	6.4	6.4	0.4	93.8	96.3	96.7	7.0	96.4	10.0	10.5	0.4
G45	89.8	83.6	6.2	6.2	0.4	94.4	96.5	97.2	6.7	98.2	10.0	12.0	0.7
Avg.	88.8	82.1	6.7	6.4	0.4	93.3	94.8	95.3	7.0	96.6	11.0	13.0	0.6
Std Dv	0.7	1.1	0.4	0.2	0.0	0.9	1.3	1.4	0.2	0.9	0.9	1.8	0.2
90% CI	0.6	0.9	0.3	0.1	0.0	0.8	1.1	1.1	0.2	0.8	0.9	1.7	0.1
APPROACH -- TARGET IAS 85 KTS (ICAO)													
H30		----------		NO DATA		----------							
H31	96.6	88.8	7.8	7.1	0.5	100.5	102.2	102.8	7.0	100.4	12.5	12.5	0.6
H32	97.2	89.3	7.9	7.4	0.5	101.7	103.3	103.9	7.4	101.7	12.0	11.0	0.6
H33	98.2	89.5	8.7	7.1	0.4	102.2	103.2	104.0	6.9	101.3	16.5	16.0	0.9
H34	97.3	90.4	6.9	6.4	0.4	101.6	103.6	104.6	6.5	101.8	12.0	12.5	0.9
H35	96.6	88.9	7.7	7.4	0.5	101.0	103.3	104.1	6.7	101.7	11.0	10.5	0.9
Avg.	96.8	89.0	7.8	7.0	0.5	100.9	102.6	103.3	6.9	100.8	13.7	12.6	0.8
Std Dv	1.2	1.2	0.6	0.5	0.1	1.5	1.4	1.5	0.3	1.4	2.9	1.9	0.1
90% CI	1.0	1.0	0.5	0.4	0.1	1.2	1.2	1.2	0.3	1.2	2.4	1.6	0.1

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED
FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-5.1

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/13/84

SUMMARY NOISE LEVEL DATA

AS MEASURED *

SITE: 5 CENTERLINE - 188 M. EAST JULY 12,1983

EV	SEL	ALm	SEL-ALm	K(A)	Q	EPNL	PNLm	PNLTm	K(P)	OASPLm	DUR(A)	DUR(P)	TC
TAKEOFF -- TARGET IAS 85 KTS													
J47	86.3	77.9	8.3	7.1	0.5	-	90.4	91.1	-	93.7	15.0	-	0.8
J49	86.9	78.4	8.4	6.9	0.4	91.0	91.2	91.8	7.4	93.4	16.5	17.5	0.6
J51	87.9	81.0	6.9	6.8	0.5	92.3	93.8	94.5	7.5	95.2	10.5	11.0	0.7
Avg.	87.0	79.1	7.9	6.9	0.4	91.7	91.8	92.5	7.4	94.1	14.0	14.2	0.7
Std Dv	0.8	1.6	0.8	0.1	0.0	0.9	1.8	1.8	0.1	1.0	3.1	4.6	0.1
90% CI	1.4	2.8	1.4	0.3	0.0	4.0	3.0	3.0	0.3	1.6	5.3	20.5	0.1
TAKEOFF -- TARGET IAS 70 KTS (MILITARY)													
L53	91.5	85.7	5.9	6.3	0.5	96.6	99.4	100.0	6.6	100.1	8.5	10.0	0.6
L54	91.2	85.3	5.9	6.3	0.5	96.6	98.9	99.9	6.9	100.4	8.5	9.5	1.0
L55	92.1	85.8	6.3	6.6	0.5	97.3	99.5	100.4	7.1	101.4	9.0	9.5	0.9
Avg.	91.6	85.6	6.0	6.4	0.5	96.8	99.2	100.1	6.8	100.6	8.7	9.7	0.8
Std Dv	0.4	0.2	0.2	0.2	0.0	0.4	0.3	0.3	0.3	0.6	0.3	0.3	0.2
90% CI	0.7	0.4	0.4	0.3	0.0	0.7	0.5	0.5	0.5	1.1	0.5	0.5	0.3
APPROACH -- TARGET IAS 100 KTS													
K46	97.3	90.1	7.2	6.7	0.4	101.4	103.7	104.4	6.4	101.8	12.0	12.5	0.6
K48	97.3	91.5	5.7	6.2	0.4	101.9	105.3	105.8	6.6	103.1	8.5	8.5	0.4
K50	96.9	91.4	5.4	6.0	0.4	101.4	105.5	106.0	6.1	103.2	8.0	7.5	0.5
K52	96.5	89.8	6.7	6.5	0.4	100.7	103.4	104.0	6.6	101.4	10.5	10.5	0.6
Avg.	97.0	90.7	6.3	6.3	0.4	101.3	104.5	105.0	6.4	102.4	9.7	9.7	0.5
Std Dv	0.4	0.9	0.8	0.3	0.0	0.5	1.1	1.0	0.2	0.9	1.8	2.2	0.1
90% CI	0.4	1.1	1.0	0.4	0.0	0.5	1.3	1.2	0.3	1.1	2.2	2.6	0.1
APPROACH -- TARGET IAS 70 KTS (MILITARY)													
I36	99.3	92.2	7.0	7.0	0.5	103.7	105.8	106.5	7.1	104.2	10.0	10.5	0.7
I37	99.3	91.2	8.1	7.1	0.5	103.4	104.7	105.5	7.0	103.9	14.0	13.5	0.8
I38	99.7	94.0	5.8	6.0	0.4	103.8	106.9	107.5	6.3	105.0	9.0	10.0	0.6
I39	99.4	93.1	6.3	6.5	0.4	103.5	105.9	106.6	6.8	103.1	9.5	10.5	0.7
Avg.	99.4	92.6	6.8	6.7	0.5	103.6	105.8	106.5	6.8	104.0	10.6	11.1	0.7
Std Dv	0.2	1.2	1.0	0.5	0.0	0.2	0.9	0.8	0.4	0.8	2.3	1.6	0.1
90% CI	0.3	1.4	1.2	0.6	0.0	0.2	1.1	1.0	0.4	0.9	2.7	1.9	0.1

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED
FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-5.2

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/13/84

SUMMARY NOISE LEVEL DATA

AS MEASURED *

SITE: 5 CENTERLINE - 188 M. EAST JULY 12,1983

EV	SEL	AL*	SEL-AL*	K(A)	Q	EPNL	PNL*	PNLT*	K(P)	DASPL*	DUR(A)	DUR(P)	TC
500 FT. FLYOVER -- TARGET IAS 135 KTS													
C11	86.7	78.2	8.5	7.9	0.6	91.4	92.3	93.0	7.9	96.4	12.0	11.5	1.1
C12	87.8	80.2	7.6	7.3	0.5	92.4	94.8	95.4	6.7	97.0	11.0	11.0	0.6
C13	87.8	79.8	8.0	7.3	0.5	92.4	94.1	94.3	7.4	96.1	12.5	12.5	0.4
C14	87.7	80.4	7.2	7.1	0.5	92.3	95.0	95.6	6.5	94.9	10.5	10.5	0.6
Avg.	87.5	79.7	7.8	7.4	0.5	92.1	94.1	94.6	7.1	96.1	11.5	11.4	0.7
Std Dv	0.5	1.0	0.6	0.4	0.0	0.5	1.2	1.2	0.6	0.9	0.9	0.9	0.3
90% CI	0.6	1.2	0.7	0.4	0.1	0.6	1.5	1.4	0.7	1.1	1.1	1.0	0.3
500 FT. FLYOVER -- TARGET IAS 135 KTS (ICAO)													
A1	86.6	79.1	7.5	7.3	0.5	91.6	94.0	94.5	6.7	96.3	10.5	11.5	0.5
A2	87.7	79.8	7.9	7.0	0.5	92.9	95.0	95.4	6.4	96.1	13.5	14.5	0.5
A3	87.2	78.9	8.3	6.7	0.4	92.4	94.4	94.9	6.4	95.8	17.0	15.0	0.5
A4	88.5	80.2	8.3	6.9	0.4	94.1	95.8	96.3	6.6	96.6	16.0	15.5	0.5
A5	87.2	79.3	7.9	6.4	0.4	-	94.5	94.9	-	95.8	17.0	-	0.5
A6	87.2	79.0	8.2	7.2	0.5	92.3	94.4	94.7	6.6	96.2	13.5	14.0	0.5
Avg.	87.4	79.4	8.0	6.9	0.4	92.7	94.7	95.1	6.5	96.1	14.6	14.1	0.5
Std Dv	0.6	0.5	0.3	0.3	0.1	0.9	0.6	0.6	0.1	0.3	2.6	1.6	0.0
90% CI	0.5	0.4	0.3	0.3	0.1	0.9	0.5	0.5	0.1	0.3	2.1	1.5	0.0
500 FT. FLYOVER -- TARGET IAS 135 KTS (MILITARY)													
B7	89.0	81.4	7.7	6.3	0.4	94.8	97.4	97.7	6.0	96.7	16.5	15.0	0.4
B8	90.0	83.5	6.5	6.5	0.4	95.9	99.3	99.8	6.2	[illegible]	10.0	9.5	0.5
B9	91.0	84.7	6.3	6.3	0.4	97.2	100.6	101.0	6.2	99.9	10.0	10.0	0.4
B10	90.3	83.3	7.0	6.1	0.4	96.1	99.1	99.6	5.9	98.6	14.0	12.5	0.5
Avg.	90.1	83.2	6.9	6.3	0.4	96.0	99.1	99.5	6.1	98.4	12.6	11.7	0.4
Std Dv	0.8	1.4	0.6	0.2	0.0	1.0	1.3	1.3	0.2	1.3	3.2	2.5	0.1
90% CI	1.0	1.6	0.7	0 2	0.1	1.2	1.6	1.6	0.2	1.6	3.8	3.0	0.1
500 FT. FLYOVER -- TARGET IAS 120 KTS													
D15	86.4	79.0	7.4	7.5	0.6	91.0	92.8	93.4	7.7	96.4	9.5	10.0	0.6
D16	86.2	78.5	7.7	8.1	0.7	-	92.7	93.1	-	95.9	9.0	-	0.3
D17	86.4	79.6	6.8	6.7	0.5	90.9	93.4	93.8	6.9	95.8	10.5	10.5	0.5
D18	87.3	79.5	7.9	7.3	0.5	-	93.0	94.5	-	94.8	12.0	-	1.6
D19	86.2	78.6	7.6	7.3	0.5	90.4	92.5	92.9	7.2	94.3	11.0	11.0	0.5
Avg.	86.5	79.0	7.5	7.4	0.5	90.8	92.9	93.5	7.2	95.4	10.4	10.5	0.7
Std Dv	0.5	0.5	0.4	0.5	0.1	0.3	0.3	0.7	0.4	0.9	1.2	0.5	0.5
90% CI	0.5	0.5	0.4	0.5	0.1	0.6	0.3	0.6	0.7	0.8	1.1	0.8	0.5

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

TABLE NO. A.7-5.3

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/13/84

SUMMARY NOISE LEVEL DATA

AS MEASURED *

SITE: 5 CENTERLINE - 188 M. EAST JULY 12,1983

EV	SEL	AL*	SEL-AL*	K(A)	Q	EPNL	PNL*	PNLT*	K(P)	OASPL*	DUR(A)	DUR(P)	TC
500 FT. FLYOVER -- TARGET IAS 105 KTS													
E20	89.3	80.6	8.8	7.6	0.5	93.6	94.6	95.2	7.4	95.2	14.5	14.0	0.8
E21	86.1	77.6	8.4	7.8	0.6	90.4	91.4	92.2	7.6	93.4	12.0	12.0	0.8
E22	86.7	77.5	9.2	7.1	0.4	90.8	91.5	92.0	7.0	91.8	19.5	18.5	0.5
E23	86.3	78.3	8.0	7.6	0.6	90.5	92.2	92.7	7.5	92.7	11.5	11.0	0.6
E24	86.5	77.4	9.2	7.8	0.5	-	91.6	92.2	-	92.1	15.0	-	0.6
E25	86.1	78.2	7.9	7.2	0.5	90.3	92.2	92.9	6.7	95.5	12.5	12.5	0.7
Avg.	86.8	78.2	8.6	7.5	0.5	91.1	92.2	92.9	7.2	93.4	14.2	13.6	0.7
Std Dv	1.3	1.2	0.6	0.3	0.1	1.4	1.2	1.2	0.4	1.6	3.0	2.9	0.1
90% CI	1.0	1.0	0.5	0.2	0.0	1.4	1.0	1.0	0.4	1.3	2.4	2.8	0.1
1000 FT. FLYOVER -- TARGET IAS 135 KTS													
F26	83.7	75.0	8.6	7.1	0.4	87.7	88.2	88.8	7.2	90.6	16.5	17.0	0.6
F27	83.5	76.0	7.5	6.3	0.4	87.3	90.3	91.0	5.7	90.1	15.5	13.0	0.7
F28	82.4	73.7	8.7	6.9	0.4	86.3	86.9	87.3	6.5	89.0	18.0	23.5	0.4
F29	82.5	73.6	8.9	7.0	0.4	86.2	86.2	87.1	7.0	89.7	19.0	20.5	0.9
Avg.	83.0	74.6	8.4	6.8	0.4	86.9	87.9	88.5	6.6	89.9	17.2	18.5	0.6
Std Dv	0.7	1.1	0.6	0.4	0.0	0.7	1.8	1.8	0.7	0.7	1.6	4.5	0.2
90% CI	0.8	1.3	0.7	0.4	0.0	0.9	2.1	2.1	0.8	0.8	1.8	5.3	0.2
TAKEOFF -- TARGET IAS 85 KTS (ICAO)													
G40	92.8	86.4	6.5	6.6	0.5	98.7	101.5	102.5	6.4	105.5	9.5	9.0	1.1
G41	92.2	86.5	5.8	5.9	0.4	-	100.2	101.0	-	103.2	9.5	-	0.7
G42	93.5	87.8	5.7	5.5	0.3	-	101.8	102.4	-	103.7	10.5	-	0.6
G43	92.3	86.4	5.8	6.1	0.4	97.1	100.2	100.8	6.4	101.7	9.0	9.5	0.8
G44	95.1	90.5	4.6	4.6	0.3	100.0	104.4	104.8	5.3	105.7	10.0	9.5	0.4
G45	93.6	88.6	5.0	5.4	0.4	-	102.4	102.9	-	104.2	8.5	-	0.5
Avg.	93.3	87.7	5.6	5.7	0.4	98.6	101.7	102.4	6.1	104.0	9.5	9.3	0.7
Std Dv	1.1	1.6	0.6	0.7	0.1	1.4	1.5	1.4	0.6	1.5	0.7	0.3	0.2
90% CI	0.9	1.3	0.5	0.6	0.0	2.4	1.3	1.2	1.1	1.2	0.6	0.5	0.2
APPROACH -- TARGET IAS 85 KTS (ICAO)													
H30	99.1	92.3	6.8	6.7	0.5	103.4	106.1	106.9	6.8	104.5	10.5	9.0	0.8
H31	97.7	90.5	7.2	7.2	0.5	101.9	103.7	104.4	7.6	102.6	10.0	10.0	0.7
H32	98.7	91.5	7.2	6.7	0.4	102.7	105.2	106.0	6.6	102.9	12.0	10.5	0.9
H33	98.7	92.8	5.9	6.2	0.4	103.3	106.9	107.6	6.3	104.4	9.0	8.0	0.7
H34	99.2	92.9	6.2	6.2	0.4	103.0	106.4	106.8	6.1	104.4	10.0	9.5	0.5
H35	97.9	91.7	6.2	6.4	0.4	102.6	105.6	106.2	6.7	103.8	9.5	9.0	0.6
Avg.	98.6	91.9	6.6	6.6	0.5	102.8	105.7	106.3	6.7	103.8	10.2	9.3	0.7
Std Dv	0.6	0.9	0.6	0.4	0.0	0.5	1.1	1.1	0.5	0.8	1.0	0.9	0.2
90% CI	0.5	0.8	0.5	0.3	0.0	0.4	0.9	0.9	0.4	0.7	0.8	0.7	0.1

* - NOISE INDEXES CALCULATED USING MEASURED DATA UNCORRECTED
FOR TEMPERATURE,HUMIDITY,OR AIRCRAFT DEVIATION FROM REF FLIGHT TRACK

APPENDIX B

Direct Read Acoustical Data and Duration Factors for Flight Operations

In addition to the magnetic recording systems, four direct-read, Type-1 noise measurement systems were deployed at selected sites during flight operations. The data acquisition is described in Section 5.6.2.

These direct read systems collected single event data consisting of maximum A-weighted sound level (AL), Sound Exposure Level (SEL), integration time (T), and equivalent sound level (LEQ). The SEL and dBA, as well as the integration time were put into a computer data file and analyzed to determine two figures of merit related to the event duration influence on the SEL energy dose metric. The data reduction is further described in Section 6.2.2; the analysis of these data is discussed in Section 9.4.

This appendix presents direct read data and contains the results of the helicopter noise duration effect analysis for flight operations. The direct read acoustical data for static operations is presented in Appendix D.

