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Noise Levels and Data Analyses for Small Prop-Driven Aircraft

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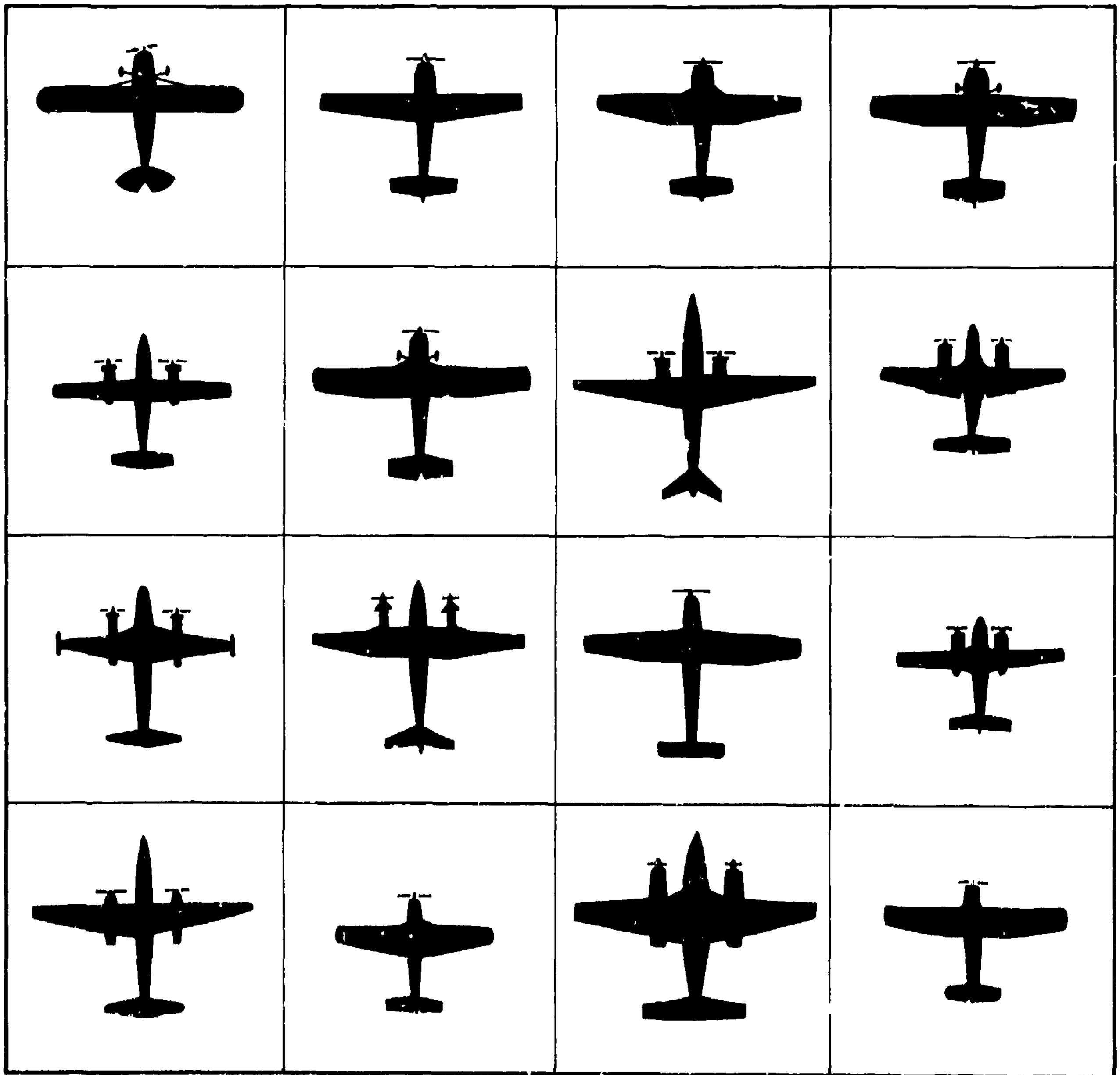

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16. Abstract

During the Summer and Fall of 1982, the FAA Office of Environment and Energy, Noise Abatement Division, conducted a noise measurement program to evaluate proposed revisions of International and U.S. noise certification standards for light-weight propeller-driven aircraft. Tests were conducted using both single- and twin-engine propeller-driven light aircraft. Normally aspirated, turbo-charged, and turboprop engines were included, as were both fixed and variable pitch propellers. Takeoff noise measurements were made for eighteen aircraft. Additional measurements for nine of these aircraft (during level flight) provided sufficient data to examine the relationship of noise level versus helical tip Mach Number and engine power setting. This report presents noise measurements, aircraft position data, meteorological data, and cockpit instrument readings acquired during the test. Data analyses include: 1) corrections to proposed noise certification reference conditions, 2) development of Mach Number and Power Correction functions, 3) empirical examination of sound propagation, 4) regression of noise level versus weight (and the logarithm of weight) and 5) correlation of acoustical intensity (AL) and acoustical dose (SEL) noise metrics. While this report concludes that a takeoff noise certification procedure is feasible and will provide consistent results for a given aircraft, it remains uncertain whether or not equal stringency (or even comparable stringency) can be achieved between the existing certification procedure and the proposed takeoff procedure.

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Errata

In a recently conducted(July 1983) retest of the identical Cessna 210 Centurion discussed in this report it was determined that a tachometer error existed. While the tachometer read 2700 the actual propeller RPM was 2882.

Accordingly, it is assumed that the tachometer error existed during the 1982 test. Therefore, any reference in the main body of this document to the C-210 or any presentation of C-210 data should be noted as reflecting a propeller speed approximately 182 RPM greater than the stated value. The results of the 1983 retest are presented in Appendix E.

Addenda

Appendix E of this document provides a summary of the 1983 Cessna 210, "retest" measurement program designed to obtain additional data on the relationship between level flyover and takeoff noise levels.

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- Beech Aircraft Company
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GLOSSARY

ABS	=	Atmospheric absorption correction applied to each 1/3 octave band of the ALM
AGL	=	Above Ground Level
AL	=	A-Weighted Sound Level, expressed in decibels (See L_A)
ALM	=	Maximum A-weighted Sound Level, expressed in decibels (see L_{AM})
AL_{cx}	=	Maximum A-weighted Sound Level Corrected using complex procedure
AL_{cs}	=	Maximum A-weighted Level corrected using simplified procedures
AL_{AM}	=	As measured maximum A-weighted Level
ALT	=	Aircraft altitude above the microphone location
ALT_R	=	Reference Altitude - reference height of aircraft
ALT_T	=	Test Altitude - actual height of aircraft directly over noise measurement site
ATM	=	Standard day atmospheric correction
BRC	=	Best Rate of Climb
c	=	Speed of Sound
cm	=	When used as subscript cm refers to distance and Mach number corrected levels
CPA	=	Closest Point of Approach
CR	=	Correction Ratio
dB	=	Decibel
dBA	=	A-Weighted Sound Level expressed in units of decibels (see A_L)

df	=	Degree of freedom
d	=	Distance
d_{50}	=	Distance from brake release to clear a 50' (15.4m) obstacle
Δ	=	Delta, or Change in Value
Δ_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
Δ_2	=	Correction term accounting for changes in event duration with deviations from the reference flight path
EPNL	=	Effective Perceived Noise Level (symbol is L_{EPN})
EV	=	Event, test run number
FAA	=	Federal Aviation Administration
FAR	=	Federal Aviation Regulation
FAR-36	=	Federal Aviation Regulation, Part 36
GA	=	General Aviation
GLR	=	Graphic Level Recorder
IAS	=	Indicated Airspeed
K(A)	=	Propagation constant describing the change in dBA with distance
K(DUR)	=	The constant used to correct SEL for distance and velocity duration effects in Δ_2
K(S)	=	Propagation constant describing the change in SEL with distance
$K(M)_A$	=	Mach Number correction constant for AL
$K(M)_S$	=	Mach Number correction constant for SEL

$K(P)_A$	=	Power correction constant for the AL
$K(P)_S$	=	Power correction for SEL
Kts	=	Knots
L_A	=	Symbol for A-Weighted Sound Level expressed in decibels (see AL)
$L_{A_{cx}}$	=	Symbol for Maximum A-weighted Sound Level corrected using complex procedure
L_{AE}	=	Symbol for Sound Exposure Level expressed in decibels (see SEL)
$L_{AE_{cs}}$	=	Symbol for Sound Exposure Level corrected with simplified procedure
$L_{AE_{cx}}$	=	Symbol for Sound Exposure Level corrected with complex procedures
$L_{AE_{AM}}$	=	Symbol for As measured Sound Exposure Level
L_{AM}	=	Symbol for maximum A-weighted Sound Level expressed in decibels (See ALM)
$L_{AM(am)}$		Symbol for as measured Maximum A-weighted Sound Level expressed in decibels
Leq	=	Symbol for Equivalent Sound Level
LFO	=	Level Flyover operational mode
M_H	=	Helical Tip Mach number
$M_H(T)$	=	Test helical tip Mach number
$M_H(R)$	=	Reference helical tip Mach number
MTOGW	=	Maximum Takeoff Gross Weight
N	=	Sample Size
P_R	=	Reference engine power
P_T	=	Test engine power
Q	=	Time history "shape factor"
RH	=	Relative Humidity in percent
RPM	=	Revolutions per minute

SD	=	Standard Deviation
SEL	=	Sound Exposure Level expressed in decibels. The integration of the AL time history, normalized to 1 second (symbol is L_{AE})
SEL_{AM}	=	As measured Sound Exposure Level
SEL_{CX}	=	Sound Exposure Level corrected with complex procedures
SEL_{CS}	=	Sound Exposure Level corrected with simplified procedure
SEL_{FC}	=	Fully corrected SEL value
SPH	=	Correction added to the 1/3 octave band value to adjust for spherical spreading
SPL	=	Sound Pressure Level
SR	=	Distance from the noise source to receiver
T	=	Ten-dB-down duration time
T/O	=	Takeoff
v	=	Velocity
Vy	=	Velocity for best rate of climb
V_R	=	Rotational Velocity
V_T	=	Translational Velocity
Vg	=	Ground speed
V_{IAS}	=	Indicated Air Speed
αi	=	Atmospheric absorption coefficient for the i-th 1/3 octave Sound Pressure Level
$\alpha°i$	=	SAE ARP-866A absorption coefficient for the i-th 1/3 octave band for the reference conditions of 59°F (15°C) and 70% RH

Executive Summary of Findings

1. For the aircraft, groundspeeds, and altitudes tested, a strong correlation is observed between SEL and ALM. ALM and SEL are linearly related, with a coefficient of determination (R^2) of 0.965.

In a noise certification scheme the use of ALM is substantially simpler and more direct than SEL because:

a. there is no need for tracking information, which is required to measure ground speed;

b. measurement instrumentation is far less sophisticated;

c. corrections for off-reference test conditions are simpler and less time-consuming; and

d. fewer corrections are required.

Based on these observations, it is reasonable to consider use of ALM as the noise evaluation measure for a takeoff noise certification procedure.

2. For ratios of test altitude to reference altitude from 1.2 to 0.8, a comparisons of two methods (i.e., a "simplified" and a "complex) for correcting nonreference altitudes and nonstandard atmospheric absorption resulted in an average difference of only 0.2 dB between the two methods. It is concluded that the less complex correction method is quite acceptable. Using the "simplified" procedure, measured noise levels (ALM) may be corrected for altitude by algebraically adding an increment equal to:

Delta-1 = 22 log (ALT_T/ALT_R) dB.

3. The results of the helical tip Mach Number (M_H) correlation study suggest that no single function should be universally applied. Test results show that functions for the aircraft tested lie between 20 and 150 times log $(M_{H(R)}/M_{H(T)})$. However, the method of application as a correction function minimizes the net difference in correction value, since, in most cases, the $M_{H(R)}/M_{H(T)}$ was very close to 1.0. On the average there was less than a 1 percent difference over the range of coefficients, primarily due to warmer than standard day temperatures.

4. Test results reveal a range of values for the power correction constant $K(P)_A$ between 2 and 30, with an average $K(P)_A = 17$. The relationship $\Delta = K(P)_A \log (P_{(R)}/P_{(T)})$ db is considered a reasonable correction factor for estimating change in noise level with engine power.

5. Pilots participating in the FAA tests flew within 5 kts. of the reference airspeed.

6. In most cases (11 of 18) the altitude correction ratios (ALT_T/ALT_R) for the test aircraft lie within the limits of 0.7 and 1.4. In a number of cases an unusually high correction ratio is observed, generally associated with winds aloft and/or light weight.

7. Linear and logarithmic regression analyses of noise level versus maximum gross takeoff weight failed to reveal any significant trends for the general population of aircraft tested. Subsequent analyses using sub-ground populations made no significant improvement.

8. Pilots participating in the FAA test reported difficulty in maintaing the reference heading due to their inability to see the ground while in the climbout flight regime. Typically each pilot would make practice flights

until receiving radio confirmation from ground observers verifying the proper flight track. The pilot would then fly that compass heading for subsequent takeoff events. After having found the right compass heading, pilots typically deviated no more than ±10 degrees from the zenith over the microphone location.

1.0 Introduction - During the Summer and Fall of 1982, the Federal Aviation Administration's Office of Environment and Energy, Noise Abatement Division, conducted an extensive propeller-driven aircraft noise measurement program at Dulles International Airport. This program was intended to obtain noise measurement data necessary for analysis of the proposed revision of ICAO Annex 16/FAA FAR Part 36, noise standards for certification of small (less than 12,500 lbs) propeller-driven aircraft.

ICAO and FAA noise standards prescribe procedures for noise certification of small propeller-driven airplanes. The standards require measurement of noise levels associated with 1000 ft (300m) level flyover at not less than the highest power in the normal operating range. The regulations also require application of a general performance correction. This correction considers climb performance capability and the associated effect on noise levels.

Suggested changes to Chapter 6 of ICAO Annex 16 and FAR Part 36 Appendix F would substitute a takeoff test for the current flyover test. Along with this change comes the need to develop reliable correction procedures for changes in noise level which accompany non-reference helical tip Mach Number, non-reference engine power levels, and non-reference altitudes.

In an effort to assess the proposed revision, takeoff noise measurements were made for 18 aircraft. Additional measurements for nine of these aircraft during level flyover provided sufficient data to examine the relationship of noise levels versus variations in helical tip Mach Number and engine power setting.

Table 1 presents selected physical attributes for each of the test aircraft, while Table 2 lists the reference takeoff performance characteristics for each airplane. The parameters shown in Table 2 are used for normalizing test measurement data to reference takeoff performance and meteorological conditions.

TABLE 1.1

GENERAL AVIATION AIRCRAFT SPECIFICATIONS
1982 NOISE TEST; DULLES INTERNATIONAL AIRPORT

Aircraft	Engine(s) Model	Max Cont Pwr (total)	Prop Shaft RPM	Manifold Press/T	Number Engines	Engine Type	Air Intake	Propeller Model	Number Blades	Dia	Pitch	Wing Span (ft)	Gear Fixed/ Retractable
Cessna 180	Continental 0-470-L	230hp	2550	27.5	1	piston	normally aspirated	McCauley	2	82.2"	var	36.0'	F
Archer II PA-28 181	Lycoming 0-360	180hp	2700	fixed pitch	1	piston	normally aspirated	Sensenich	2	76"	fixed	35.0'	F
Turbo ArrowIV PA28RT 201T	Continental TSIO-360	200hp	2575	41"	1	piston	turbocharged	Hartzell	3	76"	var	35.4'	R
Tomahawk PA-38-112	Lycoming 0-235	112hp	2350	fixed pitch	1	piston	normally aspirated	Sensenich	2	72"	fixed	34.0'	F
Cessna 170	Continental 0-300C	145hp	2375	fixed pitch	1	piston	normally aspirated	Sensenich	2	76"	fixed	36.0'	F
King Air 200	P&W PT6A-41	850shp	2000	2230 (Torque)	2	turboprop	compressor stages	Hartzell	3	98 5'	var	54.5'	R
Cheyenne PA-42	P&W PT6A-41	720shp	2000	1985 (Torque)	2	turboprop	compressor stages	Hartzell	3	95"	var	47.7'	R
Chancellor C-414	Continental TSIO-520	310	2700	39.5"	2	piston	turbocharged	McCauley	3	76.5"	var	44.7'	R
Baron B58-P	Continental TSIO-520-WB	325hp	2700	39.5"	2	piston	turbocharged	Hartzell	3	78"	var	37.8'	R
Centurion C-210	Continental IO-520-L	300hp	2700	30"	1	piston	normally aspirated	McCauley	3	80"	var	36.8'	R
Skylane C-182	Continental 0-470	230hp	2400	31"	1	piston	normally aspirated	McCauley	3	79"	var	35.8'	R
Skyhawk C-172	Lycoming 0-320	160hp	2300	fixed	1	piston	normally aspirated	McCauley	2	75"	fixed	36.0'	F
Merlin 227-AT	Garrett TPE-331-11U	1000shp	1591	3301 (Torque)	2	turboprop	compressor stages	Dowty-Rotol	4	106"	var	57.0'	R
Gulfstream Commander900	Garrett TPE-331-5	712shp	1591	-	2	turboprop	compressor stages	Dowty-Rotol	3	106"	var	52.1'	R
Beech Duchess	Lycoming 0-360	180hp	2700	29"	2	piston	normally aspirated	Hartzell	2	76"	var	38.0'	R
Beech BonanzaA-36	Continental IO-520	285hp	2700	29"	1	piston	normally aspirated	McCauley	3	80"	var	33.5'	R
Piper Navajo 350	Lycoming TIO-540	340hp	2525	41"	2	piston	turbocharged	Hartzell	3	80"	var	40.7'	R
Cessna Conquest I C-425	P&W PT6A-112	450hp	1900	1244 (Torque)	2	turboprop	compressor stages	McCauley	3	93.4"	var	44.1'	R

TABLE 1.2

REFERENCE TAKEOFF

CONDITIONS

Aircraft	Max Gross T/O Wt (lbs)	T/O Ref Mach No.	D_{50}(ft)	Sea Level Std Day Vy(kt)	Sea Level Std Day Max Climb Rate (feet per minute)	Climb Angle (degrees)	Ref* Alt (ft)
Cessna 180	2800	.8271	1205	76	1100	8.2	1058
Archer II PA-28 181	2550	.7074	1860	76	735	5.5	658
Turbo Arrow IV PA28RT 201T	2900	.7789	1620	97	940	5.5	682
Tomohawk PA-38 112	1680	.6637	1460	70	718	5.8	736
Cessna 170	2000	.7151	1850	77.3	760	5.6	669
King Air 200	12500	.7932	2579	126	2450	11.1	1149
Cheyenne PA-42	11200	.7645	3220	120	2400	11.4	1052
Chancellor C414	6750	.8236	2592	108	1520	8.0	837
Baron B58-P	6200	.8413	2643	115	1475	7.3	759
Centurion C-210	3800	.8571	2030	98	950	5.5	643
Skylane C-182	3100	.7529	1570	88.2	1040	6.7	827
Skyhawk C-172	2300	.6839	1625	76	700	5.2	650
Merlin 227-AT	14500	.6959	3760	147.0	2330	9.1	752
Gulfstream Commander 900	10700	.6901	1850	130	2840	12.4	1452
Beech Duchess	3900	.8155	2119	97.5	1248	7.3	824
Beach BonanzaA-36	3400	.8564	2041	95	1036	6.2	717
Piper Navajo 350	7000	.8195	2780	101	1390	6.3	830
Cessna Conquest I C-425	8200	.7151	2341	115	2027	10.0	1085

*8200 ft (2500m) from brake release

2.0 Aircraft Operations: Reference Conditions - For purposes of this series of tests, a reference ground track was defined as a line parallel to, and fifty feet west of the edge of Runway 36 at Dulles. The test program was structured to accommodate either a north or a south traffic flow.

2.1 North Operations - In the case of a northbound traffic flow, it was necessary to use a simulated takeoff procedure. Calculations were made to determine the ground location and altitude to intercept the climbout path. The resulting altitude achieved over the North measurement location (Site 2) theoretically would equal the reference takeoff altitude.

2.2 South Operations - In the case of southbound traffic flow, a full stop takeoff procedure was utilized with brake release at a point nominally 8200 feet (2500 meters) from the south measurement location (Site 1). The full stop takeoff procedure has been specified in the proposed noise certification test as follows:

First phase

a. takeoff power shall be used from the brake release point to the point at which the height of 50 ft (15m) above the runway is reached.

b. a constant takeoff configuration selected by the applicant shall be maintained throughout this first phase.

Second phase

a. the beginning of the second phase corresponds to the end of the first phase.

b. the aircraft shall be in the climb configuration with landing gear up, if retractable, and flap setting corresponding to normal climb throughout this second phase.

c. the speed shall be the best rate of climb speed Vy.

d. The maximum continuous power and RPM that can be delivered by the engine or engines in this flight condition shall be maintained throughout the second phase (unless a lower limiting power is established by the certificating authority,.

2.3 Level Flyovers - In both cases (north or south traffic flow), level flyover operations were conducted in concert with the normal traffic flow. In each level flyover test, target values were specified for altitude, propeller RPM, and engine power.

2.4 Reference Meteorological Conditions for Calculating Reference Takeoff Altitudes - the following paragraph, taken from the proposed takeoff noise certification standard, specifies reference meteorological conditions:

The airplane reference flight procedures shall be calculated under the following atmospheric conditions.

a. sea level atmospheric pressure of 1013.25 hPa (1013.25mb);

b. ambient air temperature of 15°C;

c. relative humidity of 70 percent; and

d. zero wind.

3.0 Acoustical Data - This section describes the procedures used in measurement, recording and reduction of acoustical data.

3.1 Measurement Locations - Two noise measurement sites were utilized during takeoff and level flyover conditions. The sites were located on the flight track centerline, 3000 feet (914m) apart on level ground with short clipped grass. The full-stop takeoff measurement site was approximately 9000 feet from the start of takeoff roll. In the case of full stop takeoff and in the case of flight path intercept takeoff, noise data were corrected to values which would be expected at a distance of 8200 feet from brake release. A schematic of the test array is shown in Figure 3.1.

3.2 Measurement Instrument - Each noise measurement site utilized two identical microphone-preamp systems situated 12" apart. The systems consisted of General Radio one-half inch electret microphones (1962-9610) driving General Radio P-42 Preamplifiers, with the microphones oriented for grazing incidence and mounted 4 feet (1.2m) above the ground. A three-inch windscreen covered each microphone. A 100-foot (30.5m) cable connected one microphone system with a General Radio 1988 Precision Integrating Sound Level Meter driving a Metrosonics Graphic Level Recorder (GLR). The other microphone system was connected by a 100-foot (30.5m) cable to a two-channel Nagra IV-SJ Magnetic Tape Recorder. Amplification was provided by Ithaco Model 451 Amplifier. Data were recorded simultaneously on both channels in the linear mode; however, on windy days, one channel was A-weighted in order to increase the signal-to-noise ratio. Measurement instrumentation schematics are shown in Figures 3.2 and 3.3.

3.3 <u>Noise Data/Data Reduction</u> - The 1988 system provided ALM, SEL, Equivalent Sound Level (Leq), and the duration of the integration. The 10-dB-down duration time was scaled from the Graphic Level Recorder time history charts. The data from the magnetic tape recorder system were processed using a General Radio 1995 1/3 octave real time analyzer interfaced to a PDP 11/05 computer system. It provided ALM, SEL, 10-dB-down duration, time of ALM, one-third octave spectrum for ALM, and one-half second average AL values encompassing the entire 10-dB-down time history.

The 1988 systems were the primary measurement instruments and generated the data presented in the appendices of this report. The magnetic tape recorder systems were deployed selectively on a limited number of days at certain measurement sites. As explained in subsequent sections, the tape recorder systems were utilized for the express purpose of evaluating complex versus simplified data correction procedures to account for non-standard atmospheric absorption.

Summary tables of acoustical measurements data are provided in Appendix A (Takeoff) and Appendix B (Level Flyover).

Microphone and Acoustical Measurement Instrumentation Deployment

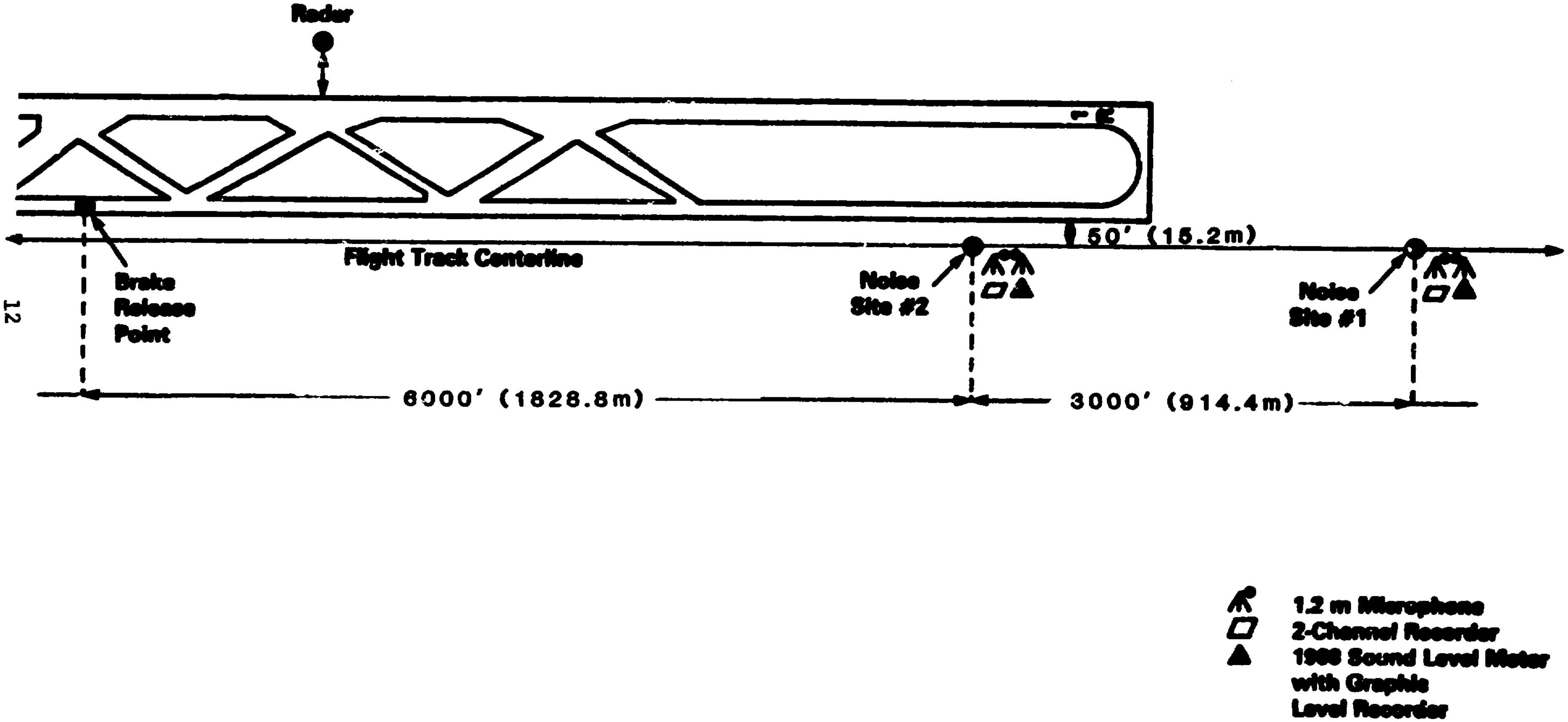
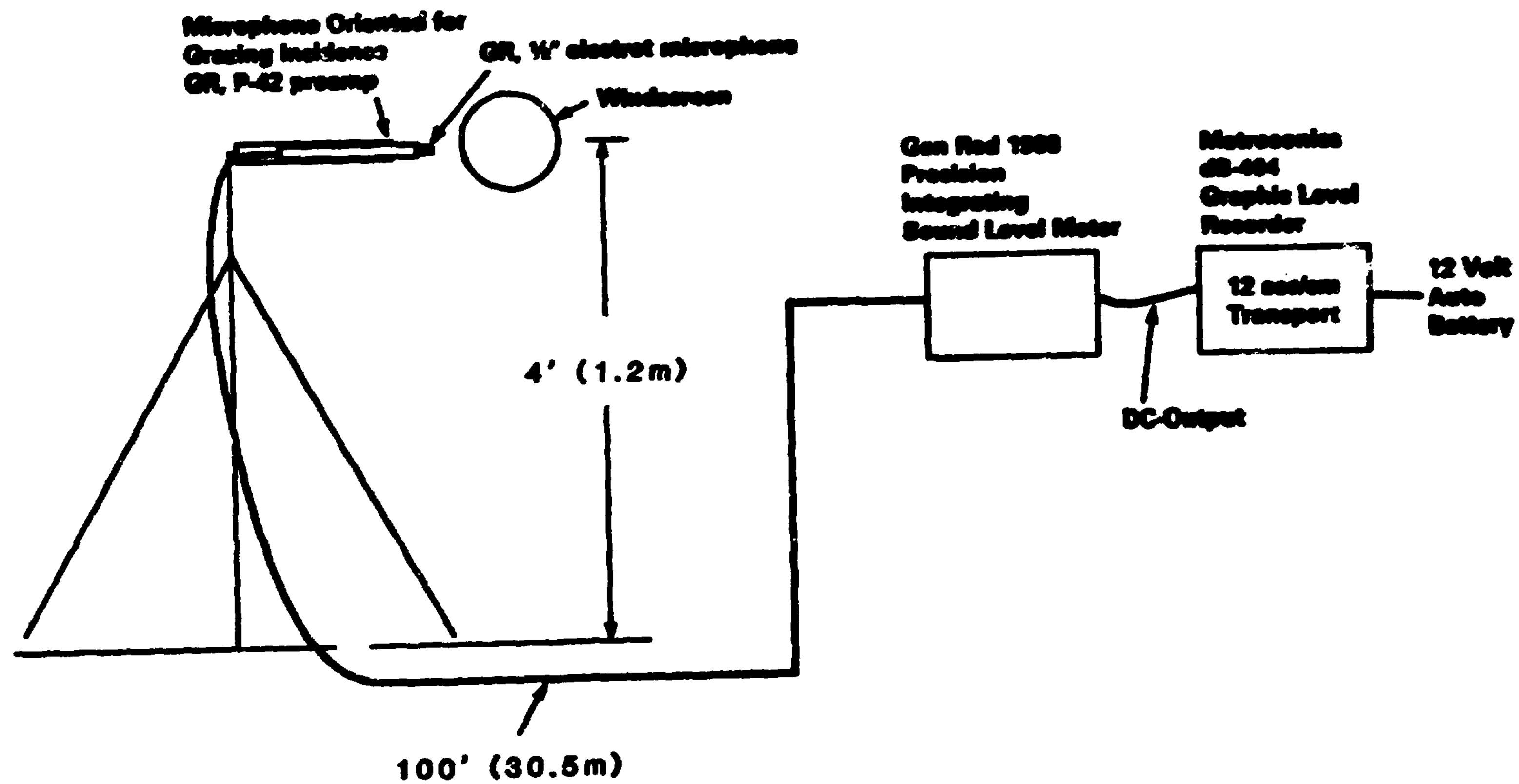


FIGURE 3.1

1988/GLR Direct Read

Acoustical Measurement Instrumentation



Noise Measurement Systems

FIGURE 3.2

NAGRA Tape Recorder

Acoustical Measurement Instrumentation

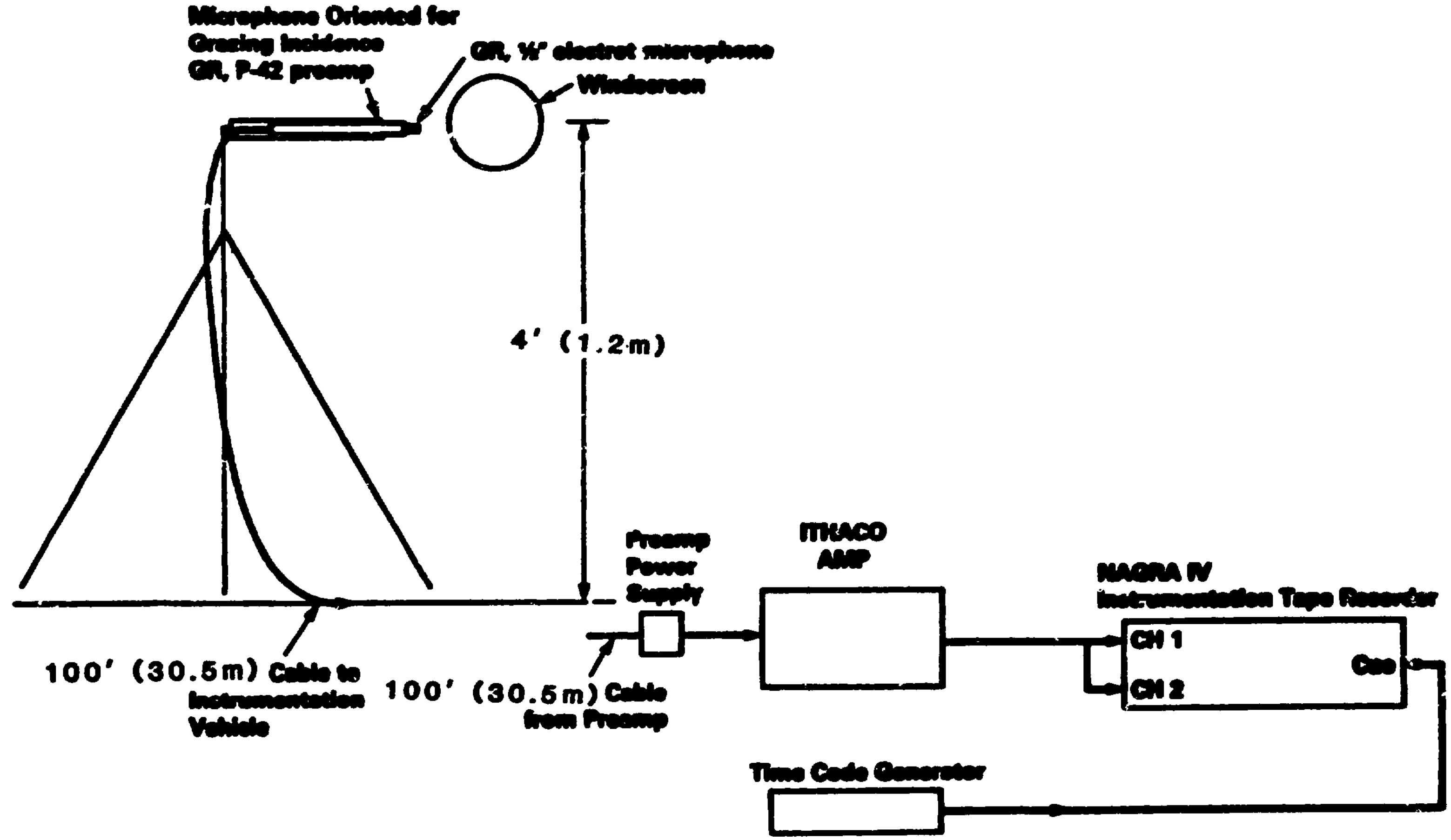


FIGURE 3.3

4.0 Meteorological Data - On-site measurements were taken approximately every 1/2 hour using a sling-psychrometer to measure air temperature and relative humidity. Wind was monitored constantly using a three-cup anemometer.