Each table within this appendix provides the following information:

Run No.	The test run number
SEL(dB)	Sound Exposure Level, expressed in decibels
AL(dB)	A-Weighted Sound Level, expressed in decibels
T(10-dB)	Integration time
K(A)	Propagation constant describing the change in dBA with distance
Q	Time hiistory "shape factor"
Average	The average of the column
N	Sample size
Std Dev	Standard Deviation
90% C.I.	Ninety percent confidence interval
Mic Site	The centerline mircophone site at which the measurements were taken

TABLE B.1.1

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT ICAO FLYOVER/TARGET IAS=135 KTS

MIC SITE: 5

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
A1	87.4	79.6	11	7.5	.5
A2	88.5	80.2	15	7.1	.5
A3	87.7	79.4	16	6.9	.4
A4	89.1	81	15	6.9	.4
A5	87.5	79.5	16	6.6	.4
A6	87.6	79.5	13	7.3	.5
AVERAGE	88.00	79.90	14.30	7.00	.5
N	6	6	6	6	6
STD.DEV.	0.68	0.63	1.97	.3	.06
90% C.I.	0.56	0.51	1.62	.25	.05

TABLE B.1.2

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT ICAO FLYOVER/TARGET IAS=135 KTS

MIC SITE: 1

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
A1	88	80.7	10	7.3	.5
A2	88.8	80.9	12	7.3	.5
A3	88.9	80	14	7.8	.6
A4	89.4	81.2	15	7	.4
A5	87.8	79.9	13	7.1	.5
A6	88.2	79.5	16	7.2	.5
AVERAGE	88.50	80.40	13.30	7.30	.5
N	6	6	6	6	6
STD.DEV.	0.61	0.66	2.16	.27	.04
90% C.I.	0.51	0.54	1.78	.22	.04

TABLE B.1.3

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT ICAO FLYOVER/TARGET IAS=135 KTS

MIC SITE: 4

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
A1	87.6	79.7	14	6.9	.4
A2	88.3	80.2	12	7.5	.5
A3	89.6	81.1	16	7.1	.4
A4	88.9	80.3	17	7	.4
A5	87.7	79.6	16	6.7	.4
A6	87.6	79.3	15	7.1	.5
AVERAGE	88.30	80.00	15.00	7.00	.5
N	6	6	6	6	6
STD.DEV.	0.82	0.64	1.79	.26	.05
90% C.I.	0.68	0.53	1.47	.21	.04

TABLE B.2.1

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT MILITARY FLYOVER/TARGET IAS=135 KTS

MIC SITE: 5

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
B7	89.7	82.3	9	7.8	.6
B8	91.4	85.5	7	7	.6
B9	91.8	86.1	9	6	.4
B10	90.6	83.8	9	7.1	.5
AVERAGE	90.90	84.40	8.50	7.00	.5
N	4	4	4	4	4
STD.DEV.	0.93	1.72	1.00	.74	.08
90% C.I.	1.09	2.02	1.18	.87	.1

TABLE B.2.2

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT MILITARY FLYOVER/TARGET IAS=135 KTS

MIC SITE: 1

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
B7	91	83.1	14	6.9	.4
B8	92.2	85.8	10	6.4	.4
B9	92.6	87.9	7	5.6	.4
B10	90.4	82.7	13	6.9	.5
AVERAGE	91.60	84.90	11.00	6.40	.4
N	4	4	4	4	4
STD.DEV.	1.02	2.44	3.16	.63	.01
90% C.I.	1.21	2.87	3.72	.74	.02

TABLE B.2.3

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT MILITARY FLYOVER/TARGET IAS=135 KTS

MIC SITE: 4

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
B7	91.4	82.4	13	8.1	.6
B8	92.5	85.3	12	6.7	.4
B9	90.7	84.9	7	6.9	.5
B10	89.4	81.4	16	6.6	.4
AVERAGE	91.00	83.50	12.00	7.10	.5
N	4	4	4	4	4
STD.DEV.	1.30	1.90	3.74	.68	.1
90% C.I.	1.53	2.23	4.40	.8	.12

TABLE B.3.1

HELICOPTER: BOEING-VERTCL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT FLYOVER/TARGET IAS=135 KTS

MIC SITE: 5

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
C11	86.3	77.5	12	8.2	.6
C12	87.6	79.8	12	7.2	.5
C13	87.7	79.6	15	6.9	.4
C14	87.7	79.7	13	7.2	.5
AVERAGE	87.30	79.20	13.00	7.40	.5
N	4	4	4	4	4
STD.DEV.	0.68	1.10	1.41	.55	.09
90% C.I.	0.81	1.30	1.66	.65	.1

TABLE B.3.2

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT FLYOVER/TARGET IAS=135 KTS

MIC SITE: 1

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
C11	87.9	80.8	9	7.4	.6
C12	89.3	82	10	7.3	.5
C13	89.1	80.9	10	8.2	.7
C14	88.5	81.1	11	7.1	.5
AVERAGE	88.70	81.20	10.00	7.50	.6
N	4	4	4	4	4
STD.DEV.	0.63	0.55	0.82	.48	.07
90% C.I.	0.74	0.64	0.96	.56	.08

TABLE B.3.3

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT FLYOVER/TARGET IAS=135 KTS

MIC SITE: 4

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
C11	87.1	79.7	12	6.9	.5
C12	89.4	81.2	11	7.9	.6
C13	88.5	81.2	9	7.7	.6
C14	88.3	80	12	7.7	.6
AVERAGE	88.30	80.50	11.00	7.50	.6
N	4	4	4	4	4
STD.DEV.	0.95	0.79	1.41	.45	.07
90% C.I.	1.11	0.93	1.66	.53	.08

TABLE B.4.1

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT FLYOVER/TARGET IAS=120 KTS

MIC SITE: 5

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
D15	86.2	78.6	12	7	.5
D16	86.5	78.1	15	7.1	.5
D17	86.5	79.1	12	6.9	.5
D18	87	79	16	6.6	.4
D19	85.9	77.9	15	6.8	.4
AVERAGE	86.40	78.50	14.00	6.90	.4
N	5	5	5	5	5
STD.DEV.	0.41	0.53	1.87	.2	.03
90% C.I.	0.39	0.51	1.78	.19	.03

TABLE B.4.2

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT FLYOVER/TARGET IAS=120 KTS

MIC SITE: 1

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
D15	86.9	79.7	10	7.2	.5
D16	87.5	79.3	13	7.4	.5
D17	86.6	78.7	12	7.3	.5
D18	88	79.7	12	7.7	.6
D19	87	79.4	10	7.6	.6
AVERAGE	87.20	79.40	11.40	7.40	.5
N	5	5	5	5	5
STD.DEV.	0.55	0.41	1.34	.2	.03
90% C.I.	0.53	0.39	1.28	.19	.03

TABLE B.4.3

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT FLYOVER/TARGET IAS=120 KTS

MIC SITE: 4

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
D15	NA	NA	NA	NA	NA
D16	87.2	78.7	14	7.4	.5
D17	85.5	77.5	14	7	.5
D18	87.2	78.3	13	8	.6
D19	86.8	78.7	12	7.5	.5
AVERAGE	86.70	78.30	13.30	7.50	.5
N	4	4	4	4	4
STD.DEV.	0.81	0.57	0.96	.41	.06
90% C.I.	0.95	0.67	1.13	.49	.07

TABLE B.5.1

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT FLYOVER/TARGET IAS=105 KTS

MIC SITE: 5

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
E20	88.9	80.2	11	8.4	.7
E21	85.3	76.6	10	8.7	.7
E22	85.8	76.7	13	8.2	.6
E23	NA	NA	10	NA	NA
E24	86	76.3	15	8.2	.6
E25	86.4	78.4	13	7.2	.5
AVERAGE	86.50	77.60	12.00	8.10	.6
N	5	5	6	5	5
STD.DEV.	1.41	1.65	2.00	.57	.09
90% C.I.	1.34	1.57	1.65	.54	.09

TABLE B.5.2

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT FLYOVER/TARGET IAS=105 KTS

MIC SITE: 1

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
E20	90.2	82.1	13	7.3	.5
E21	86.8	79.1	11	7.4	.5
E22	87.6	78.3	16	7.7	.5
E23	86.3	78.4	13	7.1	.5
E24	87.1	78.3	18	7	.4
E25	86.6	78.2	13	7.5	.5
AVERAGE	87.40	79.10	14.00	7.30	.5
N	6	6	6	6	6
STD.DEV.	1.43	1.52	2.53	.27	.05
90% C.I.	1.17	1.25	2.08	.22	.04

TABLE B.5.3

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT FLYOVER/TARGET IAS=105 KTS

MIC SITE: 4

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
E20	88.6	80.1	NA	NA	NA
E21	86.7	77.9	NA	NA	NA
E22	86.9	77.7	NA	NA	NA
E23	86	77.8	NA	NA	NA
E24	86.8	77.5	NA	NA	NA
E25	NA	NA	NA	NA	NA
AVERAGE	87.00	78.20			
N	5	5			
STD.DEV.	0.96	1.07			
90% C.I.	0.92	1.02			

TABLE B.6.1

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 1000 FT FLYOVER/TARGET IAS=135 KTS

MIC SITE: 5

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
F26	83.8	74.9	16	7.4	.5
F27	84	76.9	15	6	.3
F28	82.7	74.2	17	6.9	.4
F29	82.2	74.1	20	6.2	.3
AVERAGE	83.20	75.00	17.00	6.60	.4
N	4	4	4	4	4
STD.DEV.	0.87	1.30	2.16	.62	.07
90% C.I.	1.02	1.53	2.54	.74	.09

TABLE B.6.2

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 1000 FT FLYOVER/TARGET IAS=135 KTS

MIC SITE: 1

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
F26	84.9	75.2	17	7.9	.5
F27	84.6	76.6	14	7	.5
F28	83.9	75.1	15	7.5	.5
F29	84.1	75.6	18	6.8	.4
AVERAGE	84.40	75.60	16.00	7.30	.5
N	4	4	4	4	4
STD.DEV.	0.46	0.68	1.83	.5	.07
90% C.I.	0.54	0.81	2.15	.59	.08

TABLE B.6.3

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 1000 FT FLYOVER/TARGET IAS=135 KTS

MIC SITE: 4

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
F26	84	74	NA	NA	NA
F27	84.3	74.9	NA	NA	NA
F28	83	73.6	NA	NA	NA
F29	83.7	73.9	NA	NA	NA
AVERAGE	83.80	74.10			
N	4	4			
STD.DEV.	0.56	0.56			
90% C.I.	0.66	0.66			

TABLE B.7.1

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: ICAO TAKEOFF/TARGET IAS=85 KTS

MIC SITE: 5

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
G40	92.2	85.7	9	6.8	.5
G41	92.1	85.8	12	5.8	.4
G42	92.8	87.1	9	6	.4
G43	91.8	85.8	9	6.3	.4
G44	95	89.8	6	6.7	.6
G45	94	88.4	7	6.6	.5
AVERAGE	93.00	87.10	8.70	6.40	.5
N	6	6	6	6	6
STD.DEV.	1.26	1.69	2.07	.4	.07
90% C.I.	1.04	1.39	1.70	.33	.06

TABLE B.7.2

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: ICAO TAKEOFF/TARGET IAS=85 KTS

MIC SITE: 1

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
G40	90.1	83.7	10	6.4	.4
G41	90.4	84.2	9	6.5	.5
G42	90.9	84.7	9	6.5	.5
G43	90.3	83.6	10	6.7	.5
G44	91.9	86.2	8	6.3	.5
G45	92.2	86.5	7	6.7	.5
AVERAGE	91.00	84.80	8.80	6.50	.5
N	6	6	6	6	6
STD.DEV.	0.88	1.25	1.17	.17	.03
90% C.I.	0.73	1.03	0.96	.14	.03

TABLE B.7.3

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: ICAO TAKEOFF/TARGET IAS=85 KTS

MIC SITE: 4

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
G40	88.8	81.8	NA	NA	NA
G41	88.2	80.7	NA	NA	NA
G42	89.2	82	NA	NA	NA
G43	88.2	80.3	NA	NA	NA
G44	89.5	82.5	NA	NA	NA
G45	89.8	83.2	NA	NA	NA
AVERAGE	89.00	81.80			
N	6	6			
STD.DEV.	0.67	1.09			
90% C.I.	0.55	0.90			

TABLE B.8.1

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: ICAO APPROACH/TARGET IAS=85 KTS

MIC SITE: 5

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
H30	100.5	93.5	9	7.3	.6
H31	98.7	91.3	9	7.8	.6
H32	99.6	92.1	12	6.9	.5
H33	99.8	93.7	9	6.4	.5
H34	100.2	93.8	9	6.7	.5
H35	99	82.5	9	17.3	5
AVERAGE	99.60	91.20	9.50	8.70	1.3
N	6	6	6	6	6
STD.DEV.	0.69	4.35	1.22	4.22	1.82
90% C.I.	0.57	3.58	1.01	3.47	1.49

TABLE B.8.2

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: ICAO APPROACH/TARGET IAS=85 KTS

MIC SITE: 1

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
H30	99.2	92	10	7.2	.5
H31	98.4	91	13	6.6	.4
H32	99.2	92.2	10	7	.5
H33	99.8	92.4	12	6.9	.5
H34	99.3	92.2	NA	NA	NA
H35	98.7	92	8	7.4	.6
AVERAGE	99.10	92.00	10.60	7.00	.5
N	6	6	5	5	5
STD.DEV.	0.49	0.50	1.95	.3	.06
90% C.I.	0.40	0.41	1.86	.29	.06

TABLE B.8.3

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: ICAO APPROACH/TARGET IAS=85 KTS

MIC SITE: 4

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
H30	98	89.8	NA	NA	NA
H31	97.6	89.7	NA	NA	NA
H32	98.3	90.3	NA	NA	NA
H33	99.1	90.4	NA	NA	NA
H34	98.5	91.3	NA	NA	NA
H35	97.6	90.1	NA	NA	NA
AVERAGE	98.20	90.30			
N	6	6			
STD.DEV.	0.58	0.58			
90% C.I.	0.48	0.47			

TABLE B.9.1

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: MILITARY APPROACH/TARGET IAS=70 KTS

MIC SITE: 5

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
136	100.4	93.1	10	7.3	.5
137	99.2	90.8	NA	NA	NA
138	100.1	94.1	9	6.3	.4
139	99.9	93	10	6.9	.5
AVERAGE	99.90	92.80	9.70	6.80	.5
N	4	4	3	3	3
STD.DEV.	0.51	1.39	0.58	.51	.05
90% C.I.	0.60	1.64	0.97	.86	.08

TABLE B.9.2

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: MILITARY APPROACH/TARGET IAS=70 KTS

MIC SITE: 1

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
136	100	92.3	12	7.1	.5
137	98.6	90.4	13	7.4	.5
138	100.6	92.9	11	7.4	.5
139	99.4	91.3	12	7.5	.5
AVERAGE	99.70	91.70	12.00	7.30	.5
N	4	4	4	4	4
STD.DEV.	0.85	1.10	0.82	.16	.02
90% C.I.	1.01	1.30	0.96	.18	.03

TABLE B.9.3

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: MILITARY APPROACH/TARGET IAS=70 KTS

MIC SITE: 4

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
I36	98	89.7	NA	NA	NA
I37	97.7	88.8	NA	NA	NA
I38	98.7	90.6	NA	NA	NA
I39	98.5	90	NA	NA	NA
AVERAGE	98.20	89.80			
N	4	4			
STD.DEV.	0.46	0.75			
90% C.I.	0.54	0.88			

TABLE B.10.1

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: TAKEOFF/TARGET IAS=85 KTS

MIC SITE: 5

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
J47	84.2	77.3	16	5.7	.3
J49	86.5	78	14	7.4	.5
J51	87.9	80.5	11	7.1	.5
AVERAGE	86.20	78.60	13.70	6.80	.4
N	3	3	3	3	3
STD.DEV.	1.87	1.68	2.52	.9	.11
90% C.I.	3.15	2.84	4.24	1.51	.19

TABLE B.10.2

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: TAKEOFF/TARGET IAS=85 KTS

MIC SITE: 1

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
J47	85.8	77.6	16	6.8	.4
J49	86.6	79	13	6.8	.4
J51	87.8	79.8	13	7.2	.5
AVERAGE	86.70	78.80	14.00	6.90	.4
N	3	3	3	3	3
STD.DEV.	1.01	1.11	1.73	.21	.04
90% C.I.	1.70	1.88	2.92	.36	.06

TABLE B.10.3

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: TAKEOFF/TARGET IAS=85 KTS

MIC SITE: 4

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
J47	84.6	75.8	NA	NA	NA
J49	85.7	76.7	NA	NA	NA
J51	86.2	77.1	NA	NA	NA
AVERAGE	85.50	76.50			
N	3	3			
STD.DEV.	0.82	0.67			
90% C.I.	1.38	1.12			

TABLE B.11.1

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: APPROACH/TARGET IAS=100 KTS

MIC SITE: 5

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
K46	97.3	89.8	12	6.9	.5
K48	97.5	91.4	NA	NA	NA
K50	97.1	91.4	NA	NA	NA
K52	96.5	89.8	NA	NA	NA
AVERAGE	97.10	90.60	12.00	6.90	.5
N	4	4	1	1	1
STD.DEV.	0.43	0.92			
90% C.I.	0.51	1.09			

TABLE B.11.2

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: APPROACH/TARGET IAS=100 KTS

MIC SITE: 1

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
K46	98.1	91.1	10	7	.5
K48	NA	NA	9	NA	NA
K50	97	91	9	6.3	.4
K52	97.3	91.1	9	6.5	.5
AVERAGE	97.50	91.10	9.30	6.60	.5
N	3	3	4	3	3
STD.DEV.	0.57	0.06	0.50	.37	.03
90% C.I.	0.96	0.10	0.59	.62	.05

TABLE B.11.3

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: APPROACH/TARGET IAS=100 KTS

MIC SITE: 4

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
K46	97.6	90.2	NA	NA	NA
K48	95.9	89	NA	NA	NA
K50	96.4	89.6	NA	NA	NA
K52	96.6	89.5	NA	NA	NA
AVERAGE	96.60	89.60			
N	4	4			
STD.DEV.	0.71	0.49			
90% C.I.	0.84	0.58			

TABLE B.12.1

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: MILITARY TAKEOFF/TARGET IAS=70 KTS

MIC SITE: 5

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
L53	91	85	9	6.3	.4
L54	90.8	84.8	9	6.3	.4
L55	91.6	85.4	9	6.5	.5
AVERAGE	91.10	85.10	9.00	6.40	.4
N	3	3	3	3	3
STD.DEV.	0.42	0.31	0.00	.12	.01
90% C.I.	0.70	0.52	0.00	.2	.02

TABLE B.12.2

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: MILITARY TAKEOFF/TARGET IAS=70 KTS

MIC SITE: [illegible]

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
L53	90.2	83.7	9	6.8	.5
L54	90.3	83.3	11	6.7	.5
L55	90.4	83.5	11	6.6	.4
AVERAGE	90.30	83.50	10.30	6.70	.5
N	3	3	3	3	3
STD.DEV.	0.10	0.20	1.15	.09	.03
90% C.I.	0.17	0.34	1.95	.16	.05

TABLE B.12.3

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: MILITARY TAKEOFF/TARGET IAS=70 KTS

MIC SITE: 4

RUN NO.	SEL(DB)	AL(DB)	T(10-DB)	K(A)	Q
L53	88	79.5	NA	NA	NA
L54	88.6	81	NA	NA	NA
L55	89.4	81.5	NA	NA	NA
AVERAGE	88.70	80.70			
N	3	3			
STD.DEV.	0.70	1.04			
90% C.I.	1.18	1.75			

APPENDIX C

Magnetic Recording Acoustical Data for Static Operations

This appendix contains time averaged, A-weighted sound level data along with time averaged, one-third octave sound pressure level information for eight different directivity emission angles. These data were acquired June 6 using the TSC magnetic recording system discussed in Section 5.6.1.

Thirty-two seconds of corrected raw spectral data (64 contiguous 1/2 second data records) have been energy averaged to produce the data tabulated in this appendix. The spectral data presented are "As Measured" for the given emission angles established relative to each microphone location. Also included in the tables are the 360 degree (eight emission angle) average levels, calculated by both arithmetic and energy averaging. The data reduction is further described in Section 6.1. Figure 6.1 (previously shown) provides the reader with a quick reference to the emission angle convention.

The data contained in these tables have been used in analyses presented in Sections 9.2 and 9.7. The reader may cross reference the magnetic recording data of this appendix with direct read static data presented in Appendix D.

Appendix C

"As Measured" 1/3 Octave Noise Data--Static Test are presented.

The key to the table numbering system is as follows:

Table No. C. 1-1H. 1

Appendix No.