The U.S. National Weather Service provided upper air observations from routine Radiosonde launchings at nearby Sterling, Virginia. FAA personnel also monitored the wind information provided by the Dulles Low-Level Wind Shear monitoring system.

A tabulation of meteorological data is provided in Appendix D of this report.

5.0 Aircraft Position Data - Aircraft position relative to the reference flight track and noise measurement sites was determined using three different techniques; radar, photoscaling and transit.

A brief description of each technique is provided below:

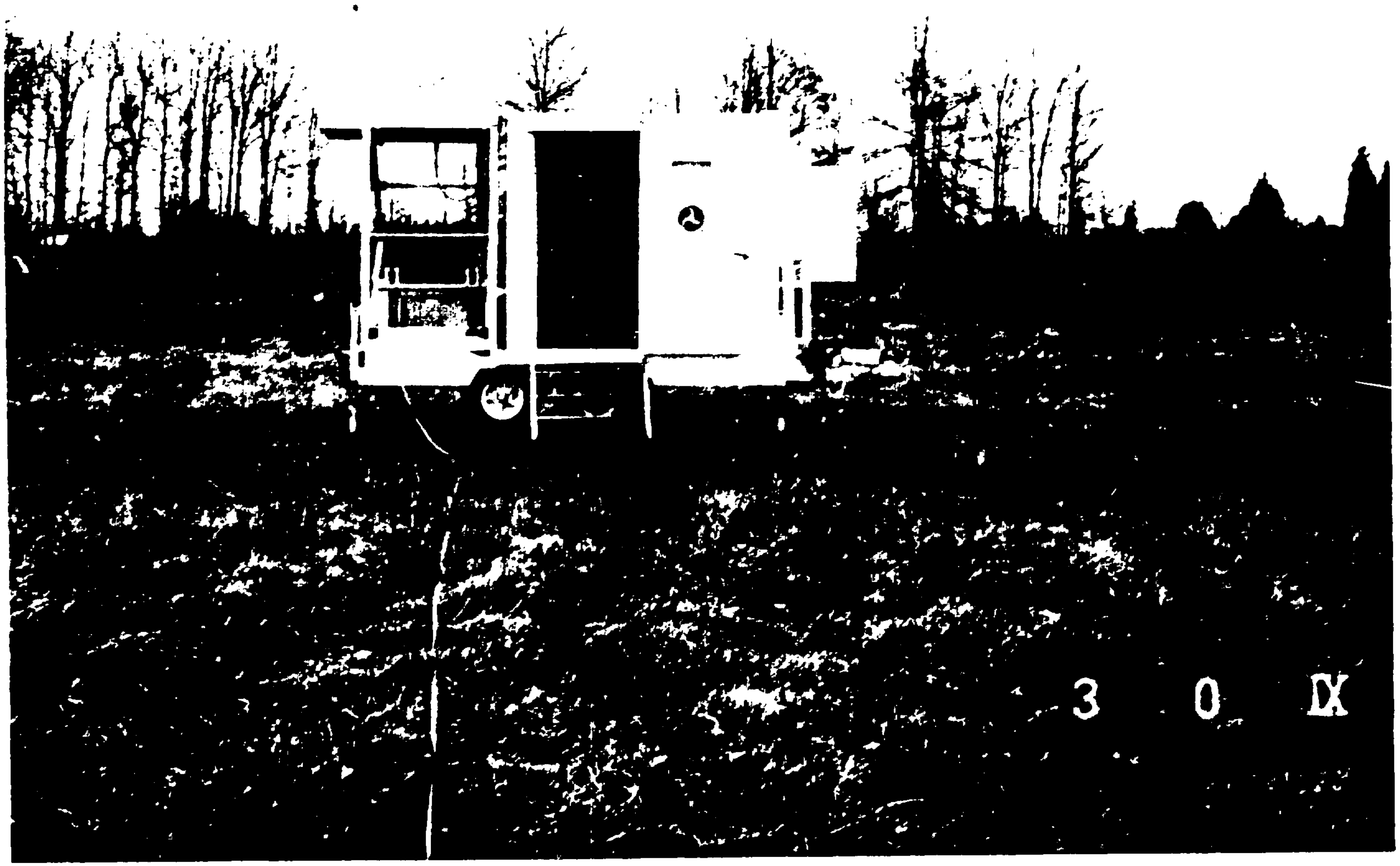
Photo-Scaling - 35mm photographs were taken of each aircraft as it passed over the noise site. Each image was measured and compared with an appropriate calibration photograph to determine altitude.

Radar - Aircraft position data were supplied, for some events, by a tracking radar system. A photograph of the radar system is shown in Figure 5.1.

Transit - A surveyor's transit was placed approximately 1500' (457m) abeam (east) of the primary noise site. The observer visually followed the target aircraft through the transit until the aircraft passed over the noise site (transit turret was blocked from moving beyond the noise site). An elevation reading was taken to determine the aircraft's altitude above the noise site. This method was included in the test program merely to evaluate its feasibility. None of the transit data was used in the analyses presented in this paper.

The three different measurement systems were used, in part, for the purpose of evaluating comparative performance and in part, to maintain back-up tracking capability. A comparative analysis is provided in sections which follow.

The aircraft position data used in level flyover analyses (see Appendix B) were primarily from the photo-scaling systems while radar data were primarily used in evaluating takeoff noise data (see Appendix A). This methodology reflects the timing and sequence of data analysis as well as delays encountered in developing radar data reduction software.



RADAR PHOTOGRAPH
FIGURE 5.1

6.0 Cockpit Instrument Readings - Cockpit data were logged by an FAA observer for each noise run when the aircraft was approximately over the (proposed) noise certification measurement location. These data were essential for developing and (in the case of takeoff), applying propeller tip speed corrections and power corrections. A tabulation of the acquired cockpit data is presented in Appendix C.

7.0 Propagation - This section of the report utilizes takeoff noise data from test runs in which aircraft position data were available at both measurement sites. An implicit assumption is that the acoustical emission characteristics of the test aircraft remain constant over the 3000 feet between sites.

7.1 Intensity metric: Propagation Effects - In the case of the intensity metric, maximum A-weighted Sound Level, the primary considerations are spherical spreading and atmospheric absorption. Adjustment for these factors is referred to as the Delta-1 correction. The Delta-1 process involves application of the spreading law plus absorption to each of the 24 one-third octave Sound Pressure Levels between 44 Hz and 11,200 Hz. The correction for most atmospheres and most spectra is given in simplified format as:

$$\Delta_1 = K(A) \log ({}^{d}1/d_2) \text{ dB}$$

where K(A) is greater than 20 and generally less than 27.

7.2 Energy Metric: Propagation Effects - In the case of the energy metric, SEL, one observes the same losses described above plus the effects of duration. In the example below we consider only distance-duration effects, assuming no change in ground speed. The change in SEL with distance can be written as:

$$\Delta = K(A) \log ({}^{d}1/d_2) + K(D) \log ({}^{d}2/d_1)$$

or

$$\Delta = (K(A) - K(D)) \log ({}^{d}1/d_2)$$

By defining (K(A) - K(D)) = K(S), the SEL propagation constant, one can write:

$$\Delta = K(S) \log ({}^{d}1/d_2)$$

In summary, the object of this study is to determine empirical values of K(A) and K(S) using takeoff noise measurement data.

7.3 Results - A total of 30 individual takeoff noise events (encompassing six different aircraft types) have been examined. If all data are grouped as a single population, the following overall averages result:

	N	Propagation Constant	σ	90% C.I.	90% C.I. Range for True Value of "K"
K(A)	31	21.1	4.9	1.5	22.6 to 19.6
K(S)	30	15.0	3.4	1.07	16.1 to 13.9

It is seen that a much greater uncertainty exists in the estimate of K(S), while the K(A) estimate appears reasonable within the context of applicable theory. As seen in the next sub-section, the K(A) estimate is largely corroborated by other similar studies.

7.4 Examination of Other Test Data - This section uses values of Delta-1 computed in previous noise tests to determine comparison values of K(A). Using available information the following calculation was made.

$$K(A) = [\text{Delta-1}] \div \log [d_1/d_2]$$

Each value of Delta-1 used in this analysis contains three components. The first term accounts for the effects of change in atmospheric sound absorption between actual and reference atmospheres. The second term accounts for the effects of atmospheric sound absorption on the change in sound propagation path length between actual and reference flight path. The third term accounts for the effects of the inverse square law on the change in the sound propagation path length.

The following values of K(A) were obtained using this method for a number of previous helicopter and general aviation aircraft noise tests as described below:

a. K(A) = 24.38, S.D. = 2.7, Sample size - 23 for seven general aviation aircraft tested in 1978.[1]

b. K(A) = 21.7, S.D. = 0.6, Sample size - 15 for four helicopters tested in 1979.[2]

c. K(A) = 23.3, S.D. = 4.0, Sample size = 30 for eight helicopters tested in 1978.[3]

7.5 Discussion - The method of determining K(A) in this paper is strictly empirical, depending entirely on measured data. The comparison technique using previously reported data employs computed values of Delta-1. These computed values are in turn dependent on the accuracy of Society of Automative Engineers Aerospace Recommended Practice -866A.[4] While the two techniques are not strictly comparable, they both provide a means for evaluating propagation decay rate. When considered together they point to the similarity of the results and lead to the conclusion that for small propeller-driven aircraft, the appropriate value of K(A) falls between 20 and 24.

Since experimental values of K(A) determined from the summer 1982 tests are slightly over 20, it can be concluded that there is little absorption taking place. This is not surprising since the test aircraft produce sounds dominant in the low frequency range (i.e., $<$260 Hz). It is worthwhile to note that some changes in acoustical emission characteristics probably take place between two sites which may account for some of the variability.

8.0 Comparison of Simplified and Complex Procedures for Considering the Effects of Atmospheric Absorption and Spherical Spreading - the new ICAO proposal would substitute takeoff noise measurements for the current level flyover measurement requirement. This proposal would also incorporate some form of combined atmospheric absorption and spherical spreading correction similar to that outlined in Annex 16/FAR Part 36 Appendix A. This complex correction is referred to as "Delta-1". One option is a "simplified" correction concept for atmospheric absorption. In this section simplified values are calculated and compared with those of the more complex Delta-1 correction procedure to determine the magnitude and significances of the differences.

8.1 Analytical Process - Computer software was developed at the FAA's Noise Lab for use in this test. One such program accepts noise, position, and weather data, calculates corrections, and computes the desired metrics. These metrics are described below:

1. Determination of As-Measured ALM - Using the spectrum of the half-second sample producing the maximum noise level, provided by the "1995" system, this software applies A-weighting constants (unless A-weighting was applied during the test) to each 1/3 octave band sound pressure level and computes the A-weighted value.

$$L_{AM} = 10 \log \left[\sum_{i=1}^{24} \left[\text{ANTILOG} \frac{[SPL_i + [A\text{-}Wt]_i]}{10} \right] \right]_M \qquad \text{(EQUATION 1)}$$

2. Determination of Complex Correction AL (AL_{cx}) - This program calculates "corrected" A-weighted value as it does ALM. However, in this case the program also computes, for each 1/3 octave band, corrections

which are added to the A-weighted SPL's to adjust for effects associated with differences between test and reference conditions.

$$L_{Acx} = 10x \log \left[\sum_{i=1}^{24} \left[\text{ANTILOG } \frac{[SPL_i + [A\text{-}Wt]_i + ATM_i + ABS_i + SPH_i]}{10} \right] \right] \quad \text{(EQUATION 2)}$$

The corrections applied (ATM_i, ABS_i, SPH_i) in the above equation are defined as follows:

ATM_i represents the standard day atmospheric correction for a particular 1/3 octave band

$$ATM_i = ((\alpha_i - \alpha_{\circ i})/1000')\,(ALT_T)$$

NOTE: α_i: is the SAE-ARP-866A[6] absorption coefficient for the i-th 1/3 octave band for test day temperature and relative humidity.

$\alpha_{\circ i}$: is the SAE-ARP-866A absorption coefficient for the i-th 1/3 octave band for the reference conditions of 59°F (15°C) and 70% RH. All data have been analyzed using the 77°F, 70%RH reference conditions as well as the 59°F, 70% RH reference values. Although only the 59°F, 70% RH results are reported herein, the 77°F, 70% RH values are nearly identical.

ALT_T: Test altitude

ALT_R: Reference altitude

ABS_i: is the atmospheric absorption correction applied to each 1/3 octave band of the ALM spectrum.

$$ABS_i = (\alpha_{\circ i}/1000')(ALT_T - ALT_R)$$

SPH_i: is the correction added to the 1/3 octave band value to adjust for spherical spreading.

$$SPH_i = 20 \log (ALT_T/ALT_R)$$

This correction strictly parallels the "Delta-1" correction process contained in FAR Part 36 and ICAO Annex 16.

3. Determination of Simplified Corrected ALM (AL_{cs}) - To "correct the ALM value using the proposed simplified technique, this program adds as a correction factor the product of a constant (24) and the log of the ratio between the test and reference altitudes.

$$LA_{cs} = L_{AM} + 24 \log (ALT_T/ALT_R) \qquad \text{(EQUATION 3)}$$

NOTE: The value 24 has been derived from previous empirical studies of noise propagation characteristics. For further discussion please refer to Section 12.5.

4. "As Measured" Sound Exposure Level (SEL_{AM}) - The A-weighted values for each half-second sample (provided by the "1995" system) were used to compute the "as measured" SEL.

$$L_{AE_{AM}} = 10 \log \left[\sum_{i=1}^{n} \text{ANTILOG } [L_{A_i}/10]\right] - 3\text{dB} \qquad \text{(EQUATION 4)}$$

NOTE: The correction of 3 dB normalizes the value to a one-second base.

5. Complex Corrected Sound Exposure Level (SEL_{cx}) - The "corrected" SEL was calculated by adding to the AL_{cx} values an "as measured" duration correction (SEL_{AM}-AL_{AM}) along with an altitude duration correction, 7 log (ALT_R/ALT_T). In this analysis it is assumed that test and reference velocities are equal.

$$L_{AE_{cx}} = LA_{cx} + (L_{AE_{AM}} - L_{AM(am)}) + 7 \log (ALT_R/ALT_T) \qquad \text{(EQUATION 5)}$$

6. Simplified Corrected Sound Exposure Level (SEL_{cs}) - The simplified version for determining a corrected SEL is the same as the SEL_{cx} procedure, except the value AL_{cx} is replaced with the value AL_{cs}

$$L_{AEcs} = L_{A_s} + (L_{AE_{AM}} - L_{AM_{(am)}}) + 7 \log (ALT_R/ALT_T) \quad \text{(EQUATION 6)}$$

NOTE: Use of the constant 7 in the above equations (5 and 6), rather than the value of 10, was found to provide a better fit to the test data. (see Section 9.2).

8.2 A Parametric Analysis of Complex versus Simplified Differences - The "Delta-1" process described above incorporates corrections for the influence of non-reference temperature and relative humidity operating over some finite "Correction Ratio", the test altitude divided by the reference altitude (ALT_T/ALT_R). As discussed in later sections the "Altitude is observed to be approximately equal to the "Closest Point of Approach". Therefore, in subsequent discussion the correction ratio is defined as CPA_T/CPA_R). This chapter attempts to explore the differences between simplified and complex correction procedures taking into account the three variables 1) temperature, 2) relative humidity, and 3) correction ratio.

This analysis uses takeoff noise spectra for test aircraft measured over a wide range of temperature (T) and relative humidity (RH) conditions.

For each spectrum acquired at a given T, RH, and test altitude, the following corrections are developed:

1. Correct to 77°,70% using simplified procedures for a series of reference altitudes resulting in Correction Ratios (CR) which span the range 0.5 to 1.5.

2. Correct to 77",70% over the same CR range using the complex procedures.

Having exercised both the complex and simplified techniques over the dimensions T,RH,CR, for a variety of representative aircraft spectra, we have plotted the differences in figure 8.1-8.10. It is observed that the complex-minus-simplified differences increase as the CR diverges from 1.0 (as one might expect), with the complex procedure yielding greater corrections (resulting in higher corrected noise levels) when CR is less than 1.0 (CPA_T less than CPA_R). When the CR is greater than 1.0 the simplified technique yields a higher correction value resulting in a lower corrected noise level. In both cases one will find a higher corrected noise level using complex procedures.

The magnitude of this difference, however, is small (generally less than 0.5 dB) with a CR range of 0.7-1.3. As long as allowable deviations from the reference flight path are restricted to CR range of 0.7-1.3, differences between the complex and simplified Delta-1 corrections are so small that the additional time and expense of generating complex correction values is unjustified.

8.3 Atmospheric Absorption Variation with Temperature and Relative Humidity for Dominant One-Third Octave Bands. - This analysis examines which one-third octave sound pressure levels dominate the A-weighted acoustical spectrum for each aircraft. A summary of dominant and second highest bands is presented in Tabel 8-1 for typical takeoff and level flyover noise events for test aircraft. As these bands are the most influential in determining the maximum A-weighted sound level their sensitivity to atmospheric absorption is an important indicator of the need for the more rigorous "Delta-1" correction process.

Complex versus Simplified Analysis

Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = .5$

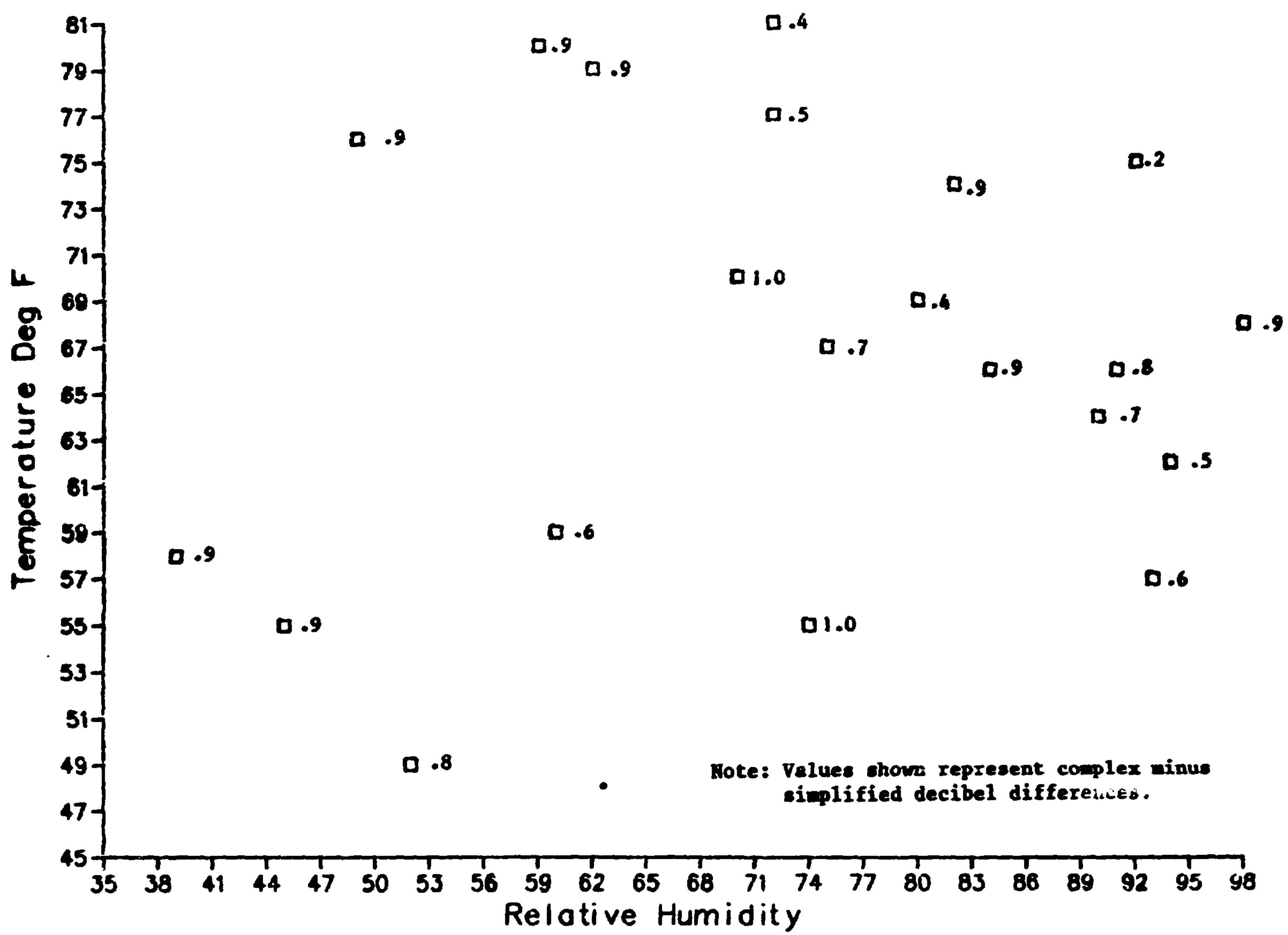


FIGURE 8-1

Complex versus Simplified Analysis

Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = .6$

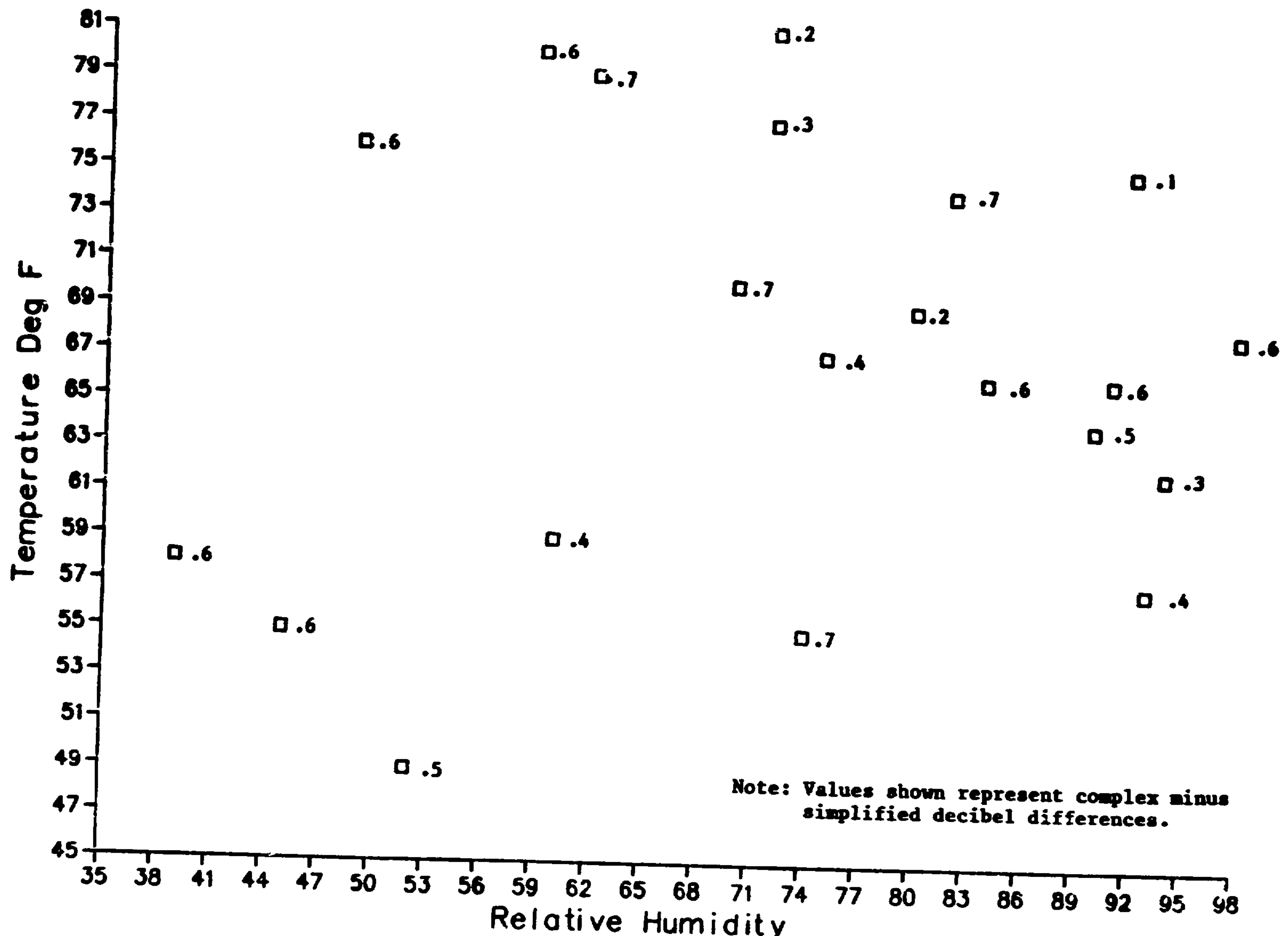


FIGURE 8-2

Complex versus Simplified Analysis

Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = .7$

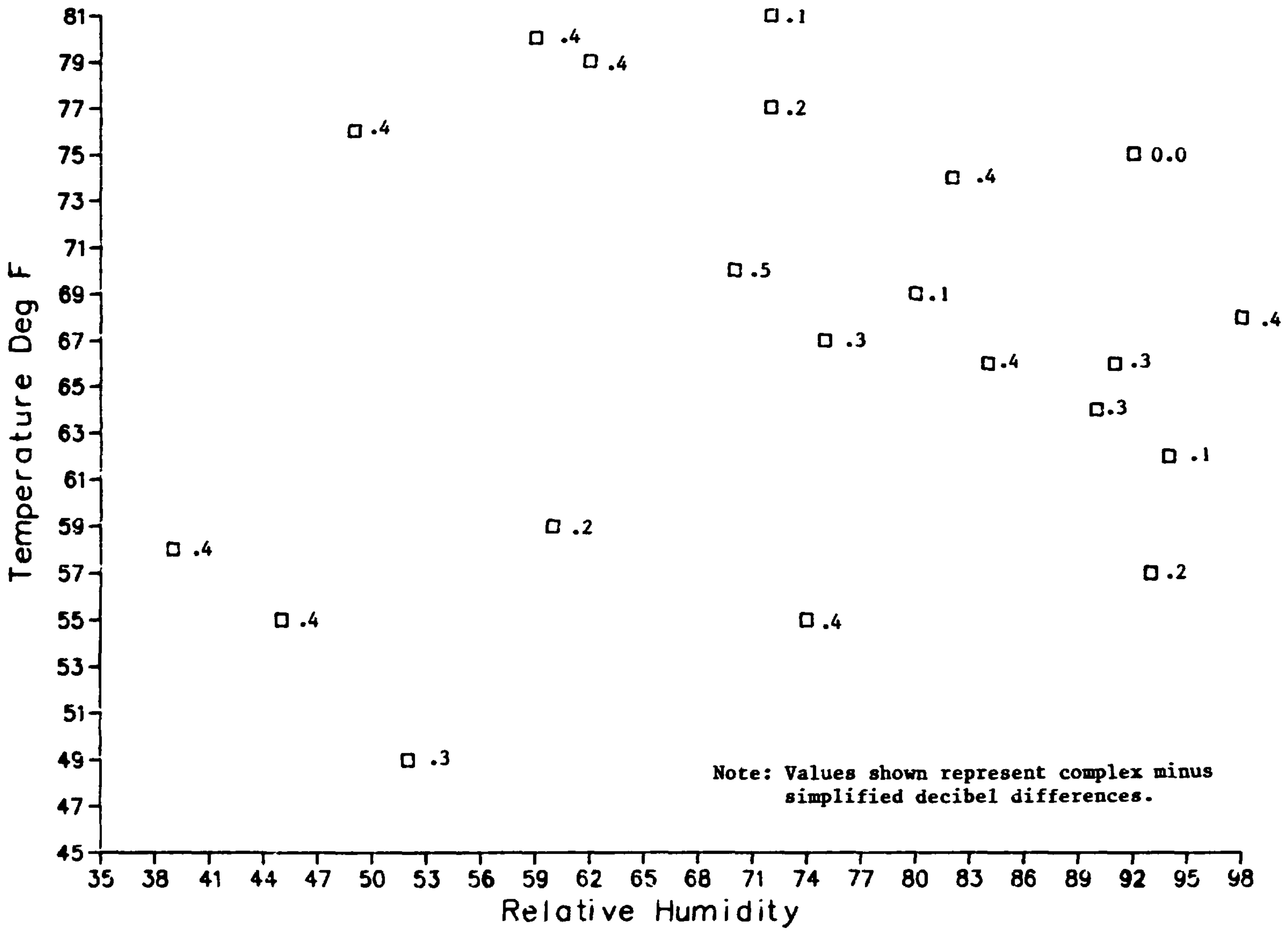
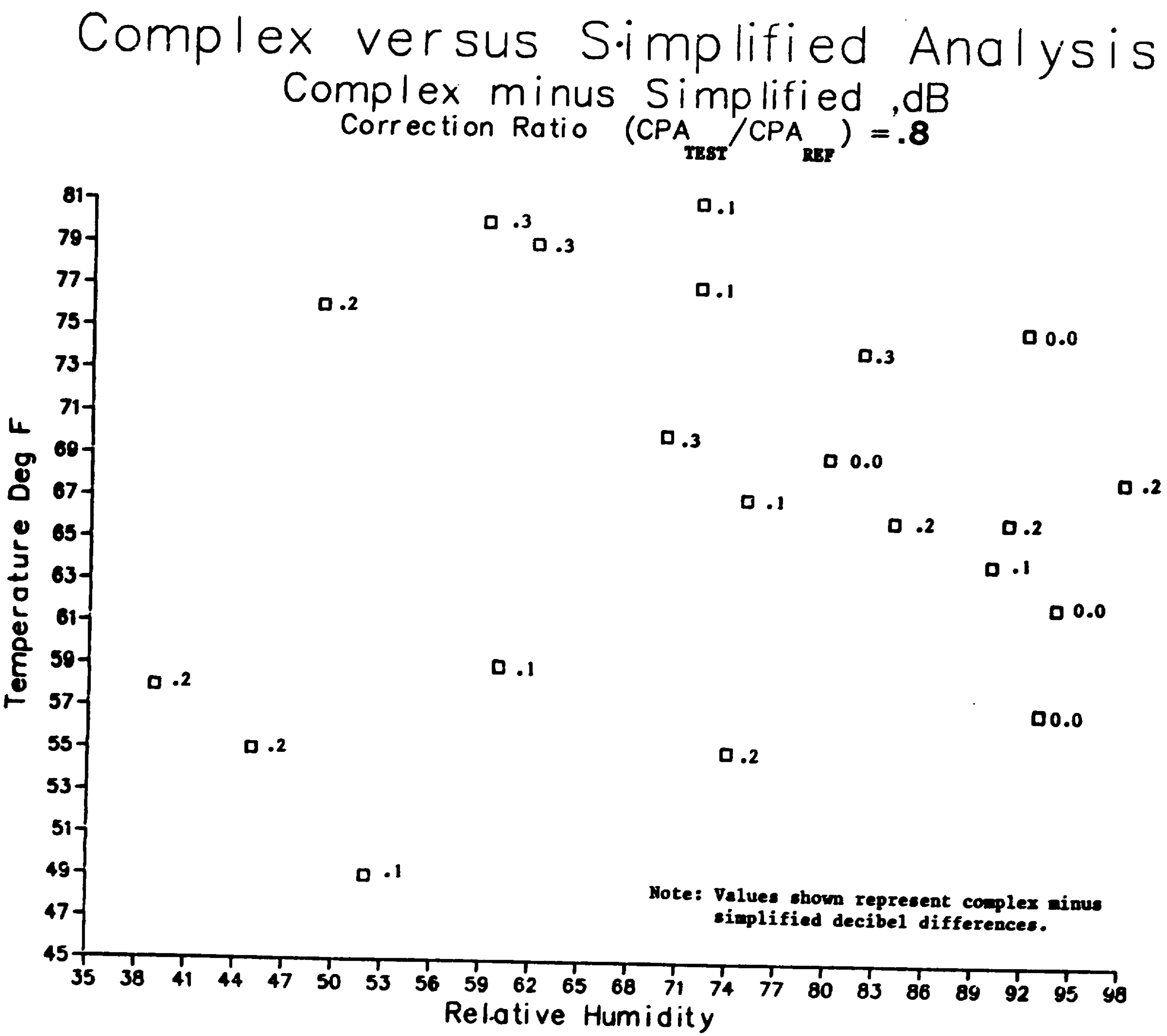


FIGURE 8-3



Complex versus Simplified Analysis
Complex minus Simplified ,dB
Correction Ratio (CPA TEST /CPA REF) = .8
Temperature Deg F
81
79
77
75
73
71
69
67
65
63
61
59
57
55
53
51
49
47
45
35 38 41 44 47 50 53 56 59 62 65 68 71 74 77 80 83 86 89 92 95 98
Relative Humidity
.1
.3
.3
.1
.2
0.0
.3
.3
0.0
.2
.1
.2
.2
.1
0.0
.1
.2
0.0
.2
.2
.1
Note: Values shown represent complex minus simplified decibel differences.

FIGURE 8-4

Complex versus Simplified Analysis

Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = .9$

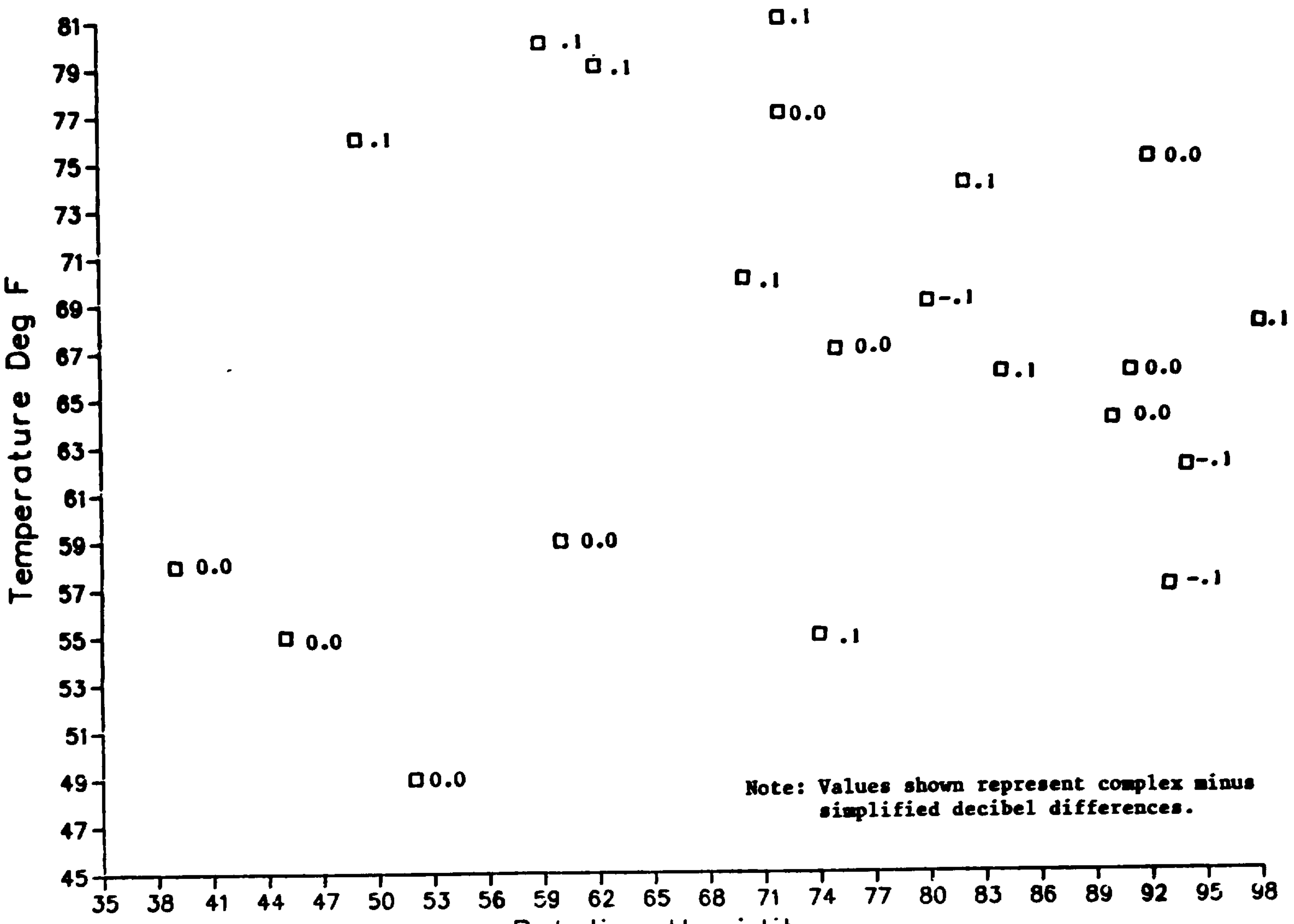


FIGURE 8-5

Complex versus Simplified Analysis

Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = \mathbf{1.1}$

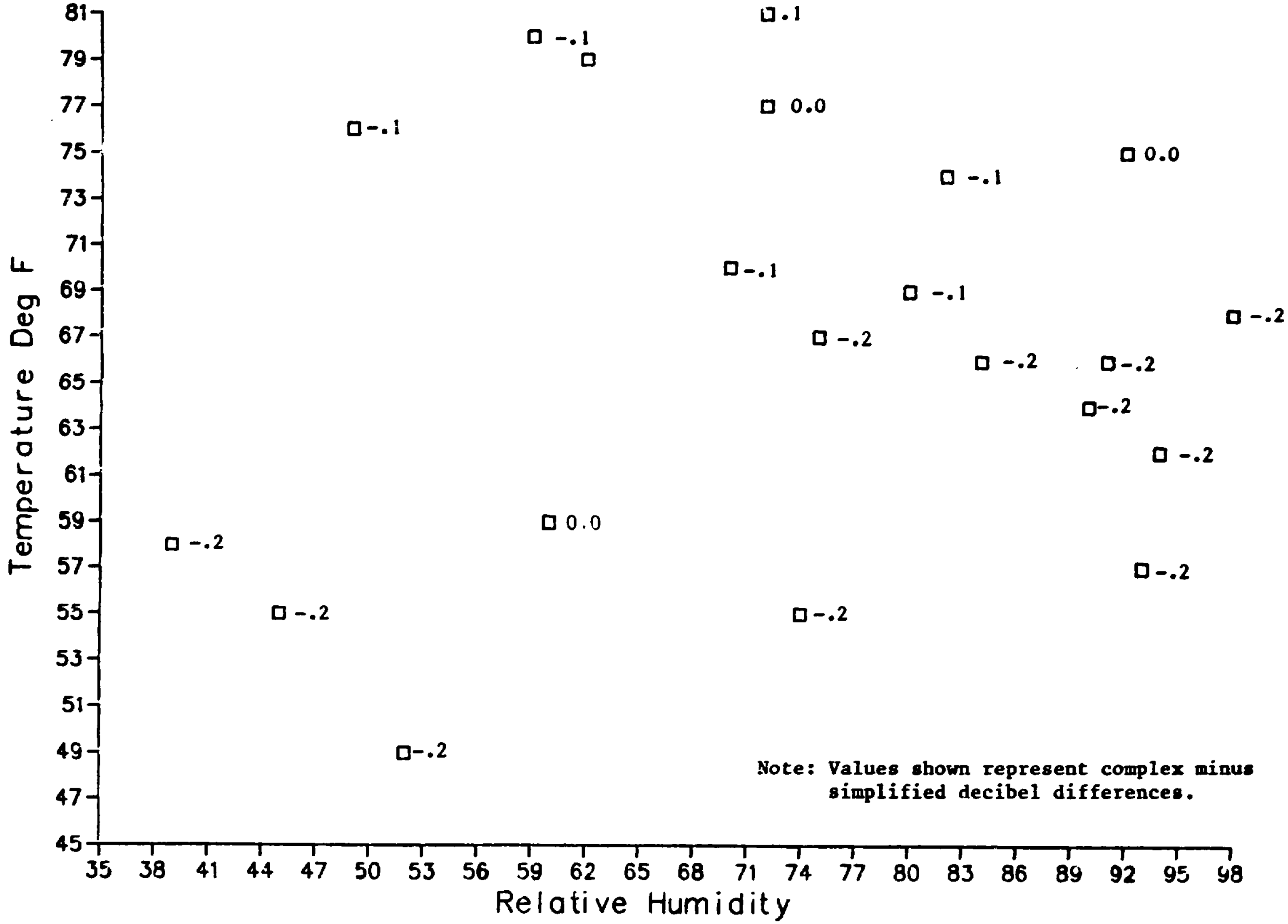


FIGURE 8-6

Complex versus Simplified Analysis

Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = 1.2$

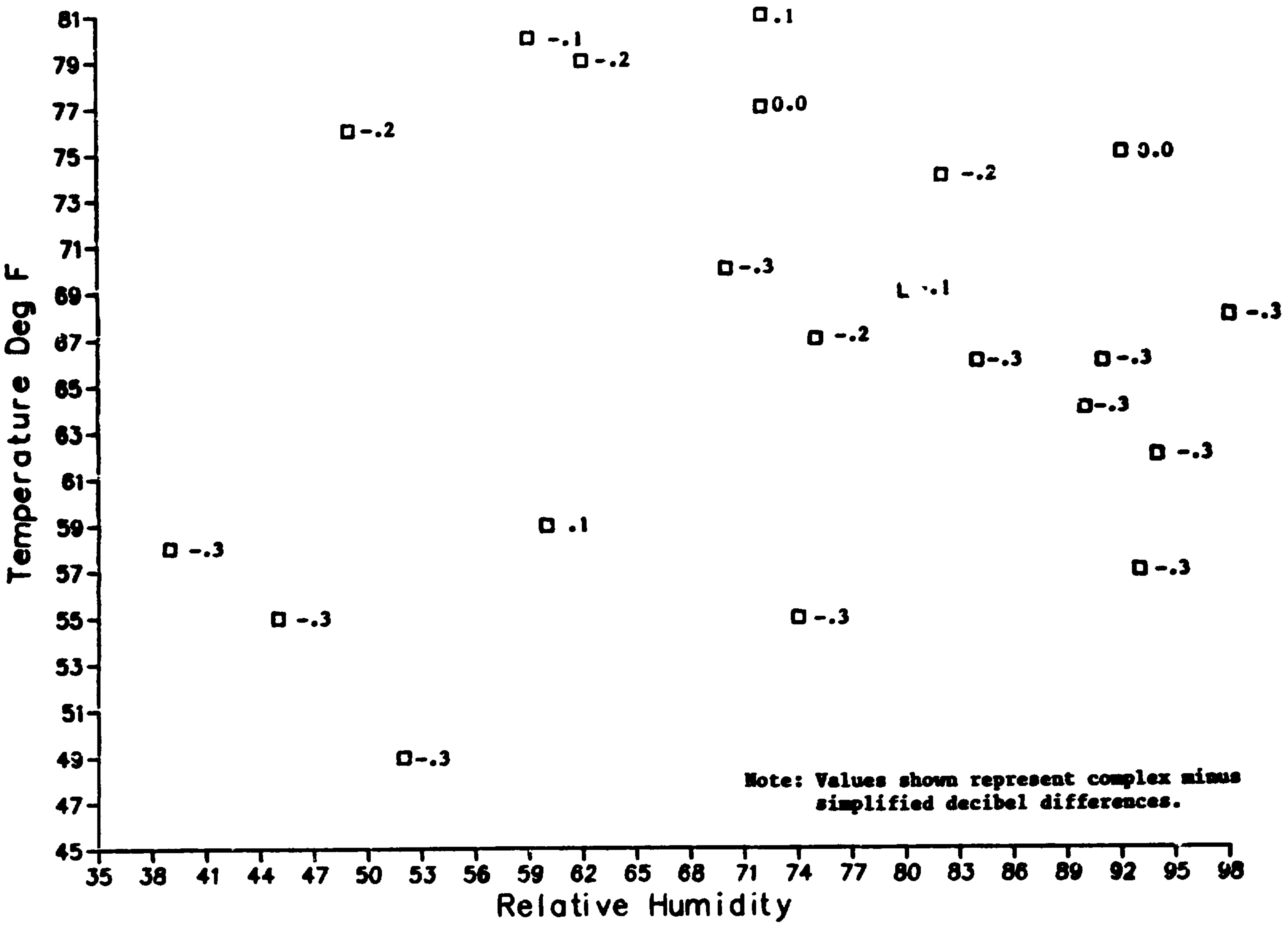


FIGURE 8-7

Complex versus Simplified Analysis

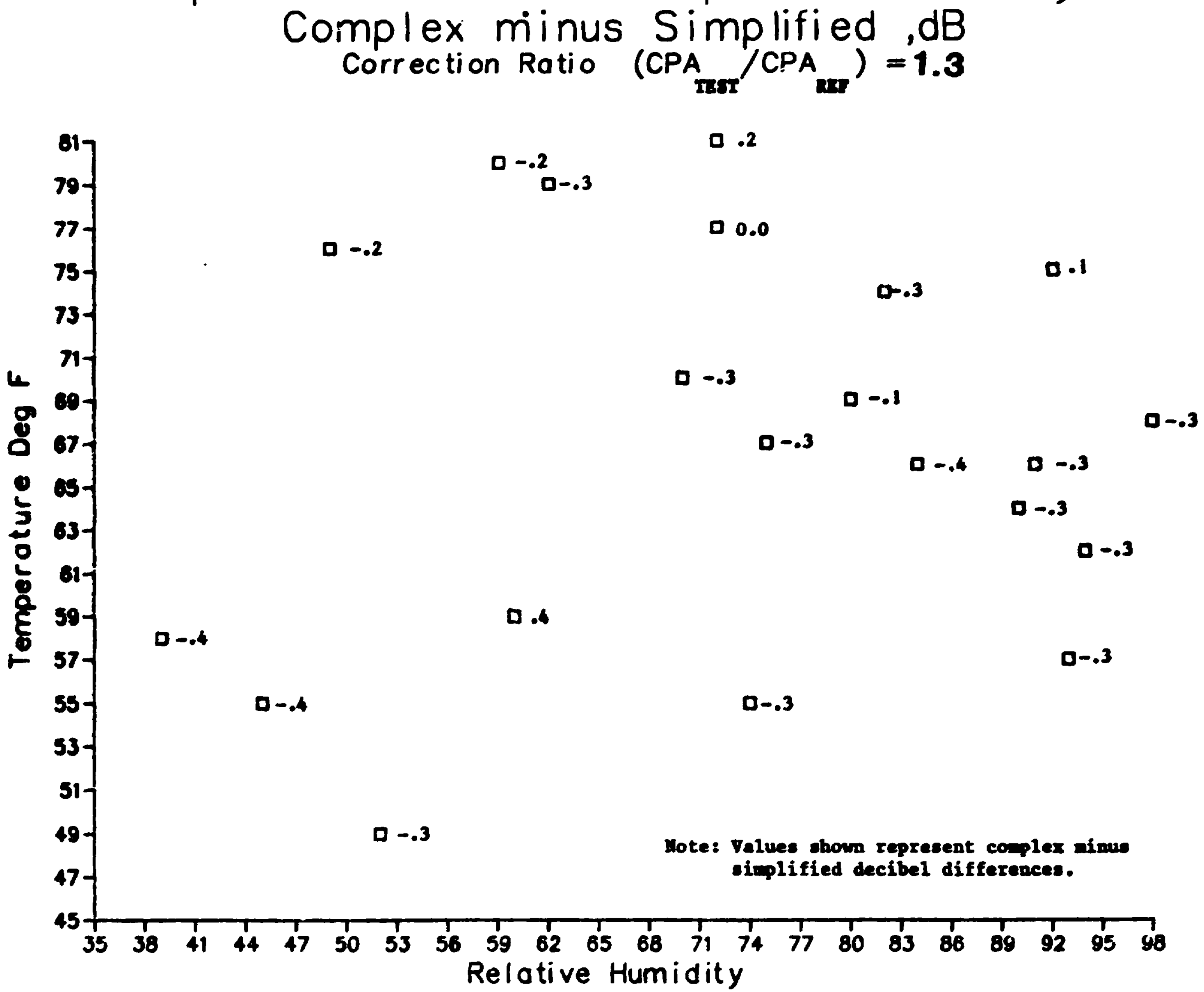


FIGURE 8-8

Complex versus Simplified Analysis

Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = \mathbf{1.4}$

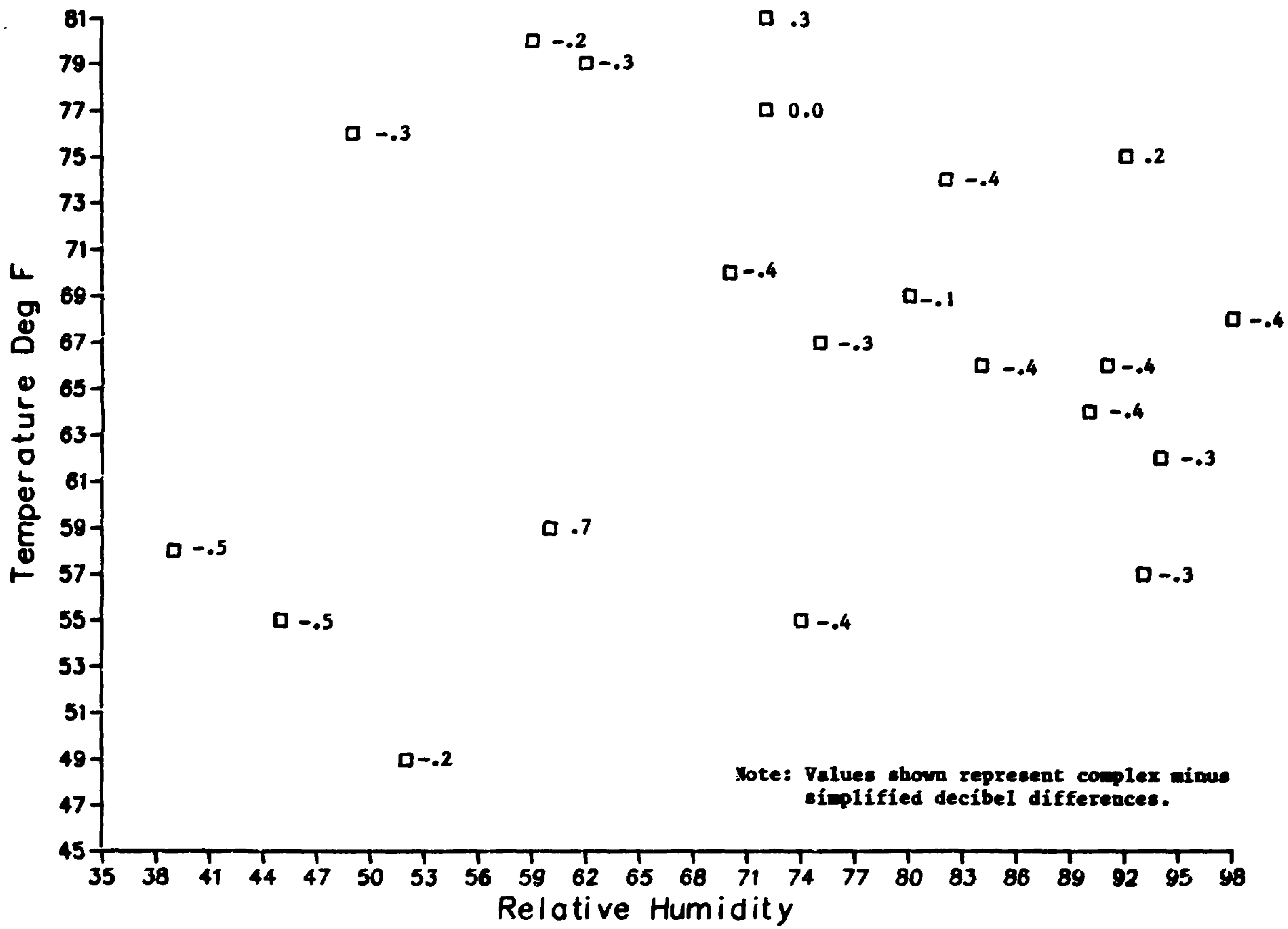


FIGURE 8-9

Complex versus Simplified Analysis

Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = \mathbf{1.5}$

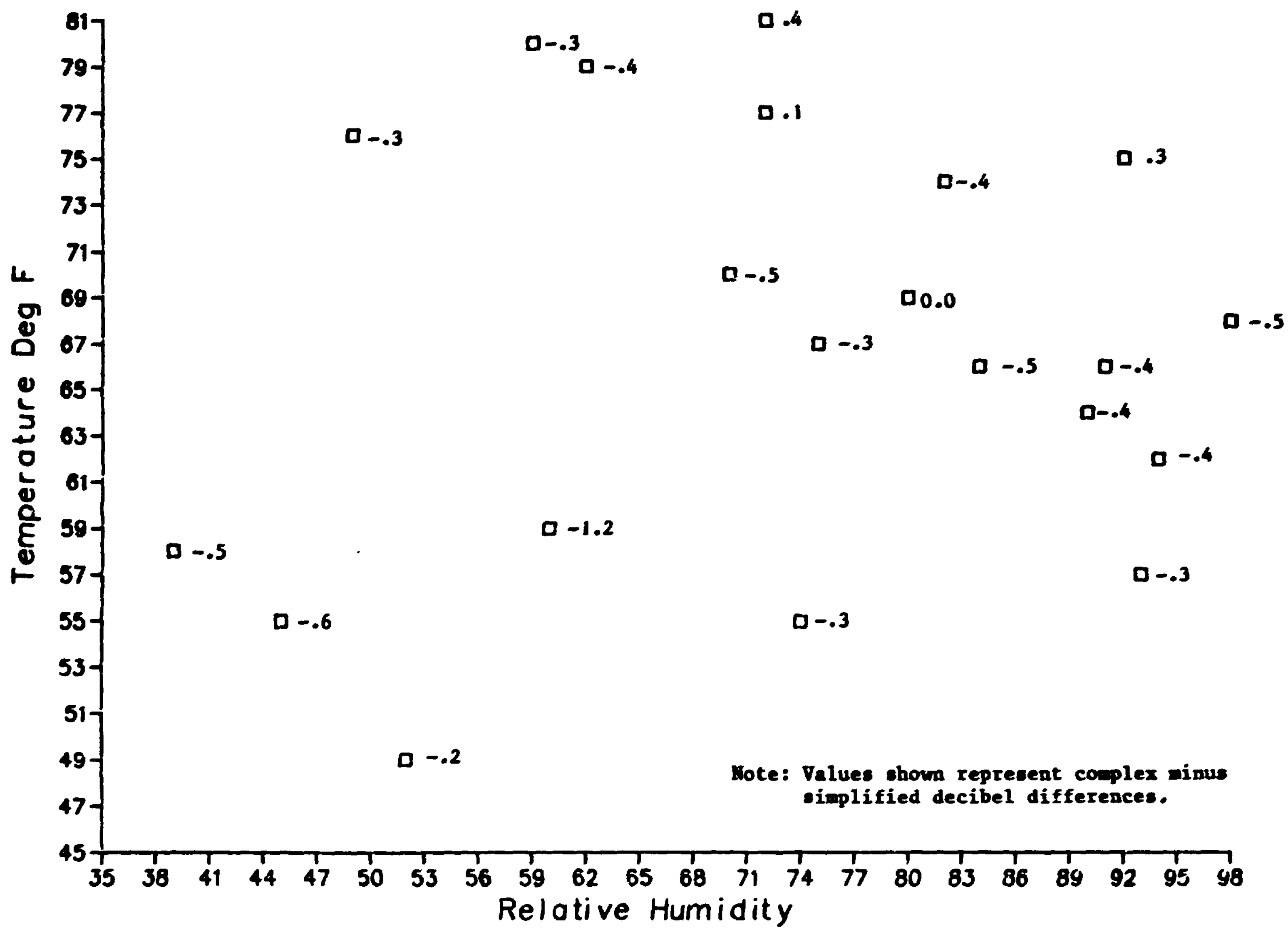


FIGURE 8-10

Having established the dominant bands one can now examine the sensitivity to absorption by inspecting Table 8-2 which provides rates of absorption for the standard acoustical day (77°F,70%) and five other T-RH combinations which encompass a realistic test condition window. In cases where a significant difference (1dB/1000') exists between the 77°F,70% rate of absorption and a selected test condition, one would expect to see greater sensitivity to atmospheric absorption in the correction process and perhaps a greater need for the complex correction procedure. Accordingly, one would expect to see a greater difference between the results of complex and simplified correction procedures. In cases where very little difference exists between reference and test rates of absorption then the need for complex procedures is diminished and one would expect good agreement between complex and simplified procedures.

This is in fact the case observed for almost all of the aircraft tested with the exception of the Duchess and Archer II which are dominated by acoustical energy in the 1 kHz to 2 kHz range.

TABLE 8-1

A-WEIGHTED ACOUSTICAL SPECTRA

DOMINANT ONE-THIRD OCTAVE BANDS

	TAKEOFF			LEVEL FLYOVER		
AIRCRAFT TYPE	NO. 1 FREQ (Hz)	NO. 2 FREQ (Hz)	dB-DOWN	NO. 1 FREQ (Hz)	NO. 2 FREQ (Hz)	dB-DOWN
CESSNA 170	125	315	0.9	125	315	3.3
TURBOW ARROW IV	250	400	0.2	250	125	1.0
TOMOHAWK	160	315	2.3	160	315	1.0
KING AIR 200	400	315	2.3	500	400	1.1
CESSNA 414	125	630	3.6	125	250	6.5
PIPER CHEYENNE	200	315	1.7	315	100	3.8
BARON 58P	400	630	1.6	250	400	2.0
CESSNA 210	800	1000	0.5			
CESSNA 182	125	250	10.3			
CESSNA 172	160	315	2.3			
MERLIN 227AT	20	125	1.8			
GULFSTREAM 900	160	315	8.7			
DUCHESS	1000	800	0.5			
ARCHER II	2000	2500	0.5			
CESSNA 441	200	315	1.8	315	250	3.5
NAVAJO 350	125	400	2.7			
BONANZA A-36	400	250	1.24			
CESSNA 180	315	500	0.4	125	400	1.96

TABLE 8.2

ATMOSPHERIC ABSORPTION
FOR SELECTED
TEMPERATURES AND RELATIVE HUMIDITY

(dB/1000 ft.)

FREQUENCY (Hz)	77°F 70%	36°F 60%	36°F 95%	45°F 30%	65°F 50%	95°F 20%	95°F 90%
50	0.1	0.1	0.1	0.1	0.1	0.1	0.1
63	0.1	0.1	0.1	0.1	0.1	0.1	0.1
80	0.1	0.1	0.1	0.1	0.1	0.2	0.2
100	0.2	0.1	0.1	0.1	0.2	0.2	0.2
125	0.2	0.1	0.1	0.1	0.2	0.3	0.3
160	0.3	0.2	0.2	0.2	0.2	0.3	0.3
200	0.3	0.2	0.2	0.3	0.3	0.4	0.4
250	0.4	0.3	0.3	0.4	0.4	0.5	0.5
315	0.6	0.4	0.4	0.5	0.5	0.7	0.7
400	0.7	0.5	0.5	0.8	0.6	0.9	0.9
500	0.9	0.7	0.6	1.1	0.8	1.1	1.1
630	1.1	0.9	0.7	1.5	1.0	1.3	1.3
800	1.4	1.3	0.9	2.2	1.2	1.7	1.7
1000	1.8	1.9	1.3	3.1	1.6	2.2	2.2
1250	2.2	2.7	1.7	4.3	2.0	2.7	2.7
1600	2.9	3.9	2.4	6.2	2.6	3.5	3.5
2000	3.6	5.6	3.4	8.5	3.4	4.7	4.4
2500	4.6	7.8	4.8	11.7	4.6	6.2	5.5
3150	5.9	11.1	7.0	16.4	6.3	8.6	7.1
4000	7.6	16.0	10.2	21.6	9.1	12.2	9.1
5000	8.7	19.0	12.2	24.3	10.9	14.7	10.4
6300	11.0	25.9	17.3	30.1	15.4	20.7	13.2
8000	14.9	36.6	25.0	37.4	22.7	30.5	17.2
10000	20.6	52.0	36.1	45.4	33.1	44.2	22.7

9.0 Analysis of Duration Correction Procedures - Originally, the proposed metric for evaluating takeoff noise was the Sound Exposure Level, abbreviated SEL (symbol, L_{AE}). This metric considers not only the intensity but also the duration of the noise event. This section develops an empirical approach to evaluating changes in SEL with changes in event duration associated with non-reference testing. However, in light of recent conclusions favoring the use of ALM rather than SEL for certification purposes, this discussion can now be considered moot.

9.1 Establishing the Relationship Between 10-dB Duration Time and Aircraft-to-Observer Distance - In order to develop this relationship it was necessary to utilize takeoff data. In this flight condition it is assumed that acoustical emission characteristics of the aircraft are nominally the same as the aircraft passes over the two measurement locations. As the two sites were separated by 3000 feet, the aircraft altitudes differed significantly. Table 9.1 depicts the results of correlation analyses between distance and duration. The high average correlation coefficient indicates that a change in distance is accompanied by a proportional change in duration. These results are consistent with theory and substantiate the assumptions inherent in the ICAO Annex 16, Distance Duration Correction Adjustment (Δ 2) procedure.