Helicopter No. & Microphone Location

Page No. of Group

Table No.	C.1-X.X	Aerospatiale	SA-365N (Dauphin)
	C.2-X.X	Aerospatiale	SA-355F (Twinstar)
	C.3-X.X	Aerospatiale	AS-350D (Astar)
	C.4-X.X	Sikorsky	S-76 (Spirit)
	C.5-X.X	Bell	222
	C.6-X.X	Hughes	500D
	C.7-X.X	Boeing Vertol	CH-470D (Shinook)

Microphone No.	1H	(soft)	150 m northwest
	2	(soft)	150 m west
	4H	(soft)	300 m west
	5H	(hard)	150 m north

Page No.	1	Hover-in-Ground-Effect
	2	Flight Idle
	3	Ground Idle
	4	Hover-Out-of-Ground-Effect

TABLE NO. C.7-1H.1 (REV.1)

BOEING VERTOL CH-47D HELICOPTER (CHINOOK) DOT/TSC 6/11/84

1/3 OCTAVE NOISE DATA -- STATIC TESTS

AS MEASURED****

SITE: 1H (SOFT) - 150 M. NW JULY 12,1983

HOVER-IN-GROUND-EFFECT

BAND NO.	LEVELS @ ACOUSTIC EMMISION ANGLES OF (DEGREES) 0	45	90	135	180	225	270	315	AVERAGE LEVEL OVER 360 DEGREES ENERGY *	AVE **	ARITH ***	Std Dv
	SOUND PRESSURE LEVEL dB re 20 microPascal											
14	84.6	89.4	81.2	86.7	88.7	83.9	83.0	85.2	96.1	41.4	85.3	2.8
15	81.6	87.9	77.5	88.7	80.0	82.5	80.1	72.5	83.9	44.5	81.3	5.3
16	73.9	80.1	83.5	80.7	76.1	75.0	72.1	73.7	78.6	44.0	76.9	4.0
17	73.9	81.0	87.3	83.0	79.2	79.4	73.4	77.5	81.5	51.3	79.3	4.6
18	79.3	84.7	84.8	83.3	82.6	80.6	74.1	77.6	82.0	55.8	80.9	3.7
19	79.0	86.0	84.0	83.8	83.3	77.4	71.3	75.7	82.1	59.6	80.1	5.1
20	78.3	87.7	86.0	82.8	79.8	80.4	72.8	76.4	82.8	63.7	80.5	4.9
21	77.9	88.4	82.3	62.3	79.3	77.1	70.9	74.6	82.0	65.9	79.1	5.3
22	73.7	84.9	77.6	79.6	75.9	73.6	67.1	70.9	78.5	65.1	75.4	5.5
23	67.9	76.2	68.9	73.2	68.8	67.8	57.3	63.4	70.6	59.7	67.9	5.7
24	60.1	67.8	60.2	63.3	61.5	61.5	50.3	56.0	62.3	53.7	60.1	5.2
25	58.8	62.9	57.5	59.1	59.8	61.2	52.6	54.4	59.3	52.7	58.3	3.4
26	61.7	66.4	58.1	61.2	61.5	63.4	54.8	55.3	61.8	57.0	60.3	4.0
27	62.2	73.5	61.4	64.2	64.9	65.8	57.9	57.0	66.5	63.3	63.4	5.2
28	62.5	69.6	60.7	65.0	64.6	66.6	59.4	57.8	64.8	62.9	63.3	3.9
29	63.4	69.8	62.6	67.2	66.3	67.6	61.6	60.3	65.9	65.1	64.8	3.3
30	62.9	69.3	61.9	67.1	65.3	66.3	60.9	60.0	65.3	65.3	64.2	3.3
31	63.2	68.8	60.9	66.9	64.7	65.2	58.6	61.2	64.8	65.4	63.7	3.4
32	64.0	68.8	60.4	67.4	64.5	65.4	56.9	62.9	65.0	66.0	63.8	3.8
33	64.0	68.1	59.5	67.1	64.5	64.7	55.6	63.6	64.7	65.9	63.4	4.1
34	62.3	65.5	57.1	65.2	62.8	62.6	53.8	61.7	62.6	63.9	61.4	4.0
35	62.8	66.1	55.6	63.8	61.3	61.8	52.7	63.3	62.4	63.6	60.9	4.5
36	61.6	64.5	53.8	62.3	60.1	59.9	51.1	61.3	60.8	61.8	59.3	4.5
37	60.9	64.0	52.9	60.8	58.4	58.4	50.7	61.1	60.0	60.5	58.4	4.5
38	61.9	65.4	52.8	59.9	57.6	57.5	50.2	62.4	60.6	60.5	58.5	5.1
39	66.4	70.6	55.3	60.5	57.4	57.8	52.4	68.4	65.0	63.9	61.1	6.6
40	52.8	56.2	47.1	53.4	51.1	50.5	43.5	53.1	52.3	49.8	51.0	4.0
AL	75.2	81.4	74.2	77.8	75.7	76.0	68.7	74.4	76.6	76.6	75.4	3.6
OASPL	89.2	96.2	93.3	94.0	92.1	89.7	86.3	88.0	92.2	-	91.1	3.3
PNL	90.2	97.2	91.5	92.9	90.5	90.2	81.9	89.2	92.2	-	90.4	4.3
PNLT	91.7	98.9	92.4	93.6	90.9	90.9	82.8	91.0	93.6	-	91.5	4.4

BANDS 14 TO 40 - STANDARD 1/3 OCTAVE BANDS 25 TO 10KHz

* - UNWEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
** - A-WEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
*** - UNWEIGHTED ARITHMETIC AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

**** - 32 SECOND AVERGING TIME

TABLE NO. C.7-1H.2 (REV.1)

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/11/84

1/3 OCTAVE NOISE DATA -- STATIC TESTS

AS MEASURED****

SITE: 1H (SOFT) - 150 M. NW JULY 12,1983

FLIGHT IDLE

BAND NO.	LEVELS @ ACOUSTIC EMMISION ANGLES OF (DEGREES) 0	45	90	135	180	225	270	315	AVERAGE LEVEL OVER 360 DEGREES ENERGY *	AVE **	ARITH ***	Std Dv
	SOUND PRESSURE LEVEL dB re 20 microPascal											
14	81.8	84.8	88.4	82.8	84.6	83.0	76.4	81.8	84.0	39.3	82.9	3.4
15	81.8	80.8	74.6	73.5	79.3	77.1	73.0	81.9	79.0	39.6	77.7	3.7
16	72.5	73.8	79.8	71.7	70.6	75.7	70.8	74.7	74.8	40.2	73.7	3.1
17	68.4	75.9	84.4	76.8	71.0	79.8	74.7	75.8	78.3	48.1	75.8	4.9
18	72.2	73.8	72.5	75.7	73.5	74.0	71.2	70.3	73.2	47.0	72.9	1.7
19	66.4	71.5	74.9	71.7	68.1	72.0	69.3	66.2	70.9	48.4	70.0	3.0
20	67.0	72.7	77.9	73.6	69.4	73.4	71.8	68.0	73.0	53.9	71.7	3.5
21	66.3	73.2	73.2	72.1	68.9	72.6	69.2	67.6	71.1	55.0	70.4	2.7
22	63.6	69.8	69.2	68.8	65.5	69.7	65.9	64.4	67.7	54.3	67.1	2.5
23	56.7	63.6	61.5	63.1	59.0	63.7	59.8	57.6	61.3	50.4	60.6	2.8
24	46.2	51.7	51.9	52.5	50.6	53.6	47.1	47.1	50.8	42.2	50.1	2.9
25	42.5	46.9	47.7	46.5	47.1	48.8	43.9	44.0	46.4	39.8	45.9	2.2
26	45.4	49.5	49.3	49.1	49.9	51.2	47.3	47.4	49.0	44.2	48.6	1.8
27	47.4	51.2	51.7	50.0	51.7	53.7	50.2	49.5	51.0	47.8	50.7	1.9
28	49.5	52.9	53.5	51.3	52.7	54.0	51.6	51.0	52.3	50.4	52.1	1.5
29	52.1	54.9	56.2	55.2	53.8	55.4	53.5	53.0	54.5	53.7	54.3	1.4
30	52.9	55.2	56.6	56.0	54.4	55.4	54.1	53.3	54.9	54.9	54.7	1.3
31	53.7	55.5	57.3	57.0	54.8	55.4	54.2	54.0	55.4	56.0	55.2	1.3
32	55.5	57.7	58.5	58.1	55.6	56.5	55.1	56.9	56.9	57.9	56.7	1.3
33	55.7	57.8	58.4	58.7	56.1	56.1	54.3	56.8	57.0	58.2	56.7	1.5
34	55.8	57.0	58.3	58.4	55.1	55.9	53.9	55.9	56.5	57.8	56.3	1.5
35	56.6	57.4	59.2	59.1	55.1	56.1	54.1	57.3	57.2	58.4	56.9	1.8
36	57.3	57.8	59.5	59.5	55.0	56.0	53.5	57.7	57.5	58.5	57.0	2.1
37	57.0	58.5	58.8	58.3	53.8	55.0	52.4	57.6	56.9	57.4	56.4	2.4
38	63.9	69.7	60.1	58.5	54.9	55.9	54.6	66.4	63.7	63.6	60.5	5.6
39	54.7	57.8	56.7	55.9	51.9	52.4	49.5	55.1	54.9	53.8	54.2	2.8
40	49.9	51.1	52.7	52.3	47.7	48.7	45.6	49.3	50.2	47.7	49.7	2.4
AL	68.5	72.3	70.5	69.8	66.7	68.2	66.0	69.9	69.4	69.4	69.0	2.1
OASPL	85.6	87.7	90.9	85.8	86.5	86.8	82.0	86.2	87.1	-	86.4	2.5
PNL	84.0	88.6	86.1	85.2	81.6	83.5	80.9	85.7	85.4	-	84.4	2.5
PNLT	85.4	90.5	86.7	85.5	82.2	83.7	81.5	87.4	86.7	-	85.4	2.9

BANDS 14 TO 40 - STANDARD 1/3 OCTAVE BANDS 25 TO 10KHz

* - UNWEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
** - A-WEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
*** - UNWEIGHTED ARITHMETIC AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

**** - 32 SECOND AVERGING TIME

TABLE NO. C.7-1H.3 (REV.1)

BOEING VERTOL CH-47D HELICOPTER (CHINOOK) DOT/TSC 6/11/84

1/3 OCTAVE NOISE DATA -- STATIC TESTS

AS MEASURED****

SITE: 1H (SOFT) - 150 M. NW JULY 12,1983

GROUND IDLE

BAND NO.	LEVELS @ ACOUSTIC EMMISION ANGLES OF (DEGREES)								AVERAGE LEVEL OVER 360 DEGREES			
	0	45	90	135	180	225	270	315	ENERGY *	AVE **	ARITH ***	Std Dv
	SOUND PRESSURE LEVEL dB re 20 microPascal											
14	47.6	48.2	58.5	53.3	50.9	56.3	54.8	52.7	54.2	9.5	52.8	3.8
15	49.2	48.5	66.0	56.4	55.7	60.8	61.0	55.9	59.9	20.5	56.7	5.9
16	49.6	50.3	60.4	61.6	56.0	60.5	57.5	52.0	57.9	23.3	56.0	4.8
17	49.8	50.0	58.6	56.9	55.0	59.8	59.0	52.5	56.6	26.4	55.2	4.0
18	51.2	50.8	60.9	62.1	57.4	60.9	63.3	54.3	59.6	33.4	57.6	5.0
19	54.1	52.6	65.0	62.2	59.9	63.8	66.2	56.6	62.2	39.7	60.0	5.1
20	53.5	51.4	64.4	61.3	60.2	62.2	63.4	56.8	60.9	41.8	59.1	4.8
21	54.1	50.1	62.1	60.7	58.2	60.9	61.9	56.1	59.4	43.3	58.0	4.3
22	49.4	45.0	54.5	56.8	53.3	56.7	56.9	50.3	54.3	40.9	52.9	4.3
23	39.9	37.5	47.8	48.4	46.5	48.6	50.2	41.7	46.8	35.9	45.1	4.7
24	35.9	30.8	38.2	39.8	39.8	39.4	38.7	35.6	38.0	29.4	37.3	3.1
25	34.4	30.1	34.1	39.6	39.5	38.0	37.0	34.9	36.9	30.3	35.9	3.2
26	34.4	31.9	36.5	43.0	40.5	39.8	39.0	36.4	38.9	34.1	37.7	3.6
27	35.8	33.5	37.2	40.8	41.6	41.0	41.2	35.8	39.3	36.1	38.4	3.2
28	35.7	35.0	38.8	43.9	41.8	43.8	43.5	36.6	41.2	39.3	39.9	3.8
29	39.8	38.7	40.3	46.2	43.6	46.2	44.8	38.6	43.3	42.5	42.3	3.3
30	42.6	43.3	41.4	45.5	45.4	47.8	45.7	42.6	44.8	44.8	44.3	2.2
31	44.6	45.7	43.8	47.2	47.9	50.4	47.4	43.9	46.9	47.5	46.4	2.3
32	45.9	43.6	42.1	46.1	47.6	51.0	48.0	42.8	46.8	47.8	45.9	3.0
33	52.8	47.4	45.0	47.8	48.8	53.3	50.7	46.7	50.0	51.2	49.1	3.0
34	51.1	48.5	44.6	48.7	48.7	53.5	51.6	47.0	50.0	51.3	49.2	2.8
35	51.3	50.0	44.7	48.5	48.3	53.3	52.3	47.8	50.2	51.4	49.5	2.8
36	52.3	52.1	44.8	48.1	48.4	53.4	52.1	48.6	50.7	51.7	50.0	2.9
37	56.3	60.0	45.8	47.6	48.1	53.2	52.4	56.5	54.8	55.3	52.5	5.0
38	51.5	52.5	43.4	46.3	46.7	51.3	50.2	48.4	49.7	49.6	48.8	3.1
39	52.1	52.1	42.0	44.4	46.1	49.1	48.0	48.2	48.9	47.8	47.7	3.5
40	55.5	47.7	38.5	42.9	41.8	46.3	45.5	43.8	48.4	45.9	45.2	5.0
AL	62.8	63.2	56.3	59.0	59.1	63.2	61.8	60.2	61.2	61.2	60.7	2.5
OASPL	64.9	64.5	72.0	69.8	67.3	71.0	71.7	65.5	69.3	-	68.3	3.2
PNL	76.7	77.6	70.8	73.6	73.2	77.4	76.4	75.4	76.3	-	75.1	2.4
PNLT	78.1	80.2	71.2	74.1	73.5	77.6	76.9	78.0	77.8	-	76.2	3.0

BANDS 14 TO 40 - STANDARD 1/3 OCTAVE BANDS 25 TO 10KHz

* - UNWEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
** - A-WEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
*** - UNWEIGHTED ARITHMETIC AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

**** - 32 SECOND AVERGING TIME

TABLE NO. C.7-1H.4 (REV.1)

BOEING VERTOL CH-47D HELICOPTER (CHINOOK) DOT/TSC 6/11/84

1/3 OCTAVE NOISE DATA -- STATIC TESTS

AS MEASURED****

SITE: 1H (SOFT) - 150 M. NW JULY 12,1983

HOVER-OUT-OF-GROUND-EFFECT

BAND NO.	LEVELS @ ACOUSTIC EMMISION ANGLES OF (DEGREES)								AVERAGE LEVEL OVER 360 DEGREES			
	0	45	90	135	180	225	270	315	ENERGY *	AVE **	ARITH ***	Std Dv
	SOUND PRESSURE LEVEL dB re 20 microPascal											
14	91.6	87.2	70.8	84.8	-	81.4	83.2	85.1	86.3	41.6	83.4	6.4
15	76.5	80.7	70.6	88.3	-	84.8	78.8	82.1	83.0	43.6	80.3	5.8
16	70.0	73.2	87.7	82.6	-	76.3	79.9	76.0	81.5	46.9	78.0	6.0
17	74.0	77.0	91.6	86.0	-	80.7	83.0	78.5	85.2	55.0	81.5	5.9
18	83.2	79.6	87.7	87.8	-	82.3	80.7	80.8	84.3	58.1	83.2	3.3
19	79.7	83.3	87.4	85.5	-	79.8	83.4	75.8	83.5	61.0	82.1	3.9
20	77.6	85.3	89.6	85.4	-	79.8	83.1	77.7	84.6	65.5	82.6	4.5
21	77.9	86.2	87.4	84.1	-	79.1	80.2	77.7	83.4	67.3	81.8	4.0
22	75.6	84.3	85.1	80.6	-	75.8	75.3	74.6	80.8	67.4	78.8	4.5
23	71.6	81.2	80.0	72.0	-	73.0	72.1	69.5	76.4	65.5	74.2	4.5
24	73.1	78.8	78.0	70.8	-	73.9	74.3	70.4	75.2	66.6	74.2	3.2
25	75.8	77.6	80.0	74.7	-	75.5	76.4	72.4	76.6	70.0	76.1	2.4
26	75.8	77.9	77.7	79.5	-	75.5	76.5	73.1	77.0	72.2	76.6	2.1
27	74.3	79.0	77.0	80.7	-	76.6	77.1	74.0	77.5	74.3	77.0	2.4
28	72.4	76.3	74.5	78.5	-	74.5	75.1	71.8	75.3	73.4	74.7	2.3
29	67.0	73.2	70.6	73.8	-	70.9	72.8	69.3	71.6	70.8	71.1	2.4
30	67.2	70.0	73.0	73.6	-	71.2	72.9	69.7	71.6	71.6	71.1	2.3
31	68.3	72.8	72.7	74.0	-	70.6	71.3	70.7	71.8	72.4	71.5	1.9
32	65.9	71.3	69.2	69.9	-	68.9	70.7	71.2	69.9	70.9	69.6	1.9
33	65.4	71.5	69.0	69.7	-	67.5	69.0	69.0	69.1	70.3	68.7	1.9
34	63.3	68.4	66.4	67.1	-	65.8	67.5	66.5	66.7	68.0	66.4	1.6
35	63.1	68.0	65.7	65.4	-	64.7	67.3	68.4	66.4	67.6	66.1	1.9
36	60.8	66.1	63.4	63.2	-	62.4	64.7	66.2	64.2	65.2	63.8	2.0
37	60.6	66.2	62.6	62.2	-	61.5	64.7	66.8	64.1	64.6	63.5	2.4
38	60.4	66.5	62.7	61.4	-	60.3	64.0	66.9	63.9	63.8	63.2	2.7
39	63.8	69.5	65.6	61.1	-	61.4	66.6	71.2	67.0	65.9	65.6	3.8
40	52.0	56.9	54.1	53.5	-	52.7	56.3	57.8	55.2	52.7	54.8	2.2
AL	79.6	84.3	83.8	84.4	-	81.4	82.7	81.4	82.8	82.8	82.5	1.8
OASPL	93.3	94.2	97.4	95.7	-	91.2	92.0	90.4	94.1	-	93.5	2.5
PNL	93.2	98.2	99.1	97.6	-	94.6	96.2	95.5	96.6	-	96.3	2.1
PNLT	94.5	99.5	100.3	98.1	-	95.4	97.3	96.9	97.8	-	97.4	2.1

BANDS 14 TO 40 - STANDARD 1/3 OCTAVE BANDS 25 TO 10KHz

* - UNWEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
** - A-WEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
*** - UNWEIGHTED ARITHMETIC AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

**** - 32 SECOND AVERGING TIME

TABLE NO. C.7-2H.1 (REV.1)