9.2 Establishing an Empirical Relationship Between SEL, AL, and 10-dB Duration Time - In order to investigate this relationship an empirical formula was developed, $L_{AE} = L_A + K(D) \times \log (T)$ and evaluated using measurement data. For selected noise events the "duration constant"

K(D) was determined. Table 9.2 is a summary of these results. As the table shows, the values are consistently between 5.7 and 7.2 with the overall average of 6.5. This suggests that the appropriate value should be somewhere in this range. These results are generally consistent with the findings of Reference 2 in which a nominal duration constant K(D) of 7.0 was observed.

This similiarity of results has led to the decision to adopt a duration constant of 7.0 as the appropriate value for duration corrections in this study.

NOTE: It is worthwhile to note that on May 13, 1983, the ICAO Committee on Aircraft Noise formally endorsed a value of 7.5 as the duration correction constant for use in aircraft noise certification and noise impact assessment.

9.3 Summary of Observations/Conclusion

a. Change in distance is proportional to change in 10-dB down duration time.

b. $L_{AE} = L_A + 7 \log$ [Duration Time].

c. Duration Correction $= 7 \log \left[\frac{DUR_1}{DUR_2}\right]$

d. Distance Duration Correction $= 7 \log \left[\frac{Dist_1}{Dist_2}\right]$

e. Assuming that the same physics which govern change in duration with change in distance apply to changes in velocity then the expression $\Delta L_{AE} = 7 \log \left[(Vg_{(T)}/Vg_{(R)})\right]$(where $Vg_{(T)}$ is test speed and $Vg_{(R)}$ is reference ground speed) would be appropriate for establishing the velocity duration correction adjustments.

TABLE 9.1

CORRELATION BETWEEN DISTANCE
AND 10dB DOWN DURATION TIME

AIRCRAFT	TEST DATE	R	N
C-180	6-3	.943	4
C-170	6-23	.859	3
PA-38	8-10	.858	7
KING AIR 200	8-31	.956	6
C-414	9-14	.946	6
BEECH 58-P	9-28	.963	2
		R = .921	

TABLE 9.2

K(DUR) SUMMARY SHEET

AIRCRAFT	TEST DATE	AVG K(DUR)	SAMPLE SIZE
CESSNA 170	6-23-82	7.04	10
Turbow ARROW	7-13-82	6.48	8
KING AIR 200	8-31-82	5.70	7
CESSNA 210	10-5-82	6.3	6
PIPER NAVAJO	10-20-82	7.2	6

AVG K(DUR) = 6.5

10.0 <u>Development of Propeller Tip Mach Number Correction Functions</u> - This section describes the procedures employed in developing propeller tip Mach Number corrections along with derived correction functions for nine test aircraft.

When noise measurement tests are conducted under conditions other than those specified as reference test conditions, corrections are required to account for the resulting changes in the measured noise levels.

There are two categories of factors which significantly influence the noise levels of small propeller-driven aircraft and give rise to the need for corrections: 1) test flight procedures and 2) non-standard environmental conditions.

10.1 <u>Influences on Helical Tip Mach Number</u> - Figure 10.1 shows a schematic representative of the factors which influence helical tip Mach Number (M_H) and aircraft power. It is seen that in determining the M_H of an aircraft, one has to consider such influences as outside air temperature, propeller RPM, and indicated airspeed (V_{IAS}).

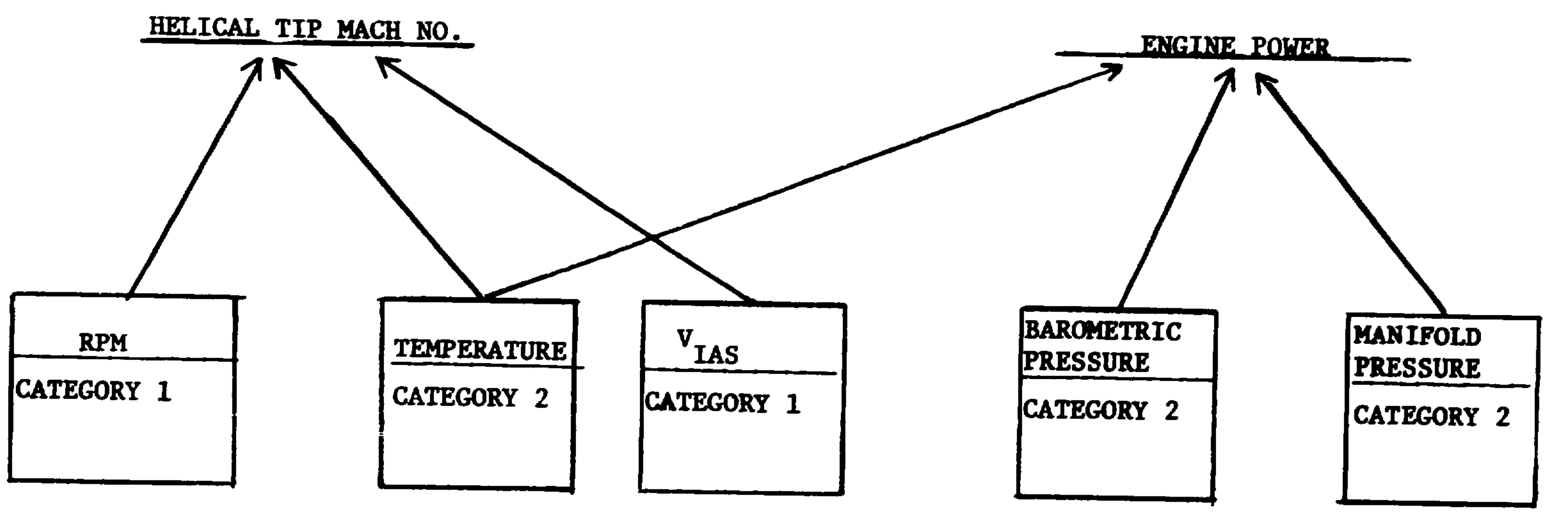
In general terms, the higher the Mach Number, the higher the noise levels produced. The following equations show the relationship of RPM, V_{IAS}, and air temperature in determining aircraft helical tip Mach Number.

(1) $M_H = \frac{(V_R^2 + V_T^2)^{1/2}}{c}$ $\quad V_T = V_{IAS}$ (kts.) x 1.689

(2) where $V_R = \frac{\text{Prop Dia. (in) x RPM}}{229.18}$

(3) $c = 49.02 \times (T°F + 459.67)^{1/2}$

While temperature is an environmental influence, RPM and airspeed are influences governed by test flight procedures. It should be noted that usually the contribution of V_T (translational velocity) is small in determining the



CAUSES OF VARIATION OF AIRCRAFT PERFORMANCE

CATEGORY #1
PILOT TEST FLIGHT PROCEDURES

CATEGORY #2
ENVIRONMENTAL CONDITIONS

INFLUENCES ON
HELICAL TIP MACH NO. AND ENGINE POWER SETTING

FIGURE 10.1

Mach Number, while the dominant components of Mach Number are the variables V_R (rotational velocity) and C (speed of sound). This shows that both test flight procedures and environmental conditions can affect the noise levels produced, due primarily to an increase or decrease in helical tip Mach Number.

10.2 Removing the Influence of Other Factors - To identify the variation of noise level with Mach Number, the test program included a selected group of flights for which power was held constant while the Mach Number was varied by varying propeller RPM and airspeed.

The first step involves normalizing all variables within the data set except the variable of interest (M_H). This is accomplished by correcting the "As Measured" metrics for spherical spreading, absorption, and duration differences associated with deviations from a reference altitude of 500 ft.

The intensity metric, AL, was corrected for spherical spreading and atmospheric absorption using the following equation:

$$L_A = L_A \text{ (As Measured)} + 24 \log \frac{ALT_T}{ALT_R}$$

where:

ALT_T = measured test altitude.

ALT_R = reference altitude (typically 500 ft).

The constant 24 accounts for spherical spreading and atmospheric absorption.

(NOTE: Upon analysis of the test data, this constant was found to be closer to the value of 22 as discussed in Section 7.0).

The energy metric, SEL, was corrected for spreading, absorption, distance-duration and velocity-duration effects using the following equation:

$$L_{AE} \simeq L_{AE} \text{ (As Measured)} + 17 \log \frac{ALT_T}{ALT_R} + 7 \log \frac{Vg}{Vy}$$

where: Vg = ground speed determined by radar or consideration of airspeed from cockpit data logs along with radiosonde upper air wind data.

Vy = speed for best rate of climb which is the reference speed for a takeoff operation.

The constant 17 accounts for spreading, absorption and distance-duration and the constant 7 accounts for velocity-duration.

10.3 <u>Determination of Noise Level - M_H Relationships</u> - At this point the noise levels have been corrected for all influences except aircraft Mach Number and power setting.

It was assumed that Mach Number is related to noise level in either a linear or logarithmic fashion. The following relationships provide the appropriate mathematical models used in regression analyses.

$$L_A = K(M)_A \log (M_H) + b \qquad \text{or } L_A = K(M)_A \times (M_H) + b$$

$$L_{AE} = K(M)_S \log (M_H) + b \qquad L_{AE} = K(M)_S \times (M_H) + b$$

where $K(M)_A$ and $K(M)_S$ represent the slopes and b represents the y-intercepts of the relationships. Each equation is developed for a specific power setting, and airspeed, depicting variation of noise levels with Mach Number.

The constants $K(M)_A$ and $K(M)_S$ are used in the following manner to correct for influence of M_H variation on noise levels.

$$L_{Aam} = L_{Ac} + K(M)_A \log \frac{M_{H(R)}}{M_{H(T)}}$$

$$L_{AEcm} = L_{AEc} + K(M)_S \log \frac{M_{H(R)}}{M_{H(T)}}$$

where L_{Ac} and L_{AEc} are the "as-measured" noise metrics corrected for distance and duration. The subscription "cm" refers to distance and duration corrected as well as Mach Number corrected noise levels.

TABLE 10-1

SUMMARY

A_L v. BASE 10 LOGARITHM OF HELICAL TIP MACH NUMBER

AIRCRAFT	EQUATION	R	%PWR	M_H RANGE
C-170	$L_A = 70.2 \log M_H + 86.4$	.91	-	.56 - .73
PA-38	$L_A = 75.8 \log M_H + 83.6$	.95	-	.61 - .68
PA-28	$L_A = 148.2 \log M_H + 92.2$	.93	75	.74 - .84
	$L_A = 114.8 \log M_H + 88.0$	.70	55	.69 - .75
C-180	$L_A = 126.6 \log M_H + 91.5$	.90	75	.79 - .84
	$L_A = 105.2 \log M_H + 87.6$	.85	50	.71 - .78
BARON 58P	$L_A = 143.6 \log M_H + 95.4$	.95	67	.72 - .86
C-414	$L_A = 148.9 \log M_H + 95.6$	.71	89	.80 - .84
	$L_A = 85.8 \log M_H + 89.2$	.79	75	.71 - .83
	$L_A = 69.5 \log M_H + 83.7$	.61	52	.68 - .75
KING AIR200	$L_A = 53.7 \log M_H + 89.0$	.79	85	.74 - .84
PA-42	$L_A = 76.6 \log M_H + 91.8$	.92	85	.72 - .82
CONQUEST 441	$L_A = 21.5 \log M_H + 82.1$	.36	90	.68 - .76

10.4 Noise-Mach Number Relationships - Table 10-1 represents the results of regression analyses relating AL to the Base 10 logarithm of helical tip Mach Number. The correlation coefficient is displayed along with the equation for the line of regression, percent power (for the sample population) and M_H range. Table 10-2 provides the corresponding results for linear regression analyses of AL versus Mach Number.

Table 10-3 and 10-4 present comparable analyses for the SEL metric.

10.5 Discussion - The first, and most obvious conclusion is that a negligible difference exists between results of linear and log-linear regression of noise level versus Mach Number. Further, results suggest that no single function can be universally applied. It is observed that functions for the aircraft tested lie between 20 log M_H and 150 log M_H. However, the method of application as a correction function minimizes the net difference in correction value: M_H Corr. = k log (M_H ref/M_H test). For a M_H ratio of 1.001, (0.1 percent) the difference between 20 log (M_H ratio) and 150 log (M_H ratio) is only .05 dB. For a 1 percent ratio the difference increases to .56 dB and for a 10 percent ratio the difference becomes 5.4 dB. In conducting a noise certification test in accordance with acceptable window limits it would be possible to arrive at a 1.4 percent deviation in M_H due to low/high temperature and/or RPM deviations.

In the absence of suitable level flyover data from which to derive a unique M_H function it may be reasonable (in a conservative sense) to permit correction using the most sensitive function, 150 log M_H when M_H test is less than M_H ref. This will relieve the applicant from the

TABLE 10-2

SUMMARY

A_L vs. HELICAL TIP MACH NUMBER

LINEAR REGRESSION

AIRCRAFT	EQUATION	R	%PWR	M_H RANGE
C-170	$L_A = 48.06\ M_H + 16.95$	.95	-	.56 - .73
PA-38	$L_A = 51.44\ M_H + 11.64$	.91	-	.61 - .68
PA-28	$L_A = 84.5\ M_H + -7.77$	.93	75	.74 - .84
	$L_A = 69.96\ M_H + 1.05$	.71	55	.69 - .75
C-180	$L_A\ \ 58.04\ M_H + 17.96$	.87	75	.79 - .84
	$L_A = 61.40\ M_H + 9.92$	.85	50	.71 - .78
BARON 58P	$L_A = 78.79\ M_H + 2.32$	.96	67	.72 - .86
C-414	$L_A = 79.26\ M_H + 3.11$	.71	89	.80 - .84
	$L_A = 48.83\ M_H + 23.55$	.80	75	.71 - .83
	$L_A = 50.30\ M_H + 16.21$	.65	52	.68 - .75
KING AIR200	$L_A = 29.79\ M_H + 43.18$	.80	85	.74 - .84
PA-42	$L_A = 43.12\ M_H + 31.06$	.93	100	.72 - .82
CONQUEST 441	$L_A = 11.86\ M_H + 49.71$	.35	90	.68 - .76

TABLE 10-3

SUMMARY

SEL v. BASE 10 LOGARITHM OF HELICAL TIP MACH NUMBER

AIRCRAFT	EQUATION	R	%PWR	M_H RANGE
C-170	$L_{AZ} = 40.7 \log M_H + 87.2$	0.72	-	.56 - .73
PA-38	$L_{AE} = 72.9 \log M_H + 90.5$	0.88	-	.61 - .68
PA-28	$L_{AE} = 112.5 \log M_H + 92.4$	0.98	75	.74 - .85
	$L_{AE} = 58.4 \log M_H + 86.5$	0.42	55	.69 - .75
C-180	$L_{AE} = 75.1 \log M_H + 92.2$	.84	75	.79 - .84
	$L_{AE} = 80.4 \log M_H + 90.6$	.84	50	.71 - .78
BARON 58P	$L_{AE} = 88.9 \log M_H + 95.3$	.88	67	.72 - .86
C-414	$L_{AE} = 122 \log M_H + 97.6$	.72	89	.80 - .84
	$L_{AE} = 43.9 \log M_H + 89.4$	.69	75	.71 - .83
	$L_{AE} = 40.9 \log M_H + 86.5$	.58	52	.68 - .75
KING AIR200	$L_{AE} = 34.8 \log M_H + 90.2$	.47	85	.74 - .84
PA-42	$L_{AE} = 52.1 \log M_H + 92.3$	.87	85	.72 - .82
CONQUEST I	$L_{AE} = 13.9 \log M_H + 85.0$	.26	90	.68 - .76

*NOTE — SEL BECOMES L_{AE}

TABLE 10-4

SUMMARY

SEL vs. HELICAL TIP MACH NUMBER

LINEAR REGRESSION

AIRCRAFT	EQUATION	R	%PWR	M_H RANGE
C-170	$L_{AE} = 22.8\ M_H + 38.54$	.61	-	.56 - .73
PA-38	$L_{AE} = 52.92\ M_H + 15.73$	.94	-	.61 - .68
PA-28	$L_{AE} = 62.4\ M_H + 12.6$	.98	75	.74 - .85
	$L_{AE} = 35.9\ M_H + 30.2$	.43	55	.69 - .75
C-150	$L_{AE} = 40.00\ M_H + 37.13$	.84	75	.79 - .84
	$L_{AE} = 46.97\ M_H + 25.45$	.84	50	.71 - .78
BARON 58P	$L_{AE} = 48.90\ M_H + 30.44$	.88	67	.72 - .86
C-414	$L_{AE} = 67.22\ M_H + 16.59$	.74	89	.80 - .84
	$L_{AE} = 25.03\ M_H + 45.77$	.70	75	.71 - .83
	$L_{AE} = 29.26\ M_H + 36.15$	.62	52	.68 - .75
KING AIR200	$L_{AE} = 19.45\ M_H + 53.84$	.48	85	.74 - .84
PA-42	$L_{AE} = 29.52\ M_H + 44.05$	.88	100	.72 - .82
CONQUEST I	$L_{AE} = 7.16\ M_H + 56.09$	.24	90	.68 - .76

burden of additional testing and analysis, while providing motivation to be on target with performance parameters. Any deviations from reference M_H due to test temperature variation higher than reference temperature can also be accounted for using the 150 log M_H relationship. Additional testing should be required to derive a unique M_H function for a particular aircraft when the test M_H is higher than reference M_H as would occur in the case of low temperature testing.

11.0 Development of Engine Power Correction Functions - This section describes the analytical procedures employed in developing engine power corrections along with the correction values derived for test aircraft.

11.1 Influences on Engine Power - Aircraft power level is another performance parameter that can have a significant contribution in determining aircraft noise levels. In Figure 10.2 we see that power is a function of temperature, barometric pressure and engine manifold pressure (or torque).

Temperature and barometric pressure fall into Category 2 (environmental conditions) influencing (thermodynamically) the internal combustion process. Engine manifold pressure (or torque) setting can be placed in Category 1, affected by test procedures.

Horsepower is related to temperature as follows:

$$H.P. = \sqrt{\frac{460 + 59°F}{460 + T°F}}$$

This equation provides approximately one percent correction for each 10°F variation from 59°F.

In the case of pressure/density effects, a simplified but reasonable approach is to assume that horsepower changes are directly related to changes in density ratio (pressure ratio).

The values can be obtained from typical standard atmosphere tables.

11.2 Analytical Methodology - Two different schemes were employed (as required) in developing Power Correction relationships: 1) using data runs that have the same Mach Number, a constant is derived which relates the change in AL to the log of the power ratio; 2) when two constant-power, noise versus log (M_H) functions overlap, a common Mach Number was evaluated and the change in AL was determined, from which the power correction constant was derived. These two methods are shown in the following example.

Example (Power correction constant determination)

<u>Method 1:</u> Data with same Mach No.

Data

75%pwr	50%pwr
$L_{AC} = \overline{85.4}$ dB	$L_{AC} = \overline{82.3}$ dB
$L_{AEc} = \overline{88.4}$	$L_{AEc} = \overline{86.9}$
Vg = 166.4 mph	Vg = 139.7 mph

$$\Delta L_A = L_{A\ 75\%} - L_{A\ 50\%} = K(P)_A \log \frac{P1}{P2}$$

$$= 85.4 - 82.3 = K(P)_A \log \frac{75\%}{50\%}$$

$$K(P)_A = 17.60$$

In the case of SEL we must make certain that we consider the effects of velocity on the noise levels, at two different power settings. Therefore, we will normalize the SEL at 50% to the ground speed of the 75% power level, as follows:

$$\text{SEL(50\% normalized to 75\% pwr Vg)} = L_{AE\,c50\%} + 7 \log \frac{139.7}{166.4}$$

$$= 86.9 + (-.53)$$

$$= 86.4$$

Then proceed as above

$$\Delta L_{AE} = L_{AE\,75\%} - L_{AE\,50\%norm} = k(P)_S \log \frac{P1}{P2}$$

$$= 88.4 - 86.4 = K(P)_S \log \frac{75\%}{50\%}$$

$$K(P)_S = 11.4$$

NOTE: Vg above is the average ground speed for the runs used in the analysis at the particular power setting.

Method 2: Identify two constant power (noise versus log M_H) functions where the Mach numbers are the same.

Data

89% power $\quad$ Vg = 170.5 mph

$L_A = 148.87 \log (M_H) + 95.64$

$L_{AE} = 122.17 \log (M_H) + 97.67$

75% pwr $\quad$ Vg - 156.3 mph $\quad$ Common Mach Number = .83

$L_A = 85.82 \log (M_H) + 89.16$

$L_{AE} = 43.93 \log (M_H) + 89.13$

Substitute the common Mach Number into each of the above equations and solving yields:

89% pwr	75% pwr
$L_A = 83.6$	$L_A = 82.2$
$L_{AE} = 87.8$	$L_{AE} = 85.9$

Hence now we can derive a power correction constant for AL as in Method 1, as follows:

$$\Delta L_A = L_A\ 89\% - L_A\ 75\% = K(P)_A \log \frac{P1}{P2}$$

$$83.6 - 82.2 = K(P)_A \log (89/75)$$

$$K(P)_A = 18.8$$

Again as in Method 1 in correction SEL for power differences, the effects of velocity on the noise levels at different power settings must considered. Hence, normalize the 89% SEL down to the 75% pwr setting as follows:

$$L_{AE89\%} \text{ normalized to } 75\%\ Vg = 156.3 = L_{AE}89\% + 7 \log \frac{170.5}{156.3}$$

$$= 87.8 + .26 = 88.1$$

Then we proceed to calculate a correction constant for SEL as before.

$$L_{AE} = L_{AE_{89\%norm}} - L_{AE_{75\%}} = K(P)_S \log\left(\frac{P1}{P2}\right)$$

$$88.1 - 85.9 = K(P)_S \log\left(\frac{89}{75}\right)$$

$$K(P)_S = 29.6$$

The resulting power correction equations are as follows:

$$L_{A_{FC}} = L_{A_{mc}} + K(P)_A \log\left[\frac{P1}{P_{REF}}\right]$$

$$L_{AE_{FC}} = L_{AE_{mc}} + K(P)_S \log\left[\frac{P1}{P_{REF}}\right]$$

where P_1 is the actual test power.

11.3 Results - Tables 11-1 and 11-2 show the derived relationships between AL (and SEL) and the base ten logarithm of the power ratios respectively for 7 of the 9 aircraft tested. The reference M_H and power ratio are identified for each equation. In the case of the Cessna 170 and the Piper PA-38 (fixed pitch propeller) the power and M_H vary simultaneously, thus a single relationship is adequate, reflecting both of these influences (see Section 10.0).

11.4 Discussion - In the case of $K(P)_A$ power correction constants, once again there is a wide range of values. The range 1.5 to 39.3 has a central tendency toward a value of 17. The method of deriving these values is acutely sensitive to the measured and corrected difference in sound levels between the two power settings. Thus a 0.6 dB change in the difference between noise levels for two different powers (i.e., 1.2 dB rather than 1.8 dB) can result in a difference in $K(P)_A$ of nearly 8 for a power ratio of (90/75):

$22.7 = 1.8/\log (90/75)$

$15.2 = 1.2/\log (90/75)$

Viewed within this experimental context, the variation in $K(P)_A$ is better understood.

While this analysis is by no means definitive, the selection of the average observed $K(P)_A$, = 17 is proposed as an interim factor to be used in adjusting for non-reference engine power. The constant is recommended as applicable to all engine/exhaust combinations.

TABLE 11-1

SUMMARY

AL VARIATION WITH BASE 10 LOGARITHM OF POWER RATIO

AIRCRAFT	EQUATION	POWER RANGE %	M_H
C-170	-	-	-
PA-38	-	-	-
PA-28	L_A = 3.2 log (100/75)	100-75	.79
	L_A = 1.5 log (75/75)	75-55	.735
C-180	L_A = 12 log (100/75)	100-75	.85
	L_A = 17 log (75/50)	75-50	.78
BARON 58P	L_A = 1.79 log (67/75)	75-67	.84
	L_A = 17.6 log (75/50)	75-50	.84
CESSNA 414	L_A = 18.8 log (89/75)	89-75	.83
	L_A = 20.1 log (75/50)	75-52	.72
KING AIR 200	L_A = 17.4 log (95/71)	95-71	.81
	L_A = 5.0 log (71/47)	71-47	.78
PA-42	L_A = 10.5 log (100/75)	100-75	.77
	L_A = 17.4 log (75/50)	75-50	.76
CONQUEST I	L_A = 39.3 log (100/90)	100-90	.77
	L_A = 12.6 log (90/75)	90-75	.76

TABLE 11-2

SUMMARY

SEL VARIATION WITH BASE 10 LOGARITHM OF POWER RATIO

AIRCRAFT	EQUATION	POWER RANGE %	M_H
C-170	-	-	-
PA-38	-	-	-
PA-28	$L_{AE} = 1.6 \log (100/75)$ $L_{AE} = 9.9 \log (75/55)$	100-75 75-55	.79 .735
C-180	$L_{AE} = 10.4 \log (100/75)$ $L_{AE} = 17 \log (75/50)$	100-75 75-50	.85 .78
BARON 58P	$L_{AE} = 13.4 \log (97/75)$ $L_{AE} = 11.4 \log (75/50)$	75-67 75-50	.84 .84
CESSNA 414	$L_{AE} = 29.6 \log (89/75)$ $L_{AE} = 21.4 \log (75/52)$	89-75 75-52	.83 .72
KING AIR 200	$L_{AE} = 16.9 \log (95/71)$ $L_{AE} = 5.6 \log (71/47)$	95-71 71-47	.81 .78
PA-42	$L_{AE} = 30.7 \log (100/75)$ $L_{AE} = 12.2 \log (75/50)$	100-75 75-50	.77 .76
CONQUEST I	$L_{AE} = 30.6 \log (100/90)$ $L_{AE} = 13.9 \log (90/75)$	100-90 90-75	.77 .76

12.0 Fully Corrected Takeoff Noise Data and a Description of the Correction Process - Fully corrected takeoff noise levels are presented in Table 12-1 for both SEL and ALM computed for the 18 GA aircraft participating in the aircraft noise measurement program. The 90 percent confidence interval is also displayed for each aircraft along with sample size. All noise levels have been corrected to account for nonreference altitude, velocity, Mach Number and power associated with actual takeoff operations.

12.1 The Need for Corrections - When noise measurement tests are conducted under conditions outside those specified as reference test conditions corrections are required to account for the resulting influence on the measured noise level.

12.2 Reference Test Conditions - The measured noise data obtained during the noise measurement tests conducted by the FAA in the summer and fall of 1982 were corrected to the following reference atmospheric conditions;

a. sea level atmospheric pressure of 1013.24 hPa (1013.25),

b. ambient air temperature of 15°C(ISA),

c. relative humidity of 70 percent; and

d. zero wind.

Note: The acoustic reference day conditions are the same as the airplane reference flight conditions except that the ambient air temperature shall be 25°C (ISA + 10°C).

12.3 Reference Test Parameters - In addition to these "primary" reference conditions it was necessary to compute three test parameter reference values, based on the reference atmospheric conditions.

TABLE 12-1

FULLY CORRECTED TAKEOFF NOISE LEVEL

AIRCRAFT	MGTOW	SEL_{fc}	90% C.I.	N	AIM_{fc}	90% C.I.	N
C-180	2800	87.5	0.7	5	78.7	.6	5
C-170	2000	80.5	1.2	5	71.8	1.8	5
PA-28	2900	82.6	0.7	10	76.5	.9	10
PA-38	1680	80.0	0.5	5	69.9	0.8	5
KING AIR	12,500	86.0	0.5	7	80.0	.8	7
PA-42	11,200	87.1	0.7	6	81.1	.7	6
C-414	6750	88.6	1.1	6	82.4	1.1	6
B58-P	6200	91.0	.4	7	84.8	.5	7
C-210	3800	96.5	0.9	6	92.C	1.1	6
C-182	3100	80.4	1.1	6	72.4	.2	6
C-172	2300	83.0	0.3	6	74.1	.5	6
MERLIN	14,500	85.3	0.3	6	80.6	.5	6
COMMANDER 900	10,700	79.3	0.5	6	70.9	.6	6
DUCHESS	3900	91.6	0.4	7	84.5	.5	7
ARCHER	2550	87.3	0.7	6	78.5	.9	6
BONANZA	3400	93.2	0.3	7	87.3	.5	6
NAVAJO	7000	94.1	0.3	7	87.9	.5	7
C-425	8200	80.7	0.6	7	72.7	.5	7

1. Speed of Sound - The reference speed of sound (c) used to compute the reference Mach No. was computed using the formula $(T°F + 459.67)^{1/2} \times 49.02$. The reference temperature of 59°F yields the value for c of 1116.4 feet per second

2. Reference Helical Tip Mach Number - The reference helical tip Mach Number for each aircraft was computed using the specified propeller diameter and rpm along with the manufacturers specification of speed for best rate of climb (Vy) at sea level and at 59°F.

3. Reference Altitude - The reference altitude was computed for 8200 ft. (2500m) from brake release point (BRP) using the formula $(50 + (8200 - D_{50}) \times \tan \theta)$. The distance to reach 50 ft. in altitude (D_{50}) was obtained from the manufacturer's specification for each aircraft tested. In each case, the climb angle θ was computed using the reference value for Vy and best rate of climb specified in the pilot operating handbook.

12.4 Corrections Involving Deviations from Reference Altitude. Initially, it is helpful to define three terms intimately involved and sometimes confused in considering position deviations.

Closest Point of Approach (CPA)	:	The distance where a 90-degree angle exists between the aircraft flight path and a ray between the aircraft and the microphone.
Slant Range (SR)	:	The distance between the aircraft and the microphone at the time maximum noise level is recorded
Altitude (ALT)	:	The distance between the aircraft and the microphone at the point where the aircraft is directly overhead (assuming no lateral deviation).

For the test conducted in the FAA noise measurement program, the "as measured" noise values were corrected for spherical spreading, absorption and distance duration using altitude position data as opposed to CPA or Slant Range.

This procedure may be considered a "simplified" method. Prior to using this technique, a careful evaluation was conducted of previous FAA propeller driven aircraft noise tests. It was observed that the CPA, SR, and ALT distances were so close that, from a practicable standpoint, any one of the three could be used as shown in the following synopsis.

A similar trend was also noted in a French technical report abstracted below.

"Measured DeBruit Prodvit Par Les Avions Legers AV Decollage"

Rapport D'eTude No. 283.

This report compares slant range and altitude position correction using the following formulas:

a. $S_{21} = 20 \log H/H_{ref}$ where: H = altitude

b. $S_{22} = 20 \log AB/AB_{ref}$ where: AB = slant range

$S_{21} - S_{22}$ results in a mean average of 0.02 dB which suggests that there is no significant difference between the two methods.

Report AEE-80-26 "Noise Levels and Data Correction Analysis for Seven General Aviation Propeller Aircraft" - Tracking data were presented in this report in terms of the average "Acoustical Angle" or angle associated with the emission of ALM. Table 12-2 lists the aircraft tested, number of samples, and the mean and standard deviation of the acoustical angle. The distance from brake release is also provided. The individual mean acoustical angles range from 70° - 119° with an aggregate average of 88.1°. This translates to an average acoustical error of less than one tenth of a decibel.

TABLE 12-2

STATISTICAL ANALYSIS OF ACOUSTICAL ANGLE DATA

RPT. (REF. NO. 1) FAA-AEE-80-26, "NOISE LEVELS AND DATA CORRECTION ANALYSIS FOR SEVEN GENERAL AVIATION PROPELLER AIRCRAFT"

A/C TYPE	NO. SAMPLES*	MEAN ACOUST ANG	S.D. ACOUST ANG	MIC LOCAT
PIPER PA36 375	12	86.4	4.5	3896M(12781') from BRP
PIPER PA31 325	2	94.9	0	3896M(12781') from BRP
	8	97.4	8.8	5296M(17375') from BRP
	2	93.8	0	5482M(19625') from BRP
CV 580	4	70.1	2.7	5115M(16781') from BRP
	8	82.2	5.6	6515M(21375') from BRP
CESSNA 421C	4	119	17.3	5296M(17375') from BRP
	4	85.5	3.8	5982M(19625') from BRP
ROCKWELL 590B	4	89	2.3	5982M(19625') from BRP
ROCKWELL 500S	4	80.8	5.7	5296M(17375') from BRP
	8	82	16.6	5982M(19625') from BRP

*DEPARTURE EVENTS ONLY

**ANGLE OF AIM DURING OVERFLIGHT

12.5 Atmospheric Absorption and Spherical Spreading - In this report, takeoff noise data were corrected for the effects of absorption and spreading by using a simplified technique. The analysis presented in Section 8.0 shows that the simplified technique is a reasonable correction methodology. The simplified method consists of the formula $\Delta AL = 24 \log (ALT_T/ALT_R)$, which was derived from previous studies of noise propagation characteristics.