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/11/84

1/3 OCTAVE NOISE DATA -- STATIC TESTS

AS MEASURED****

SITE: 2 (SOFT) - 150 M. WEST JULY 12,1983

HOVER-IN-GROUND-EFFECT

BAND NO.	LEVELS @ ACOUSTIC EMMISION ANGLES OF (DEGREES) 0	45	90	135	180	225	270	315	AVERAGE LEVEL OVER 360 DEGREES ENERGY *	AVE **	ARITH ***	Std Dv
	SOUND PRESSURE LEVEL dB re 20 microPascal											
14	90.9	91.8	84.4	88.2	91.6	84.1	88.2	89.4	89.4	44.7	88.6	3.0
15	84.0	90.5	78.3	91.0	82.4	88.1	78.7	78.2	86.6	47.2	83.9	5.4
16	76.7	82.9	84.6	82.7	78.2	80.5	73.3	77.3	80.8	46.2	79.5	3.8
17	75.4	84.8	88.2	85.5	80.4	82.8	74.6	80.3	83.5	53.3	81.5	4.8
18	82.6	87.8	85.0	87.5	85.0	83.7	73.0	80.7	84.7	58.5	83.2	4.7
19	81.4	88.0	82.3	85.5	86.1	79.2	70.7	78.4	83.7	61.2	81.4	5.5
20	79.6	89.3	83.8	87.0	82.9	81.3	73.4	79.8	84.3	65.2	82.1	4.9
21	79.0	89.7	81.3	85.0	81.9	79.5	70.2	77.9	83.5	67.4	80.6	5.7
22	75.6	86.1	75.9	83.0	79.1	75.6	66 5	74.4	80.2	66.8	77.0	5.9
23	68.3	76.6	66.8	76.6	71.7	67.4	57.9	66.9	72.1	61.2	69.0	6.1
24	59.3	69.6	57.8	67.6	62.9	57.7	47.8	56.0	63.8	55.2	59.8	6.9
25	58.6	68.2	57.5	61.4	60.4	58.0	49.7	55.1	61.5	54.9	58.6	5.3
26	61.2	69.9	58.6	62.0	61.5	60.6	51.5	56.5	63.2	58.4	60.2	5.2
27	63.5	76.6	60.9	65.9	64.5	64.5	55.4	59.2	68.7	65.5	63.8	6.2
28	63.7	72.9	61.4	67.2	64.9	65.8	57.0	60.8	66.7	64.8	64.2	4.8
29	64.8	72.6	62.2	67.9	66.2	67.2	58.6	63.1	67.1	66.3	65.3	4.2
30	64.5	72.4	61.5	67.5	65.9	66.3	56.9	62.6	66.7	66.7	64.7	4.6
31	64.7	72.2	60.1	67.1	65.8	66.3	54.7	63.9	66.6	67.2	64.3	5.2
32	64.9	71.0	58.1	67.0	65.2	66.5	52.7	65.2	66.1	67.1	63.8	5.7
33	64.5	70.1	56.1	66.9	65.1	65.6	52.2	65.5	65.6	66.8	63.2	6.0
34	62.7	67.8	53.8	65.3	62.6	62.9	51.0	63.4	63.4	64.7	61.2	5.7
35	63.0	67.4	52.6	63.6	60.6	61.4	50.0	64.5	62.8	64.0	60.4	6.0
36	60.4	65.0	50.7	61.5	58.3	59.0	48.4	61.8	60.4	61.4	58.1	5.7
37	59.4	64.4	49.4	59.5	56.2	57.4	47.7	61.3	59.4	59.9	56.9	5.7
38	59.5	65.9	49.0	58.3	55.2	56.7	47.2	62.3	60.0	59.9	56.8	6.3
39	64.1	72.2	51.7	59.2	56.3	58.6	49.0	68.4	65.5	64.4	59.9	7.9
40	50.8	56.8	42.9	50.5	48.4	49.3	41.0	53.1	51.4	48.9	49.1	5.1
AL	75.6	83.5	72.8	79.0	76.5	76.3	66.0	75.9	77.8	77.8	75.7	5.0
OASPL	93.3	98.3	93.4	96.5	94.7	92.6	89.4	91.8	94.6	-	93.7	2.8
PNL	90.6	99.0	89.8	95.0	92.1	90.9	80.5	91.0	93.5	-	91.1	5.3
PNLT	92.1	100.9	90.8	95.8	92.9	91.8	81.3	92.8	95.1	-	92.3	5.5

BANDS 14 TO 40 - STANDARD 1/3 OCTAVE BANDS 25 TO 10KHz

* -- UNWEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
** - A-WEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
*** - UNWEIGHTED ARITHMETIC AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

**** - 32 SECOND AVERGING TIME

TABLE NO. C.7-2H.2 (REV.1)

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/12/84

1/3 OCTAVE NOISE DATA -- STATIC TESTS

AS MEASURED****

SITE: 2 (SOFT) - 150 M. WEST JULY 12,1983

FLIGHT IDLE

	LEVELS @ ACOUSTIC EMMISION ANGLES OF (DEGREES)								AVERAGE LEVEL OVER 360 DEGREES			
BAND NO.	0	45	90	135	180	225	270	315	ENERGY *	AVE **	ARITH ***	Std Dv
	SOUND PRESSURE LEVEL dB re 20 microPascal											
14	87.5	89.0	92.9	86.8	87.1	86.1	81.5	87.3	88.3	43.6	87.3	3.2
15	85.7	85.0	73.8	79.2	86.0	85.8	81.3	81.4	83.6	44.2	82.3	4.3
16	77.0	78.1	83.5	76.3	77.6	79.2	76.0	78.8	79.0	44.4	78.3	2.4
17	72.6	79.4	88.0	80.3	76.4	80.2	78.8	82.1	81.9	51.7	79.7	4.4
18	75.3	76.0	75.1	78.4	77.5	73.4	76.9	74.5	76.2	50.0	75.9	1.6
19	70.1	69.9	75.9	73.7	73.0	71.8	73.6	68.3	72.6	50.1	72.0	2.5
20	71.7	71.0	79.9	74.6	74.7	74.4	76.4	70.1	75.2	56.1	74.1	3.2
21	71.3	70.9	72.1	73.5	74.6	74.4	73.2	69.8	72.8	56.7	72.5	1.7
22	69.3	69.9	68.6	70.8	71.4	71.9	69.7	66.2	70.0	56.6	69.7	1.8
23	64.4	64.1	60.7	65.8	65.8	65.1	63.9	59.2	64.1	53.2	63.6	2.4
24	52.2	53.8	50.3	54.7	54.8	53.9	51.6	47.9	52.9	44.3	52.4	2.4
25	47.5	50.4	47.7	49.3	50.4	50.4	47.8	44.8	48.9	42.3	48.5	2.0
26	49.7	51.2	48.6	51.2	52.0	53.3	49.5	46.8	50.7	45.9	50.3	2.1
27	51.8	51.8	50.7	53.6	55.0	56.4	52.3	49.7	53.2	50.0	52.7	2.2
28	54.2	52.0	52.2	54.9	56.3	58.3	53.9	52.3	54.8	52.9	54.3	2.2
29	55.5	51.2	53.4	55.9	58.0	59.3	55.0	53.4	55.9	55.1	55.2	2.6
30	55.5	51.0	54.0	56.1	58.3	59.4	55.2	54.0	56.1	56.1	55.4	2.6
31	56.3	51.9	56.1	57.7	59.2	60.1	56.0	55.5	57.2	57.8	56.6	2.5
32	57.7	53.5	58.0	59.5	59.7	61.7	57.3	58.0	58.7	59.7	58.2	2.4
33	57.7	53.5	56.4	60.1	59.1	61.3	56.4	57.6	58.3	59.5	57.8	2.4
34	57.2	53.8	57.1	58.9	58.3	61.0	56.8	57.6	58.0	59.3	57.6	2.0
35	56.9	54.0	58.1	59.4	58.0	61.2	57.2	58.9	58.4	59.6	58.0	2.1
36	56.9	54.4	57.4	59.3	57.3	60.8	56.2	58.9	58.0	59.0	57.6	2.0
37	56.1	55.1	56.2	58.4	55.9	59.4	55.0	58.7	57.2	57.7	56.8	1.7
38	62.7	66.3	58.1	58.3	56.2	60.5	57.4	67.5	62.8	62.7	60.9	4.2
39	53.6	54.4	53.3	55.3	53.4	57.0	51.9	56.4	54.7	53.6	54.4	1.7
40	47.9	47.9	49.0	50.7	49.2	53.2	47.5	50.2	49.9	47.4	49.4	1.9
AL	69.4	69.3	69.6	70.6	70.3	72.3	68.8	71.1	70.3	70.3	70.2	1.1
OASPL	90.4	91.3	94.8	89.4	90.7	90.4	87.4	89.9	91.0	--	90.5	2.1
PNL	85.0	86.0	87.1	86.1	85.3	87.4	84.4	87.2	86.2	--	86.1	1.1
PNLT	86.3	87.9	88.0	86.4	85.7	87.6	85.0	88.9	87.3	-	87.0	1.3

BANDS 14 TO 40 - STANDARD 1/3 OCTAVE BANDS 25 TO 10KHz

* -- UNWEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
** - A-WEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
*** - UNWEIGHTED ARITHMETIC AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

**** - 32 SECOND AVERGING TIME

TABLE NO. C.7-2H.3 (REV.1)

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/11/84

1/3 OCTAVE NOISE DATA -- STATIC TESTS

AS MEASURED****

SITE: 2 (SOFT) - 150 M. WEST JULY 12,1983

GROUND IDLE

BAND NO.	LEVELS @ ACOUSTIC EMMISION ANGLES OF (DEGREES)								AVERAGE LEVEL OVER 360 DEGREES			
	0	45	90	135	180	225	270	315	ENERGY *	AVE **	ARITH ***	Std Dv
	SOUND PRESSURE LEVEL dB re 20 microPascal											
14	52.6	57.0	63.0	57.8	56.4	59.5	58.2	57.7	58.6	13.9	57.8	2.9
15	53.5	55.1	68.7	60.0	61.8	62.9	62.0	59.4	62.7	23.3	60.4	4.7
16	56.0	61.0	65.8	65.0	62.3	63.6	60.2	56.6	62.5	27.9	61.3	3.6
17	56.1	58.4	61.6	61.2	60.7	64.0	60.8	55.7	60.6	30.4	59.8	2.9
18	56.7	60.6	62.5	65.5	63.5	64.8	63.8	58.4	62.8	36.6	62.0	3.1
19	59.1	61.7	65.6	65.2	64.0	66.4	65.5	59.7	64.1	41.6	63.4	2.9
20	59.2	61.4	64.8	64.9	64.3	66.4	64.1	60.6	63.8	44.7	63.2	2.5
21	59.4	60.8	63.4	63.8	63.0	65.8	62.5	60.1	62.8	46.7	62.3	2.1
22	54.7	56.1	56.2	60.6	58.5	61.4	58.3	54.6	58.2	44.8	57.5	2.6
23	46.1	47.8	50.1	52.6	51.2	53.7	51.2	46.3	50.6	39.7	49.9	2.9
24	37.8	37.0	42.8	43.6	41.0	43.7	37.4	36.2	40.9	32.3	39.9	3.2
25	36.4	34.5	40.6	42.2	39.3	40.4	37.4	34.8	39.0	32.4	38.2	2.9
26	37.4	37.5	42.3	42.7	40.5	43.1	39.3	36.0	40.6	35.8	39.8	2.7
27	39.6	38.7	41.3	43.7	43.2	46.0	40.2	38.2	42.1	38.9	41.4	2.7
28	41.3	40.5	41.5	46.6	44.6	49.3	42.2	40.2	44.5	42.6	43.3	3.3
29	50.2	42.4	43.3	49.0	47.2	51.5	43.8	42.2	47.6	46.0	46.2	3.7
30	51.6	45.1	43.9	48.3	49.1	52.0	45.7	46.3	48.7	48.7	47.7	3.0
31	52.5	48.0	45.4	50.8	51.7	53.0	47.4	49.0	50.4	51.0	49.7	2.7
32	52.8	46.9	44.4	48.7	51.6	52.8	49.1	47.6	50.1	51.1	49.2	3.0
33	56.9	50.5	46.9	50.0	52.8	56.3	52.1	51.6	53.2	54.4	52.1	3.3
34	56.4	51.7	47.9	50.9	52.9	55.8	53.2	52.1	53.3	54.6	52.6	2.7
35	56.4	52.5	48.3	49.8	52.4	56.0	54.2	52.5	53.5	54.7	52.8	2.8
36	56.2	53.4	48.1	48.6	51.7	55.6	53.3	52.8	53.2	54.2	52.5	2.9
37	59.1	60.5	48.9	48.1	51.5	55.4	54.3	59.8	56.8	57.3	54.7	4.9
38	55.0	53.7	46.7	46.4	50.0	53.5	52.0	52.3	52.1	52.0	51.2	3.2
39	55.6	53.6	45.5	44.3	48.9	51.3	50.4	52.7	51.6	50.5	50.3	3.9
40	57.0	49.0	42.0	41.8	44.6	49.1	47.4	47.7	50.2	47.7	47.3	4.9
AL	66.9	64.5	58.9	61.0	62.8	65.9	63.2	64.1	64.0	64.0	63.4	2.6
OASPL	69.5	70.4	74.2	73.2	72.2	74.5	72.4	69.4	72.4	-	72.0	2.0
PNL	80.7	79.8	73.8	75.6	77.1	80.5	77.9	79.2	78.9	-	78.1	2.5
PNLT	81.9	82.1	74.2	76.1	77.4	80.9	78.2	81.6	80.3	-	79.0	3.0

BANDS 14 TO 40 - STANDARD 1/3 OCTAVE BANDS 25 TO 10KHz

* - UNWEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
** - A-WEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
*** - UNWEIGHTED ARITHMETIC AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

**** - 32 SECOND AVERGING TIME

TABLE NO. C.7-2H.4 (REV.1)

BOEING VERTOL CH-47D HELICOPTER (CHINOOK) DOT/TSC 6/11/84

1/3 OCTAVE NOISE DATA -- STATIC TESTS

AS MEASURED****

SITE: 2 (SOFT) - 150 M. WEST JULY 12,1983

HOVER-OUT-OF-GROUND-EFFECT

BAND NO.	LEVELS @ ACOUSTIC EMMISION ANGLES OF (DEGREES) 0	45	90	135	180	225	270	315	AVERAGE LEVEL OVER 360 DEGREES ENERGY *	AVE **	ARITH ***	Std Dv
	SOUND PRESSURE LEVEL dB re 20 microPascal											
14	95.3	90.8	83.5	88.5	96.3	83.7	88.6	83.9	91.4	46.7	88.8	5.1
15	80.0	84.4	75.3	91.5	82.9	89.6	78.9	87.5	86.5	47.1	83.8	5.6
16	74.0	75.9	89.8	82.7	80.9	82.2	83.1	81.2	83.6	49.0	81.2	4.8
17	76.0	78.4	93.2	85.8	84.1	85.7	85.9	83.1	86.8	56.6	84.0	5.2
18	85.1	82.6	89.1	87.1	90.1	87.4	82.6	83.9	86.8	60.6	86.0	2.9
19	82.2	84.4	88.8	87.1	86.9	82.7	83.6	76.0	85.2	62.7	84.0	4.0
20	79.3	86.6	91.2	86.2	85.7	82.1	83.9	79.0	85.9	66.8	84.2	4.1
21	79.3	87.3	88.0	83.8	85.2	80.9	81.9	79.1	84.4	68.3	83.2	3.4
22	76.2	85.7	86.2	82.4	82.5	77.8	76.8	77.2	82.2	68.8	80.6	4.1
23	71.0	80.9	80.5	75.7	75.3	73.6	72.1	70.3	76.6	65.7	74.9	4.0
24	68.5	75.8	76.7	72.0	73.5	75.9	70.9	69.6	73.8	65.2	72.9	3.1
25	72.2	76.1	79.6	78.3	77.7	80.2	75.4	73.7	77.4	70.8	76.6	2.8
26	73.6	79.0	79.3	80.7	77.6	80.0	75.6	74.6	78.2	73.4	77.5	2.7
27	74.3	80.7	78.9	82.2	77.0	79.4	76.1	75.2	78.7	75.5	78.0	2.8
28	71.7	79.9	78.7	78.8	73.6	74.7	73.8	72.1	76.5	74.6	75.4	3.2
29	66.7	73.1	73.0	73.5	70.3	73.9	71.2	69.7	71.9	71.1	71.4	2.5
30	68.4	74.2	74.6	74.8	71.8	74.6	73.3	70.9	73.3	73.3	72.8	2.3
31	68.8	76.5	73.8	75.1	69.4	70.8	71.1	71.7	72.9	73.5	72.1	2.7
32	66.8	72.6	71.2	70.9	68.0	70.9	70.4	71.8	70.6	71.6	70.3	1.9
33	66.9	73.6	71.4	70.7	67.6	69.1	69.4	70.0	70.3	71.5	69.8	2.1
34	64.8	70.4	68.6	68.4	65.1	67.4	68.0	67.6	67.9	69.2	67.5	1.8
35	65.2	70.7	68.2	67.5	63.8	66.8	67.7	70.3	68.1	69.3	67.5	2.3
36	62.8	68.4	65.9	64.9	62.5	64.3	65.1	67.6	65.6	66.6	65.2	2.1
37	62.3	68.0	64.6	62.7	59.5	63.1	64.7	67.9	64.9	65.4	64.1	2.9
38	61.9	67.9	63.8	61.6	58.3	62.2	63.8	68.1	64.5	64.4	63.4	3.3
39	65.5	71.0	66.3	62.0	57.4	63.4	65.8	72.4	67.6	66.5	65.5	4.8
40	53.3	58.3	55.5	53.7	51.4	55.4	56.4	58.6	55.9	53.4	55.3	2.5
AL	79.6	86.2	85.4	85.5	82.2	83.9	82.3	82.4	83.9	83.9	83.4	2.2
OASPL	96.4	96.1	99.0	97.1	98.8	95.1	94.0	92.7	96.6	-	96.1	2.2
PNL	93.8	99.7	100.6	98.8	96.5	97.3	96.3	97.0	97.8	-	97.5	2.2
PNLT	95.1	101.0	101.7	99.6	97.3	98.1	97.3	98.5	99.0	-	98.6	2.1

BANDS 14 TO 40 - STANDARD 1/3 OCTAVE BANDS 25 TO 10KHz

* -- UNWEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
** - A-WEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
*** -- UNWEIGHTED ARITHMETIC AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

**** - 32 SECOND AVERGING TIME

TABLE NO. C.7-4H.1 (REV.1)

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/11/84

1/3 OCTAVE NOISE DATA -- STATIC TESTS

AS MEASURED****

SITE: 4H (SOFT) - 300 M. WEST JULY 12,1983

HOVER-IN-GROUND-EFFECT

BAND NO.	LEVELS @ ACOUSTIC EMMISION ANGLES OF (DEGREES) 0	45	90	135	180	225	270	315	AVERAGE LEVEL OVER 360 DEGREES ENERGY *	AVE **	ARITH ***	Std Dv
	SOUND PRESSURE LEVEL dB re 20 microPascal											
14	81.1	76.7	75.2	78.4	81.6	74.3	79.4	81.1	79.2	34.5	78.5	2.8
15	74.0	76.0	71.4	81.8	72.3	77.8	71.0	74.0	76.3	36.9	74.8	3.6
16	67.5	68.6	77.4	73.4	69.6	70.3	65.3	72.2	72.1	37.5	70.5	3.8
17	66.2	69.5	79.5	75.6	71.2	72.7	65.8	74.0	74.0	43.8	71.8	4.7
18	73.1	72.0	76.2	78.3	75.7	73.9	64.9	73.4	74.6	48.4	73.4	4.0
19	71.9	72.0	71.8	74.8	77.2	70.0	60.4	71.0	72.8	50.3	71.1	4.9
20	68.1	71.8	71.8	74.1	72.2	69.7	62.1	69.8	70.9	51.8	69.9	3.7
21	63.4	70.6	66.9	70.1	69.3	65.8	56.1	65.9	67.5	51.4	66.0	4.7
22	59.9	61.4	61.2	65.2	61.3	57.4	50.8	59.5	60.9	47.5	59.6	4.2
23	61.5	59.6	57.5	67.2	59.6	53.6	47.2	58.9	61.0	50.1	58.1	5.8
24	62.9	60.4	55.6	65.6	58.7	52.6	45.4	59.7	60.5	51.9	57.6	6.4
25	63.3	57.6	53.4	63.7	58.8	52.9	45.2	60.0	59.6	53.0	56.9	6.2
26	64.9	56.7	54.1	62.4	61.1	54.2	47.0	61.5	60.3	55.5	57.7	5.9
27	65.7	61.0	56.0	64.3	63.9	57.3	49.7	63.4	62.2	59.0	60.3	5.4
28	65.6	58.4	57.6	65.6	64.6	57.9	50.8	64.2	62.7	60.8	60.6	5.3
29	67.4	65.1	60.1	67.4	66.1	60.1	52.8	66.7	65.0	64.2	63.2	5.2
30	66.5	65.2	59.3	66.8	65.3	59.5	51.7	65.7	64.3	64.3	62.5	5.3
31	65.4	65.2	58.4	66.1	64.7	59.4	50.7	66.0	63.9	64.5	62.0	5.5
32	64.3	64.3	57.0	65.7	63.6	59.7	50.6	66.1	63.3	64.3	61.4	5.4
33	63.2	64.1	55.2	65.1	63.0	59.0	50.2	64.9	62.5	63.7	60.6	5.4
34	62.0	61.9	54.2	62.0	60.0	56.6	48.6	61.5	60.0	61.3	58.3	4.9
35	61.9	61.6	53.2	59.7	57.9	54.6	47.5	62.7	59.4	60.6	57.4	5.3
36	57.7	57.4	49.7	55.5	53.9	49.8	44.0	57.9	55.1	56.1	53.2	5.0
37	55.0	55.4	47.0	52.8	50.3	46.4	41.8	56.3	52.7	53.2	50.6	5.2
38	54.2	56.0	46.1	50.7	48.6	45.2	40.5	56.1	52.3	52.2	49.7	5.6
39	55.9	59.2	45.8	48.9	46.3	44.5	39.5	59.9	54.8	53.7	50.0	7.5
40	38.7	41.0	32.6	35.7	34.4	31.1	26.9	40.6	37.2	34.7	35.1	4.9
AL	75.0	74.0	67.7	75.3	73.6	68.7	60.7	75.1	73.0	73.0	71.3	5.2
OASPL	84.0	82.7	84.4	86.6	85.1	82.4	80.6	84.5	84.1	-	83.8	1.8
PNL	87.5	87.1	81.2	88.3	86.1	81.7	73.5	87.9	85.9	-	84.2	5.1
PNLT	89.1	88.9	82.0	88.9	86.6	82.4	74.2	89.9	87.6	-	85.2	5.4

BANDS 14 TO 40 - STANDARD 1/3 OCTAVE BANDS 25 TO 10KHz

* - UNWEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

** - A-WEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

*** - UNWEIGHTED ARITHMETIC AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

**** - 32 SECOND AVERGING TIME

TABLE NO. C.7-4H.2 (REV.1)

BOEING VERTOL CH-47D HELICOPTER (CHINOOK) DOT/TSC 6/11/84

1/3 OCTAVE NOISE DATA -- STATIC TESTS

AS MEASURED****

SITE: 4H (SOFT) - 300 M. WEST JULY 12,1983

FLIGHT IDLE

BAND NO.	LEVELS @ ACOUSTIC EMMISION ANGLES OF (DEGREES) 0	45	90	135	180	225	270	315	AVERAGE LEVEL OVER 360 DEGREES ENERGY *	AVE **	ARITH ***	Std Dv
	SOUND PRESSURE LEVEL dB re 20 microPascal											
14	78.0	78.7	83.1	76.9	76.7	75.1	72.3	77.5	78.3	33.6	77.3	3.1
15	76.6	75.9	62.3	71.4	76.3	77.2	65.6	68.9	74.1	34.7	71.8	5.7
16	68.0	68.9	76.3	68.2	67.6	70.2	65.5	70.3	70.7	36.1	69.4	3.2
17	62.8	68.3	78.3	70.3	65.4	68.8	68.0	73.0	71.9	41.7	69.4	4.7
18	65.2	63.4	65.4	67.9	66.9	61.0	64.0	63.9	65.2	39.0	64.7	2.1
19	61.8	60.9	67.4	63.8	63.6	61.5	62.3	58.2	63.2	40.7	62.4	2.7
20	60.8	60.8	69.7	63.4	62.8	62.0	64.2	59.7	64.2	45.1	62.9	3.1
21	59.6	57.6	61.4	62.0	61.6	60.8	57.4	57.4	60.3	44.2	60.0	1.8
22	54.9	54.8	56.2	56.9	55.4	55.3	52.4	52.6	55.0	41.6	54.8	1.6
23	50.1	49.1	49.2	50.7	48.4	46.4	44.0	47.5	48.6	37.7	48.3	2.0
24	44.9	43.2	44.4	46.2	41.8	41.0	38.5	39.0	43.1	34.5	42.4	2.8
25	41.5	41.9	40.6	42.4	38.4	38.2	36.6	34.6	40.0	33.4	39.3	2.8
26	39.6	37.3	39.0	43.1	37.0	39.1	37.6	35.3	39.1	34.3	38.5	2.3
27	38.0	36.5	40.2	41.9	37.1	40.3	39.0	35.6	39.0	35.8	38.6	2.2
28	40.9	38.9	39.3	42.2	38.5	41.3	39.9	35.4	39.9	38.0	39.5	2.1
29	45.3	38.1	36.5	41.4	40.2	41.8	42.0	36.1	41.1	40.3	40.2	3.1
30	46.7	36.1	35.8	41.0	40.6	41.4	41.9	34.6	41.4	41.4	39.8	4.0
31	47.1	37.5	36.5	41.0	40.9	41.6	42.4	34.4	41.8	42.4	40.2	4.0
32	48.3	39.2	37.8	41.2	41.5	42.2	42.9	38.0	42.8	43.8	41.4	3.4
33	48.4	39.0	37.6	40.6	42.0	41.5	42.0	35.6	42.5	43.7	40.8	3.8
34	47.4	38.9	37.6	39.1	39.7	40.3	41.9	-	42.0	43.3	40.7	3.2
35	46.2	37.8	38.4	38.6	38.4	39.2	42.3	-	41.3	42.5	40.1	3.1
36	43.9	35.8	36.7	36.4	36.6	37.1	39.9	-	39.1	40.1	38.1	2.9
37	42.1	34.9	33.5	33.6	-	34.4	37.5	-	37.3	37.8	36.0	3.3
38	48.5	46.3	35.3	34.3	-	36.3	39.7	-	43.5	43.4	40.1	6.0
39	37.0	32.3	27.4	27.8	-	30.7	33.2	-	32.7	31.6	31.4	3.6
40	27.0	21.1	-	-	-	-	24.9	-	25.0	22.5	24.3	3.0
AL	58.3	53.0	55.8	54.4	53.7	53.8	54.3	51.3	54.9	54.9	54.3	2.1
OASPL	81.0	81.2	85.2	79.7	80.4	80.4	75.9	80.0	81.2	-	80.5	2.5
PNL	72.2	68.4	71.7	68.8	67.8	67.6	68.8	66.3	69.5	-	68.9	2.0
PNLT	73.7	70.5	72.6	69.4	68.6	66.2	69.5	68.5	70.9	-	70.1	2.0

BANDS 14 TO 40 - STANDARD 1/3 OCTAVE BANDS 25 TO 10KHz

* -- UNWEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
** -- A-WEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
*** -- UNWEIGHTED ARITHMETIC AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

**** - 32 SECOND AVERGING TIME

TABLE NO. C.7-4H.3 (REV.1)

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/11/84

1/3 OCTAVE NOISE DATA -- STATIC TESTS

AS MEASURED****

SITE: 4H (SOFT) - 300 M. WEST JULY 12,1983

GROUND IDLE*****

	LEVELS @ ACOUSTIC EMMISION ANGLES OF (DEGREES)								AVERAGE LEVEL OVER 360 DEGREES			
BAND NO.	0	45	90	135	180	225	270	315	ENERGY *	AVE **	ARITH ***	Std Dv
	SOUND PRESSURE LEVEL dB re 20 microPascal											
14	48.4	53.0	52.3	54.5	49.0	50.8	50.1	50.1	51.5	6.8	51.0	2.1
15	49.8	53.1	57.2	56.2	52.9	54.0	53.3	51.9	54.1	14.7	53.5	2.3
16	52.5	58.0	55.4	60.7	53.9	54.4	52.9	50.5	56.0	21.4	54.8	3.2
17	50.3	56.1	50.4	57.3	51.8	54.0	53.4	49.5	53.7	23.5	52.8	2.8
18	50.5	58.9	53.0	60.7	54.7	55.1	55.5	51.5	56.3	30.1	55.0	3.5
19	52.5	58.4	55.9	60.5	55.2	56.3	56.0	52.1	56.7	34.2	55.9	2.8
20	50.6	56.9	53.8	59.9	55.2	55.7	53.7	51.3	55.6	36.5	54.6	3.0
21	49.1	54.7	51.0	57.3	52.2	55.3	50.4	49.3	53.4	37.3	52.4	3.0
22	42.6	48.6	43.7	51.0	46.6	47.5	44.5	43.3	46.9	33.5	46.0	2.9
23	37.4	42.8	41.2	45.7	41.5	40.7	38.9	39.2	41.6	30.7	40.9	2.6
24	36.1	40.3	38.3	43.9	38.2	39.9	34.1	36.3	39.4	30.8	38.4	3.0
25	35.1	37.0	35.0	43.1	36.8	37.3	34.9	33.9	37.7	31.1	36.6	2.9
26	34.8	37.5	37.3	42.9	36.3	36.3	35.3	33.9	37.8	33.0	36.8	2.8
27	36.1	37.1	36.3	42.6	36.3	37.7	34.7	34.9	37.8	34.6	37.0	2.5
28	34.8	37.2	34.9	41.6	36.8	39.4	34.8	34.5	37.5	35.6	36.7	2.6
29	35.2	32.6	36.6	36.8	35.7	39.2	33.8	33.3	35.9	35.1	35.4	2.2
30	37.5	32.4	34.9	35.5	35.2	39.7	33.0	32.4	35.8	35.8	35.1	2.6
31	38.5	33.5	35.5	35.4	36.2	40.4	32.4	33.0	36.4	37.0	35.6	2.8
32	38.1	31.5	34.3	34.2	35.4	38.5	31.9	31.9	35.3	36.3	34.5	2.7
33	42.0	34.3	36.2	35.1	36.8	40.6	35.0	34.7	37.8	39.0	36.8	2.9
34	40.7	34.5	36.7	35.3	36.5	40.4	34.4	34.3	37.4	38.7	36.6	2.6
35	39.9	34.6	36.8	34.9	35.8	39.5	34.3	33.9	36.8	38.0	36.2	2.3
36	38.4	33.3	34.2	32.8	33.6	37.8	31.6	31.6	34.9	35.9	34.2	2.6
37	39.9	38.7	33.2	31.0	32.4	36.4	31.0	36.7	36.1	36.6	34.9	3.5
38	34.8	31.4	30.6	28.5	30.6	34.3	28.5	29.6	31.7	31.6	31.0	2.4
39	32.0	28.1	26.5	24.4	27.2	30.9	28.6	28.1	28.8	27.7	28.2	2.4
40	29.7	21.0	19.9	19.0	20.1	24.1	21.5	--	23.9	21.4	22.2	3.7
AL	50.5	48.2	47.6	50.4	47.9	51.1	46.1	45.9	48.9	48.9	48.5	2.0
OASPL	60.3	65.9	63.4	68.1	62.8	64.1	62.8	60.2	64.2	-	63.4	2.7
PNL	64.0	62.8	61.7	64.2	61.7	64.9	59.9	60.0	62.9	-	62.4	1.9
PNLT	65.0	65.0	62.1	64.6	61.9	65.3	60.5	62.0	63.8	-	63.3	1.9

BANDS 14 TO 40 - STANDARD 1/3 OCTAVE BANDS 25 TO 10KHz

* - UNWEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
** - A-WEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
*** - UNWEIGHTED ARITHMETIC AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

**** - 32 SECOND AVERGING TIME

*****- TABULATED LEVELS ARE CONTAMINATED BY LOCAL AMBIENT

TABLE NO. C.7-4H.4 (REV.1)

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/11/84

1/3 OCTAVE NOISE DATA -- STATIC TESTS

AS MEASURED****

SITE: 4H (SOFT) - 300 M. WEST JULY 12,1983

HOVER-OUT-OF-GROUND-EFFECT

	LEVELS @ ACOUSTIC EMMISION ANGLES OF (DEGREES)								AVERAGE LEVEL OVER 360 DEGREES			
BAND NO.	0	45	90	135	180	225	270	315	ENERGY *	AVE **	ARITH ***	Std Dv
	SOUND PRESSURE LEVEL dB re 20 microPascal											
14	81.5	82.0	76.8	79.9	82.8	76.8	81.8	76.7	80.4	35.7	79.8	2.6
15	67.1	80.6	69.7	83.0	69.1	76.2	65.7	72.4	77.0	37.6	73.0	6.4
16	64.5	72.2	78.9	74.4	70.9	73.4	75.9	73.5	74.4	39.8	73.0	4.2
17	65.4	73.5	79.9	76.6	73.0	77.7	75.3	73.4	75.8	45.6	74.3	4.3
18	70.7	75.7	79.3	75.8	78.9	77.7	75.2	73.7	76.6	50.4	75.9	2.8
19	69.5	74.9	78.6	78.0	76.8	72.5	75.0	70.0	75.5	53.0	74.4	3.5
20	67.5	76.6	80.2	76.0	74.7	74.7	74.6	70.7	75.7	56.6	74.4	[illegible]
21	70.7	78.6	78.4	76.1	76.2	75.2	75.5	71.0	76.0	59.9	75.2	3.0
22	68.7	78.5	77.6	75.3	74.7	72.7	71.0	71.1	74.8	61.4	73.7	3.4
23	66.2	76.4	74.3	73.5	72.3	71.8	69.8	67.2	72.6	61.7	71.4	3.5
24	64.4	73.1	70.0	70.8	69.3	69.8	65.7	64.8	69.4	60.8	68.5	3.1
25	62.8	68.0	66.0	68.8	66.9	69.0	65.1	63.3	66.8	60.2	66.2	2.4
26	63.4	66.9	67.9	63.0	66.5	69.9	64.5	63.4	66.9	62.1	66.3	2.4
27	63.9	67.8	68.7	70.1	67.3	73.2	67.6	65.3	68.9	65.7	68.0	2.8
28	63.6	67.8	70.9	69.9	67.9	71.2	69.0	66.3	68.9	67.0	68.3	2.5
29	64.6	70.8	71.8	71.5	66.8	71.0	69.1	66.5	69.7	68.9	69.0	2.7
30	62.8	68.1	69.5	68.2	64.1	67.5	66.4	64.3	66.9	66.9	[illegible]	2.4
31	59.3	67.3	65.8	64.1	60.2	62.8	61.5	63.3	63.8	64.4	63.0	2.7
32	58.3	63.4	61.8	61.6	59.2	62.2	61.8	62.9	61.7	62.7	61.4	1.8
33	60.5	66.4	64.8	63.2	62.6	63.3	63.1	63.3	63.7	64.9	63.4	1.7
34	58.1	64.0	[illegible]	60.4	58.1	60.3	60.4	60.3	61.0	62.3	60.5	2.0
35	57.2	63.3	60.5	58.7	55.9	59.1	60.0	61.8	60.1	61.3	59.6	2.4
36	53.0	59.2	56.9	54.8	53.2	55.2	55.6	57.2	56.1	57.1	55.6	2.1
37	50.9	58.0	54.3	51.5	48.6	52.6	53.7	56.2	54.1	54.6	53.2	3.0
38	49.8	57.3	52.9	50.1	47.1	51.0	52.0	55.7	53.1	53.0	52.0	3.3
39	49.9	57.3	51.5	47.1	43.1	48.9	50.9	57.2	52.9	51.8	50.7	4.8
40	34.3	40.8	37.6	35.8	32.2	36.3	37.3	39.6	37.5	35.0	36.7	2.8
AL	71.8	77.9	77.9	77.1	74.5	77.4	75.3	74.3	76.2	76.2	75.8	2.2
OASPL	83.5	88.4	88.6	88.3	87.1	86.3	86.3	83.4	86.9	-	86.5	2.1
PNL	84.7	91.4	90.8	89.3	87.6	89.6	88.1	88.0	89.1	-	88.7	2.1
PNLT	85.5	92.3	91.7	89.8	88.9	90.5	88.7	89.6	90.0	-	89.6	2.1

BANDS 14 TO 40 -- STANDARD 1/3 OCTAVE BANDS 25 TO 10KHz

* - UNWEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
** - A-WEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
*** - UNWEIGHTED ARITHMETIC AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

**** - 32 SECOND AVERGING TIME

TABLE NO. C.7-5H.1 (REV.1)

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

1/3 OCTAVE NOISE DATA -- STATIC TESTS

AS MEASURED****

DOT/TSC
6/11/84

SITE: 5H (HARD) - 150 M. NORTH JULY 12,1983

HOVER-IN-GROUND-EFFECT

BAND NO.	LEVELS @ ACOUSTIC EMMISION ANGLES OF (DEGREES)								AVERAGE LEVEL OVER 360 DEGREES			
	0	45	90	135	180	225	270	315	ENERGY *	AVE **	ARITH ***	Std Dv
	SOUND PRESSURE LEVEL dB re 20 microPascal											
14	86.3	87.9	82.6	86.1	86.9	84.1	84.8	85.2	85.8	41.1	85.5	1.7
15	80.0	86.6	76.4	86.6	80.1	79.0	74.9	76.1	82.1	42.7	80.0	4.5
16	72.9	78.7	81.8	80.2	73.3	72.9	70.7	71.5	77.2	42.6	75.2	4.3
17	73.6	79.1	86.7	83.1	74.3	76.4	73.3	74.0	80.5	50.3	77.6	5.0
18	78.9	82.5	81.9	82.2	79.0	77.7	72.5	74.5	79.8	53.6	78.6	3.7
19	80.4	83.0	79.9	79.6	78.6	75.5	69.1	74.6	79.1	56.6	77.6	4.4
20	77.4	83.4	81.4	80.4	77.9	77.9	71.1	77.0	79.5	60.4	78.3	3.7
21	78.8	84.2	80.3	80.1	75.8	77.3	70.2	76.8	79.4	63.3	77.9	4.1
22	76.7	83.5	77.9	79.3	74.5	76.5	70.9	74.4	78.2	64.8	76.7	3.7
23	75.4	83.7	77.2	78.3	74.0	76.9	70.6	73.6	77.9	67.0	76.2	3.9
24	74.6	82.9	73.7	76.3	72.7	75.8	70.3	72.4	76.7	68.1	74.8	3.8
25	74.1	79.1	71.4	75.4	71.5	74.7	69.2	70.6	74.4	67.8	73.2	3.2
26	72.5	78.0	68.9	73.6	70.0	73.2	66.7	69.2	72.9	68.1	71.5	3.5
27	70.3	80.9	69.6	72.5	69.8	73.0	67.5	69.6	74.1	70.9	71.6	4.1
28	68.4	76.3	68.1	72.1	68.9	71.4	66.1	68.5	71.2	69.3	70.0	3.2
29	65.5	73.6	65.7	70.2	67.1	69.2	64.6	66.8	68.9	68.1	67.8	3.0
30	63.7	71.3	64.0	68.2	65.5	66.9	62.7	64.7	66.8	66.8	65.9	2.8
31	62.4	70.0	61.1	65.6	63.5	64.5	60.2	63.7	65.0	65.6	63.9	3.0
32	62.5	68.1	59.1	63.6	62.3	63.0	59.4	63.2	63.5	64.5	62.6	2.8
33	61.7	65.2	57.5	63.0	62.0	62.0	58.3	61.1	61.9	63.1	61.3	2.5
34	60.2	62.7	55.6	61.4	60.5	60.6	56.9	59.2	60.1	61.4	59.6	2.3
35	60.3	61.4	54.4	59.8	59.2	59.4	56.3	60.0	59.3	60.5	58.8	2.3
36	59.2	59.8	53.2	58.4	58.0	57.8	55.1	58.0	57.8	58.8	57.4	2.2
37	58.9	59.1	52.4	57.6	56.9	56.9	54.7	58.0	57.2	57.7	56.8	2.3
38	59.9	60.3	51.9	56.7	56.0	55.9	54.1	59.3	57.6	57.5	56.8	2.9
39	65.2	66.2	54.8	58.0	56.4	56.7	56.7	65.8	62.3	61.2	60.0	4.9
40	51.2	50.9	45.5	50.3	49.7	49.4	47.1	50.3	49.6	47.1	49.3	2.0
AL	77.3	84.2	76.1	79.3	76.4	78.4	73.5	76.4	78.9	78.9	77.7	3.1
OASPL	90.3	94.9	91.8	92.9	90.1	89.3	86.8	88.4	91.3	-	90.6	2.6
PNL	91.3	97.3	90.9	93.1	89.9	91.5	86.4	90.0	92.6	-	91.3	3.1
PNLT	92.9	99.1	91.9	93.8	90.5	92.2	87.4	91.9	94.0	-	92.5	3.3