12.6 Mach Number Corrections - Level Flyover data were used to derive the Mach Number Correction constants $K(M)_S$ and $K(M)_A$ for SEL and AL respectively for use in the following equation $\Delta dB = K \log (M_{H(R)}/M_{H(T)})$. The methodologies used in deriving these formulas (see Table 10.1 and 10.3) are discussed in Section 11.2. The results suggest that in order for the correction to be accurate the formula should be derived for each aircraft under study.

12.7 Power Corrections - The as measured noise levels AL (AL_{am}) and SEL (SEL_{am}), require a power correction (P-Corr) to account for the differential influences which accompany aircraft power variations due to nonreference environmental and test flight procedures. The first step in computing this correction is to compute the test day power. The formula used to compute the test day power (%pwr) is given as follows:

$$\text{Percent Power} = \left[100 \times \sqrt{\frac{460 + 59°F}{460 + T°F}} - 2\% \right]$$

NOTE: The 2% is the power loss computed for the average altitude of 1000 ft AGL. This loss is not applicable to aircraft with a turboprop or a turbocharged engine.

The computed value is then substituted in the formula:

$$\text{P-Corr} = K(P)_A \log (100/\%Pwr)$$

$$\text{P-Corr} = K(P)_S \log (100/\%Pwr)$$

where: $K(P)_A$ and $K(P)_S$ are the constants derived from the formulas developed using level flyover data (see Table 11.1 and 11.2).

12.8 Distance - Duration Correction - The distance-duration correction accounts for the change in noise levels due to deviation of aircraft test altitude from reference altitude. The theoretical formula for this correction is $\Delta dB = 10 \log (ALT_R/ALT_T)$. However, after extensive analysis, it was observed that the empirical formula $\Delta dB = 7 \log (ALT_R/ALT_T)$ more accurately accounts for the effects of a change in duration with a change in distance as discussed in Section 9.2. When this empirical formula is combined with the formula $\Delta dB = 24 \log (ALT_T/ALT_R)$ the equation $\Delta dB = 17 \log (ALT_T/ALT_R)$ is developed. This formula is used to correct the as-measured SEL value for spherical spreading, atmospheric absorption and distance-duration due to nonstandard environmental conditions and nonreference test flight procedures.

12.9 Velocity - Duration Correction - The theoretical equation utilized to correct for the difference in the test ground speed (Vg) and the speed for best rate of climb (Vy) is: $\Delta dB = 10 \log (Vg/Vy)$. However, the formula $\Delta dB = 7 \log (Vg/Vy)$ was used because the assumption was made that the same phenomena which govern a change in duration with a change in distance apply to a change in duration with a change in velocity. This concept is discussed in greater detail in Section 9.3.

12.10 Fully Corrected AL and SEL Equations - All the correction procedures discussed in previous sections are brought together to comprise the fully corrected AL (AL_{fc}) equation.

$$L_{Afc} = L_{Aam} + 24 \log (ALT_R/ALT_T) + \text{Mach Corr} + \text{P-Corr}$$

The energy average metric SEL requires the same corrections as the intensity metric AL with the addition of (1) distance-duration and (2) velocity-duration corrections.

$$L_{AEfc} = L_{AEam} + 17 \log(ALT_R/ALT_T) + 7 \log(Vg/Vy) + \text{Mach Corr} + \text{P-Corr}$$

13.0 Correlation Between SEL and AL - The purpose of this analysis is to examine the correlation between the intensity metric AL and the energy dose metric SEL, using fully corrected takeoff noise levels.

13.1 Regression Analysis Results - A linear regression of SEL vs ALM was performed (see Figure 13.1) which provided a R^2 (coefficient of determination) of .96 for the following relation:

$$L_{AE} = .81 \times (L_{AM}) + 22.26$$

This provides the important capability (for test conditions with altitudes in the range of 4000 to 1600 ft and velocities in the range of 64 to 132 kts) to accurately estimate SEL from measured ALM noise level, and conversely ALM from measured SEL.

13.2 Discussion - Previous discussions within International Civil Aeronautical Organization indicated a preference for an energy-based noise evaluation measure for the proposed takeoff procedure, specifically the A-Weighted Sound Exposure Level, SEL. However, in light of the findings cited above it may be appropriate to consider use of maximum AL (ALM) which is a substantially simpler and more direct metric to acquire. Advantages of using the intensity (ALM) metric include:

a. there is no need for tracking information, which is required to measure ground speed;

b. measurement instrumentation is far less sophisticated;

c. corrections for off-reference test conditions are simpler and less time-consuming; and

d. fewer corrections are required.

Inasmuch as the two noise evaluation measures are highly correlated, so that either can be confidently determined from the other, and the observed 90% confidence intervals for the measured values of ALM were somewhat less th   ose for SEL in our tests (contrary to previous intuition), it is recommended that the A-weighted maximum sound level, ALM, be used as the noise evaluation measure for any new takeoff noise certification procedure.

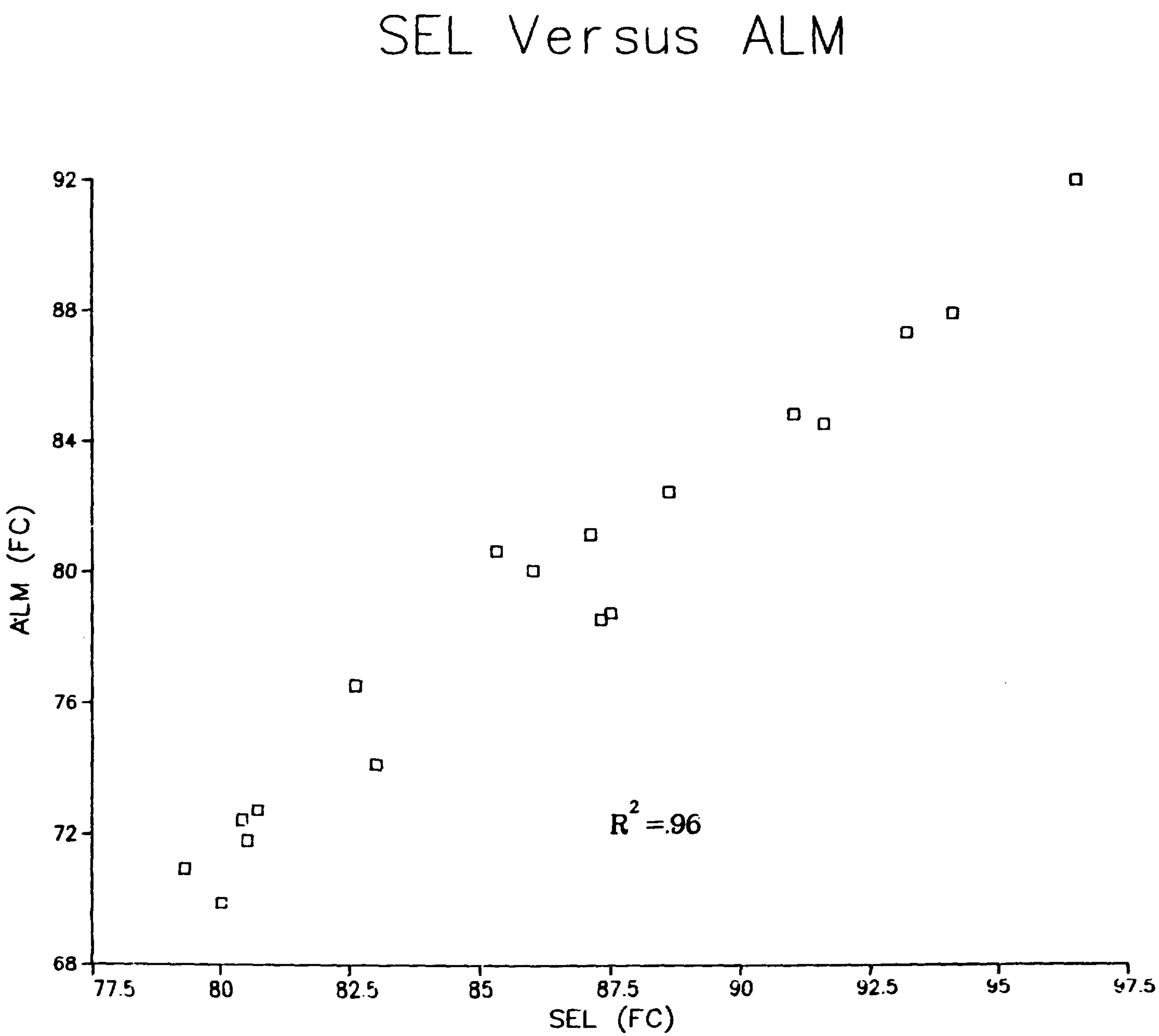

SEL Versus ALM
92
88
84
80
76
72
68
ALM (FC)
77.5
80
82.5
85
87.5
90
92.5
95
97.5
SEL (FC)
R^2 =.96

FIGURE 13.1

14.0 <u>Summary of Other Available Noise Level Data Acquired Using the Proposed Certification Takeoff Noise Test</u> - This section provides a summary of results obtained from recent noise test programs conducted in Europe. British, German and French authorities were involved in assessing the proposed takeoff noise certification format. These data are presented here in order to expand the population of aircraft used in assessing the implications of the proposed revision. Table 14.1 presents pertinent information available from each report.

REFERENCE TAKEOFF CONDITIONS

AIRCRAFT	MGTOW (lbs)	D_{50} (ft)	Vy(kts)	BRC(fpm)	CLIMB ANGLE	REFERENCE ALT (FT)	ALM	90% C.I.	REF #
Sportavia-Putzer RF-5	1433.0	1712.6	59.4	590.5	5.6°	364.2	74.5	.38	5
Robin DR 300-180	2204.6	1952.1	81.0	984.2	6.9°	406.8	74.8	.16	5
Cessna 207A	3800.7	1870.1	81.0	905.5	6.3°	360.9	83.6	.33	5
Cessna 340	5974.5	2401.5	87.1	1496	10.5	397.0	83.1	.57	5
Beech 65 B90	9645.1	2260.5	109.1	1948.8	10.2	528.8	80.0	.73	5
R 2160	1763.1	1453.4	78.2	925.2	6.7	705.4	74.1	.4	6
HR 100-250	3086.4	2427.8	94.4	984.2	5.9	928.1	78.7	.7	6
C 310R	5500.5	1837.2	106.8	1578.7	8.4	579.8	80.6	.5	6
110ST	1697.5	1345.1	75.5	629.9	4.7	825.1	71.2	.5	6
TB 10	2535.3	1778.2	72.8	750.0	5.8	651.6	75.6	.6	6
TB 20	2943.1	1673.2	91.7	1240.1	7.7	973.1	80.5	.2	6
Jet Stream	14,550	NA	123.3	NA	NA	NA	72.3	NA	7
Skyvan	12,500	NA	NA	NA	NA	NA	82.3	NA	8
Islander	6600	NA	NA	NA	NA	NA	72.9	NA	9
Firecracker	2840	1230	104	1380	7.5	NA	70.9	NA	10

*NA - Not Available

TABLE 14.1

15.0 <u>GA Regression Analysis</u> - The purpose of this analysis is to determine if there exists a well defined relationship between aircraft noise levels, SEL and ALM, and the base 10 logarithm of gross weight.

To examine this hypothesis numerous linear and logarithmic regression analyses were performed for four different populations: 1) single engine pistons, 2) twin engine pistons, 3) twin engine turboprops and 4) all the aircraft tested.

Table 15-1 shows the results of this analysis for FAA data only. Figures15.1 and 15.2 provide scatter plots of the noise metrics SEL and ALM versus the logarithm of maximum gross takeoff weight (MGTOW) for the various aircraft types.

Table 15-2 shows the results of this analysis with each population increased using data (ALM only) available from French, German, and British sources, referenced 5, 7, 8, 9, and 10 respectively.

It is seen in Tables 15-1 and 15-2 that this hypothesis seems somewhat reliable for single engine piston aircraft, since Table 15-1 shows an R^2 (coefficient of determination) of 0.65 and 0.55 for the metrics ALM and SEL respectively, and Table 15-2 shows an R^2 of 0.47 for the increased single engine piston population for the metric ALM.

In viewing the results of this analysis for the remaining populations, twin engine pistons, twin engine turboprops and the grouped population, it is evident from the low values of R^2 (coefficient of determination) that there is very little correlation between the noise metrics ALM and SEL and the base 10 logarithm of gross weight.

While a dependency is evident, it is clear that other factors such as propeller tip Mach Number and engine exhaust configuration play prominent roles in establishing noise levels. Nevertheless the concept of regulating noise level as a function of weight remains viable as a means for balancing increased productivity (weight) versus increased allowable noise level.

ALM VERSUS GROSS WEIGHT

REGRESSION ANALYSIS

FAA DATA

	LINEAR			LOGARITHMIC		
	SINGLE	TWIN	TWIN TURBO	SINGLE	TWIN	TWIN TURBO
SLOPE	0.01	3.2×10^{-4}	0.00	53.06	3.52	37.22
INTERCEPT	52.63	82.97	60.31	-103.73	71.64	-72.70
R^2	.71	.04	0.49	.65	0.03	.49
R	.84	.20	0.70	.81	0.18	.70
SAMPLE	9	4	5	9	4	5

TABLE 15-1

REGRESSION ANALYSIS

ALM VERSUS GROSS WEIGHT

FAA, FRENCH, GERMAN, BRITISH

	SINGLE	TWIN	TWIN TURBO	SINGLE	TWIN	TWIN TURBO
SLOPE	0.01	-4.4×10^{-4}	4.18×10^{-4}	33.26	-7.11	12.82
INTERCEPT	60.54	84.98	72.72	-36.09	109.14	25.53
R^2	0.55	0.03	0.04	0.47	0.03	0.05
R	.74	0.16	0.20	0.69	0.10	0.23
SAMPLE	17	8	8	17	8	8

TABLE 15-2

Fully Corrected Takeoff Data

SEL versus Gross Weight

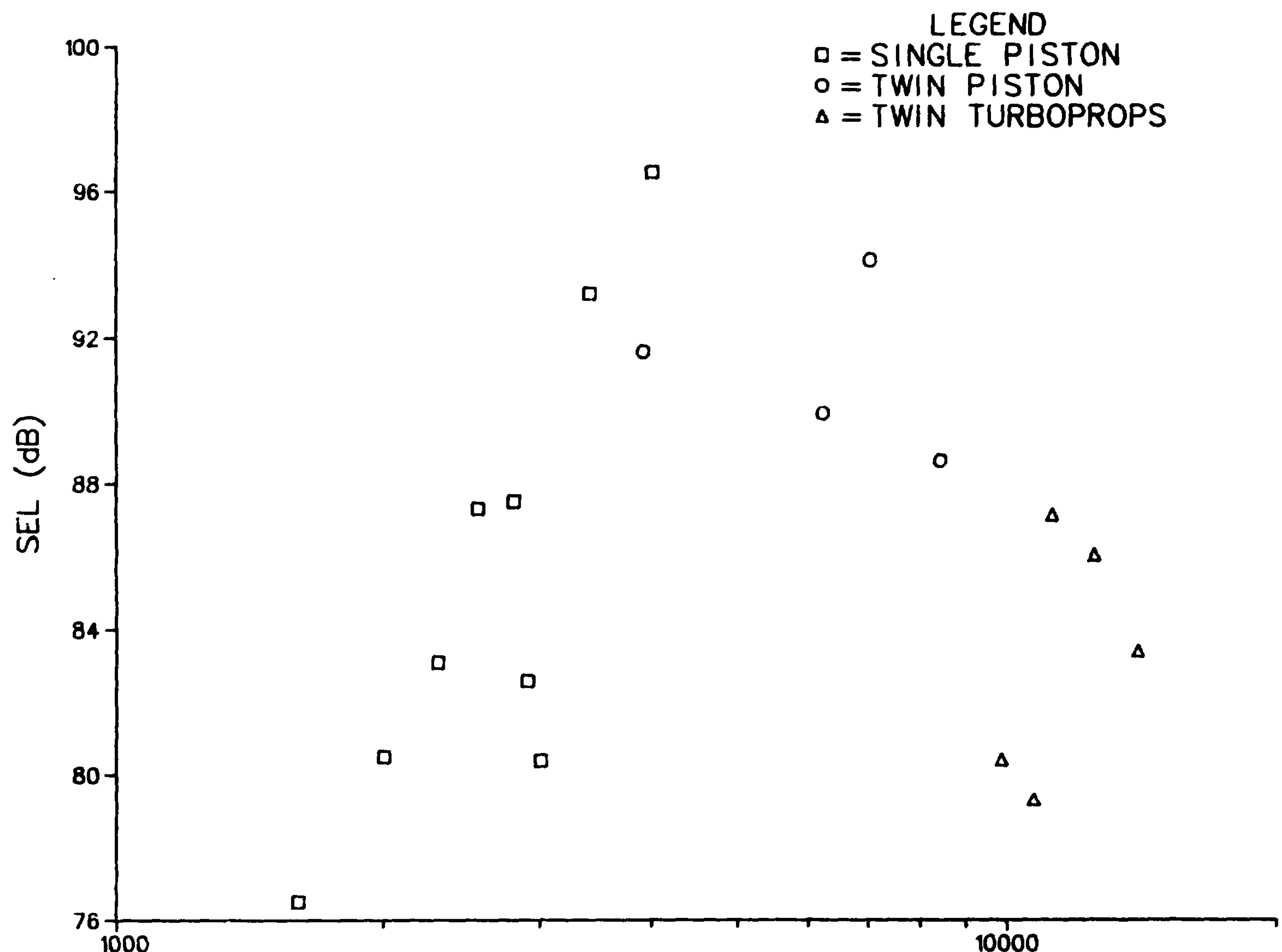


FIGURE 15.1

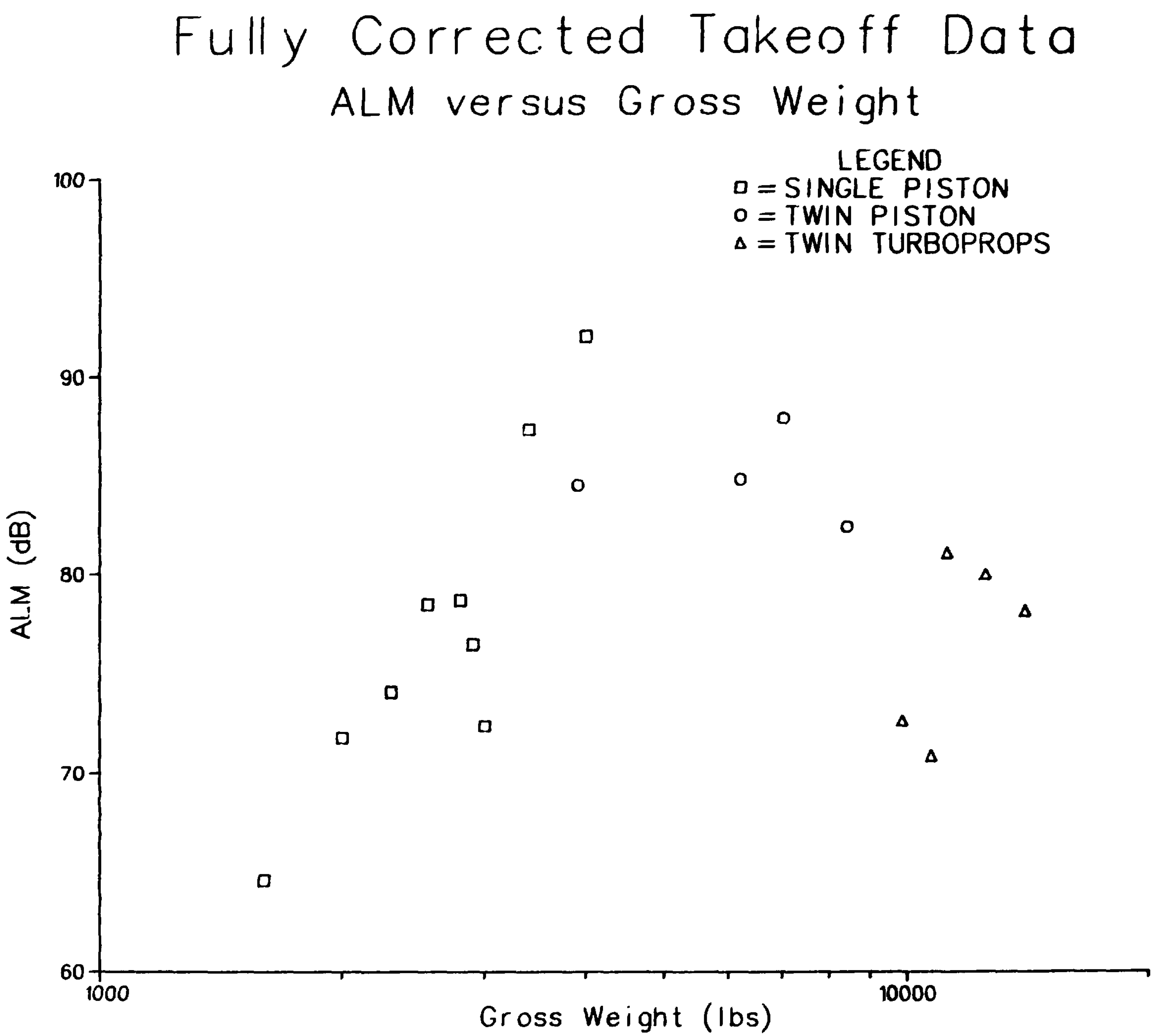

Fully Corrected Takeoff Data
ALM versus Gross Weight
LEGEND
□ = SINGLE PISTON
○ = TWIN PISTON
△ = TWIN TURBOPROPS
100
90
80
70
60
ALM (dB)
1000
10000
Gross Weight (lbs)

FIGURE 15.2

16.0 Equal Stringency Analysis - The purpose of this analysis is to examine how the rank-ordering of aircraft already certificated using FAR 36 Appendix F, would be affected if the proposed revision of ICAO Annex 16 is adopted using a takeoff procedure.

The first number indicates the rank ordering using takeoff ALM and the second number represents the rank ordering using their FAR 36 certificated ALM levels. As this figure shows, there would be some change in the ranking of aircraft. This difference is accounted for in part by the fact that the FAR 36 ALM levels were obtained using level flyover data corrected for takeoff performance, whereas the levels for the takeoff procedures were obtained for actual takeoff operations. The remaining differences likely reflect intrinsic differences between acoustical emission characteristics for the level flyover and takeoff flight regimes. The maximum change in pattern is seven places as exhibited by the King Air, and the average change in position is 2.3 for this population.

A linear and logarithmic regression analysis was performed for this population yielding equations of the formula:

Linear

$$\text{App F } L_{AM} = 0.47 (\text{Takeoff } L_{AM}) + 37.22$$

with R^2 (coefficient of determination) = .66 for a sample of 17 GA Aircraft.

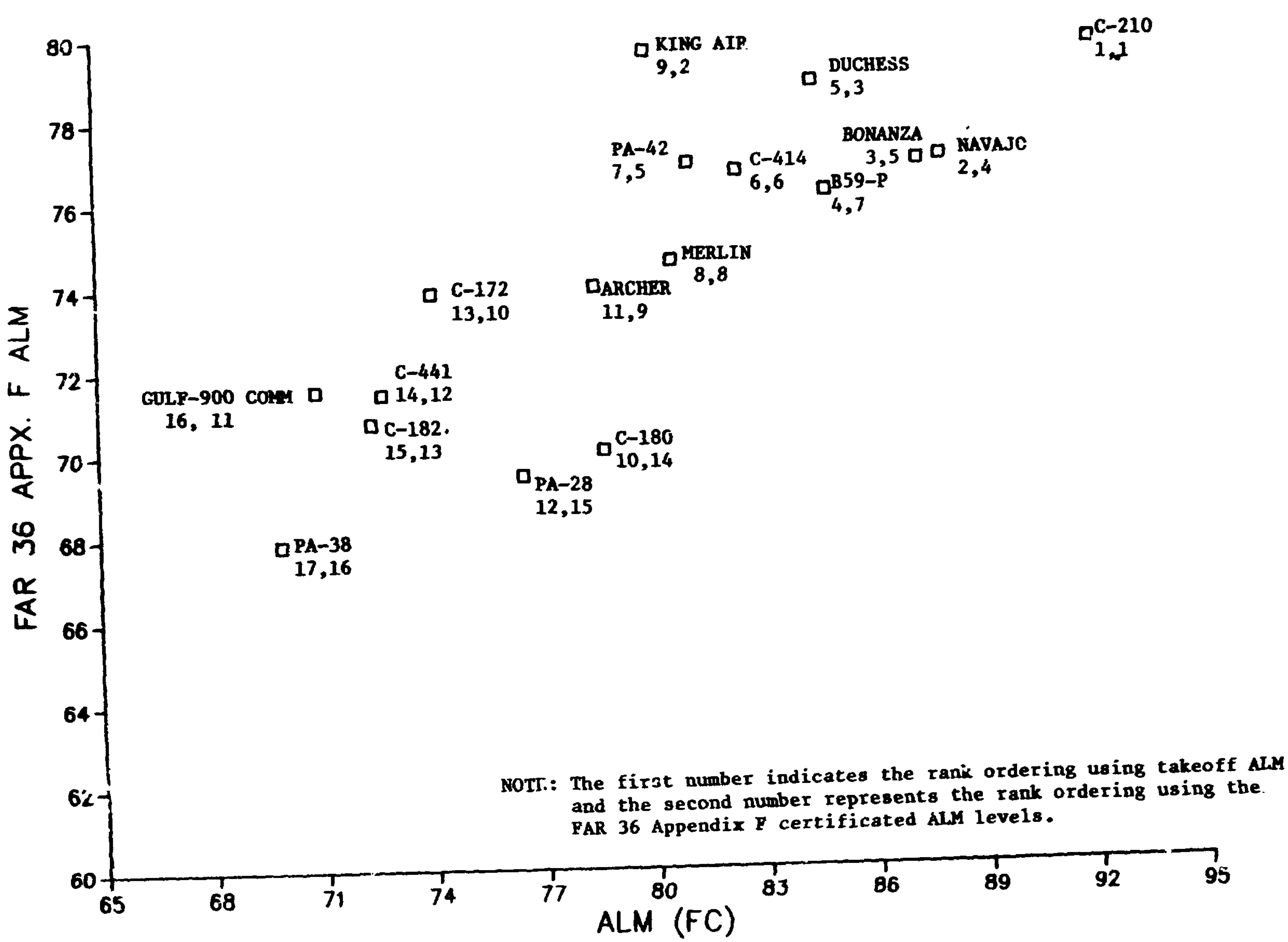
Logarithmic

$$\text{App F } L_{AM} = 85.96 \log (\text{Takeoff } L_{AM}) - 88.97$$

with R^2 (coefficient of determination) = .66 for a sample of 17 GA Aircraft.

Conclusions: The relationship between FAR 36 Appendix F ALM versus takeoff ALM yields a respectable coefficient of determination R^2 of .66 for both linear and logarithmic regression analyses. This finding coupled with the fact that the average deviation in rank ordering is about 2 positions seems to suggest that certification using takeoff ALM noise levels would be roughly equivalent to certification using level flyover ALM corrected for performance.

Level Flyover ALM versus Takeoff ALM



NOTE: The first number indicates the rank ordering using takeoff ALM and the second number represents the rank ordering using the FAR 36 Appendix F certificated ALM levels.

FIGURE 16.1

17.0 Noise Certification "Test Windows" - One of the objectives of the 1982 FAA General Aviation Noise Test program was to assess the impact of deviations from prescribed reference conditions. Another objective was to develop a logical structure of permissible deviations from reference test conditions, while quantifying the degree of confidence associated with any given correction procedure. The confidence one places in the correction procedure often plays a prominent role in defining boundaries of the "Test Window".

17.1 Deviations from Reference Flight Path - The subject of flight path deviations logically divides into separate discussions of vertical deviations and horizontal deviations.

17.1-2 Vertical Deviations - At the outset it is useful to review the probable causes associated with a vertical deviation from the reference takeoff flight path:

1. head wind (aloft)
2. non-standard day temperatures
3. non-reference weight
4. improper airspeed (not Vy)
5. high altitude testing

A second useful background tool is the concept of "correction ratio", defined herein as the ratio of the test altitude divided by the reference altitude. In Figure 17.1, the correction ratio is shown along the abscissa and corresponding decibel correction to ALM using the relationship ΔL_{AM} = 22 log (Corr. Ratio). Using this figure one can select any given allowable correction value in decibels and compute the allowable deviation above and below the reference altitude (note the asymmetry). While this particular figure has been developed for 22 log (Corr. Ratio), a similar graph can be made for any other propagation constant.

For the purpose of this discussion let us assume 1000' is the reference altitude (ALT_{REF}). For a 3 dB limit on the correction ratio we would allow a test window of 1368 feet to 730 feet, permitting 368 feet above or 270 feet below reference altitude.

Another useful perspective is gained by examining the performance of the 18 aircraft in the FAA 1982 test program. Table 17-1 shows that in many cases (12 of 18) the correction ratios lie within the nominal 3 dB ratio limits of 0.7 and 1.4. In a number of cases an unusually high correction ratio is observed, generally associated with winds aloft and/or light weight. From the data in Table I, it appears that, barring anomalous or incorrect testing conditions, a correction ratio window of 0.7 to 1.4 on vertical deviation is realistic and easily attainable.

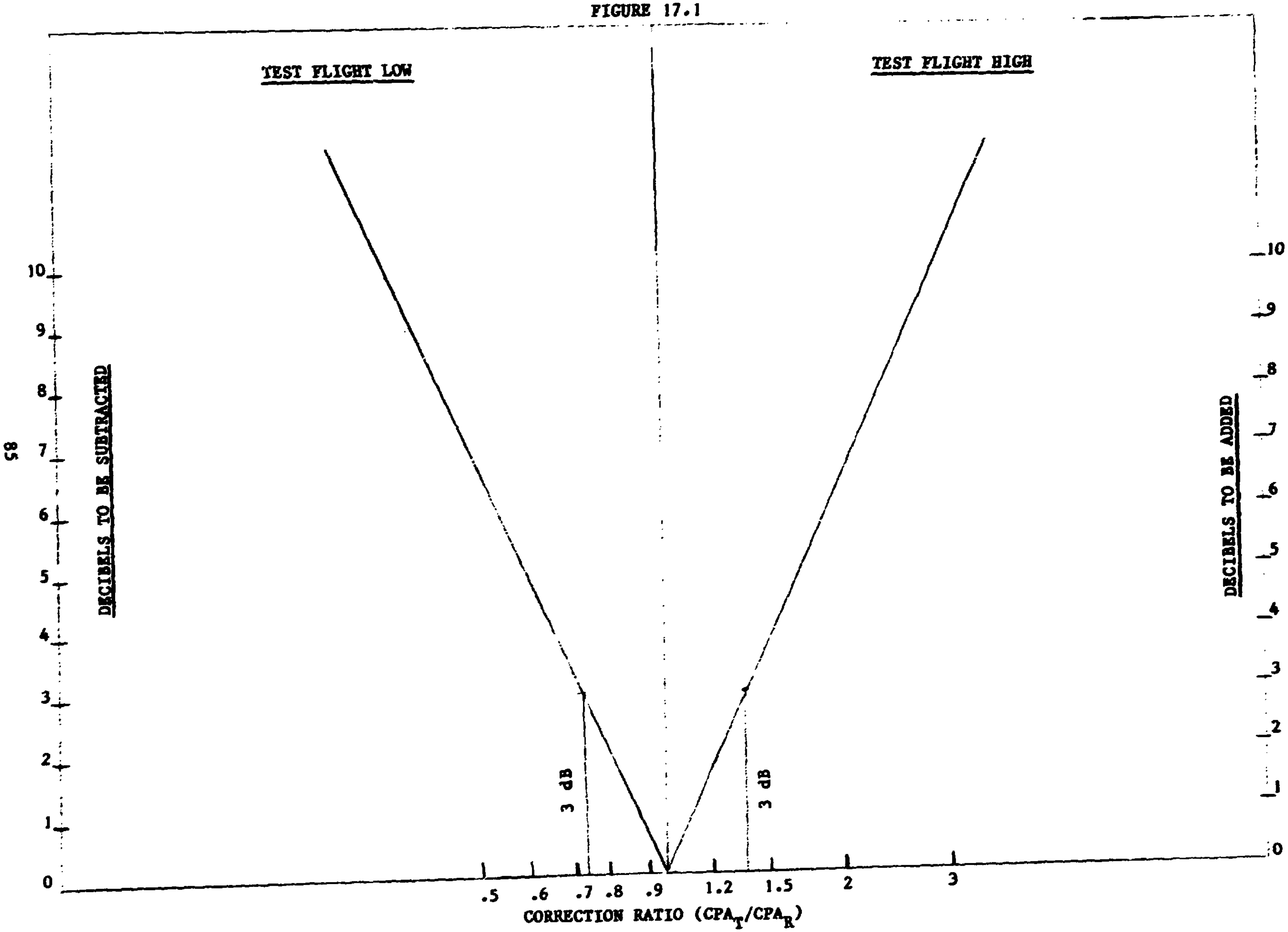
The correction for non-standard altitude can be constrained (for reasons associated with the observed ability of pilots to perform), within the correction ratio range of 0.7 and 1.4. The limiting factor in this case does not appear to be the correction algorithm itself. In fact the 90% confidence interval on the use of K(A) = 21,

$$L_{AM} = K(A) \log ({}^{d}1/{}^{d}2)$$

is less than 0.5 dB.