BANDS 14 TO 40 - STANDARD 1/3 OCTAVE BANDS 25 TO 10KHz

* - UNWEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
** - A-WEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
*** - UNWEIGHTED ARITHMETIC AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

**** - 32 SECOND AVERGING TIME

TABLE NO. C.7-5H.2 (REV.1)

BOEING VERTOL CH-47D HELICOPTER (CHINOOK) DOT/TSC 6/11/84

1/3 OCTAVE NOISE DATA -- STATIC TESTS

AS MEASURED****

SITE: 5H (HARD) - 150 M. NORTH JULY 12,1983

FLIGHT IDLE

BAND NO.	LEVELS @ ACOUSTIC EMMISION ANGLES OF (DEGREES) 0	45	90	135	180	225	270	315	AVERAGE LEVEL OVER 360 DEGREES ENERGY *	AVE **	ARITH ***	Std Dv
	SOUND PRESSURE LEVEL (dB re 20 microPascal)											
14	83.2	84.6	87.7	81.8	83.0	83.9	77.9	83.1	83.9	39.2	83.1	2.7
15	80.0	80.7	72.2	66.1	80.2	77.9	75.7	71.6	77.6	38.2	75.5	5.2
16	71.5	73.8	79.0	71.9	71.4	75.9	72.0	73.1	74.4	39.8	73.6	2.7
17	71.9	75.8	83.6	77.3	68.7	79.5	75.5	77.3	78.1	47.9	76.2	4.5
18	72.6	73.3	73.7	76.6	70.1	71.2	74.0	71.2	73.3	47.1	72.8	2.0
19	67.9	71.7	74.0	73.2	66.1	70.6	71.0	68.0	71.0	48.5	70.3	2.8
20	69.7	72.5	76.6	74.6	66.0	72.1	73.2	69.6	72.8	53.7	71.8	3.3
21	71.0	72.7	76.5	75.4	66.1	73.7	73.1	70.6	73.3	57.2	72.4	3.2
22	70.8	73.9	74.8	75.2	65.9	73.8	73.1	69.9	73.0	59.6	72.2	3.1
23	70.8	73.5	74.0	74.6	65.9	73.3	72.9	69.4	72.5	61.6	71.8	2.9
24	68.7	69.8	72.7	72.7	65.8	71.8	71.3	67.8	70.6	62.0	70.1	2.5
25	67.1	69.0	69.9	70.3	64.9	70.0	69.7	66.3	68.8	62.2	68.4	2.0
26	66.1	68.0	68.5	71.3	64.8	69.7	68.8	65.5	68.3	63.5	67.8	2.2
27	65.0	64.2	69.3	71.2	64.7	69.0	69.0	65.6	68.0	64.8	67.2	2.7
28	63.5	63.6	67.0	69.0	64.0	67.9	67.6	64.8	66.4	64.5	65.9	2.2
29	61.7	61.5	66.5	68.3	63.5	67.1	65.4	63.4	65.3	64.5	64.7	2.5
30	60.2	59.4	64.1	66.2	61.7	65.6	63.6	61.6	63.4	63.4	62.8	2.5
31	59.1	58.3	62.9	64.9	60.7	64.8	62.1	59.7	62.2	62.8	61.6	2.5
32	59.3	58.7	62.2	64.5	59.0	65.1	62.1	60.2	62.0	63.0	61.4	2.5
33	58.1	58.2	59.9	63.9	57.9	64.0	60.6	58.9	60.9	62.1	60.2	2.5
34	57.5	57.3	59.0	63.0	56.2	63.2	60.1	57.3	60.0	61.3	59.2	2.7
35	57.1	56.8	58.0	62.7	55.2	62.3	59.5	57.2	59.4	60.6	58.6	2.7
36	57.4	56.9	56.9	62.0	54.7	61.2	58.3	57.2	58.7	59.7	58.1	2.4
37	56.8	57.5	56.2	60.7	53.1	59.8	56.9	56.9	57.8	58.3	57.2	2.3
38	63.6	68.2	59.0	60.3	53.5	59.5	58.9	65.2	63.0	62.9	61.0	4.5
39	54.4	56.8	53.6	56.9	50.4	56.3	53.7	54.1	54.9	53.8	54.5	2.2
40	48.4	49.7	49.4	52.3	44.8	51.7	48.7	47.3	49.6	47.1	49.0	2.4
AL	72.7	74.1	75.5	77.5	71.6	76.7	75.2	73.2	75.0	75.0	74.6	2.0
OASPL	86.4	88.0	90.7	87.1	85.8	87.9	85.2	85.8	87.5	-	87.1	1.8
PNL	87.5	90.0	89.4	91.2	84.0	90.4	88.5	88.2	89.0	-	88.6	2.2
PNLT	88.9	91.8	90.1	91.5	84.4	90.5	89.1	89.8	90.1	-	89.5	2.3

BANDS 14 TO 40 - STANDARD 1/3 OCTAVE BANDS 25 TO 10KHz

* - UNWEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
** - A-WEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
*** - UNWEIGHTED ARITHMETIC AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

**** - 32 SECOND AVERGING TIME

TABLE NO. C.7-5H.3 (REV.1)

BOEING VERTOL CH-47D HELICOPTER (CHINOOK) DOT/TSC 6/11/84

1/3 OCTAVE NOISE DATA -- STATIC TESTS

AS MEASURED****

SITE: 5H (HARD) - 150 M. NORTH JULY 12,1983

GROUND IDLE

BAND NO.	LEVELS @ ACOUSTIC EMMISION ANGLES OF (DEGREES) 0	45	90	135	180	225	270	315	AVERAGE LEVEL OVER 360 DEGREES ENERGY *	AVE **	ARITH ***	Std Dv
	SOUND PRESSURE LEVEL dB re 20 microPascal											
14	48.9	52.0	59.0	46.0	51.4	56.8	56.5	55.3	54.9	10.2	53.2	4.4
15	51.5	52.9	66.2	48.5	54.5	58.5	61.2	57.9	59.7	20.3	56.4	5.7
16	52.8	56.5	62.7	51.1	57.4	58.1	58.1	55.3	57.8	23.2	56.5	3.6
17	54.6	54.8	62.5	48.2	55.6	59.5	59.6	55.2	57.9	27.7	56.2	4.3
18	55.5	58.2	62.2	51.0	58.7	61.4	61.6	58.2	59.4	33.2	58.3	3.7
19	56.7	59.7	63.7	51.0	60.5	65.1	64.5	60.2	61.8	39.3	60.2	4.7
20	57.0	59.9	65.4	49.9	59.7	64.8	64.5	61.2	62.2	43.1	60.3	5.1
21	58.4	60.7	65.4	50.0	60.5	65.3	65.3	62.6	62.8	46.7	61.0	5.2
22	56.5	57.8	63.8	51.1	57.6	64.8	64.1	59.7	61.3	47.9	59.4	4.7
23	54.6	56.1	61.1	48.9	56.9	63.4	63.6	58.2	59.8	48.9	57.8	4.9
24	54.1	56.4	60.2	48.7	57.2	62.7	62.6	58.3	59.2	50.6	57.5	4.6
25	53.9	57.2	60.2	52.2	58.1	64.3	63.4	58.6	60.1	53.5	58.5	4.2
26	52.8	56.3	59.2	51.1	56.9	64.2	60.9	56.7	59.0	54.2	57.3	4.2
27	52.4	54.9	58.0	47.3	56.8	62.2	59.8	55.9	57.6	54.4	55.9	4.6
28	51.7	55.0	58.1	49.3	56.7	62.6	60.7	55.3	58.0	56.1	56.2	4.4
29	50.7	53.2	56.3	60.4	56.6	62.5	60.6	54.2	58.4	57.6	56.8	4.1
30	51.7	54.2	55.5	59.1	56.2	62.5	59.9	56.0	58.1	58.1	56.9	3.4
31	51.4	55.8	55.7	60.9	57.6	63.3	59.3	56.4	58.8	59.4	57.5	3.6
32	50.4	53.1	54.7	58.9	57.1	62.8	59.1	54.7	57.9	58.9	56.3	3.9
33	53.1	57.4	55.8	60.3	57.5	63.5	60.7	57.7	59.3	60.5	58.2	3.2
34	52.7	56.0	55.5	60.8	57.2	63.9	61.0	58.9	59.5	60.8	58.2	3.6
35	52.5	55.7	55.2	59.4	56.4	63.1	61.4	58.8	59.0	60.2	57.8	3.5
36	52.9	56.6	54.6	58.1	55.7	62.4	60.5	58.9	58.4	59.4	57.5	3.1
37	57.2	63.8	56.5	56.7	55.3	62.2	61.4	65.1	61.2	61.7	59.8	3.8
38	51.6	56.6	52.7	53.8	52.8	59.5	58.1	57.0	56.1	56.0	55.3	2.9
39	52.7	56.5	51.0	51.6	51.7	57.4	56.4	56.3	54.9	53.8	54.2	2.7
40	55.3	51.8	47.0	49.4	46.3	53.5	51.5	51.6	51.7	49.2	50.8	3.1
AL	64.8	68.9	67.7	70.1	68.0	74.3	72.0	70.3	70.3	70.3	69.5	2.9
OASPL	68.4	71.5	74.9	70.0	71.3	76.9	75.7	72.8	73.6	-	72.7	2.9
PNL	79.7	84.3	81.9	82.6	81.6	88.1	86.3	85.7	84.6	-	83.8	2.8
PNLT	81.3	86.7	82.9	84.2	81.9	88.4	86.8	88.1	85.9	-	85.0	2.8

BANDS 14 TO 40 - STANDARD 1/3 OCTAVE BANDS 25 TO 10KHz

* - UNWEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
** - A-WEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES
*** - UNWEIGHTED ARITHMETIC AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

**** - 32 SECOND AVERGING TIME

TABLE NO. C.7-5H.4 (REV.1)

BOEING VERTOL CH-47D HELICOPTER (CHINOOK)

DOT/TSC
6/11/84

1/3 OCTAVE NOISE DATA -- STATIC TESTS

AS MEASURED****

SITE: 5H (HARD) - 150 M. NORTH JULY 12,1983

HOVER-OUT-OF-GROUND-EFFECT

BAND NO.	LEVELS @ ACOUSTIC EMMISION ANGLES OF (DEGREES) 0	45	90	135	180	225	270	315	AVERAGE LEVEL OVER 360 DEGREES ENERGY *	AVE **	ARITH ***	Std Dv
	SOUND PRESSURE LEVEL dB re 20 microPascal											
14	93.3	88.3	77.9	85.5	95.5	82.0	--	84.0	90.1	45.4	86.6	6.2
15	78.7	82.0	79.3	88.7	84.2	87.3	-	83.8	84.8	45.4	83.4	3.8
16	74.6	77.2	91.3	88.5	84.3	78.6	--	79.2	85.6	51.0	82.0	6.2
17	77.9	82.6	94.5	91.4	87.4	80.7	--	81.4	88.7	58.5	85.1	6.1
18	87.2	86.3	91.6	94.1	91.1	82.8	--	83.9	89.8	63.6	88.1	4.2
19	83.5	87.8	92.1	88.5	86.4	82.4	--	80.6	87.4	64.9	85.9	4.0
20	82.0	89.8	94.3	90.2	90.1	80.0	-	83.2	89.5	70.4	87.1	5.3
21	81.9	92.1	93.0	88.2	91.4	83.5	-	84.4	89.6	73.5	87.8	4.5
22	80.4	91.0	92.5	84.6	87.8	81.5	--	83.5	88.0	74.6	85.9	4.7
23	81.1	90.1	90.6	85.5	86.6	81.4	-	82.6	86.9	76.0	85.4	3.9
24	79.4	85.0	82.8	84.7	82.0	78.7	--	79.0	82.3	73.7	81.7	2.7
25	75.1	76.2	79.2	80.6	78.7	75.1	-	75.2	77.7	71.1	77.2	2.3
26	75.5	78.9	74.5	76.6	74.2	72.0	--	73.8	75.6	70.8	75.1	2.2
27	76.4	84.6	73.7	79.8	78.2	76.1	-	77.3	79.4	76.2	78.0	3.5
28	77.6	82.7	76.4	80.9	79.8	77.9	-	77.8	79.5	77.6	79.0	2.2
29	75.4	78.7	76.4	81.7	78.7	78.2	-	78.0	78.6	77.8	78.2	2.0
30	71.6	77.0	74.2	79.8	75.4	75.5	--	75.5	76.2	76.2	75.6	2.5
31	72.8	79.8	72.9	77.5	73.0	74.1	-	74.8	75.8	76.4	75.0	2.7
32	71.7	76.8	72.5	75.4	71.6	72.9	--	76.5	74.4	75.4	73.9	2.3
33	71.5	77.2	72.4	75.8	71.3	71.8	-	73.8	74.0	75.2	73.4	2.3
34	69.6	73.8	70.3	74.1	69.4	70.1	-	71.8	71.7	73.0	71.3	2.0
35	69.3	73.8	69.9	72.7	69.1	69.9	-	74.3	71.8	73.0	71.3	2.2
36	67.3	72.0	68.1	70.1	67.5	67.7	--	71.8	69.6	70.6	69.2	2.1
37	66.9	71.7	67.2	68.8	65.4	66.5	-	72.2	69.1	69.6	68.4	2.6
38	66.4	71.7	67.1	67.8	63.6	65.3	--	72.2	68.8	68.7	67.7	3.2
39	69.5	74.3	69.8	67.9	63.4	66.1	--	76.3	71.6	70.5	69.6	4.5
40	58.4	62.5	58.9	59.9	57.3	57.3	--	62.8	60.1	57.6	59.6	2.3
AL	84.2	90.1	87.4	83.8	86.5	85.0	-	86.8	87.4	87.4	87.0	2.0
OASPL	96.0	99.2	101.9	100.0	100.2	93.6	--	94.1	98.8	-	97.9	3.3
PNL	98.1	104.1	103.3	102.6	101.4	98.3	-	101.2	101.9	--	101.3	2.3
PNLT	99.3	105.3	104.4	103.3	102.0	99.1	-	102.7	103.1	-	102.3	2.4

BANDS 14 TO 40 - STANDARD 1/3 OCTAVE BANDS 25 TO 10KHz

* - UNWEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

** - A-WEIGHTED ENERGY AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

*** - UNWEIGHTED ARITHMETIC AVERAGE OF MEASURED LEVELS OVER 360 DEGREES

**** - 32 SECOND AVERGING TIME

APPENDIX D

Direct Read Acoustical Data for Static Operations

This appendix contains time averaged, A-weighted sound level data (Leq values) obtained using direct read Precision Integrating Sound Level meters. Data are presented for microphone locations 5H, 2, and 4 (see Figure 3.3).

A description of the measurement systems is provided in Section 5.6.2, and a figure of the typical PISLM system is shown in Figure 5.4. Data are shown in Table D-1, depicting the equivalent sound levels for eight different source emission angles. In each case the angle is indexed to the specific measurement site. A figure showing the emission angle convention is included in the text (Figure 6.1). In each case, the Leq (or time averaged AL) represents an average over a sample period of approximately 60 seconds.

Quantities appearing in this appendix include:

HIGE	Hover-in-ground-effect, skid height 5 feet above ground level
HOGE	Hover-out-of-ground-effect, skid height 30 feet above ground level
Flight Idle	Skids on ground
Ground Idle	Skids on ground

TABLE D.1

STATIC OPERATIONS
DIRECT READ DATA
(ALL VALUES A-WEIGHTED LEQ, EXPRESSED IN DECIBLES)

BOEING-VERTOL CH-47D

7-12-83

SITE 4H

HIGE		FLT.IDLE		GRN.IDLE		HOGE	
M-90	75.90	N-90A	58.80	N-90B	51.00	O-90	73.20
M-45	76.50	N-45A	53.90	N-45B	47.70	O-45	75.90
M-0	62.00	N-0A	56.00	N-0B	48.10	O-0	76.70
M-315	69.20	N-315A	56.30	N-315B	52.00	O-315	78.00
M-270	74.50	N-270A	56.60	N-270B	49.40	O-270	76.00
M-225	77.30	N-225A	56.80	N-225B	49.30	O-225	79.00
M-180	68.50	N-180A	57.20	N-180B	49.40	O-180	79.00
M-135	75.30	N-135A	55.50	N-135B	48.50	O-135	78.70

SITE 2

HIGE		FLT.IDLE		GRN.IDLE		HOGE	
M-90	76.60	N-90A	70.80	N-90B	64.60	O-90	80.20
M-45	77.50	N-45A	72.80	N-45B	65.60	O-45	82.50
M-0	67.20	N-0A	69.90	N-0B	64.60	O-0	82.80
M-315	77.60	N-315A	73.40	N-315B	66.60	O-315	84.20
M-270	77.70	N-270A	71.10	N-270B	64.10	O-270	82.70
M-225	80.80	N-225A	70.80	N-225B	61.20	O-225	86.20
M-180	73.90	N-180A	70.50	N-180B	58.70	O-180	86.10
M-135	84.80	N-135A	70.20	N-135B	66.20	O-135	86.40

SITE 5H

HIGE		FLT.IDLE		GRN.IDLE		HOGE	
M-90	NA	N-90A	76.30	N-90B	68.10	O-90	89.10
M-45	85.10	N-45A	75.50	N-45B	69.60	O-45	91.00
M-0	78.00	N-0A	78.60	N-0B	65.60	O-0	84.80
M-315	77.70	N-315A	74.30	N-315B	69.70	O-315	87.40
M-270	75.10	N-270A	75.00	N-270B	70.90	O-270	86.30
M-225	79.80	N-225A	77.10	N-225B	74.10	O-225	85.90
M-180	76.40	N-180A	72.00	N-180B	67.20	O-180	88.80
M-135	80.20	N-135A	78.30	N-135B	69.90	O-135	90.60

APPENDIX E

Cockpit Instrument Photo Data

During each event of the July 1983 Helicopter Noise Measurement program cockpit photos were taken. The slides were projected onto a screen (considerably enlarged) making it possible to read the instruments with reasonable accuracy. The photos were supposed to be taken when the aircraft was directly over the centerline-center microphone site. Although this was not achieved in each case the cockpit photos reflect the helicopter "stabilized" configuration during the test event. One important caution is necessary in interpreting the photographic information; the snapshot freezes instrument readings at one moment of time whereas most readings are constantly changing by a small amount as the pilot "hunts" for the reference condition. Thus fluctuations above or below reference conditions are to be anticipated. The instrument readings are most useful in terms of verifying the region of operation for different parameters. The data acquisition is discussed in Section 5.3

Each table within this appendix provides the following information:

Event No.	This event number along with the test date provides a cross reference to other data.
Event Type	This specifies the event.
Time of Photo	The time of the range control synchronized clock consistent with acoustical and tracking time bases.
Heading	The compass magnetic heading which fluctuates around the target heading.
Altimeter	Specifies the barometric altimeter reading, one of the more stable indicators.
IAS	Indicated airspeed, a fairly stable indicator.
Rotor Speed	Main Rotor speed in RPM or percent, a very stable indicator.
Torque	The torque on the main rotor shaft, a fairly stable value.