17.1-2 Lateral Deviation - In the case of lateral deviation from reference ground track, one usually thinks in terms of degrees from zenith. In the case of a 1000-foot reference altitude we observe the following lateral deviations as a function of deviation angle(s):

FIGURE 17.1



TEST FLIGHT LOW
TEST FLIGHT HIGH
DECIBELS TO BE SUBTRACTED
DECIBELS TO BE ADDED
10
9
8
7
6
5
4
3
2
1
0
3 dB
3 dB
.5
.6
.7
.8
.9
1.2
1.5
2
3
CORRECTION RATIO (CPA_T/CPA_R)

TABLE 17.1

T/O CORRECTION(s) ANALYSIS

AIRCRAFT	N	ALT_R	ALT_T	Δ	ALT_T/ALT_R	$22\log(ALT_T/ALT_R)$			
C-180	5	1058'	1582.6		1.5	3.8			
C-170	5	669'	633.6		.9	-0.5			
PA-28	10	682'	619.1		.9	-0.9			
PA-38	8	736'	420.3		.6	-5.4			
KINGAIR 200	7	969'	754.6		.8	-2.1			
PA-42	6	1052'	587.5		.6	-5.6			
C-414	6	836'	901.8		1.1	.7			
B58-P	7	759'	521.5		.7	-3.6			
C-210	6	643'	761.9		1.2	1.6			
C-182	6	827'	835.2		1.0	.1			
C-172	6	650'	659.1		1.0	.1			
MERLIN	6	762'	1136.9		1.5	3.9			
GULFSTREAM 900	6	1337'	1543.9		1.2	1.7			
DUCHESS	7	824'	1421.1		1.7	5.2			
NAVAJO	7	676'	1343.6		2.0	6.6			
ARCHER	6	658'	1242.2		1.9	6.1			
BONANZA	7	717'	1180.4		1.6	4.8			
C-441	7	1085'	1357.7		1.3	2.1			

Deviation Angle θ (Degrees)	Lateral Deviation (Tan θ x 1000), Feet
5	88
10	176
15	268
20	364
25	466
30	577

As a practical matter it was reported by pilots participating in the test that maintaining the reference heading was difficult due to their inability to see the ground while in the climbout flight regime. Typically each pilot would make practice flights until receiving radio confirmation from ground observers verifying the proper flight track. The pilot would then fly that compass heading for subsequent takeoff events. After having found the right compass heading, pilots typically deviated no more than ± 10 degrees from the zenith.

In establishing a boundary on lateral deviation, it is necessary to consider the effects of exhaust shielding and source directivity. As these effects are largely unquantified and differ from one aircraft to the next, it is deemed inappropriate to allow any unnecessary latitude in this parameter. These concerns, coupled with the known ability to fly repeatedly within ± 10 degrees, leads one to the conclusion that 10 degrees be prescribed as the maximum allowable lateral deviation angle.

17.2 Deviations from Reference Airspeed - Maintaining the proper airspeed is one of the most important aspects of the test procedure. Improper airspeed generally results in both a velocity duration correction and the need for an altitude adjustment. The airspeed is a parameter totally within the control of the pilot and governed by visual resolution of the instrument reading. Adherence of pilots participating in the FAA test was, in every case, within 5 kts of the reference airspeed, (see Table 17-2).

In view of observed pilot performance, a limitation of ± 5 kts is recommended as an appropriate test window.

TABLE 17.2

T/O CORRECTION ANALYSIS

VELOCITY CORRECTION

AIRCRAFT	N	Vv(Kts)	$\bar{V}_{g}$(Kts)	$7\log \bar{V}_g/V_v$					
C-180	5	76	64.3	-0.5					
C-170	5	77.3	69.2	-0.3					
PA-28	10	97	89.8	-0.2					
PA-38	8	70	67.8	-0.1					
KINGAIR 200		126							*NOTE* no Vcorr used in T/O analysis ground speed missing
PA-42		120							*same as above i.e., V_{corr} assumed = 0
C-414	6	108	106.1	-0.1					
B58-P	7	115	107.6	-0.2					
C-210	7	98	89.4	-0.3					
C-182	6	88.2	84.0	-0.1					
C-172	6	76	78.2	0.1					
MERLIN	6	147.5	132.5	-0.3					
GULFSTREAM 900	6	135.0	118.3	-0.4					
DUCHESS		97.5							*Note no ground speed
NAVAJO		101.0							same as above
ARCHER		76.0							same as above — assume V_{corr} = 0
BONANZA		95.0							same as above
C-441	7	115	91.4	-0.7					

NOTE: N = Vg sample size

17.3 Deviations from Reference Helical Tip Mach Number - The test helical tip Mach number ($M_{H(T)}$) may be non-reference due to any of the following influences =

1. non-standard day temperature

2. improper air speed (very minor influence)

3. improper test RPM

First, consider temperature effects, probably the greatest potential cause of off-reference M_H. A few useful facts are provided below:

- Speed of Sound at 59°F = 1116 feet per second

  Speed of Sound at 95°F = 1154 feet per second

  Speed of Sound at 36°F = 1091 feet per second

- $M_H(95) = 0.967\ M_H(59)$, 3.3% above reference

- $M_H(36) = 1.023\ M_H(59)$, 2.3% below reference

- $\Delta = K \log \frac{M_{H(R)}}{M_{H(T)}}$ dB

- K is approximated as equal to 150

For a 36°F test day, one would need to subtract 3.2 dB from the measured data to arrive at a reference sound level, assuming $\Delta = 150 \log (M_{H(R)}/M_{H(T)})$. Conversely a value of 2.2 dB should be added to measured data on a 95°F day, using the same assumptions.

It is clear, that an arbitrary limit on the correction value in decibels will impose a restriction on the allowable test temperature window. This poses quite a predicament as the confidence associated with any generic correction function is generally very low. That is to say, a unique correction function appears necessary for each individual aircraft. This would, of course require a significantly greater amount of testing for each aircraft. In order to avoid or reduce the additional testing burden it may be feasible to establish the following scheme:

1. No limit on test temperature related M_H corrections

2. If the test temperature is greater than 59°F then $\Delta = 150 \log M_{H(R)}/M_{H(T)}$ may be used to correct.

3. If the test temperature is less than 59°F then a separate, and independent correction function must be developed.

A comparison is shown in Table 17-3 between test and reference M_H for the aircraft participating in the 1982 FAA test. It is observed that in most cases the $(M_{H(R)}/M_{H(T)})$ ratio is very close to 1.0. On the average there is less than a 1 percent error, primarily due to warmer than standard day temperatures.

TABLE 17.3

TAKEOFF CORRECTION ANALYSIS

MACH NO. CORRECTIONS

AIRCRAFT	N	M_{H_R}	M_{H_T}	$M_{H(R)}/M_{H(T)}$	$150\log M_{H(R)}/M_{H(T)}$	$171\log M_{H(R)}/M_{H(T)}$			
C-180	6	.8271	.813	1.0	+1.1	+0.1			
C-170	8	.715	.702	1.0	+1.2	+0.1			
PA-28	11	.779	.769	1.0	+0.8	+0.1			
PA-38	8	.670	.658	1.C	+1.2	+0.1			
KINGAIR 200	7	.793	.789	1.0	+0.3	+0.1			
PA-42	6	.765	.755	1.0	+0.9	+0.1			
C-414	6	.824	.818	1.0	+0.5	+0.1			
B58-P	8	.841	.840	1.0	+0.7	+0.1			
C-210	7	.857	.853	1.0	+0.3	+0.03			
C-182	6	.753	.747	1.0	+0.5	+0.1			
C-172	6	.684	.673	1.0	+1.1	+0.1			
MERLIN	6	.696	.670	1.0	+2.5	+ .3			
GULFSTREAM 900	6	.690	.692	1.0	-0.2	- .02			
DUCHESS	7	.816	.810	1.0	+0.5	+ .05			
NAVAJO	8	.820	.808	1.0	+1.0	+0.1			
ARCHER	6	.707	.707	1.0	0	0			
BONANZA	7	.857	.851	1.0	+0.5	+0.1			
C-441	7	.715	.723	.99	-0.7	-0.1			

$M_{H(T)}$ = Average of the takeoff Mach numbers.

18.0 Evaluation of Aircraft Position Determination Systems - Three position determination systems were evaluated in the course of the measurement program. The first system was a 9.1 GHz primary radar unit which continuously tracked the test aircraft. The second system was a surveyers transit, set up perpendicular to the ground track at a distance of approximately 1500 feet opposite the microphone location. The third system involved a 35 millimeter SLR camera using slide film situated at the primary takeoff measurement location. While no great revelations were uncovered in comparing the three systems, a number of observations may be useful:

1. The photographic system using slide projections was remarkably accurate and easy to use.
2. Although the transit system is potentially prone to large operator error, with practice it constitutes an acceptable method for determining altitude. The transit operator also has the advantage of being able to calculate the altitude immediately.
3. The radar system, the only system capable of providing aircraft ground speed as one might expect, involves considerable expertise to operate and maintain.

Based on the above observations and the comparison of performance provided in Table 18-1 we arrive at the following recommendations:

1. The photographic system is recommended as the primary measurement tool. This recommendation is consistent with selection of the ALM metric which does not require consideration of ground speed corrections.
2. The transit method of position determination may be permitted, with certain cautions spelled out in regard to operator proficiency.

TABLE 13-1

MEASUREMENT SYSTEM COMPARISON

	ADVANTAGES	DISADVANTAGES
TRANSIT	Inexpensive Easily portable Reasonable accuracy when used by a trained operator	Not capable of obtaining velocity and time data. Prone to large error in the hands of a novice
RADAR SYSTEM	Capable of obtaining ground speed and complete flight path characteristics. Capable of generating REAL TIME position feed back data	Expensive, complex, requires lengthy learning process, requires external power supply, involved data reduction process including software development.
PHOTOGRAPHIC SYSTEM	Inexpensive, easily portable, accurate	Not capable of obtaining velocity data.

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6. Depitre, Alain (Redacteur), "Etude D'une Procedure de Mesure de Bruit Produit Par Les Avions Legers Au Decollage Niveaux Exprimes En Lax" (Measurement of Noise Produced by Light Aircraft on Takeoff), rapport d'etude No 293, Republique Franciase Ministre des Transports, Direction Generale de I'Aviation Civile, Service Technique de la Navigation, Paris, Francaise, December 1982

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Appendix A: Takeoff Noise Data

This appendix contains as measured noise data along with other pertinent information used in arriving at fully corrected takeoff noise levels.

Abbreviations used in Appendix A

RPM:	Propeller RPM (revolutions per minute)
M_H:	Helical Tip Mach Number
GS:	Ground Speed expressed in knots
ALT_T:	Observed Test Altitude (Above Ground Level)
SEL_{am}:	As measured Sound Exposure Level
ALT_{corr}:	Correction to reference altitude
V_{corr}:	Correction to reference Velocity
M_{Hcorr}:	Correction to reference Mach Number
P_{corr}:	Correction to reference Power
SEL_{fc}:	Fully corrected Sound Exposure Level
AL_{am}:	As Measured A-weighted Sound Level
AL_{fc}:	Fully Corrected A-weighted Sound Level

APPENDIX A

TAKEOFF DATA

TABLE A-1

TAKEOFF DATA

AIRCRAFT C-180 SITE #1 TEST DATE 6-3-82

A/C TEST DATA					SEL						AL				
EVENT	RPM	M_H	GS (KTS)	ALT_T (FT)	SEL_{am}	ALT_{corr}	V_{corr}	$M_{H corr}$	P_{corr}	SEL_{fc}	AL_{am}	ALT_{corr}	$M_{H corr}$	P_{corr}	AL_{fc}
1	2550	.813	68.6	1680.2	82.9	3.4	-.3	.6	.2	86.8	72.5	4.9	.9	.3	78.6
2	2550	.813	57.3	1432.7	84.9	2.2	-.8	.6	.2	87.1	73.7	2.7	.9	.3	77.6
3	2550	.813	63.0	1617.0	84.7	3.1	-.6	.6	.2	88.0	73.5	4.2	.9	.3	78.9
5	2550	.813	65.2	1664.1	84.9	3.3	[illegible]	.6	.2	88.5	73.3	4.9	.9	.3	79.4
6	2550	.813	67.4	1519.2	84.0	2.6	-.4	.6	.2	87.0	74.2	3.5	.9	.3	78.9

*ALL UNITS EXPRESSED IN dB *ALL UNITS EXPRESSED IN dB

TABLE A-2

TAKEOFF DATA

AIRCRAFT C-170 SITE #2 TEST DATE 6-23-82

A/C TEST DATA					SEL						AL					
EVENT	RPM	M_H	GS(KTS)	ALT_T(FT)	SEL_{am}	ALT_{corr}	V_{corr}	$M_{H_{corr}}$	P_{corr}	SEL_{fc}	AL_{am}	ALT_{corr}	$M_{H_{corr}}$	P_{corr}	AL_{fc}
1	2375	.7022	71.2	536	80.7	-1.6	-.2	.7	-	78.9	70.8	-2.3	.5	N/A	69.0
4	2375	.7022	68.5	755	82.0	.89	-.4	.7	-	82.5	70.9	1.3	.5	N/A	74.3
5	2375	.7022	67.6	641	81.0	-.32	-.4	.7	-	80.3	71.4	-.4	.5	N/A	71.5
7	2375	.7022	66.2	623	81.6	-.5	-.5	.7	-	80.6	72.5	-.8	.5	N/A	72.2
8	2375	.7032	72.5	613	81.2	-.6	-.2	.6	-	80.4	72.4	-.9	.5	N/A	72.0

TABLE A-3

TAKEOFF DATA

AIRCRAFT PA-28 Turbo Arrow IV　　**SITE** #[illegible]　　**TEST DATE** 7-13-82

A/C TEST DATA					SEL						AL					
EVENT	RPM	H_H	GS(KTS)	$ALT_{T(FT)}$	SEL_{am}	ALT_{corr}	V_{corr}	$H_{H corr}$	P_{corr}	SEL_{fc}	AL_{am}	ALT_{corr}	$H_{H corr}$	P_{corr}	AL_{fc}
1	2575	.7714	87.6	768.6	82.2	.9	-.3	.5	.01	83.4	76.0	1.2	.6	0	77.8
2	2575	.7714	88.9	702.8	83.0	.2	-.3	.5	.01	83.5	77.0	.3	.6	0	77.9
3	2575	.7714	89.9	738.2	81.1	.6	-.2	.5	.01	82.1	75.1	.8	.6	0	76.5
4	2575	.7714	85.5	614.1	83.0	-.8	-.4	.5	.01	82.4	77.2	-1.1	.6	0	76.7
5	2450	.7714	86.8	587.8	79.9	-.3	-.3	.5	.01	79.1	72.7	-1.5	.6	0	71.8
7	2575	.7714	89.0	651.6	83.1	-.5	-.3	.5	.01	83.1	76.9	-.5	.6	0	77.0
14	2575	.7661	92.1	527.6	84.4	-1.9	-.2	.8	.02	8[illegible].2	78.5	-2.7	1.0	0	76.8
15	2575	.7661	92.6	547.3	84.0	-1.6	-.1	.8	.02	83.2	78.2	-2.3	1.0	0	76.9
16	2575	.7661	93.7	508.0	84.3	-2.2	-.1	.8	.02	83.0	78.4	-3.1	1.0	0	76.3
17	2575	.7661	91.6	545	84.0	-1.6	-.2	.8	.02	83.1	78.3	-2.3	1.0	0	77.0

TABLE A-4

TAKEOFF DATA

AIRCRAFT PA-38 TOMOHAWK SITE #2 TEST DATE 8-10-82

A/C TEST DATA					SEL						AL				
EVENT	RPM	M_H	GS (KTS)	ALT_T (FT)	SEL_{am}	ALT_{corr}	V_{corr}	$M_{H corr}$	P_{corr}	SEL_{fc}	AL_{am}	ALT_{corr}	$M_{H corr}$	P_{corr}	AL_{fc}
1	2350	.6584	72.3	–	79.3	–	.1	.5	0	–	69.4	–	.6	0	
2	2350	.6584	70.8	680.4	80.4	-0.6	.03	.5	0	80.3	70.2	-0.9	.6	0	69.9
3	2350	.6584	66.9	–	80.6	–	-.1	.5	0	–	70.3	–	.6	0	
4	2350	.6584	67.1	–	81.1	–	-.1	.5	0	–	70.4	–	.6	0	
5	2350	.6584	72.2	707.9	80.1	-0.3	.1	.5	0	80.4	70.0	-0.4	.6	0	70.2
6	2350	.6584	64.0	674.0	80.0	-0.7	-.3	.5	0	79.5	69.9	-1.0	.6	0	69.5
7	2350	.6584	63.0	787.2	79.7	0.5	-.3	.5	0	80.4	70.0	0.7	.6	0	71.3
8	2350	.6584	66.4	680.4	79.8	-0.6	-.2	.5	0	79.5	69.2	-0.9	.6	0	68.8

TABLE A-5

TAKEOFF DATA

AIRCRAFT KING AIR 200 SITE #2 TEST DATE 8-31-82

A/C TEST DATA					SEL						AL				
EVENT	RPM	R_H	GS(KTS)	ALT_T(FT)	SEL_{am}	ALT_{corr}	V_{corr}	$R_{H corr}$	P_{corr}	SEL_{fc}	AL_{am}	ALT_{corr}	$R_{H corr}$	P_{corr}	AL_{fc}
1	2000	.7894	N/A	656	89.8	-4.2	0	.1	.1	85.8	85.3	-5.8	.1	.1	79.7
2	2000	.7894	N/A	665	90.0	-4.0	0	.1	.1	86.2	86.0	-5.7	.1	.1	80.5
3	2000	.7894	N/A	693	88.8	-3.7	0	.1	.1	85.3	84.3	-5.2	.1	.1	79.3
4	2000	.7894	N/A	766	88.4	-2.9	0	.1	.1	85.7	83.9	-4.2	.1	.1	79.9
5	2000	.7894	N/A	847	89.4	-2.2	0	.1	.1	87.4	85.1	-3.2	.1	.1	82.1
6	2000	.7894	N/A	893	87.5	-1.8	0	.1	.1	85.9	81.7	-2.6	.1	.1	79.3
7	2000	.7894	N/A	762	88.4	-3.1	0	.1	.1	85.5	83.2	-4.3	.1	.1	79.1

TABLE A-6

TAKEOFF DATA

AIRCRAFT PA-42 CHEYENNE   SITE #2   TEST DATE 9-8-82

A/C TEST DATA					SEL						AL				
EVENT	RPM	M_H	GS(KTS)	ALT_T(FT)	SEL_{am}	ALT_{corr}	V_{corr}	$M_{H corr}$	P_{corr}	SEL_{fc}	AL_{am}	ALT_{corr}	$M_{H corr}$	P_{corr}	AL_{fc}
22	2000	.7546	115	1140	85.4	0.6	0	.3	.3	86.6	78.4	.9	.4	.1	79.8
23	2000	.7546	115	1293	85.3	1.5	0	.3	.3	87.4	78.4	2.1	.4	.1	81.0
24	2000	.7546	115	1154	85.7	0.7	0	.3	.3	87.0	79.3	1.0	.4	.1	80.8
25	2000	.7546	115	1337	86.1	1.8	0	.3	.3	88.5	79.2	2.5	.4	.1	82.2
26	2000	.7546	115	997	85.8	-.4	0	.3	.3	86.0	81.3	-.6	.4	.1	81.2
27	2000	.7546	115	1232	85.4	1.2	0	.3	.3	87.2	79.7	1.6	.4	.1	81.8

TABLE A-7

TAKEOFF DATA

AIRCRAFT C-414 CHANCELLOR SITE #1 TEST DATE 9-14-82

A/C TEST DATA					SEL						AL				
EVENT	RPM	M_H	GS (KTS)	ALT_T (FT)	SEL_{am}	ALT_{corr}	V_{corr}	$M_{H corr}$	P_{corr}	SEL_{fc}	AL_{am}	ALT_{corr}	$M_{H corr}$	P_{corr}	AL_{fc}
23	2700	.8179	108.3	833.2	89.3	.5	.01	.4	.3	90.5	82.7	.7	.4	.2	84.0
24	2700	.8179	104.2	876.2	87.5	.4	-.1	.4	.3	88.5	81.4	.5	.4	.2	82.5
25	2700	.8195	107.1	825.2	85.9	-.1	-.02	.3	.3	86.4	79.4	-.1	.3	.2	79.8
26	2700	.8179	108.0	902.4	87.2	.6	0	.4	.3	88.5	81.1	.8	.4	.2	82.5
27	2700	.8185	104.9	938.7	87.4	.8	-.09	.3	.3	88.7	81.2	1.2	.4	.2	83.0
28	2700	.8179	104.2	975.1	87.4	1.2	-.1	.4	.3	89.2	80.2	1.6	.4	.2	82.4

TABLE A-8

TAKEOFF DATA

AIRCRAFT B-55P BARON   SITE #2   TEST DATE 9-28-82

A/C TEST DATA					SEL						AL				
EVENT	RPM	R_H	GS(KTS)	ALT_T(FT)	SEL_{am}	ALT_{corr}	V_{corr}	$R_{H\,corr}$	P_{corr}	SEL_{fc}	AL_{am}	ALT_{corr}	$R_{H\,corr}$	P_{corr}	AL_{fc}
2	2700	.8404	105.2	496.2	93.9	-3.2	-.3	0	0	90.4	88.4	-4.5	.1	0	84.0
3	2700	.8398	106.1	566.8	93.6	-2.1	- .3	0	0	91.2	87.6	-3.0	.1	0	84.7
4	2700	.8404	113.4	435.8	94.1	-4.1	-.03	.1	0	90.1	89.4	-5.8	.1	0	83.7
5	2700	.8404	109.1	456.3	95.4	-3.8	-.1	0	0	91.5	90.5	-5.3	.1	0	85.3
6	2700	.8404	112.2	513.2	94.4	-2.8	-.1	0	0	91.5	89.7	-4.0	.1	0	85.8
7	2700	.8404	100.0	620.1	93.3	-1.5	-.4	0	0	91.4	87.1	-2.1	.1	0	85.1
8	2700	.8404	107.2	561.8	93.2	-2.2	-.2	0	0	90.8	88.1	-3.1	.1	0	85.1

*NOTE: ACTUAL PROPELLER SPEED = 182 PLUS INDICATED VALUE

TABLE A-9

TAKEOFF DATA

AIRCRAFT C-210 CENTURION SITE #1 TEST DATE 10-5-82

A/C TEST DATA					SEL						AL				
EVENT	RPM*	R_H	GS (KTS)	ALT_T (FT)	SEL_{sm}	ALT_{corr}	V_{corr}	$R_{H corr}$	P_{corr}	SEL_{fc}	AL_{sm}	ALT_{corr}	$R_{H corr}$	P_{corr}	AL_{fc}
1	2700	.8538	89.9	814.7	93.1	1.9	-.3	.1	.1	94.9	86.9	2.4	.2	.1	89.6
2	2700	.8530	-	-	94.5	2.5	0	.2	.1	-	88.3	3.8	.3	.1	92.5
3	2700	.8530	87.3	789.3	94.3	1.3	-.3	.2	.1	95.6	88.2	2.1	.3	.1	90.6
4	2700	.8536	87.3	812	95.4	1.7	-.3	.2	.1	97.1	90.1	2.4	.2	.1	92.8
5	2700	.8538	92.4	993.8	94.6	3.2	-.2	.1	.1	97.8	89.3	4.5	.2	.1	94.1
6	2700	.8536	91.4	983.2	94.2	3.1	-.2	.2	.1	97.4	88.4	4.4	.2	.1	93.1
7	2700	.8536	87.9	978.2	93.2	3.1	-.3	.2	.1	96.3	86.9	4.3	.2	.1	91.5

TABLE A-10

TAKEOFF DATA

AIRCRAFT C-182 SKYLANE SITE #1 TEST DATE 10-5-82

A/C TEST DATA					SEL						AL				
EVENT	RPM	R_H	GS(KTS)	ALT_T(FT)	SEL_{am}	ALT_{corr}	V_{corr}	$R_{H_{corr}}$	P_{corr}	SEL_{fc}	AL_{am}	ALT_{corr}	$R_{H_{corr}}$	P_{corr}	AL_{fc}
14	2400	.7476	94.3	735	77.9	-1.2	.5	.3	.1	77.6	73.6	-1.7	.4	.1	72.4
15	2400	.7476	80.4	928	80.4	.4	.05	.3	.1	81.2	71.7	.5	.4	.1	72.7
16	2400	.7472	82.2	953	80.0	.5	.12	.3	.1	81.0	71.3	.7	.4	.1	72.5
17	2400	.7470	83.2	895	80.2	.1	.16	.3	.1	80.9	71.4	.2	.5	.1	72.2
18	2400	.7467	78.1	873	80.2	.2	-.03	.3	.1	80.8	71.8	.3	.5	.1	72.7
19	2400	.7470	85.5	883	80.0	.4	.2	.3	.1	81.0	70.9	.5	.5	.1	72.0

TABLE A-11

TAKEOFF DATA

AIRCRAFT C-172 SKYHAWK

SITE #1

TEST DATE 10-5-82

A/C TEST DATA					SEL						AL					
EVENT	RPM	M_H	GS(KTS)	$ALT_{T(FT)}$	SEL_{am}	ALT_{corr}	V_{corr}	$M_{H corr}$	P_{corr}	SEL_{fc}	AL_{am}	ALT_{corr}	$M_{H corr}$	P_{corr}	AL_{fc}
26	2300	.6728	78.5	677	82.0	.07	.1	.4	0	82.6	73.1	.1	.5	0	73.7
27	2300	.6728	78.0	724	82.5	.3	.08	.4	0	83.3	73.6	.4	.5	0	74.5
28	2300	.6728	77.8	700	82.7	.1	.07	.4	0	83.3	74.3	.2	.5	0	75.0
29	2300	.6728	81.4	635	82.9	-.5	.2	.4	0	83.0	74.6	-.8	.5	0	74.3
30	2300	.6728	78.8	745	81.9	.1	.1	.4	0	82.6	72.5	.3	.5	0	73.2
31	2300	.6728	74.7	724	82.4	.4	-.05	.4	0	83.1	72.9	.6	.5	0	74.0

TABLE A-12

TAKEOFF DATA

AIRCRAFT MERLIN 227-AT SITE #1 TEST DATE 10-19-82

A/C TEST DATA					SEL						AL				
EVENT	RPM	M_H	GS(KTS)	ALT_{T}(FT)	SEL_{sm}	ALT_{corr}	V_{corr}	$M_{H corr}$	P_{corr}	SEL_{fc}	AL_{sm}	ALT_{corr}	$M_{H corr}$	P_{corr}	AL_{fc}
2	1591	.6998	129.9	1113.6	83.6	2.9	-.4	-.1	-.1	85.9	77.0	4.1	-.1	-.1	80.9
3	1591	.6998	134.6	1124.3	82.9	3.0	-.3	-.1	-.1	85.4	76.7	4.2	-.1	-.1	80.7
4	1591	.6998	134.7	1098.9	82.7	2.8	-.3	-.1	-.1	85.0	77.2	3.9	-.1	-.1	80.7
5	1591	.6998	136.4	1127.9	82.8	3.0	-.2	-.1	-.1	85.4	76.7	4.2	-.1	-.1	80.7
6	1591	.6998	126.8	1158.2	82.8	3.2	-.4	-.1	-.1	85.4	77.1	4.5	-.1	-.1	81.4
7	1591	.6998	132.8	1138.7	81.8	3.4	-.3	-.1	-.1	84.7	74.9	4.8	-.1	-.1	79.5

TABLE A-13

TAKEOFF DATA

AIRCRAFT GULFSTREAM (COMMANDER) 900 SITE #1 TEST DATE 10-19-82

A/C TEST DATA					SEL						AL				
EVENT	RPM	M_H	GS(KTS)	ALT_T(FT)	SEL_{am}	ALT_{corr}	V_{corr}	$M_{H_{corr}}$	P_{corr}	SEL_{fc}	AL_{am}	ALT_{corr}	$M_{H_{corr}}$	P_{corr}	AL_{fc}
15	1591	.6920	116.1	1591.6	78.3	.7	-.4	-.1	0	78.5	70.2	1.0	-.1	0	71.1
16	1591	.6920	117.7	1581.9	79.1	.6	-.4	-.1	0	79.2	69.9	.9	-.1	0	70.7
17	1591	.6920	118.4	1539.1	79.8	.4	-.4	-.1	0	79.7	70.8	.6	-.1	0	71.3
18	1591	.6920	113.6	1593.1	79.9	.7	-.5	-.1	0	80.0	70.5	1.0	-.1	0	71.4
19	1591	.6920	125.0	1455.4	79.0	0	-.2	-.1	0	78.7	69.5	0	-.1	0	69.4
20	1591	.6920	119.0	1502.1	79.9	.2	-.4	-.1	0	79.6	70.8	.3	-.1	0	71.0

TABLE A-14

TAKEOFF DATA

AIRCRAFT DUCHESS SITE #1 TEST DATE 10-19-82

A/C TEST DATA					SEL						AL				
EVENT	RPM	M_H	GS(KTS)	$ALT_{T(FT)}$	SEL_{am}	ALT_{corr}	V_{corr}	$M_{H_{corr}}$	P_{corr}	SEL_{fc}	AL_{am}	ALT_{corr}	$M_{H_{corr}}$	P_{corr}	AL_{fc}
29	2700	.8091	-	1575	86.3	4.8	0	.4	.3	91.8	77.0	6.7	.5	.1	84.3
30	2700	.8091	-	1372	87.4	3.7	0	.4	.3	91.8	79.4	5.3	.5	.1	85.3
31	2700	.8091	-	1245	87.4	3.0	0	.4	.3	91.1	79.7	4.3	.5	.1	84.6
32	2700	.8091	-	1432	87.4	4.1	0	.4	.3	92.2	78.4	5.8	.5	.1	84.8
33	2700	.8091	-	1432	87.4	4.1	0	.4	.3	92.2	78.7	5.8	.5	.1	85.1
34	2700	.8091	-	1454	86.1	4.2	0	.4	.3	91.0	77.3	5.9	.5	.1	83.8
35	2700	.8091	-	1436	86.3	4.1	0	.4	.3	91.1	77.2	5.8	.5	.1	83.6

TABLE A-15

TAKEOFF DATA

AIRCRAFT NAVAJO 350 SITE #1 TEST DATE 10-20-82

A/C TEST DATA					SEL						AL				
EVENT	RPM	M_H	GS(KTS)	ALT_T(FT)	SEL_{am}	ALT_{corr}	V_{corr}	$M_{H\,corr}$	P_{corr}	SEL_{fc}	AL_{am}	ALT_{corr}	$M_{H\,corr}$	P_{corr}	AL_{fc}
1	2525	.8095	106	-	88.6	-					80.8	-	-	-	
2	2525	.8080	101	1574	89.5	4.7	0	.6	-.1	94.7	79.5	6.7	.8	0	87.0
3	2525	.8080	101	1200	90.7	2.7	0	.6	-.1	93.9	83.7	3.8	.9	0	88.4
4	2525	.8080	101	1336	89.7	3.5	0	.6	-.1	93.7	81.6	5.0	.9	0	87.5
5	2525	.8077	100	1311	90.4	3.4	0	.6	-.1	94.3	82.9	4.8	.9	0	88.6
6	2525	.8086	103	1299	90.2	3.3	0	.7	-.1	94.1	82.2	4.7	.9	0	87.8
7	2525	.8080	101	1336	89.7	3.5	0	.6	-.1	93.7	81.5	5.0	.9	0	87.4
8	2525	.8080	101	1349	90.1	3.6	0	.6	-.1	94.2	82.6	5.1	.9	0	88.6

TABLE A-16

TAKEOFF DATA

AIRCRAFT ARCHER II PA-28 181 SITE #1 TEST DATE 1_-20-82

A/C TEST DATA					SEL						AL				
EVENT	RPM	M_H	GS(KTS)	ALT_T(FT)	SEL_{am}	ALT_{corr}	V_{corr}	$M_{H corr}$	P_{corr}	SEL_{fc}	AL_{am}	ALT_{corr}	$M_{H corr}$	P_{corr}	AL_{fc}
16	2350	.7054	0	1233	82.1	4.6	0	.1	0	86.8	70.9	6.5	.1	0	77.5
17	2350	.7127	0	1245	82.9	4.7	0	-.2	0	87.4	72.6	6.6	-.2	0	79.0
18	2350	.7054	0	1298	83.1	5.0	0	.1	0	88.5	73.0	7.1	.1	0	80.2
19	2350	.7059	0	1173	82.2	4.2	0	.1	0	86.5	71.6	6.0	.1	0	77.7
20	2350	.7056	0	1271	83.0	4.8	0	.1	0	87.9	72.0	6.8	.1	0	78.9
21	2350	.7054	0	1253	81.8	4.6	0	.1	0	86.5	71.1	6.5	.1	0	77.7

TABLE A-17

TAKEOFF DATA

AIRCRAFT BONANZA A-36 SITE #1 TEST DATE 10-20-82

A/C TEST DATA					SEL						AL					
EVENT	RPM	H_H	GS (KTS)	ALT_T (FT)	SEL_{am}	ALT_{corr}	V_{corr}	$H_{H corr}$	P_{corr}	SEL_{fc}	AL_{am}	ALT_{corr}	$H_{H corr}$	P_{corr}	AL_{fc}
30	2700	.8511	0	1062	90.2	2.9	0	.2	.1	93.4	83.4	4.1	.4	0	87.9
32	2700	.8519	0	1243	88.9	4.0	0	.2	.1	93.2	80.9	5.7	.3	0	86.9
33	2700	.8511	0	1192	88.6	3.7	0	.2	.1	92.6	81.6	5.3	.4	0	87.3
34	2700	.8509	0	1270	88.5	4.2	0	.3	.1	93.1	80.4	5.9	.4	0	86.7
35	2700	.8514	0	1145	89.3	3.5	0	.2	.1	93.1	81.5	4.9	.3	0	86.7
36	2700	.8511	0	1217	89.4	3.9	0	.2	.1	93.6	82.2	5.5	.4	0	88.1

TABLE A-18

TAKEOFF DATA

AIRCRAFT C-425 CONQUEST-I   #2   TEST DATE 10-26-82

A/C TEST DATA					SEL						AL					
EVENT	RPM	M_H	GS(KTS)	ALT_T(FT)	SEL_{am}	ALT_{corr}	V_{corr}	$M_{H corr}$	P_{corr}	SEL_{fc}	AL_{am}	ALT_{corr}	$M_{H corr}$	P_{corr}	AL_{fc}
1	1900	.7220	90	1240	79.6	.9	-.7	-.1	-.1	79.6	71.9	1.4	-.1	-.2	73.0
2	1900	.7236	94	1260	80.1	1.1	-.6	-.1	-.1	80.4	72.2	1.5	-.1	-.2	73.4
3	1900	.7220	90	1349	80.2	1.6	-.7	-.1	-.1	80.9	71.9	2.2	-.1	-.2	73.8
4	1900	.7224	91	1424	80.9	2.0	-.7	-.1	-.1	82.0	71.5	2.8	-.1	-.2	72.5
5	1900	.7236	90	1303	80.0	1.3	-.7	-.1	-.1	80.4	71.5	1.9	-.1	-.2	72.4
6	1900	.7228	92	1464	79.2	2.2	-.7	-.1	-.1	80.5	70.7	3.1	-.1	-.2	71.8
7	1900	.7231	93	1464	79.8	2.2	-.6	-.1	-.1	81.2	71.3	3.1	-.1	-.2	72.3

APPENDIX B

500 FT. LEVEL FLYOVER DATA

Appendix B: Level Flyover Noise Data

This appendix contains as measured noise data along with other pertinent information used in arriving at fully corrected level flyover noise levels.

Abbreviations used in Appendix B

RPM:	Propeller RPM (revolutions per minute)
GS:	Ground Speed expressed in knots
IAS:	Indicated Air Speed expressed in knots
M_H:	Helical Tip Mach Number
ALT_T:	Test Altitude (AGL)
AL_{am}:	As Measured A-weighted Sound Level
AL_{fc}:	Fully corrected A-weighted Sound Level
SEL_{am}:	As measured Sound Exposure Level
SEL_{fc}:	Fully corrected A-weighted Sound Level

500 FT. LEVEL FLYOVER DATA

TABLE B-1

AIRCRAFT C-170 TEST DATE 6-23-82

	AIRCRAFT TEST DATA						NOISE DATA SITE 1					NOISE DATA SITE 2				
			GS (KTS)													
EVENT	% PWR	RPM	SITE 1	SITE 2	IAS (KTS)	M_H	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}
9	65	2450	88		109	.725	199	80.9	76.6	85.5	81.5	210	79.2	75.9	84.1	81.8
10	65	2450	88		109	.724	216	81.2	77.8	85.1	81.7	216	78.4	75.0	83.3	80.8
11	65	2450	88		109	.724	264	79.0	79.0	84.5	82.6	264	76.1	74.8	81.5	80.4
12	55	2225	67		91	.657	294	72.9	72.7	80.8	81.2	301	71.9	71.9	78.7	78.1
13	55	2225	69		91	.657	281	74.4	73.7	81.5	81.4	292	72.8	72.8	79.3	78.6
14	-	2175	66		85	.620	279	-	-	-	-	306	70.2	70.4	77.1	76.6
15	45	1900	57		74	.561	273	69.9	68.9	79.0	79.2	272	70.2	69.2	77.5	75.8
16	45	1900	-		78	.561	292	69.9	69.6	79.0	-	292	67.9	67.6	75.9	74.8
17	45	1900	59		74	.560	280	70.4	69.7	79.2	79.5	275	70.3	69.4	78.6	76.8
18	65	2450	81.1		104	.720	415	74.7	78.1	82.4	84.7	445	73.0	77.1	80.0	80.0
19	65	2450	79		104	.724	449	73.8	78.0	82.0	85.0	482	71.2	76.1	78.9	79.5
21	65	2450	80		-	.724	454	-	-	-	-	471	71.5	76.2	79.0	79.4
22	-	2450	79		104	.725	600	-	-	-	-	609	71.2	71.4	78.7	78.8
23	-	2450	74		102	.724	632	-	-	-	-	599	71.1	71.1	78.8	78.8
24	-	2450	79		104	.724	570	71.4	70.9	80.2	79.8	610	70.2	70.2	78.0	77.9

500 FT. LEVEL FLYOVER DATA

TABLE B-2

AIRCRAFT PA-28 Turbo Arrow IV

TEST DATE 7-13-82 and 7-20-82

AIRCRAFT TEST DATA							NOISE DATA SITE 1					NOISE DATA SITE 2				
EVENT	% PWR	RPM	GS (KTS) SITE 1	GS (KTS) SITE 2	IAS (KTS)	M_H	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}
5.8	55	2500	83	86	95	.7449	510	74.2	74.4	80.9	80.4	532	74.1	74.7	80.9	80.9
5.9	55	2500	86	86	96	.7458	532	74.1	74.7	80.8	80.8	534	74.0	74.7	80.9	80.9
6.13	55	2400	119	119	120	.7272	467	71.7	71.0	76.3	76.1	503	69.9	70.0	76.3	76.8
6.14	55	2400	119	117	119	.7272	482	71.7	71.3	76.1	76.5	513	70.1	70.4	76.1	76.7
6.15	55	2400	121	121	121	.7281	531	71.2	71.8	75.6	76.5	541	69.0	69.8	75.6	76.7
5.10	55	2400	88	88	98	.7176	504	72.7	72.8	79.6	79.3	532	71.5	72.1	79.4	79.5
5.11	55	2400	88	90	97	.7176	516	72.1	72.4	78.7	78.5	536	71.8	72.5	78.1	78.2
6.16	55	2300	120	120	120	.6997	498	69.4	69.4	76.2	76.7	508	68.2	68.4	75.5	76.1
6.17	55	2300	120	120	120	.6997	498	69.8	69.7	76.6	77.0	506	68.2	68.3	75.5	76.1
5.12	55	2300	91	90	100	.6893	498	70.6	70.6	78.6	78.2	521	70.4	70.8	78.2	78.1
5.13	55	2300	87	90	98	.6893	535	70.3	71.0	78.7	78.7	531	69.9	70.5	78.3	78.3

500 FT. LEVEL FLYOVER DATA

TABLE B-2 (CONT)

AIRCRAFT PA-28 Turbo Arrow IV (CONT)

TEST DATE 7-13-82 and 7-20-82

	AIRCRAFT TEST DATA						NOISE DATA SITE 1					NOISE DATA SITE 2				
EVENT	% PWR	RPM	GS (KTS) SITE 1	GS (KTS) SITE 2	IAS (KTS)	M_H	ALT_T (ft)	AL_{sm}	AL_{fc}	SEL_{sm}	SEL_{fc}	ALT_T (ft)	AL_{sm}	AL_{fc}	SEL_{sm}	SEL_{fc}
6.1	75	2575	133	133	138	.7839	491	-		80.6	80.4	501	76.4	76.4	80.6	80.5
6.2	75	2575	133	133	138	.7839	506	-		-		516	-		-	-
6.3	75	2575	133	135	140	.7848	467	77.7	77.0	81.1	81.1	486	76.8	76.5	81.1	80.9
6.4	75	2500	136	142	142	.7644	504	75.9	76.0	79.2	79.3	481	74.8	74.4	79.2	79.0
6.5	75	2500	136	136	141	.7635	481	75.4	75.0	79.2	78.9	491	74.2	74.0	79.2	79.
6.6	75	2450	140	142	142	.7511	507	74.3	74.4	78.6	78.8	506	73.7	73.9	78.6	78.9
6.7	75	2450	134	136	140	.7502	490	74.2	74.0	78.7	78.6	471	73.4	72.8	78.7	78.3
6.8	75	2400	137	137	142	.7360	472	73.8	73.2	78.0	77.6	482	72.5	72.1	78.0	77.7
6.9	75	2400	136	136	140	.7352	462	73.7	72.9	78.0	77.4	475	72.3	71.8	78.0	77.6
6.10	100	2575	149	149	162	.7945	432	80.8	79.3	82.6	81.5	442	78.9	77.6	82.6	81.7
6.11	100	2575	147	148	160	.7936	465	78.7	77.9	82.1	81.6	465	78.1	77.3	82.1	81.6
6.12	100	2575	147	147	160	.7936	448	79.5	78.4	82.3	81.5	458	78.3	77.4	82.3	81.7

500 FT. LEVEL FLYOVER DATA

TABLE B-3

AIRCRAFT C-180 TEST DATE 7-20-82

	AIRCRAFT TEST DATA						NOISE DATA SITE 1					NOISE DATA SITE 2				
EVENT	% PWR	RPM	GS (KTS) SITE 1	GS (KTS) SITE 2	IAS (KTS)	M_H	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}
21	100	2600	131.2	134.6	165	.85	432	82.1	80.6	86.9	86.2	477	-	-	-	-
22	100	2600	131.2	134.6	162	.85	461	82.7	81.9	87.6	87.4	506	83.2	83.3	87.9	88.5
23	100	2600	131.2	134.6	160	.85	459	83.0	82.1	87.6	87.4	504	83.2	83.3	87.8	88.3
24	100	2600	131.2	134.6	163	.85	471	83.5	82.9	87.9	87.8	516	83.5	83.8	88.2	88.9
25	75	2550	-	-	148	.82	-	82.2	-	86.7	-	-	82.4	-	87.1	-
26	75	2600	123.6	123.9	145	.84	479	81.1	80.7	85.9	85.8	519	82.0	82.4	86.8	87.3
27	75	2600	118.1	122.2	148	.84	471	81.4	80.8	86.2	85.8	514	81.9	82.2	86.8	87.2
28	75	2425	120	125.2	151	.79	503	78.3	78.4	84.2	84.4	524	78.9	79.4	84.4	85.1
29	75	2450	116.1	122.1	151	.80	506	-	-	-	-	547	78.6	79.5	84.3	85.1
30	75	2450	121	124.8	153	.80	505	77.8	77.9	83.9	84.1	527	78.8	79.3	84.4	85.0
31	50	2450	93.6	95.6	120	.78	508	74.7	74.8	81.4	80.9	553	75.8	76.9	82.2	82.4
32	50	2425	93.6	95.6	119	.77	530	75.9	76.5	82.2	82.0	547	76.6	77.5	82.7	82.8
33	50	2400	-	100	125	.77	-	74.9	-	81.3	-	550	75.3	-	81.7	82.0
34	50	2350	103.3	103	130	.76	477	74.4	73.9	80.5	79.8	520	74.2	74.6	80.8	80.7
35	50	2300	101.3	105.4	131	.74	509	73.4	73.6	80.0	79.7	525	73.3	73.8	80.1	80.2
36	50	2200	104.8	104.9	124	.71	513	71.4	71.7	78.5	78.4	539	71.8	72.6	79.0	79.3

500 FT. LEVEL FLYOVER DATA

TABLE B-4

AIRCRAFT PA-38 Tomahawk

TEST DATE 8-10-82

	AIRCRAFT TEST DATA						NOISE DATA SITE 1					NOISE DATA SITE 2				
			GS (KTS)													
EVENT	% PWR	RPM	SITE 1	SITE 2	IAS (KTS)	M_H	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}
16	75	2410	100	102	98	.678	526	70.4	70.9	78.0	78.7	551	70.0	71.0	77.5	78.6
17	75	2410	98	99	100	.679	572	70.3	71.7	77.9	79.1	569	69.7	71.0	78.2	79.4
18	70	2350	95	94	95	.661	541	69.2	70.0	77.5	78.2	551	69.3	70.3	77.3	78.1
19	70	2350	100	96	97	.662	554	67.8	68.9	76.1	77.1	533	69.5	70.2	77.1	77.7
20	65	2300	88	91	90	.647	525	67.3	67.8	75.5	75.8	553	68.0	69.1	76.1	76.8
21	65	2300	86	87	90	.647	558	68.2	69.3	76.2	76.8	580	68.1	69.6	76.2	77.1
22	55	2170	80	87	85	.610	555	65.9	67.0	74.6	75.0	565	66.7	68.0	74.6	75.4
23	55	2170	83	87	85	.610	564	65.9	67.1	74.4	75.0	571	66.6	68.0	74.9	75.7

500 FT. LEVEL FLYOVER DATA

TABLE B-5

AIRCRAFT King Air 200 TEST DATE 8-31-82

AIRCRAFT TEST DATA							NOISE DATA SITE 1					NOISE DATA SITE 2				
			GS (KTS)													
EVENT	% PWR	RPM	SITE 1	SITE 2	IAS (KTS)	M_H	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}
8	85	1700			235	.740	552	81.4	82.4	84.5	85.3	582	80.7	82.3	84.7	85.8
9	85	1750			235	.757	488	82.1	81.8	86.0	85.8	564	81.4	82.7	85.5	86.4
10	85	1800			230	.770	490	82.9	82.7	86.0	85.9	524	83.2	83.7	86.9	87.2
11	85	1850			232	.789	557	81.5	82.6	84.7	85.5	578	83.2	84.7	86.8	87.9
12	85	1900			232	.806	572	82.6	84.0	85.6	86.6	597	82.5	84.3	86.0	87.3
13	85	1950			231	.823	455	86.0	85.0	88.4	87.7	504	84.1	84.2	87.5	87.6
14	85	2000			234	.842	453	86.4	85.4	88.7	88.0	506	86.0	86.1	89.1	89.2
15	85	1900			233	.807	466	83.4	82.7	86.6	86.1	554	82.2	83.3	86.2	87.0
16	85	1950			232	.823	510	82.6	82.8	84.7	82.9	506	83.8	83.9	87.3	87.4
17	85	2000			233	.841	519	85.2	85.6	87.1	87.4	578	83.9	85.4	87.3	88.4
18	95	1900			238	.810	490	85.6	85.4	87.9	87.8	617	81.9	84.1	86.1	87.7
19	95	1900			240	.811	488	83.5	83.2	86.4	86.2	552	83.4	84.4	85.9	86.6
20	95	1900			239	.810	530	83.0	83.6	86.1	86.5	550	83.1	84.1	87.0	87.7
21	95	1900			239	.810	496	84.4	84.3	87.2	87.1	509	82.8	83.0	86.7	86.8

500 FT. LEVEL FLYOVER DATA

TABLE B-6

AIRCRAFT King Air 200 (CONT) TEST DATE 8-31-82

AIRCRAFT TEST DATA							NOISE DATA SITE 1					NOISE DATA SITE 2				
			GS (KTS)													
EVENT	% PWR	RPM	SITE 1	SITE 2	IAS (KTS)	M_H	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}
22	71	1900			214	.795	525	80.7	81.2	83.5	83.9	543	80.7	81.6	86.5	87.1
23	71	1900			214	.795	525	81.2	81.7	84.2	84.6	492	81.1	80.9	85.6	85.5
24	71	1900			215	.795	493	81.3	81.2	83.6	83.5	520	80.3	80.7	84.3	84.3
25	71	1900			214	.795	482	80.9	80.5	84.2	83.9	528	81.9	82.5	85.9	86.3
26	47	1900			195	.783	496	81.0	80.9	83.8	83.7	537	80.1	80.8	84.7	85.2
27	47	1900			194	.783	505	80.3	80.4	83.8	83.9	556	79.8	80.9	84.7	85.5
28	47	1900			194	.783	523	79.1	79.6	82.9	83.2	560	79.4	80.6	84.0	84.8
29	47	1900			195	.783	519	78.3	78.7	81.3	81.6	522	80.9	81.3	85.3	85.6

500 FT. LEVEL FLYOVER DATA

TABLE B-7

AIRCRAFT PA-42 Cheyenne

TEST DATE 9-8-82

AIRCRAFT TEST DATA							NOISE DATA SITE 1					NOISE DATA SITE 2				
			GS (KTS)													
EVENT	% PWR	RPM	SITE 1	SITE 2	IAS (KTS)	M_H	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}
1	100	2000	248.3	247.1	240	.821	548	83.7	84.7	86.6	87.3	555	85.4	86.5	88.1	88.9
2	100	1950	252.8	248.3	236	.802	551	83.4	84.4	86.9	87.7	551	83.6	84.6	86.8	87.6
3	100	1900	236.2	240.3	236	.785	593	82.2	84.0	85.2	86.4	553	82.4	83.5	85.6	86.4
4	100	1850	241.4	239.9	236	.769	561	82.2	83.4	85.3	86.2	592	81.2	83.0	85.0	86.2
5	100	1800	-	-	236	.769	-	81.3	-	84.6	-	-	80.7	-	84.6	-
6	100	1800	238.2	240.2	230	.765	564	-	-	-	-	580	80.5	82.1	84.6	85.7
7	100	1750	242.1	242.5	230	.732	548	80.9	81.8	84.5	85.2	550	80.6	81.6	84.8	85.5
8	100	1700	234.9	241.8	231	.717	573	-	-	-	-	556	80.1	81.2	84.6	85.4
9	100	1850	238	244.3	231	.766	528	81.3	81.9	85.1	85.5	566	81.8	83.1	85.4	86.3
10	100	1900	212	219.1	210	.769	522	80.1	80.5	84.8	84.6	580	79.8	81.4	84.4	85.4
11	100	1900	217.3	217.3	210	.769	587	80.6	82.3	85.1	86.2	588	80.9	82.6	85.2	86.3
12	100	1900	214.9	227.5	210	.769	555	80.6	81.7	84.9	85.4	583	80.6	82.2	84.7	85.8
13	100	1900	221.1	223.6	210	.769	478	81.3	80.8	85.4	85.2	573	80.8	82.2	84.9	85.9
14	100	1900	230.2	238	-	-	572	80.9	82.3	85.1	86.9	567	81.2	82.5	85.4	86.5

500 FT. LEVEL FLYOVER DATA

TABLE B-7 (CONT)

AIRCRAFT P-42 Cheyenne (CONT)

TEST DATE 9-8-82

AIRCRAFT TEST DATA							NOISE DATA SITE 1					NOISE DATA SITE 2				
			GS (KTS)													
EVENT	% PWR	RPM	SITE 1	SITE 2	IAS (KTS)	M_H	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}
15	75	1900	212	218	209	.768	551	80.0	81.0	83.9	84.7	541	79.3	80.1	83.6	84.2
16	75	1900	200	201	210	.769	510	80.0	80.2	81.5	81.5	543	79.7	80.6	83.6	84.2
17	75	1900	201	204	205	.765	584	80.0	81.6	83.8	85.8	592	79.1	80.9	83.1	84.3
18	75	1900	-	-	203	.764	-	80.0	-	84.0	-	-	79.1	-	83.3	-
19	75	1900	208	210	205	.765	537	79.1	79.8	83.4	83.9	552	79.1	80.1	83.4	84.1
20	50	1900	190	185	183	.753	531	77.3	77.9	82.2	82.6	521	77.5	77.9	82.2	82.5
21	50	1900	187	187	183	.753	523	76.0	76.5	81.0	81.3	502	77.6	77.6	82.3	82.3

500 FT. LEVEL FLYOVER DATA

TABLE B-8

AIRCRAFT C-414 Chancellor

TEST DATE 9-14-82

AIRCRAFT TEST DATA							NOISE DATA SITE 1					NOISE DATA SITE 2				
EVENT	% PWR	RPM	GS (KTS) SITE 1	GS (KTS) SITE 2	IAS (KTS)	M_H	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}
1	89	2700	166	171	170	.840	522	-	-	-	-	498.4	84.1	84.1	88.1	88.0
2	89	2650	175	170	176	.829	491.3	83.7	83.5	87.6	87.6	498.3	84.3	84.3	87.9	87.8
3	89	2600	171	188	176	.815	500.5	80.6	80.6	85.5	85.5	564	83.2	84.5	87.5	88.6
4	89	2550	174	175	175	.801	488.8	80.1	79.9	85.1	85.0	498.2	82.0	82.0	86.2	86.2
18	89	2700	168	170	175	.842	482.4	83.5	83.1	87.7	87.3	461.9	86.1	85.3	90.4	89.7
6	75	2600	152	151	154	.805	505.9	78.9	79.0	83.5	83.5	475.4	81.9	81.4	85.9	85.5
7	75	2500	159	152	160	.779	518.7	79.7	80.1	84.5	84.8	485.4	79.7	79.4	84.5	84.3
8	75	2450	159	155	160	.765	490.5	77.4	77.2	83.5	83.4	480.7	81.8	81.4	86.1	85.9
10	75	2300	161	173	162	.724	493	76.5	76.4	83.0	83.0	579.0	78.7	80.2	83.8	85.3
11	75	2250	162	159	163	.710	504.4	75.0	75.1	82.0	82.2	469	77.2	76.5	83.0	82.7
19	75	2700	145	144	147	.830	525.1	83.1	83.6	86.9	87.1	479.4	83.2	82.8	86.8	86.4
20	75	2500	156	119	162	.780	495	78.4	78.3	83.7	83.6	519.4	79.8	80.2	84.8	84.4

500 FT. LEVEL FLYOVER DATA

TABLE B-6 (CONT)

AIRCRAFT C-414 Chancellor (CONT)

TEST DATE 9-14-82

AIRCRAFT TEST DATA							NOISE DATA SITE 1					NOISE DATA SITE 2				
			GS (KTS)													
EVENT	% PWR	RPM	SITE 1	SITE 2	IAS (KTS)	M_H	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}
13	52	2400	115	114	120	.734	519.5	75.5	73.4	81.7	81.9	500.4	75.0		81.0	80.9
14	52	2350	115	116	118	.718	499.8	75.3	75.3	81.3	81.2	511.2	72.5		79.7	79.8
16	52	2250	123	121	118	.690	486.3	72.6	72.3	79.5	79.4	564.0	72.1		79.8	80.7
17	52	2200	128	129	130	.681	482.5	70.8	70.4	78.7	78.6	519.2	72.0		79.9	80.4
21	52	2350	123	119	130	.723	514.1	72.1	72.4	79.4	79.7	544.0	74.8		80.6	81.2
22	52	2300	116	116	118	.704	527.7	72.1	72.7	79.7	80.0	532.3	71.8		79.4	79.8

500 FT. LEVEL FLYOVER DATA

TABLE B-9

AIRCRAFT Baron 58P

TEST DATE 9-28-82

AIRCRAFT TEST DATA							NOISE DATA SITE 1					NOISE DATA SITE 2				
EVENT	% PWR	RPM	GS (KTS) SITE 1	GS (KTS) SITE 2	IAS (KTS)	M_H	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}
9	67	2700	140	153	158	.857	[illegible]	84.6	85.7	89.9	90.3	564.6	85.4	86.7	90.7	91.5
10	67	2650	160	152	160	.844	530	84.7	85.3	89.0	89.4	597.1	82.5	84.3	85.9	87.1
11	67	2600	163	160	166	.832	548.6	81.9	82.9	85.2	86.0	579.2	82.9	84.4	86.7	87.8
12	67	[illegible]	165	168	172	.820	543.9	81.6	82.5	85.5	86.2	585.4	79.0	80.6	84.8	86.2
13	67	[illegible]	164	161	169	.804	538.4	79.7	80.5	85.2	85.0	553.5	79.3	80.4	85.3	86.1
14	67	2450	153	157	163	.787	575.5	78.2	79.7	84.5	85.4	540.6	79.2	80.0	85.1	85.7
15	67	2400	176	164	166	.774	527.4	78.8	79.4	84.5	85.2	558.4	77.6	78.8	84.2	85.1
16	67	2300	168	160	164	.744	540.1	76.6	77.4	83.7	84.4	542.7	76.1	77.0	83.3	83.9
17	67	2200	162	161	164	.715	501.1	76.2	76.2	83.5	83.5	523.4	75.0	75.5	83.3	83.6
18	67	2700	156	158	160	.858	525.6	88.1	88.6	91.2	91.5	570.2	86.2	87.6	90.1	91.1
19	97	2600	180	190	194	.846	565.1	83.5	84.8	87.8	88.6	546.4	85.5	86.4	88.9	89.6
22	97	2600	186	185	194	.846	513.3	84.5	84.8	89.5	89.8	590.3	84.8	86.5	89.1	90.3

500 FT. LEVEL FLYOVER DATA

TABLE B-10 (CONT)

AIRCRAFT Baron 58P (CONT) TEST DATE 9-28-82

	AIRCRAFT TEST DATA						NOISE DATA SITE 1					NOISE DATA SITE 2				
EVENT	% PWR	RPM	GS (KTS) SITE 1	GS (KTS) SITE 2	IAS (KTS)	M_H	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}
20	75	2600	170	174	176	.836	547.9	87.3	88.3	90.5	91.3	531.9	86.3	86.9	8[illegible].8	90.4
23	75	2600	172	171	176	.836	503	84.2	84.3	89.1	89.2	557.2	83.6	84.7	88.0	88.9
25	75	2600	163	168	176	.836	565.3	81.7	83.0	87.1	87.9	574.6	84.9	86.3	79.6	80.6
26	75	2600	161	157	176	.836	591.1	83.3	85.0	89.0	90.1	698.9	81.3	84.8	86.5	88.8
21	50	2600	139	138	145	.823	551.2	79.8	80.8	85.5	86.2	577.3	81.9	83.4	86.6	87.7
24	50	2600	141	138	145	.823	529.4	81.0	81.6	85.1	85.5	550	82.5	83.5	87.5	88.2

500 FT. LEVEL FLYOVER DATA

TABLE B-11

*Indicates Estimate

AIRCRAFT C- 425 Conquest-I

TEST DATE 10-26-82

AIRCRAFT TEST DATA							NOISE DATA SITE 1					NOISE DATA SITE 2				
			GS (KTS)													
EVENT	% PWR	RPM	SITE 1	SITE 2	IAS (KTS)	M_H	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}
9	90	1650	85	185*	210	.6849	402	80.8	78.5	84.9	82.7	548	79.1	80.1	83.5	84.3
10	90	1750	175	175*	200	.7109	395	80.3	77.8	84.4	81.8	481	79.7	79.3	83.9	83.5
11	90	1750	180	180*	205	.7143	414	80.8	78.8	84.4	82.4	462	79.5	78.7	83.7	83.1
12	90	1850	175	175*	200	.7443	424	81.2	79.5	84.6	82.8	462	78.5	77.7	83.1	82.4
13	90	1850	175	175*	200	.7443	417	80.4	78.5	84.2	82.2	421	80.5	78.7	84.3	82.9
14	90	1900	182	182*	207	.7655	428	80.6	79.0	84.4	82.8	436	82.4	81.0	85.7	84.7
15	90	1900	182	182*	207	.7655	393	82.1	79.6	85.5	83.0	471	81.5	80.9	85.0	84.6
22	90	1875	180	180*	205	.7588	418	80.8	78.9	84.7	82.8	453	80.0	79.0	84.2	83.5
23	90	1875	180	180*	205	.7588	454	81.0	80.0	84.6	83.6	496	80.0	79.9	84.2	84.1
20	100	1900	190	190*	215	.7705	421	81.9	80.1	85.8	84.0	491	82.9	82.7	86.1	86.0
21	100	1900	190	190*	215	.7705	434	83.8	82.3	85.8	84.3	501	82.4	83.4	85.9	85.9
16	75	1900	165	165*	190	.7552	418	82.7	80.8	85.8	83.9	436	78.4	81.7	82.7	81.7
17	75	1900	165	165*	190	.7552	425	81.3	79.6	84.9	83.2	471	79.6	83.2	83.6	83.2

500 FT. LEVEL FLYOVER DATA

TABLE B-11 (CONT)

AIRCRAFT C-425 Conquest-I (CONT)

TEST DATE 10-26-82

AIRCRAFT TEST DATA							NOISE DATA SITE 1					NOISE DATA SITE 2				
			GS (KTS)													
EVENT	% PWR	RPM	SITE 1	SITE 2	IAS (KTS)	M_H	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}	ALT_T (ft)	AL_{am}	AL_{fc}	SEL_{am}	SEL_{fc}
18	50	1900	145	145*	170	.7440	415	79.7	77.8	83.4	81.5	453	76.6	75.6	81.2	80.5
19	50	1900	145	145*	170	.7440	444	78.6	77.4	82.7	81.5	449	77.6	76.5	82.6	81.8

APPENDIX C

COCKPIT DATA

Appendix C: Cockpit Data

This appendix contains various cockpit instrumentation readings logged by a cockpit observer. The readings were logged when the aircraft was approximately over the prime site. Due to the difficulty in seeing the ground from the cockpit during the takeoff operation, it was hard to determine when the aircraft was in fact directly over the site. This will account for the difference between test altitude (ALT_T) listed in Appendices A and B and the altitude listed in Appendix C.