TABLE E.1

COCKPIT PHOTO DATA

HELICOPTER CH-47D TEST DATE 7/12/83

EVENT NO.	EVENT TYPE	TIME OF PHOTO	HEADING (DEGREES)	ALTIMETER (AGL) FT. (METERS)	IAS (KTS)	ROTOR SPEED (RPM OR %)	TORQUE (%)
A1	500' LFO ICAO	9:12	120	-	135	101	62
A2	500' LFO ICAO	9:15	300	-	130	-	65
A3	500' LFO ICAO	9:18	120	-	135	98	68
A4	500' LFO ICAO	9:22	-	-	-	-	-
A5	500' LFO ICAO	9:25	120	-	135	101	65
A6	500' LFO ICAO	9:27	-	-	-	-	-
B7	500' LFO Military	9:31	120	-	130	101	65
B8	500' LFO Military	9:33	300	-	-	101	-
B10	500' LFO Military	9:38	-	-	140	-	-
C11	500' LFO	9:41	120	-	-	98	-
C12	500' LFO	9:44	300	-	135	98	70
C13	500' LFO	9:47	120	-	-	98	-
C14	500' LFO	9:50	300	-	135	98	70
D15	500' LFO	9:53	120	-	120	98	62
D16	500' LFO	9:57	300	-	125	98	65
D17	500' LFO	10:00	-	-	-	-	-
D18	500' LFO	10:04	300	-	120	98	65
D19	500' LFO	10:07	120	-	120	98	70
E20	500' LFO	10:14	-	690	110	98	52
E21	500' LFO	10:16	-	-	105	98	50
E22	500' LFO	10:19	300	-	-	98	56
E23	500' LFO	10:21	120	800	100	98	50
E24	500' LFO	10:24	300	-	105	98	56
E25	500' LFO	12:17	120	-	98	98	66
F26	1000' LFO	12:22	120	1251	135	99	64
F27	1000' LFO	12:26	120	1200	135	99	74
F28	1000' LFO	12:31	120	1225	135	98	70
F29	1000' LFO	12:35	120	-	132	98	70

TABLE E.2

COCKPIT PHOTO DATA

HELICOPTER CH-47D (Cont.) TEST DATE 7/12/83

EVENT NO.	EVENT TYPE	TIME OF PHOTO	HEADING (DEGREES)	ALTIMETER (AGL) FT. (METERS)	IAS (KTS)	ROTOR SPEED (RPM OR %)	TORQUE (%)
H30	APPROACH (ICAO)	12:41	120	-	132	98	70
H31	APPROACH (ICAO)	12:46	120	700	80	99	40
H32	APPROACH (ICAO)	12:50	120	600	-	100	35
H33	APPROACH (ICAO)	12:55	120	670	80	99	32
H34	APPROACH (ICAO)	12:59	120	790	79	99	20
H35	APPROACH (ICAO)	13:04	125	810	90	100	30
I36	APPROACH (MILITARY)	13:08	-	-	-	99	40
I37	APPROACH (MILITARY)	13:18	120	-	-	99	35
I38	APPROACH (MILITARY)	13:23	125	-	67	100	23
I39	APPROACH (MILITARY)	13:28	125	-	79	99	25
G40	TAKEOFF (ICAO)	14:01	300	-	-	101	73
G42	TAKEOFF (ICAO)	14:11	300	-	79	101	75
G43	TAKEOFF (ICAO)	14:17	300	-	90	101	75
G44	TAKEOFF (ICAO)	14:22	-	-	-	-	-
G45	TAKEOFF (ICAO)	14:28	305	470	77	101	87
K46	APPROACH	14:32	120	0	77	98	40
J47	TAKEOFF	14:35	305	750	85	101	72
K48	APPROACH	14:38	120	-	90	98	38
J49	TAKEOFF	14:41	300	-	80	100	70
K50	APPROACH	14:44	120	0	95	98	40
J51	TAKEOFF	14:47	305	-	83	100	76
K52	APPROACH	14:49	120	-	100	98	33
L53	TAKEOFF (MILITARY)	14:53	305	-	70	101	68
L54	TAKEOFF (MILITARY)	14:56	305	-	73	100	65
L55	TAKEOFF (MILITARY)	14:59	305	500	70	101	66

APPENDIX F

Photo-Altitude and Flight Path Trajectory Data

This appendix contains the results of the photo-altitude and flight path trajectory analysis.

The helicopter altitude over a given microphone was determined by a photographic technique which involves photographing an aircraft during a flyover event and proportionally scaling the resulting image with the known dimensions of the aircraft. The data acquisition is described in detail in Section 5.2. The detailed data reduction procedures is set out in Section 6.2.1; the analysis of these data is discussed in Section 8.2

Each table within this appendix provides the following information:

Event No.	the test run number
Est. Alt.	estimated altitude above microphone site
P-Alt.	altitude above photo site, determined by photographic technique
Est. CPA	estimated closest point of approach to microphone site
Est. ANG	Helicopter elevation with respect to the ground as viewed from a sideline site as the helicopter passes through a plane perpendicular to the flight track and coincident with the observer location.
ANG 5-1	flight path slope, expressed in degrees, between P-Alt site 5 and P-Alt site 1.
ANG 1-4	flight path slope, expressed in degrees, between P-Alt Site 1 and P-Alt Site 4.
ANG 5-4	flight path slope, expressed in degrees, between P-Alt Site 5 and P-Alt Site 4.
Reg C/D Angle	flight path slope, expressed in degress, of regression line through P-Alt data points.

TABLE F.1

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT.ICAO FLYOVER/TARGET IAS=135 KTS

	C: TERLINE						SIDELINE							
	MIC #5		MIC #1		MIC #4		MIC #2		MIC #3					REG.
EVENT NO	EST. ALT.	P-ALT.	EST. ALT.	P-ALT.	EST. ALT.	P-ALT.	EST. CPA	ELEV ANG	EST. CPA	ELEV ANG	ANG 5-1	ANG 1-4	ANG 5-4	C/D ANGLE
A1	499.8	500.7	525.5	509.9	546	548.2	719.9	46.9	717.5	47	1.1	4.5	2.8	2.4
A2	533.1	518.1	536.8	568.7	539.7	521	728.1	47.5	727.8	47.5	5.9	-5.4	.2	.3
A3	525.7	525.9	515.2	520.2	506.9	506.8	712.4	46.3	713.4	46.3	-.6	-1.5	-1	-.9
A4	524.7	525.5	516.9	519.3	510.7	511.4	713.7	46.4	714.4	46.4	-.6	-.8	-.7	-.6
A5	531.6	530	530	534.3	528.7	526.7	723.1	47.1	723.3	47.1	.5	-.8	-.1	0
A6	560.8	557.4	569.5	572.6	576.5	572.6	752.6	49.2	751.8	49.2	1.8	0	.9	.8
AVERAGE	529.3	526.3	532.3	537.5	534.8	531.1	725	47.2	724.7	47.3				
STD. DEV	19.6	18.5	19.9	26.9	25.6	25	14.7	1.1	14.4	1.1				

TABLE F.2

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT.MILITARY FLYOVER/TARGET IAS=135 KTS

	CENTERLINE						SIDELINE							
	MIC #5		MIC #1		MIC #4		MIC #2		MIC #3					REG.
EVENT NO	EST. ALT.	P-ALT.	EST. ALT.	P-ALT.	EST. ALT.	P-ALT.	EST. CPA	ELEV ANG	EST. CPA	ELEV ANG	ANG 5-1	ANG 1-4	ANG 5-4	C/D ANGLE
B7	486.8	484.1	484.1	491.5	481.9	478.5	690.2	44.5	690.5	44.5	.9	-1.4	-.2	-.1
B8	524.5	523.4	531	530	536.2	535.1	723.9	47.2	723.3	47.2	.8	.6	.7	.6
B9	505.9	504.5	506.1	509.1	506.2	504.5	705.8	45.8	705.8	45.8	.5	-.4	0	0
B10	504.1	501.8	513.9	513.8	521.7	519.3	711.4	46.2	710.5	46.3	1.4	.6	1	.9
AVERAGE	505.3	503.5	508.8	511.1	511.5	509.4	707.8	45.9	707.5	46				
STD. DEV	15.4	16.1	19.5	15.8	23.2	24.1	14	1.1	13.6	1.1				

TABLE F.3

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT.FLYOVER/TARGET IAS=135 KTS

	CENTERLINE						SIDELINE							
	MIC #5		MIC #1		MIC #4		MIC #2		MIC #3					REG.
	EST.		EST.		EST.		EST.	ELEV	EST.	ELEV	ANG	ANG	ANG	C/D
EVENT NO	ALT.	P-ALT.	ALT.	P-ALT.	ALT.	P-ALT.	CPA	ANG	CPA	ANG	5-1	1-4	5-4	ANGLE
C11	518.3	518.9	509.9	513	503.3	503.7	708.6	46	709.4	46	-.6	-1	-.8	-.7
C12	606.9	633.992	534.3	511.4	476.5	507.5	726.3	47.4	733.2	47.1	-13.9	-.4	-7.2	-6.6
C13	485.4	484.1	483.7	487.6	482.3	480.6	690	44.5	690.1	44.5	.4	-.7	-.1	-.1
C14	511.2	513.4	510.7	506	510.3	513	709.1	46.1	709.2	46.1	-.8	.8	0	0
AVERAGE	530.4	537.6	509.7	504.5	493.1	501.2	708.5	46	710.5	45.9				
STD. DEV	52.9	66.1	20.7	11.7	16.2	14.3	14.8	1.2	17.6	1.1				

TABLE F.4

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT.FLYOVER/TARGET IAS=120 KTS

	CENTERLINE						SIDELINE							
	MIC #5		MIC #1		MIC #4		MIC #2		MIC #3					REF.
	EST.		EST.		EST.		EST.	ELEV	EST.	ELEV	ANG	ANG	ANG	C/D
EVENT NO	ALT.	P-ALT.	ALT.	P-ALT.	ALT.	P-ALT.	CPA	ANG	CPA	ANG	5-1	1-4	5-4	ANGLE
D15	476.7	479.6	476.4	469.9	476.2	479.9	684.9	44.1	684.9	44.1	-1	1.2	0	0
D16	496	494.8	498.6	500	500.6	499.2	700.5	45.4	700.2	45.4	.6	0	.3	.2
D17	487.7	480.6	497.6	508.3	505.5	497	699.7	45.3	698.8	45.4	3.2	-1.2	1	.9
D18	487.1	489	490	484.1	492.3	494.8	694.4	44.9	694.1	44.9	-.5	1.2	.3	.3
D19	487.8	489	473.7	478.5	462.4	463.3	683	43.9	684.2	43.8	-1.1	-1.7	-1.4	-1.2
AVERAGE	487.1	486.6	487.2	488.2	487.4	486.8	692.5	44.7	692.5	44.7				
STD. DEV	6.9	6.4	11.7	15.[illegible]	17.9	15.2	8.2	.7	7.6	.7				

TABLE F.5

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 500 FT.FLYOVER/TARGET IAS=105 KTS

	CENTERLINE						SIDELINE							
	MIC #5		MIC #1		MIC #4		MIC #2		MIC #3					REG.
EVENT NO	EST. ALT.	P-ALT.	EST. ALT.	P-ALT.	EST. ALT.	P-ALT.	EST. CPA	ELEV ANG	EST. CPA	ELEV ANG	ANG 5-1	ANG 1-4	ANG 5-4	C/D ANGLE
E20	414.2	417.1	418.4	409.5	421.7	425.6	645.8	40.4	645.5	40.4	-.8	1.9	.5	.4
E21	517.9	518.5	507.3	511.4	498.8	499.2	706.7	45.9	707.6	45.8	-.7	-1.3	-1	-.9
E22	519.8	521.8	526.4	518.5	531.6	534.3	720.5	46.9	719.9	47	-.3	1.8	.7	.6
E23	525.6	523.8	524.4	529.2	523.4	521	719.1	46.8	719.2	46.8	.6	-.9	-.1	0
E24	535.7	531.7	545.2	549.1	552.8	548.2	734.4	47.9	733.5	48	2	0	1	.9
E25	545.2	NA	522.2	525.9	503.8	507.5	717.4	46.7	716.2	NA	NA	-2	NA	-2
AVERAGE	509.7	502.6	507.3	507.3	505.3	506	707.3	45.8	707	45.6				
STD. DEV	47.9	48	45.2	49.6	45.4	43.2	31.4	2.7	31.3	3				

TABLE F.6

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: 1000 FT.FLYOVER/TARGET IAS=135 KTS

	CENTERLINE						SIDELINE							
	MIC #5		MIC #1		MIC #4		MIC #2		MIC #3					REG.
EVENT NO	EST. ALT.	P-ALT.	EST. ALT.	P-ALT.	EST. ALT.	P-ALT.	EST. CPA	ELEV ANG	EST. CPA	ELEV ANG	ANG 5-1	ANG 1-4	ANG 5-4	C/D ANGLE
F26	932.8	931.4	939.9	938.5	947	NA	1060.9	62.4	1061.5	NA	.8	NA	NA	.8
F27	909.5	910.9	902.8	904.2	896.1	NA	1028.2	61.4	1027.6	NA	-.7	NA	NA	-.7
F28	957.3	960.3	942.6	945.6	927.9	NA	1063.3	62.4	1062.1	NA	-1.6	NA	NA	-1.6
F29	944.2	945.6	937.1	938.5	930	NA	1058.4	62.3	1057.8	NA	-.7	NA	NA	-.7
AVERAGE	936	937.1	930.6	931.7	925.3	ERROR	1052.7	62.1	1052.3	ERROR				
STD. DEV	20.3	21.1	18.7	18.6	21.2	0	16.5	.5	16.5	ERROR				

TABLE F.7

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: ICAO TAKEOFF/TARGET IAS=85 KTS

	CENTERLINE						SIDELINE							
	MIC #5		MIC #1		MIC #4		MIC #2		MIC #3					REG.
	EST.		EST.		EST.		EST.	ELEV	EST.	ELEV	ANG	ANG	ANG	C/D
EVENT NO	ALT.	P-ALT.	ALT.	P-ALT.	ALT.	P-ALT.	CPA	ANG	CPA	ANG	5-1	1-4	5-4	ANGLE
G40	282.1	257.3	387.1	387.7	470.8	444	626	38.2	617.8	38.8	14.8	6.5	10.7	9.7
G41	258	241.4	368.3	347.5	456.3	440.1	614.6	36.8	606.2	37.4	12.2	10.7	11.4	10.2
G42	21[illegible]	194.4	305.6	293.5	381	363.9	579.2	31.8	572.9	32.4	11.4	8.1	9.8	8.8
G43	251.8	233.5	371	349.5	466.1	448	616.2	37	607.2	37.7	13.3	11.3	12.3	11.1
G44	156.6	142.9	253.7	233.5	331.1	317.9	553.6	27.3	548	27.9	10.4	9.7	10.1	9
G45	[illegible]	[illegible]	267.7	250.9	334.9	323	560.1	28.6	555	29.1	9.2	8.3	8.8	7.8
AVERAGE	223.8	206.8	325.6	310.4	406.7	389.5	591.6	33.3	584.5	33.9				
STD. DEV	48.3	44.7	57.6	61	65.8	61.9	31.3	4.7	29.8	4.7				

TABLE F.8

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: ICAO APPROACH/TARGET IAS=85 KTS

	CENTERLINE						SIDELINE							
	MIC #5		MIC #1		MIC #4		MIC #2		MIC #3					REG.
	EST.		EST.		EST.		EST.	ELEV	EST.	ELEV	ANG	ANG	ANG	C/D
EVENT NO	ALT.	P-ALT.	ALT.	P-ALT.	ALT.	P-ALT.	CPA	ANG	CPA	ANG	5-1	1-4	5-4	ANGLE
H30	348.9	335.9	430.2	416.5	495.1	482.2	653.6	41.2	646.8	41.6	9.3	7.6	8.5	7.6
H31	372.7	358.9	445.5	438.2	503.6	489.3	663.7	42.2	657.5	42.5	9.2	5.9	7.5	6.8
H32	352.9	341.6	422.5	411.4	478	466.6	648.5	40.7	642.7	41	8.1	6.4	7.2	6.5
H33	358.7	343.6	438.8	430.7	502.6	486.9	6[illegible].2	41.7	652.5	42.1	10	6.5	8.3	7.4
H34	316.3	305.4	409.1	384.7	483	473.2	639.8	39.7	632.3	40.2	9.2	10.2	9.7	8.6
H35	360.2	349.5	439.1	421.7	501.9	491.7	659.4	41.7	652.7	42.1	8.3	8.1	8.2	7.3
AVERAGE	351.6	339.2	430.9	417.2	494	481.7	654	41.2	647.4	41.6				
STD. DEV	19.1	18.3	13.3	18.6	11	9.9	8.7	.9	9	.9				

TABLE F.9

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: MILITARY APPROACH/TARGET IAS=70 KTS

	CENTERLINE						SIDELINE							
	MIC #5		MIC #1		MIC #4		MIC #2		MIC #3					REG.
	EST.		EST.		EST.		EST.	ELEV	EST.	ELEV	ANG	ANG	ANG	C/D
EVENT NO	ALT.	P-ALT.	ALT.	P-ALT.	ALT.	P-ALT.	CPA	ANG	CPA	ANG	5-1	1-4	5-4	ANGLE
I36	373.3	357.8	461.9	450	532.6	516.9	674.9	43.2	667.1	43.6	10.6	7.7	9.2	8.2
I37	365	349.5	453.9	442	524.8	509	669.4	42.7	661.7	43.1	10.6	7.8	9.2	8.3
I38	374.9	357.8	465.2	456	537.2	519.5	677.1	43.4	669.2	43.8	11.3	7.4	9.3	8.4
I39	379.3	365.4	453.9	44[illegible]	513.4	499	669.4	42.7	663	43	9.3	6.1	7.7	6.9
AVERAGE	373.1	357.6	458.7	448.5	527	511.1	672.7	43	66[illegible].3	43.4				
STD. DEV	6	6.5	5.7	6	10.4	9.2	3.9	.4	[illegible].5	.4				

TABLE F.10

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: TAKEOFF/TARGET IAS=85 KTS

	CENTERLINE						SIDELINE							
	MIC #5		MIC #1		MIC #4		MIC #2		MIC #3					REG.
	EST.		EST.		EST.		EST.	ELEV	EST.	ELEV	ANG	ANG	ANG	C/D
EVENT NO	ALT.	P-ALT.	ALT.	P-ALT.	ALT.	P-ALT.	CPA	ANG	CPA	ANG	5-1	1-4	5-4	ANGLE
J47	[illegible]74.2	671	737.9	711.4	788.7	787.4	886.9	56.3	880.1	56.5	4.7	8.8	6.7	5.9
J49	607.4	595.4	671.2	664.5	722.2	709.8	832.2	53.[illegible]	825.7	54	8	5.3	6.6	5.9
J51	495.7	491.6	623.2	565.1	724.9	725.1	794	51.7	781.3	52.1	8.5	18	13.3	11.8
AVERAGE	592.4	586	677.5	647	745.3	740.8	837.7	53.9	829	54.2				
STD. DEV	90.2	90.1	57.6	74.7	37.7	41.1	46.7	2.3	49.5	2.2				

TABLE F.11

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: APPROACH/TARGET IAS=100 KTS