TABLE C-1

COCKPIT DATA

AIRCRAFT C-180

TEST DATE 6-3-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE
1	Takeoff	27.5	N/A	2550	78.3	180	-
2	Takeoff	27.5	N/A	2550	78.3	180	-
3	Takeoff	27.5	N/A	2550	78.3	180	-
4	Takeoff	27.5	N/A	2550	78.3	180	-
5	Takeoff	27.5	N/A	2550	78.3	180	-
6	Takeoff	27.5	N/A	2550	78.3	180	-
7	Takeoff	27.5	N/A	2550	78.3	180	-

TABLE C-2

COCKPIT DATA

AIRCRAFT C-170 TEST DATE 6-23-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE
1	Takeoff	-	N/A	2375	85	360	-
2	Takeoff	-	N/A	2375	85	360	-
3	Takeoff	-	N/A	2375	90	360	-
4	Takeoff	-	N/A	2375	85	360	-
5	Takeoff	-	N/A	2375	85	360	-
6	Takeoff	-	N/A	2375	85	360	-
7	Takeoff	-	N/A	2375	85	360	-
8	Takeoff	-	N/A	2375	90	360	-
9	Flyover	-	N/A	2450	125	360	-
10	Flyover	-	N/A	2450	125	360	-
11	Flyover	-	N/A	2450	125	360	-
12	Flyover	-	N/A	2225	105	360	-
13	Flyover	-	N/A	2225	105	360	-
14	Flyover	-	N/A	2175	98	360	-
15	Flyover	-	N/A	1900	85	360	-
16	Flyover	-	N/A	1900	90	360	-
17	Flyover	-	N/A	1700	85	360	-
18	Flyover	-	N/A	2450	120	360	-
19	Flyover	-	N/A	2450	120	360	-
21	Flyover	-	N/A	2450	120	360	-
22	Flyover	-	N/A	2450	120	360	-
23	Flyover	-	N/A	2450	117	360	-
24	Flyover	-	N/A	2450	120	360	-

TABLE C-3

COCKPIT DATA

AIRCRAFT PA-28RT-201T Turbo Arrow IV

TEST DATE 7-13-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE
1	Takeoff	41.0	N/A	2600	97	010	-
2	Takeoff	41.0	N/A	2600	97	010	-
3	Takeoff	41.0	N/A	2600	97	011	-
4	Takeoff	41.0	N/A	2600	97	010	-
5	Takeoff	41.0	N/A	2450	96	008	-
6	Takeoff	41.0	N/A	2600	96	009	-
7	Takeoff	41.0	N/A	2600	95	010	-
8	Flyover	26.0	N/A	2500	95	-	-
9	Flyover	26.0	N/A	2500	96	010	-
10	Flyover	26.8	N/A	2400	98	010	-
11	Flyover	26.8	N/A	2400	97	008	-
12	Flyover	27.7	N/A	2300	100	006	-
13	Flyover	27.7	N/A	2300	98	004	-
14	Takeoff	41.0	N/A	2600	96	010	-
15	Takeoff	40.0	N/A	2600	99	004	-
16	Takeoff	40.0	N/A	2600	98	010	-
17	Takeoff	41.0	N/A	2600	99	008	-

TABLE C-4

COCKPIT DATA

AIRCRAFT C-180 TEST DATE 7-20-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE
1	Flyover	31.5	N/A	2575	138	005	-
2	Flyover	31.5	N/A	2575	138	185	-
3	Flyover	32.0	N/A	2575	140	005	-
4	Flyover	33.0	N/A	2500	142	185	-
5	Flyover	32.8	N/A	2500	140	005	-
6	Flyover	33.3	N/A	2450	142	185	-
7	Flyover	33.3	N/A	2450	140	005	-
8	Flyover	33.8	N/A	2400	142	185	
9	Flyover	33.8	N/A	2400	140	005	-
10	Flyover	41.0	N/A	2575	162	185	-
11	Flyover	41.0	N/A	2575	160	005	-
12	Flyover	40.5	N/A	2575	160	005	-
13	Flyover	26.8	N/A	2400	120	006	-
14	Flyover	26.8	N/A	2400	119	008	-
15	Flyover	26.8	N/A	2400	121	008	-
16	Flyover	27.7	N/A	2300	120	008	-
17	Flyover	27.5	N/A	2300	120	005	-
21	Flyover	27.0	N/A	2600	165	-	-
22	Flyover	27.0	N/A	2600	162	-	-
23	Flyover	27.0	N/A	2600	160	-	-
24	Flyover	27.0	N/A	2550	163	-	-
25	Flyover	22.0	N/A	2600	148	355	-
26	Flyover	22.0	N/A	2600	145	355	-

TABLE C-4 (CONT)

COCKPIT DATA

AIRCRAFT C-180 (CONT)

TEST DATE 7-20-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE
27	Flyover	22.0	N/A	2425	148	355	-
28	Flyover	23.0	N/A	2450	151	355	-
29	Flyover	23.0	N/A	2450	151	355	-
30	Flyover	23.0	N/A	2450	153	355	-
31	Flyover	16.8	N/A	2450	120	355	-
32	Flyover	16.8	N/A	2425	119	355	-
33	Flyover	17.1	N/A	2400	125	355	-
34	Flyover	17.5	N/A	2350	130	355	-
35	Flyover	17.9	N/A	2300	131	355	-
36	Flyover	18.9	N/A	2200	124	355	-

TABLE C-5

COCKPIT DATA

AIRCRAFT PA-38-112 Tomahawk

TEST DATE 8-10-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE
1	Takeoff	-	N/A	2350	70	360	-
2	Takeoff	-	N/A	2350	70	350	-
3	Takeoff	-	N/A	2350	70	350	-
4	Takeoff	-	N/A	2350	70	350	-
5	Takeoff	-	N/A	2350	70	352	-
6	Takeoff	-	N/A	2350	69	340	-
7	Takeoff	-	N/A	2350	70	[illegible]	-
8	Takeoff	-	N/A	2350	72	345	-
9	Takeoff	-	N/A	2500	95	345	-
10	Takeoff	-	N/A	2500	95	340	-
11	Takeoff	-	N/A	2500	90	340	-
12	Takeoff	-	N/A	2550	98	-	-
13	Takeoff	-	N/A	2600	110	345	-
14	Takeoff	-	N/A	2600	105	345	-
15	Takeoff	-	N/A	2600	105	345	-
16	Flyover	-	N/A	2410	98	360	-
17	Flyover	-	N/A	2410	100	355	-
18	Flyover	-	N/A	2350	95	360	-
19	Flyover	-	N/A	2350	97	355	-
20	Flyover	-	N/A	2300	90	350	-
21	Flyover	-	N/A	2300	90	355	-
22	Flyover	-	N/A	2170	85	355	-
23	Flyover	-	N/A	2170	85	350	-

TABLE C-6

COCKPIT DATA

AIRCRAFT King Air 200

TEST DATE 8-31-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE (MSL)
1	Takeoff	N/A	2230	2000	126	010	1500
2	Takeoff	N/A	2230	2000	126	010	1000
3	Takeoff	N/A	2230	2000	126	010	1100
4	Takeoff	N/A	2230	2000	126	010	1200
5	Takeoff	N/A	2230	2000	126	010	1200
6	Takeoff	N/A	2230	2000	126	010	1100
7	Takeoff	N/A	2230	2000	126	010	1100
8	Flyover	N/A	2230	1700	235	010	-
9	Flyover	N/A	2165	1750	235	010	800
10	Flyover	N/A	2105	1800	230	010	800
11	Flyover	N/A	2050	1850	232	010	800
12	Flyover	N/A	1995	1900	232	010	800
13	Flyover	N/A	1945	1950	231	010	800
14	Flyover	N/A	1895	2000	234	010	800
15	Flyover	N/A	1995	1900	233	010	800
16	Flyover	N/A	1945	1950	232	010	800
17	Flyover	N/A	1895	2000	233	010	800
18	Flyover	N/A	2230	1900	238	010	800
19	Flyover	N/A	2230	1900	240	010	800
20	Flyover	N/A	2230	1900	239	010	800
21	Flyover	N/A	2230	1900	239	010	800
22	Flyover	N/A	1672	1900	214	010	800
23	Flyover	N/A	1672	1900	214	010	800

TABLE C-6 (CONT)

COCKPIT DATA

AIRCRAFT King Air 200 (CONT)

TEST DATE 8-31-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE (MSL)
24	Flyover	N/A	1672	1900	215	010	800
25	Flyover	N/A	1672	1900	214	010	800
26	Flyover	N/A	1115	1900	195	010	800
27	Flyover	N/A	1115	1900	194	010	800
28	Flyover	N/A	1115	1900	194	010	800
29	Flyover	N/A	1115	1900	194	010	800

TABLE C-7

COCKPIT DATA

AIRCRAFT PA-42 Cheyenne

TEST DATE 9-8-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE
1	Flyover	N/A	1895	2000	240	010	-
2	Flyover	N/A	1945	1950	236	010	-
3	Flyover	N/A	1995	1900	236	010	-
4	Flyover	N/A	2050	1850	236	010	-
5	Flyover	N/A	2105	1800	236	010	-
6	Flyover	N/A	2105	1750	230	010	-
7	Flyover	N/A	2165	1700	230	010	-
8	Flyover	N/A	2230	1850	231	010	-
9	Flyover	N/A	2050	1900	231	010	-
10	Flyover	N/A	1995	1900	210	010	-
11	Flyover	N/A	1995	1900	210	010	-
12	Flyover	N/A	1995	1900	210	010	-
13	Flyover	N/A	1995	1900	210	010	-
14	Flyover	N/A	1995	1900	210	010	-
15	Flyover	N/A	1493	1900	209	010	-
16	Flyover	N/A	1493	1900	210	010	-
17	Flyover	N/A	1493	1900	205	010	-
18	Flyover	N/A	1493	1900	203	010	-
19	Flyover	N/A	1493	1900	205	010	-
20	Flyover	N/A	995	1900	183	010	-
21	Flyover	N/A	995	1900	183	010	-
22	Takeoff	N/A	1895	2000	115	010	-
23	Takeoff	N/A	1895	2000	115	010	-

TABLE C-7 (CONT)

COCKPIT DATA

AIRCRAFT PA-42 Cheyenne (CONT) TEST DATE 9-8-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE
24	Takeoff	N/A	1895	2000	115	010	-
25	Takeoff	N/A	1895	2000	115	010	-
26	Takeoff	N/A	1895	2000	115	010	-
27	Takeoff	N/A	1895	2000	115	010	-
28	Takeoff	N/A	995	1900	170	010	-
29	Takeoff	N/A	995	1900	171	010	-

TABLE C-8

COCKPIT DATA

AIRCRAFT C-414 Chancellor | TEST DATE 9-14-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE
1	Flyover	33.8	N/A	2700	170	180	-
2	Flyover	34.3	N/A	2650	170	175	-
3	Flyover	34.8	N/A	2600	176	180	-
4	Flyover	35.5	N/A	2550	176	185	-
5	Flyover	27.0	N/A	2700	145	179	-
6	Flyover	28.5	N/A	2600	154	178	-
7	Flyover	30.0	N/A	2500	160	180	-
8	Flyover	30.8	N/A	2450	160	187	-
9	Flyover	31.5	N/A	2400	162	185	-
10	Flyover	32.9	N/A	2300	162	185	-
11	Flyover	33.7	N/A	2250	163	185	-
12	Flyover	21.7	N/A	2450	120	185	
13	Flyover	22.2	N/A	2400	120	190	-
14	Flyover	22.6	N/A	2350	118	190	-
15	Flyover	23.1	N/A	2300	120	181	-
16	Flyover	23.5	N/A	2250	118	181	-
17	Flyover	24.3	N/A	2200	130	182	-
18	Flyover	33.8	N/A	2700	175	185	-
19	Flyover	27.0	N/A	2700	-	-	-
20	Flyover	30.0	N/A	2500	162	185	-
21	Flyover	22.6	N/A	2350	130	185	-
22	Flyover	23.1	N/A	2300	118	187	-
23	Takeoff	-	N/A	-	110	187	-

TABLE C-8 (CONT)

COCKPIT DATA

AIRCRAFT C-414 Chancellor (CONT) TEST DATE 9-14-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE
24	Takeoff	-	N/A	-	110	187	-
25	Takeoff	-	N/A	-	115	187	-
26	Takeoff	-	N/A	-	110	187	-
27	Takeoff	-	N/A	-	112	187	-
28	Takeoff	-	N/A	-	110	187	-

TABLE C-9

COCKPIT DATA

AIRCRAFT B58-P Baron

TEST DATE 9-28-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE (AGL)
1	Takeoff	39.5	N/A	2700	115	005	-
2	Takeoff	39.5	N/A	2700	115	005	1100
3	Takeoff	39.5	N/A	2700	113	005	1100
4	Takeoff	39.5	N/A	2700	115	010	1000
5	Takeoff	39.5	N/A	2700	115	010	1200
6	Takeoff	39.5	N/A	2700	115	010	1000
7	Takeoff	39.5	N/A	2700	115	010	1100
8	Takeoff	39.5	N/A	2700	115	010	1100
9	Flyover	27.2	N/A	2700	158	010	500
10	Flyover	27.5	N/A	2700	160	010	500
11	Flyover	27.9	N/A	2650	166	010	500
12	Flyover	28.3	N/A	2600	172	010	500
13	Flyover	28.7	N/A	2550	169	010	500
14	Flyover	29.2	N/A	2500	163	010	500
15	Flyover	29.7	N/A	2450	166	010	500
16	Flyover	31.0	N/A	2400	164	010	500
17	Flyover	33.0	N/A	2300	164	010	500
18	Flyover	27.2	N/A	2200	160	010	500
19	Flyover	29.5	N/A	2700	194	010	500
20	Flyover	31.8	N/A	2600	176	010	500
21	Flyover	23.5	N/A	2600	145	010	500
22	Flyover	39.5	N/A	2600	194	010	500
23	Flyover	31.8	N/A	2600	176	010	500

TABLE C-9 (CONT)

COCKPIT DATA

AIRCRAFT B58-P Baron (CONT) TEST DATE 9-28-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE (AGL)
24	Flyover	23.5	N/A	2600	145	010	500
25	Flyover	31.8	N/A	2600	176	010	500
26	Flyover	31.8	N/A	2600	176	010	500

*NOTE: ACTUAL PROPELLER SPEED = 182 PLUS INDICATED VALUE

TABLE C-10

COCKPIT DATA

AIRCRAFT C-210 Centurion

TEST DATE 10-5-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE (MSL)
1	Takeoff	N/A	-	2700	98	180	1100
2	Takeoff	N/A	2700	2700	95	185	1200
3	Takeoff	N/A	2700	2700	95	175	1300
4	Takeoff	N/A	2700	2700	97	185	1200
5	Takeoff	N/A	2700	2700	98	180	1300
6	Takeoff	N/A	2700	2700	97	180	1300
7	Takeoff	N/A	2700	2700	97	180	1350

TABLE C-11

COCKPIT DATA

AIRCRAFT C-182 Skylane

TEST DATE 10-5-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE (MSL)
14	Takeoff	30.0	N/A	2400	92	180	1250
15	Takeoff	31.0	N/A	2400	92	182	1200
16	Takeoff	31.0	N/A	2400	91	182	1200
17	Takeoff	31.0	N/A	2400	90	182	1100
18	Takeoff	31.0	N/A	2400	89	182	1100
19	Takeoff	31.0	N/A	2400	90	182	1150

TABLE C-12

COCKPIT DATA

AIRCRAFT C-172 Skyhawk

TEST DATE 10-5-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE (MSL)
26	Takeoff	-	N/A	2300	75	180	900
27	Takeoff	-	N/A	2300	75	180	900
28	Takeoff		N/A	2300	75	180	900
29	Takeoff	-	N/A	2300	75	180	900
30	Takeoff	-	N/A	2300	75	180	900
31	Takeoff	-	N/A	2300	75	180	900

TABLE C-13

COCKPIT DATA

AIRCRAFT Merlin 227-AT

TEST DATE 10-19-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE (AGL)
2	Takeoff	N/A	100%	100%	147	180	1300
3	Takeoff	N/A	100%	100%	147	180	1200
4	Takeoff	N/A	100%	100%	147	180	1200
5	Takeoff	N/A	100%	100%	147	180	1300
6	Takeoff	N/A	100%	100%	147	180	1300
7	Takeoff	N/A	100%	100%	147	180	1300

TABLE C-14

COCKPIT DATA

AIRCRAFT Gulfstream Commander 900 TEST DATE 10-19-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE (MSL)
15	Takeoff	N/A	97.5%	100%	135	180	-
16	Takeoff	N/A	97.5%	100%	135	185	1500
17	Takeoff	N/A	97.5%	100%	135	185	1700
18	Takeoff	N/A	97.5%	100%	135	185	1900
19	Takeoff	N/A	97.5%	100%	135	185	2000
20	Takeoff	N/A	97.5%	100%	135	185	2200

TABLE C-15

COCKPIT DATA

AIRCRAFT Beech Duchess

TEST DATE 10-19-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE (MSL)
29	Takeoff	29.0	N/A	2700	97	185	-
30	Takeoff	29.0	N/A	2700	97	185	1500
31	Takeoff	29.0	N/A	2700	98	180	1600
32	Takeoff	29.0	N/A	2700	97	180	1500
33	Takeoff	29.0	N/A	2700	97	180	1600
34	Takeoff	29.0	N/A	2700	96	180	1800
35	Takeoff	29.0	N/A	2700	97	179	1700

TABLE C-16

COCKPIT DATA

AIRCRAFT Piper Navajo 350

TEST DATE 10-20-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE
1	Takeoff	41.0	N/A	2525	106	-	-
2	Takeoff	41.0	N/A	2525	101	-	-
3	Takeoff	41.0	N/A	2525	101	-	-
4	Takeoff	41.0	N/A	2525	101	-	-
5	Takeoff	41.0	N/A	2525	100	-	-
6	Takeoff	41.0	N/A	2525	103	-	-
7	Takoeff	41.0	N/A	2525	101	-	-
8	Takeoff	41.0	N/A	2525	101	-	-

TABLE C-17

COCKPIT DATA

AIRCRAFT PA28-181 Archer II

TEST DATE 10-20-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE
16	Takeoff	-	N/A	2350	76	-	-
17	Takeoff	-	N/A	2375	76	-	-
18	Takeoff	-	N/A	2350	76	-	-
19	Takeoff	-	N/A	2350	80	-	-
20	Takeoff	-	N/A	2350	77	-	-
21	Takeoff	-	N/A	2350	76	-	-

TABLE C-18

COCKPIT DATA

AIRCRAFT Beech Bonanza-36

TEST DATE 10-20-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE (AGL)
30	Takeoff	29.0	N/A	2700	97	185	1300
31	Takeoff	28.5	N/A	2700	98	180	1300
32	Takeoff	28.0	N/A	2700	100	180	1300
33	Takeoff	28.0	N/A	2700	97	180	1300
34	Takeoff	28.0	N/A	2700	96	180	1400
35	Takeoff	28.0	N/A	2700	98	182	1400
36	Takeoff	28.5	N/A	2700	97	183	1400

TABLE C-19

COCKPIT DATA

AIRCRAFT C-425 Conquest-I

TEST DATE 10-26-82

EVENT NO.	EVENT TYPE	MANIFOLD PRESS.	TORQUE	PROP RPM	IAS (KTS)	HEADING (DEGREES)	ALTITUDE (MSL)
1	Takeoff	N/A	1244	1900	115	360	1500
2	Takeoff	N/A	1244	1900	119	005	1800
3	Takeoff	N/A	1244	1900	115	010	1600
4	Takeoff	N/A	1244	1900	116	010	1800
5	Takeoff	N/A	1244	1900	115	010	1500
6	Takeoff	N/A	1244	1900	117	012	1600
7	Takeoff	N/A	1244	1900	118	010	1650

APPENDIX D

METEOROLOGICAL DATA

Appendix D: Meteorological Data

Surface

Surface temperature, relative humidity, and wind data were acquired in the vicinity of the noise measurement array during each test.

Upper Air

On certain test days upper air meteorological data were reported as available from the National Weather Service Radiosonde Launch facility at nearby Sterling Park, Virginia (approx 3 miles away).

TABLE D-1

METEOROLOGICAL DATA

AIRCRAFT C-180

TEST DATE 6-3-82

	SURFACE				UPPER AIR				
			WIND					WIND	
TIME	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION	HT. ABOVE GND (FT.)	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION
9:56	77	64	13	150					
10:15	77	60	13	150					
10:30	78	56	12	180					
10:45	77	58	13	160					
10:57	77	60	12	160					
11:17	76	62	12	170					
11:31	78	58	11	150					
11:46	77	58	12	140					
11:55	76	58	12	140					
12:14	80	54	13	140					
12:31	80	54	14	170					
12:46	78	54	16	170					
12:54	79	52	14	140					

TABLE D-2

METEOROLOGICAL DATA

AIRCRAFT C-170 TEST DATE 6-23-82

	SURFACE				UPPER AIR				
			WIND					WIND	
TIME	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION	HT. ABOVE GND (FT.)	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION
5:53	61	84	3	340					
6:53	65	78	8	300					
7:54	68	70	7	300					
8:51	71	61	9	300					
9:52	73	57	8	310					
10:53	75	52	8	310					
11:53	76	48	5	330					
12:15	77	60	-	-					

TABLE D-3

METEOROLOGICAL DATA

AIRCRAFT PA-28RT-201T Turbo Arrow IV

TEST DATE 7-13-82

	SURFACE				UPPER AIR				
			WIND					WIND	
TIME	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION	HT. ABOVE GND (FT.)	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION
					0	68	91	3	340
					246	71	79	-	-
					709	75	59	-	-
					910	-	-	10	013

TABLE D-4

METEOROLOGICAL DATA

AIRCRAFT C-180 TEST DATE 7-20-82

	SURFACE				UPPER AIR				
			WIND					WIND	
TIME	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION	HT. ABOVE GND (FT.)	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION
5:30	71	97	2	100	0	70	94	0	230
5:44	71	97	0	000	269	71	93	-	-
5:55	71	97	0	000	620	73	86	-	-
6:13	71	100	2	230	1075	-	-	10	307
6:27	71	100	0	000	1874	70	83	-	-
6:45	72	97	0	000					
6:54	72	97	0	000					
7:15	73	100	4	310					
7:30	74	97	4	300					
7:46	74	97	4	280					
7:55	75	97	4	270					
8:19	77	94	4	280					
8:32	77	94	6	300					
8:45	77	90	5	310					
8:57	77	90	6	310					
9:15	78	88	7	290					
9:35	82	82	8	300					
9:52	82	85	9	310					

TABLE D-5

METEOROLOGICAL DATA

TEST DATE 8-10-82

AIRCRAFT PA-38-112 Tomahawk

	SURFACE				UPPER AIR				
			WIND					WIND	
TIME	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION	HT. ABOVE GND (FT.)	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION
5:39	71	90	0	0	0	68	98	0	200
5:53	71	90	0	0	154	70	100	-	-
6:07	-	-	0	0	499	71	94	-	-
6:22	72	97	3	120	761	74	82	-	-
6:41	-	-	3	210	939	-	-	13	289
6:55	72	97	0	0					
7:10	74	90	3	250					
7:27	77	87	6	290					
7:50	79	88	6	290					
8:06	80	85	7	029					
8:22	81	79	8	030					
8:37	82	72	8	030					
8:52	83	65	8	029					
9:10	83	63	9	027					
9:25	84	59	8	028					
9:53	84	57	9	031					
10:53	86	48	10	031					

TABLE D-6

METEOROLOGICAL DATA

AIRCRAFT King Air 200 TEST DATE 8-31-82

	SURFACE				UPPER AIR				
			WIND					WIND	
TIME	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION	HT. ABOVE GND (FT.)	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION
6:45	64	90	4	160	0	62.1	97	3	170
6:53	64	90	5	190	345	62.9	97	-	-
7:15	65	90	4	180	1060	-	97	13	228
7:30	66	91	4	180					
7:53	67	90	5	180					
8:15	68	90	6	170					
8:30	69	87	7	150					
8:43	70	84	7	170					
8:53	71	87	8	180					

TABLE D-7

METEOROLOGICAL DATA

TEST DATE 9-8-82

AIRCRAFT PA-42 Cheyenne

	SURFACE				UPPER AIR				
			WIND					WIND	
TIME	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION	HT. ABOVE GND (FT.)	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION
6:46	66	84	0	0	0	65	84	6	140
6:54	66	84	4	270	407	63	87	-	-
7:05	66	84	0	0	903	-	-	10	142
7:20	66	84	3	270	1005	60	93	-	-
7:47	66	84	3	260					
7:52	66	84	4	260					
8:20	66	84	0	0					
8:53	70	78	0	0					
12:53	70	78	4	180					
1:53	70	78	6	140					
2:53	70	78	4	140					
3:53	70	78	4	150					

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TABLE D-8

METEOROLOGICAL DATA

AIRCRAFT C-414 Chancellor

TEST DATE 9-14-82

SURFACE					UPPER AIR				
			WIND					WIND	
TIME	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION	HT. ABOVE GND (FT.)	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION
12:53	84	61	5	160					
1:31	84	-	4	120					
1:54	84	59	5	130					
2:54	84	57	5	130					
3:51	84	57	8	110					

TABLE D-9

METEOROLOGICAL DATA

AIRCRAFT C-210, C-182, C-172 TEST DATE 10-5-82

	SURFACE				UPPER AIR				
			WIND					WIND	
TIME	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION	HT. ABOVE GND (FT.)	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION
6:53	63	87	0	0	0	61	97	2	360
7:05	-	-	6	010	282	63	78	-	-
7:53	63	90	4	310	535	63	75	-	-
8:53	66	84	0	0	820	65	90	-	-
9:53	70	76	3	340	909	-	-	7	140
10:53	74	71	3	340					

TABLE D-10

METEOROLOGICAL DATA

AIRCRAFT Merlin, Gulfstream 900, Duchess TEST DATE 10-19-82

SURFACE					UPPER AIR				
			WIND					WIND	
TIME	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION	HT. ABOVE GND (FT.)	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION
7:54	49	86	4	190	0	37	85	3	250
8:53	55	74	6	170	1000	51	40	17	215
9:53	59	60	5	210	2000	48	41	22	205
10:51	63	46	9	170					
11:51	67	39	10	150					

TABLE D-11

METEOROLOGICAL DATA

AIRCRAFT Navajo 350, PA-21-181, Bonanza

TEST DATE 10-20-82

	SURFACE				UPPER AIR				
			WIND					WIND	
TIME	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION	HT. ABOVE GND (FT.)	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION
7:55	57	93	7	130	0	49	98	7	170
8:52	62	93	8	160	230	54	96	-	-
9:51	67	84	12	190	423	56	96	-	-
10:50	67	75	9	170	946	-	-	21	194
					1208	54	90	-	-

TABLE D-12

METEOROLOGICAL DATA

AIRCRAFT C-425 Conquest-I TEST DATE 10-26-82

SURFACE					UPPER AIR				
			WIND					WIND	
TIME	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION	HT. ABOVE GND (FT.)	TEMP (°F)	HUMIDITY (%)	SPEED (KTS)	DIRECTION
7:52	44	60	9	320	0	46	48	6	335
8:52	49	52	13	320	276	46	40	-	-
9:52	55	45	12	3[illegible]0	948	-	-	25	354
10:50	56	39	15	350	1241	47	30	-	-

APPENDIX E

CESSNA 210 SUPPLEMENTAL NOISE MEASUREMENTS

Appendix E

CESSNA 210 Supplemental Noise Measurements

Introduction - In order to obtain additional data on the relationship between level flyover and takeoff noise levels, additional noise measurements were conducted with a Cessna Model 210 at Dulles International Airport on June 28, 1983.

A specific objective was to obtain data on the effect of angle of attach on noise levels. The same Cessna 210, N6333C, that was used in FAA takeoff measurements during 1982, was flown to provide a direct comparison with the earlier measurements. (see Table 1.1 and Table 1.2).

The noise measurements were conducted over a two-position array separated by 492 feet under the flight path.

The noise measurement systems were identical to the systems used in the test of June 1982.

Following the noise measurement flights, the tachometer was removed from the airplane for calibration. It was determined that the tachometer readings are approximately 180 RPM less than the true RPM's and the data were corrected accordingly.

Summary - The following comments summarize analysis of the data for the Cessna Model 210:

a. takeoff noise level at maximum continuous power 85.6dBA max

b. change in noise level with helical tip Mach Number (M_H) over a M_H range of 0.77 to 0.91; dBA = 98.7 + 226 log (M_H)

c. there was no statistically significant change in noise level with engine power over a power range of 68% to 98%

d. the noise level at 98% engine power varied linearly with airspeed from 84.4 dBA in level flight at 150 kts true airspeed to 85.6 dBA in climbing flight at 100 kts TAS, normalized to the reference altitude of 640 feet.

Test Operations

Thirty-one flights were conducted over the measurement sites on a magnetic heading of approximately 300°. Seven different takeoff power-airspeed combinations were flown and flight path intercepts were used on these flights. Seven different power RPM combinations were flown in level flight. All flights were targeted for an altitude of 640 feet AGL over the primary site. All but two flights were within 20% of the target altitude and the average of all of the flights was 23 feet above the target altitude.

Weather conditions during the test period were close to a standard acoustic day. The wind was less than 2 knots; the temperature 82°F to 84°F; and the relative humidity 75% to 80%.

Tachometer Calibration - Following the noise measurement flights, the tachometer was removed from the airplane and calibrated. It was determined that the tachometer readings are approximatel 180 RPM less than the actual RPM's over the test range.

Results - Corrected data for the 31 events are listed in the Table. The noise level data are corrected to a reference altitude of 640 feet using the expression 22 log (Altitude/640). The true airspeed listed for the level flyover is the true airspeed over the primary Site 1. Due to flight pattern constraints, the aircraft was accelerating over the sites during the level flyovers. Speeds over Site 2 were not recorded but are estimated to be on the order of 10 knots faster for the level flyovers. Speed was stabilized for the takeoff tests.

Linear regressions of the data were calculated with the following results:

Takeoff using 98% power: dBA = 92.67 - 0.02399 (TAS in knots)

Takeoff using 87% power: dBA = 90.03 - 0.04481 (TAS in knots)

For the level flyover data:

$$dBA = 15.97 + 115.9 M_H$$

$$dBA = 98.70 + 225.9 \log M_H$$

Quadratic regressions were evaluated and provided very similar correlations. There was no significant change in noise level with engine power over the range measured.

Using the linear regressions, the data was corrected to the reference takeoff conditions, resulting in:

Takeoff noise level at maximum continuous power 85.6 dBA max

TABLE E-1

TAKEOFF

EVENT	RPM	% PWR	TRUE AIRSPEED KTS	M_H	L_{AM} (CORRECTED TO 640 ft) PRIMARY SITE 1	SITE 2
A1	2880	98%	103	.896	90.1	86.4
A2	2880	98%	103	.896	90.2	89.4
A3	2880	98%	103	.896	91.7	89.5
A4	2880	98%	103	.896	92.6	88.4
C5	2880	95%	84	.892	93.0	90.3
C6	2880	98%	82	.891	90.8	90.3
D7	2880	98%	92	.894	93.6	89.1
D8	2880	98%	92	.894	91.9	89.1
E9	2880	98%	113	.899	91.6	88.0
E10	2880	98%	113	.899	91.2	88.4
F11	2880	98%	133	.905	89.6	88.4
F12	2880	98%	133	.905	88.2	89.3
B13	2770	87%	82	.858	86.9	85.4
B14	2770	87%	82	.858	87.0	84.8
B15	2770	87%	103	.863	87.3	83.6
B16	2770	87%	103	.863	87.5	85.2

TABLE E-2

LEVEL FLYOVER

EVENT	RPM	% PWR	TRUE AIRSPEED KTS	M_H	L_{AM} (CORRECTED TO 640 ft) PRIMARY SITE 1	SITE 2
G17	2880	98%	149	.910	88.1	89.5
G18	2880	98%	149	.910	90.2	88.0
G19	2880	98%	149	.910	88.7	90.1
G20	2880	98%	149	.910	89.0	89.7
G21	2880	98%	151	.911	89.8	90.3
G22	2880	98%	154	.912	88.7	89.4
H23	2710	85%	146	.859	84.4	82.3
H24	2710	85%	146	.859	84.7	81.9
I25	2830	84%	133	.890	90.2	86.5
I26	2830	84%	135	.891	88.5	88.0
I27	2830	84%	140	.893	89.3	86.6
K28	2420	62%	131	.768	74.0	73.4
L29	2550	63%	133	.807	77.2	76.2
M30	2670	64%	131	.842		79.9
N31	2770	63%	123	.869	87.1	84.6

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