	CENTERLINE						SIDELINE							
	MIC #5		MIC #1		MIC #4		MIC #2		MIC #3					REG.
	EST.		EST.		EST.		EST.	ELEV	EST.	ELEV	ANG	ANG	ANG	C/D
EVENT NO	ALT.	P-ALT.	ALT.	P-ALT.	ALT.	P-ALT.	CPA	ANG	CPA	ANG	5-1	1-4	5-4	ANGLE
K46	414.3	406.2	454.3	451.3	486.1	477.7	669.6	42.7	666.2	42.9	5.2	3.1	4.2	3.7
K48	420.9	415.6	467	454.6	503.7	499	678.3	43.5	674.3	43.7	4.5	5.2	4.8	4.3
K50	415.9	410	462.5	451.3	499.6	494.1	675.2	43.2	671.2	43.4	4.8	5	4.9	4.3
K52	408.9	403.1	443.2	438.3	470.4	464.5	662.2	42	659.2	42.2	4.1	3	3.6	3.2
AVERAGE	415	408.7	456.7	448.9	490	483.8	671.3	42.9	667.7	43.1				
STD. DEV	4.9	5.4	10.5	7.2	15	15.8	7.1	.7	6.6	.7				

TABLE F.12

HELICOPTER: BOEING-VERTOL CH-47D

TEST DATE: 7-12-83

OPERATION: MILITARY TAKEOFF/TARGET IAS=70 KTS

	CENTERLINE						SIDELINE							
	MIC #5		MIC #1		MIC #4		MIC #2		MIC #3					REG.
	EST.		EST.		EST.		EST.	ELEV	EST.	ELEV	ANG	ANG	ANG	C/D
EVENT NO	ALT.	P-ALT.	ALT.	P-ALT.	ALT.	P-ALT.	CPA	ANG	CPA	ANG	5-1	1-4	5-4	ANGLE
L53	264.6	254.637	345	325.1	409.2	400	600.9	35	595.1	35.5	8.2	8.7	8.4	7.5
L54	286.3	276.273	359.6	343.6	418.1	408.5	609.4	36.2	603.9	36.6	7.8	7.5	7.7	6.8
L55	278.7	NA	338.3	328.6	385.8	376.1	597.1	34.5	599.6	NA	NA	5.5	NA	5.5
AVERAGE	276.5	265.5	347.6	332.4	404.3	394.9	602.5	35.2	599.5	36.1				
STD. DEV	11	15.3	10.9	9.8	16.7	16.8	6.3	.9	4.4	.8				

APPENDIX G

NWS Upper Air Meteorological Data

This appendix presents a summary of meteorological data gleaned from National Weather Service radiosonde (rawinsonde) weather balloon ascensions conducted at Sterling, VA. The data collection is further described in Section 5.4. Tables are identified by launch date and launch time. Within each table the following data are provided:

Time	expressed first in Eastern Standard, then in Eastern Daylight Time
Surface Height	height of launch point with respect to sea level
Height	height above ground level, expressed in feet
Pressure	expressed in millibars
Temperature	expressed in degrees centigrade
Relative Humidity	expressed as a percent
Wind Direction	the direction from which the wind is blowing (in degrees)
Wind Speed	expressed in knots

TABLE G.1

DATE: 7 / 12 / 83

TIME: 500 EST FLIGHT # 1 6:00 EDT

SURFACE HEIGHT= 279 FT MSL -999= MISSING DATA

HEIGHT FEET	PRESSURE MB	TEMPERATURE DEG C	RELATIVE HUMIDITY	WIND DIRECTION	WIND SPEED KTS
0	1008.0	12.8	99	0	0
100	1004.4	15.5	99	-999	-999
200	1000.8	16.8	99	-999	-999
300	997.2	16.7	100	-999	-999
400	993.7	18.9	88	316	2
500	990.2	20.8	76	289	9
600	986.7	21.4	68	290	10
700	983.3	21.8	61	304	9
800	979.8	22.2	54	310	10
900	976.4	22.6	47	310	11
1000	973.0	22.7	43	316	10
1100	969.6	22.9	39	320	11
1200	966.2	23.0	36	323	10
1300	962.9	23.1	32	325	9
1400	959.5	23.3	29	316	8
1500	956.2	23.1	28	321	9
1600	952.8	22.9	29	322	9
1700	949.5	22.7	29	320	9
1800	946.2	22.5	29	321	9
1900	942.9	22.3	30	328	9
2000	939.6	22.0	30	334	8
2100	936.3	21.8	30	333	9
2200	932.9	21.6	31	334	9
2300	929.6	21.4	31	332	10
2400	926.4	21.2	31	331	10
2500	923.2	20.9	32	332	11
2600	920.0	20.7	33	333	11
2700	916.8	20.4	34	337	11
2800	913.6	20.2	34	335	11
2900	910.4	19.9	35	334	11
3000	907.2	19.7	36	334	11

TABLE G.2

DATE: 7 / 12 / 83

TIME: 600 EST FLIGHT # 2 7:00 EDT

SURFACE HEIGHT= 279 FT MSL -999= MISSING DATA

HEIGHT FEET	PRESSURE MB	TEMPERATURE DEG C	RELATIVE HUMIDITY	WIND DIRECTION	WIND SPEED KTS
0	1008.2	13.8	99	0	0
100	1004.6	14.7	98	-999	-999
200	1000.9	17.0	97	-999	-999
300	997.5	19.5	87	66	7
400	994.0	20.5	74	294	18
500	990.5	21.4	62	290	27
600	987.0	22.2	49	296	21
700	983.6	22.9	42	302	17
800	980.1	23.5	37	305	15
900	976.7	24.0	32	307	13
1000	973.2	24.3	29	312	13
1100	969.9	24.3	27	318	13
1200	966.5	24.2	26	318	11
1300	963.1	23.9	25	321	11
1400	959.8	23.7	24	325	12
1500	956.4	23.4	24	322	11
1600	953.1	23.2	23	323	9
1700	949.7	22.9	23	317	8
1800	946.4	22.7	22	328	10
1900	943.1	22.4	23	327	11
2000	939.9	22.2	24	322	9
2100	936.6	22.0	25	322	9
2200	933.4	21.8	27	322	11
2300	930.1	21.5	28	328	10
2400	926.9	21.3	29	328	9
2500	923.6	21.1	30	329	9
2600	920.3	20.9	31	331	10
2700	917.1	20.6	32	326	13
2800	913.8	20.4	33	334	13
2900	910.6	20.2	34	339	11
3000	907.3	20.0	35	330	14

TABLE G.3

DATE: 7 / 12 / 83

TIME: 700 EST FLIGHT # 3 8:00 EDT

SURFACE HEIGHT= 279 FT MSL -999= MISSING DATA

HEIGHT FEET	PRESSURE MB	TEMPERATURE DEG C	RELATIVE HUMIDITY	WIND DIRECTION	WIND SPEED KTS
0	1008.4	18.9	89	0	0
100	1004.8	18.2	82	-999	-999
200	1001.3	19.8	74	-999	-999
300	997.7	21.1	67	302	5
400	994.3	21.5	60	306	9
500	990.8	22.1	57	302	11
600	987.3	22.6	55	302	12
700	983.9	23.2	53	307	11
800	980.4	23.3	51	306	12
900	977.0	23.3	49	305	13
1000	973.6	23.3	47	308	12
1100	970.2	23.3	45	310	11
1200	966.9	23.2	44	307	9
1300	963.5	23.1	43	311	8
1400	960.2	23.0	41	311	7
1500	956.8	22.9	40	308	7
1600	953.5	22.8	39	309	7
1700	950.2	22.7	38	311	7
1800	946.9	22.5	39	315	7
1900	943.6	22.3	40	316	7
2000	940.3	22.1	41	323	9
2100	937.0	21.9	42	326	9
2200	933.8	21.6	43	330	9
2300	930.5	21.4	44	330	9
2400	927.2	21.2	45	330	8
2500	923.9	21.0	46	338	8
2600	920.6	20.8	46	337	9
2700	917.4	20.6	47	329	10
2800	914.1	20.4	48	328	10
2900	910.8	20.2	49	331	10
3000	907.6	19.9	49	333	11

TABLE G.4

DATE: 7 / 12 / 83

TIME: 800 EST FLIGHT # 4 9:00 EDT

SURFACE HEIGHT= 279 FT MSL -999= MISSING DATA

HEIGHT FEET	PRESSURE MB	TEMPERATURE DEG C	RELATIVE HUMIDITY	WIND DIRECTION	WIND SPEED KTS
0	1008.5	22.2	71	290	4
100	1005.0	22.3	67	-999	-999
200	1001.5	22.4	64	-999	-999
300	998.0	22.2	64	-999	-999
400	994.5	22.1	64	349	7
500	991.1	22.2	59	279	9
600	987.6	22.4	54	290	11
700	984.1	23.1	49	298	13
800	980.7	23.4	46	299	14
900	977.2	23.6	44	301	15
1000	973.8	23.7	43	306	14
1100	970.4	23.9	42	319	12
1200	967.1	24.0	41	315	9
1300	963.7	24.1	40	316	7
1400	960.4	24.2	39	310	8
1500	957.1	23.9	40	310	9
1600	953.8	23.7	40	313	9
1700	950.5	23.5	41	315	8
1800	947.2	23.2	42	320	7
1900	943.9	23.0	42	318	7
2000	940.6	22.8	43	327	8
2100	937.3	22.5	44	330	8
2200	934.0	22.3	44	328	8
2300	930.7	22.1	45	326	9
2400	927.4	21.8	46	331	9
2500	924.1	21.6	46	330	9
2600	920.8	21.4	47	331	9
2700	917.6	21.1	47	327	10
2800	914.4	20.8	48	330	10
2900	911.2	20.5	48	331	11
3000	908.0	20.2	48	334	11

TABLE G.5

DATE: 7 / 12 / 83

TIME: 855 EST FLIGHT # 5 9:55 EDT

SURFACE HEIGHT= 279 FT MSL -999= MISSING DATA

HEIGHT FEET	PRESSURE MB	TEMPERATURE DEG C	RELATIVE HUMIDITY	WIND DIRECTION	WIND SPEED KTS
0	1008.4	26.1	52	330	6
100	1004.9	25.5	52	-999	-999
200	1001.5	24.9	51	-999	-999
300	998.0	24.4	51	286	21
400	994.6	24.2	51	290	20
500	991.1	23.9	51	311	6
600	987.7	23.6	50	301	8
700	984.2	23.4	50	291	8
800	980.8	23.1	50	299	8
900	977.3	22.8	50	308	7
1000	973.9	23.0	48	302	12
1100	970.5	23.2	45	309	11
1200	967.1	23.3	43	319	10
1300	963.8	23.3	41	314	11
1400	960.4	23.2	40	305	10
1500	957.1	23.1	39	312	10
1600	953.7	23.0	38	313	8
1700	950.4	23.0	37	318	5
1800	947.0	22.9	36	335	4
1900	943.7	22.7	35	319	6
2000	940.4	22.5	36	327	6
2100	937.2	22.2	37	330	5
2200	933.9	22.0	37	329	5
2300	930.7	21.8	38	334	5
2400	927.4	21.5	39	344	5
2500	924.1	21.3	40	338	7
2600	920.9	21.0	40	343	8
2700	917.6	20.8	41	352	8
2800	914.4	20.6	42	350	7
2900	911.1	20.3	42	356	7
3000	907.9	20.1	43	356	7

TABLE G.6

DATE: 7 / 12 / 83

TIME: 1001 EST FLIGHT # 6 11:01 EDT

SURFACE HEIGHT= 279 FT MSL -999= MISSING DATA

HEIGHT FEET	PRESSURE MB	TEMPERATURE DEG C	RELATIVE HUMIDITY	WIND DIRECTION	WIND SPEED KTS
0	1008.2	28.2	48	290	7
100	1004.7	27.5	49	-999	-999
200	1001.3	26.8	51	-999	-999
300	997.8	26.4	51	-999	-999
400	994.4	26.0	52		
500	991.0	25.6	52	289	4
600	987.6	25.2	53	300	7
700	984.2	24.9	52	326	6
800	980.8	24.7	52	325	6
900	977.4	24.6	51	322	6
1000	974.0	24.4	50	335	4
1100	970.6	24.2	49	331	4
1200	967.2	24.1	48	308	5
1300	963.9	23.9	47	298	4
1400	960.5	23.7	46	278	2
1500	957.1	23.5	45	302	2
1600	953.8	23.3	45	316	3
1700	950.5	23.1	46	301	4
1800	947.2	22.9	46	302	3
1900	943.9	22.6	46	308	2
2000	940.6	22.4	46	327	2
2100	937.3	22.2	47	331	3
2200	934.0	21.9	47	331	3
2300	930.8	21.7	47	340	4
2400	927.5	21.5	48	3	4
2500	924.2	21.3	48	11	4
2600	920.9	21.1	48	353	4
2700	917.7	21.0	46	351	4
2800	914.5	20.9	45	338	4
2900	911.3	20.9	44	332	6
3000	908.1	20.8	42	335	7

TABLE G.7

DATE: 7 / 12 / 83

TIME: 1103 EST FLIGHT # 7 12:03 EDT

SURFACE HEIGHT= 279 FT MSL -999= MISSING DATA

HEIGHT FEET	PRESSURE MB	TEMPERATURE DEG C	RELATIVE HUMIDITY	WIND DIRECTION	WIND SPEED KTS
0	1008.1	29.4	43	300	6
100	1004.7	28.7	43	-999	-999
200	1001.2	28.0	44	-999	-999
300	997.8	27.5	44	-999	-999
400	994.4	27.1	45	269	8
500	990.9	26.7	46	272	9
600	987.5	26.3	47	283	9
700	984.1	26.0	47	276	8
800	980.8	25.7	48	277	8
900	977.4	25.5	48	291	6
1000	974.1	25.3	49	300	5
1100	970.8	25.0	49	306	5
1200	967.4	24.8	50	303	5
1300	964.1	24.6	50	299	6
1400	960.8	24.3	51	300	8
1500	957.4	24.1	51	321	7
1600	954.1	23.9	51	354	6
1700	950.8	23.6	52	358	6
1800	947.4	23.4	52	351	7
1900	944.1	23.2	53	359	7
2000	940.7	22.9	53	6	7
2100	937.4	22.7	54	360	7
2200	934.1	22.4	55	350	6
2300	930.9	22.1	56	341	5
2400	927.6	21.8	57	343	5
2500	924.3	21.4	57	5	5
2600	921.1	21.1	58	21	5
2700	917.8	20.8	59	18	5
2800	914.6	20.5	58	6	5
2900	911.4	20.1	55	353	4
3000	908.2	19.8	51	14	3

APPENDIX H

NWS - IAD Surface Meteorological Data

This appendix presents a summary of meteorological data gleaned from measurements conducted by the National Weather Service Station at Dulles. Readings were noted evey 15 minutes during the test. The data acquisition is described in Section 5.5.

Within each table the following data are provided:

Time(EDT)	time the measurement was taken, expressed in Eastern Daylight Time
Barometric pressure	expressed in inches of mercury
Temperature	expressed in degrees Fahrenheit and centigrade
Humidity	relative, expressed as a percent
Wind Speed	expressed in knots
Wind Direction	direction from which the wind is moving

TABLE H.1

SURFACE METEOROLOGICAL DATA (NWS)

TEST DATE: July 12, 1983 HELICOPTER: Boeing-Vertol CH-47D LOCATION: DULLES AIRPORT*

TIME (EDT)	BAROMETRIC PRESSURE (INCHES)	TEMPERATURE °F(°C)	HUMIDITY (%)	WIND	
				SPEED (MPH)	DIRECTION (DEGREES)
05:30	30.07	57(14)	97	0	000
05:44	30.07	55(13)	100	0	000
05:53	30.07	56(13)	97	0	000
06:23	30.07	55(13)	97	0	000
06:37	30.07	56(13)	97	0	000
06:44	30.08	56(13)	93	0	000
06:51	30.08	57(14)	93	0	000
07:13	30.08	60(15)	93	2	160
07:29	30.08	62(17)	90	2	170
07:42	30.08	64(18)	90	2	150
07:51	30.08	65(18)	90	2	300
08:15	30.09	68(20)	87	2	130
08:30	30.09	70(21)	87	2	150
08:44	30.08	71(22)	87	4	280
08:49	30.08	72(22)	84	3	280
09:15	30.08	75(24)	76	5	300
09:28	30.08	76(24)	74	5	290
09:44	30.08	78(25)	69	6	310
09:49	30.08	79(26)	65	7	320
10:15	30.08	80(27)	62	7	310
10:30	30.07	81(27)	59	8	320
10:45	30.07	82(28)	55	6	280

*Sensors located approximately 2 miles east of measurement array

TABLE H.2

SURFACE METEOROLOGICAL DATA (NWS)

TEST DATE: July 12, 1983 HELICOPTER: Boeing-Vertol CH-47D (CONT) LOCATION: DULLES AIRPORT*

TIME (EDT)	BAROMETRIC PRESSURE (INCHES)	TEMPERATURE °F(°C)	HUMIDITY (%)	WIND	
				SPEED (MPH)	DIRECTION (DEGREES)
11:00	30.07	82(28)	55	7	310
11.16	30.07	83(28)	53	5	330
11:30	30.07	84(29)	50	6	290
11:45	30.07	84(29)	51	5	310
12:00	30.07	85(29)	48	6	330
12:15	30.07	86(30)	45	7	310
12:30	30.07	86(30)	45	7	300
12:45	30.07	86(30)	45	7	310
1:00	30.06	87(30)	43	9	270
2:00	30.06	87(3[illegible]	43	6	240
3:00	30.06	88([illegible]	44	6	250
4:00	30.06	90(3[illegible]	44	6	230

*Sensors located approximately 2 miles east of measurement array

APPENDIX I

On-Site Meteorological Data

This appendix presents a summary of meteorological data collected on-site by TSC personnel using a climatronics model EWS weather system. The anemometer and temperature sensor were located 5 feet above ground level at noise site 4. The data collection is further described in Section 5.5.

Within each table, the following data are provided:

Time(EDT)	expressed in Eastern Daylight Time
Temperature	expressed in degrees Fahrenheit and centigrade
Humidity	expressed as a percent
Windspeed	expressed in knots
Wind Direction	direction from which the wind is blowing
Remarks	observations concerning cloud cover and visibility

TABLE I

SURFACE METEOROLOGICAL DATA

TEST DATE: July 12, 1983 HELICOPTER: Boeing-Vertol CH-47D LOCATION: DULLES, SITE #4*

TIME (EDT)	TEMPERATURE °F(°C)	HUMIDITY (%)	WINDSPEED AVG (MPH)	WINDSPEED RANGE (MPH)	WIND DIRECTION (DEGREES)	REMARKS
05:18	62(	95	0	0-0		Before sunrise
06:02	55	93	0	0-0		Haze, fog, light clouds
08:25	72	66	0	0-0		Grass dry, humid, haze on harizon
08:48	72	54	3	0-3	157.5	
09:37	72	52	5	0-5	157.5	
09:57	80	50	4	3-5	157.5	
10:29	78	44	5	3-10	157.5	
10:45	80	44	3	3-5	157.5	Dry, hot and breezy, clear sky
11:00	86	40	3	0-5	135	with haze on harizon
11:15	86	40	3	0-10	135	
11:30	90	38	3	0-5	90	
11:51	90	38	5	3-10	90	
12:27	86	36	2	0-3	157.5	Hazy
12:47	90	36	2	0-3	157.5	
1:20	92	34	2	0-3	270	
1:34	84	36	3	0-5	247.5	
1:51	90	34	2	0-3	157.5	
2:13	88	34	3	0-10	270	
2:43	88	32	3	0-5	180	
3:00	92	34	0	0-0		